Hybrid human powered vehicle: Research area of electric bicycles.

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Abstract

Increasing internal combustion propelled vehicles in urban and rural areas has given rise to many adverse effects such as emissions of harmful pollutants like hydrocarbons, nitrogen oxides, carbon monoxide and particulate matter which directly or indirectly affects human health. A busy lifestyle and less exercise can lead to physical problems. To reduce use of fossil fuel and health related problems Human powered vehicles are one of the practical possibilities for sustainable transport systems. The vehicle which is driven by human power i.e. muscular power will provide an immediate solution to fuel limitations and pollution caused by conventional fuel propelled vehicles. Although much research has been done on electric bicycles, more research is needed on speed, power sources, batteries, charging methods, bicycling facilities/infrastructures, rider comfort, and safety. This paper focuses on the improvements needed in the field of electric bicycles such as energy sources, Electric motors, Control method, Transmission, Charging methods, Safety, infrastructures and ergonomics etc.

Keywords: Human powered vehicle (HPV), Electric vehicles(EVs), Electric Bicycle(EBs), Effortless bicycle, sustainable mobility; future mobility etc.

1. Introduction

Environmental pollution is a big issue caused by exhaust emissions of fossil-fueled internal combustion vehicles. Many countries are planning to reduce use of petrol and diesel vehicles. All over the world research is going on to reduce environmental pollution caused by the automobile sector. Electric vehicles are the best solution to reduce environmental pollution but still many power plants which are using coal as fuels lead to pollution. There will be a large number of electric vehicles in the future. The electric vehicle is still in the developing stage, Cost of the electric vehicle is still high and its range is less. It is necessary to develop such a type of transportation system which should be affordable, environmentally friendly and safe. Electric bicycles are environmentally-friendly, having zero-emission and many benefits among electric vehicles. Electric bicycles cost less; require less maintenance and also health related benefits. The use of electric bicycles is encouraged in most countries. Separate infrastructure has also been created for this. Due to the health of citizens, zero emission environment friendly electric bicycles do not require licenses and taxes in most of the countries. Electric bicycles are generally classified into pure e-bicycles, power-assisted electric bicycles and combine mode. Electric motors used to drive the wheel of electric bicycles. Speed of an electric bicycle is controlled by controlling electric currents through a handlebar throttle. The pure EBs may be used as a hub motor or in some cases a motor installed on the frame and power is transmitted to the wheel through the drive mechanism. The use of electric motors in power assisted cycling helps the rider to cycle. This means the driver can cycle in low power. In combine mode electric motors and muscle power are used together. In pure mode only electric motors are used and in power assisted mode driver and motor power are used. Much research is still being done to improve performance of electric bicycles. In order to provide research of EBs, this review paper presents development needed in the field of electric bicycles.

2. Energy sources of electric bicycles.

The muscular power, electric battery and solar energy are the energy sources of an EBs. Solar energy is still in the developing stage and it is having great exposure in the field of EBs. The most widely used energy source in electric bicycles is the battery. Battery is the heart of electric bicycles and its important properties include high energy density, fast charging, light weight, long lifespan, discharging, safety, recycling, Eco-friendliness and low cost. The patent of a zinc-carbon battery filed by Hosea W. Libbey which was then used for the EB in 1897 [4]. Lead-acid battery, Nickel-metal hydride battery, Nickel-cadmium battery, Lithium-ion battery, and Lithium-ion polymer battery were commonly used in electric bicycle and still having research exposure in storage capacities, charging and discharging rate, weight reduction, life of battery and safety. Other power sources like fuel cells, zinc batteries and sodium batteries can be used for EBs. Fuel cell efficiency is high, so researchers are focusing more on this. Due to the use of fuel cells it can cause more travel in a single charge. Hydrogen is expensive, it is explosive and difficult to store. Using it in the electric cycle can be challenging for researchers [1].

3. Electric motors

Electric motors on EB are generally classified into brushed DC and brushless DC (BLDC). Brushed DC motors are cheaper and stronger but they are heavier and noisier. In addition, they need frequent maintenance. Compared to DC motors, BLDC motors are lighter in weight, less noisy and have less maintenance. According to the location of motors, electric motors are classified into rear wheel hub motors, front wheel hub motors and in a mid-drive position. Researchers have challenges while developing motors like speed, torque, wheel slippage and uniform weight distribution for smooth function of EBs [1].

4. Control method.

EB's performance is improving due to electric motors and its control methods. Most of scientists presented research studies on operating performance of EBs. Their research helps to investigate the dynamic characteristics and optimize the power requirement of an electric bicycle. They have used different controlling systems such as PI, PID, Fuzzy PID, Hybrid Fuzzy and NMPC for effective and smooth functioning of EBs. Effective control of solar batteries and pedaling forces is a challenge for researchers as the smooth and effective function of EBs [1].

5. Transmission

The transmission system is a basic system that affects the dynamics performance of the electric bicycle. The EBs transmission systems provide different outputs for the input of the gearbox. As per the design requirement location of the gearbox varies and it can affect the performance. Hung and his team presented an experiment and simulation on the operating performance of a semi-automatic transmission system of EBs [2]. Abagnale et al. showed the motion transmission for the simple bevel gear and planetary gearbox and[5].Wu and Sun designed and developed speed-wheel hub motors which made transmission systems more compact[6]. Transmission systems play an important role in EBs and still have their challenges for speed and torque of EBs.

6. Charging methods and charging stations.

Good charging methods and charging stations will promote the use of EBs in the future. The constant current [7] and constant voltage [8] are the charging methods of EBs. Later on, a combination of constant current and constant voltage came to charge the EBs. The overheating problem and charging time reduced, also improved the life of the battery [9]. The charging method of EBs is also classified into plugged in and wireless charging. Inductive power transfer systems are used in the Wireless charging methods [10]. Wireless charging is safer because of no physical contact. It is maintenance-free and unaffected by any type of chemicals, water and dirt. Availability of charging stations along with suitable charging methods will contribute to the EBs market.

7. Cost of Electric bicycle

Battery, electric motors, electronic control units and other accessories increase the cost of electric bicycles. Cost of the battery is more and the range of an electric bicycle battery is up to 25 to 30km. Average time is 4 to 5 hr. required for charging and the battery can be charged up to 1000 cycles. The running cost of electric bicycles is less but because of limited battery life leads to increase in the maintenance cost. Research work is necessary in optimization of design, performance of battery, effectiveness of motor and control systems which will affect the cost of EBs [1].

8. Bicycle aerodynamics and ergonomics, Infrastructure

After realizing that wind is an important source of cycling resistance, aerodynamics and driver position were used in cycling. Fabio Malizia presented a review paper in which he elaborated the components of bicycle and its speed performance according to the ergonomics [17]. He also focused on his next studies cycling flows, cyclist wearing components and aerodynamic interaction [19].Shih-Wen Hsiao presented concept "fitting object to the human body". In which he designed bicycle frames and proposed a table of frame size for common bicycles [20].V. Balasubramanian presented his studies about the investigation of muscle activity during cycling. In which he experimented on different bicycles and he came to the conclusion that suspension cycling feels more relaxed as compared to rigid and sport bicycles [21]. Hongliang Ding et al. presented study on cycle path for safety of bicycle and his study is useful for bicycle infrastructures which improve the bicycle safety and reduce accident.[11]. Rider safety and Development of infrastructure is the most challenging field in development of high speed electric bicycles.[11-16]. Redesigning electric bicycles is necessary to avoid rider fatigue and it will provide more safety along with driver comfort. In the EBs, the main resistance is wind and the main challenges of researchers to develop bicycles which will reduce it.

9. Conclusion

Due to the many advantages of electric bicycles, there may be huge demand in the future. These research areas can be useful for manufacturers and researchers for the development of electric bicycles. These research fields could be providing good references for readers, manufacturers and researchers to develop their electric bicycles according to the research ideas. EBs have many challenges such as safety and rider comfort during riding, battery range, infrastructure which include charging station and battery recycling. Battery waste is going to be one of the biggest environmental challenges of the future. Although electric bicycles are environmentally friendly and useful for health, research in torque, batteries, ergonomics, bicycle infrastructure and aerodynamics will be important for the electric bicycle market.

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Review and Design of Indirect Evaporative Cooling System

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Abstract.

Active air conditioning system consume a significant amount of electricity for cooling application, therefore it is necessary to investigate low-energy consuming cooling systems such as evaporative cooling. The objective of this paper is to give an overview of evaporative cooling as well as a design for an in-direct type evaporation cooling system. This paper describes an evaporation type passive cooling system and uses Evapcal software to design an in-direct type evaporation passive cooling system. A hospital building in Karnataka's eastern region was studied as a case study. It was observed that the in-direct type evaporation cooler system's air output temperature and relative humidity will be 25.4 ^{0}C and 53% respectively. During summer season, indirect evaporative cooling system provides comfort condition for 60% of operational hours.

Keywords. Evaporative Cooling, Evapcal, Indirect evaporative cooling

1. INTRODUCTION

The buildings uses large amount energy out of total energy consumption worldwide. Cooling accounts for large amount of energy consumption out of total building energy consumption. Existing vapour compression system uses large amount of electricity for cooling purpose. To reduce the electricity consumption for cooling, evaporation type passive cooling systems can be used to replace the existing mechanical vapour compression systems. The two main types of evaporation based cooling systems are direct type evaporation passive cooling and in-direct type evaporation passive cooling. Direct type evaporative cooling occurs when air molecules comes into direct contact with water particles, cooling the air and adding moisture to it. In an in-direct evaporative cooling process, product air passes through a dry passage while working air passes through a wet passage and the product air is cooled without addition of water particles. When compared to an active air conditioner, an evaporation kind cooling system can save up to 60% of energy [1].

Nomenclature

DB_O	Output air dry bulb temperature
DB_I	Input air dry bulb temperature
WB_I	Input air wet bulb temperature
LPH	Liters per hour

2. DESCRIPTION OF EVAPORATIVE COOLING SYSTEM

2.1 Direct evaporative cooling (DEC)

Figure 1 illustrates configuration for direct evaporation type cooling. As depicted in figure 1, in direct evaporation based cooling treatment, water from the sump is pumped by recirculating pump and sprinkled over on cooling pads through which inlet air passes and transfers heat along with water molecules. When atmospheric air passes through cooling pad, where air molecules makes direct contact with the water particles, water particles absorb the sensible heat of the air so that air get cooled and water particles vaporizes and added to the air. Figure 2 depicts a psychrometric chart, depicting the direct type evaporation based cooling method. The effectiveness of the direct type evaporative cooling method is[2]

$$\text{Effectiveness} = \frac{(DB_O - DB_I)}{(DB_I - WB_I)} \quad (1)$$

For direct evaporative cooling effectiveness lies between 80 - 90%. Effectiveness is depends on type of cooling pad, depth of media and face velocity of air.

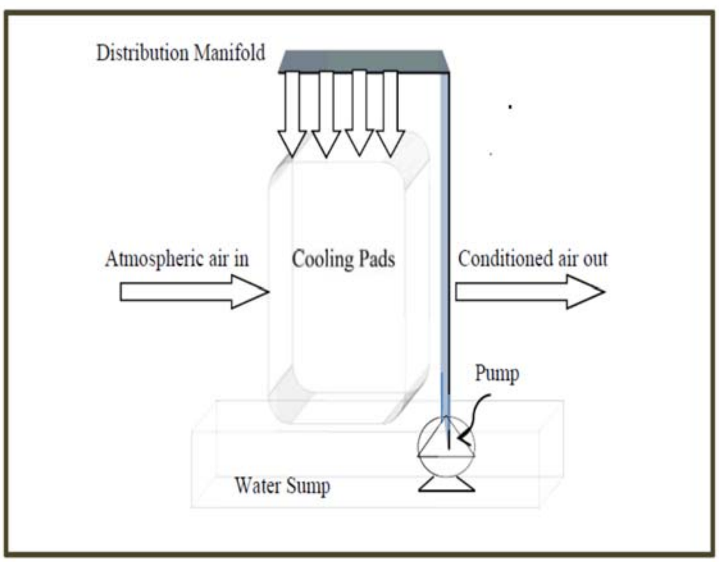

Figure1. Direct Evaporation Type Passive Cooling Method [3]

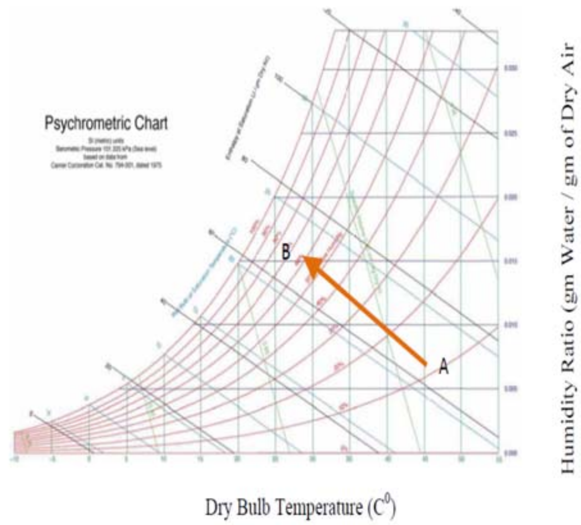

Figure 2. Direct Evaporation Type Passive Cooling method on Psychrometric Chart [4]

2.2 In-direct evaporation type cooling (IDEC)

Diagram 3 illustrates the in-direct evaporation type passive cooling process. The dry passage and the wet passage make up the indirect evaporative cooling process and a thin wall separates the two passages. In wet passage, cooling of working air is done by direct evaporation type cooling process and this cooled working air is use to cool product air flowing through dry passage. Product air is prudently cooled without addition of water particles, lowering both dry bulb temperature and wet bulb temperature. Moisture content of product air remains same during in-direct evaporation type passive cooling method. The air flow in an in-direct type evaporative passive cooling method can be in parallel, counter, or mixed flow arrangement. Figure 4 depicts the in-direct type evaporation cooling methods on a psychrometric chart. The total enthalpy of air gradually decreases in the in-direct type evaporation passive cooling method, which travels horizontally along a steady straight line on a psychrometric chart.

The effectiveness of indirect evaporative cooling (IEE) is [5],

$$\text{IEE} = \left(\frac{t_1 - t_2}{t_1 - t_3}\right) * 100 \qquad (2)$$

Where, $t_1 = Supply\ air\ inlet\ dry - bulb\ temperature.$
$t_2 = \ Supply\ air\ outlet\ dry - bulb\ temperature.$
$t_3 = Wet\ side\ air\ inlet\ wet - bulb\ temperature.$

Effectiveness of In-direct type evaporation coolers can have up to 80%. The heat exchanger surface size, facing velocity, and degree of wetness obtained on the wet side heat exchanger surface all contribute to the efficacy of in-direct evaporation cooling. A design of an indirect evaporative cooler was created for use in data centers. In this cross flow heat exchanger was used, it was observed that simulation results were good in agreement with experimental results [6]. As a precooling unit, an in-direct evaporation cooler with intrinsic baffles may be used. [7] .The numerical and experimental work on a regenerative in-direct evaporation cooler that can provide lower wet bulb cooling was done with the Lewis factor set to unity. [8]. Heat and mass transport parameters in in-direct evaporation cooling with counter flow configurations were explored by Wan, Ren and Xing [9]. Chauhan and Rajput [10] created a combination dew point evaporative-vapour compression based air cooling system for dry and somewhat humid areas. This combination system outperforms active vapour compression devices. Antonellis et.al.[11] explored an in-direct evaporation cooling system with cross flow. and discovered that counter flow nozzles outperform parallel flow nozzles. Duan et.al. [12] carried out an experimental investigation on a counter flow regenerative cooler and discovered that the working to intake air ratio should be between 0.4 and 0.5 in order to achieve a balance of effectiveness, energy efficiency and cooling capacity. Analysis of thermal insulation material and suitability of evaporative cooling method was done [13].

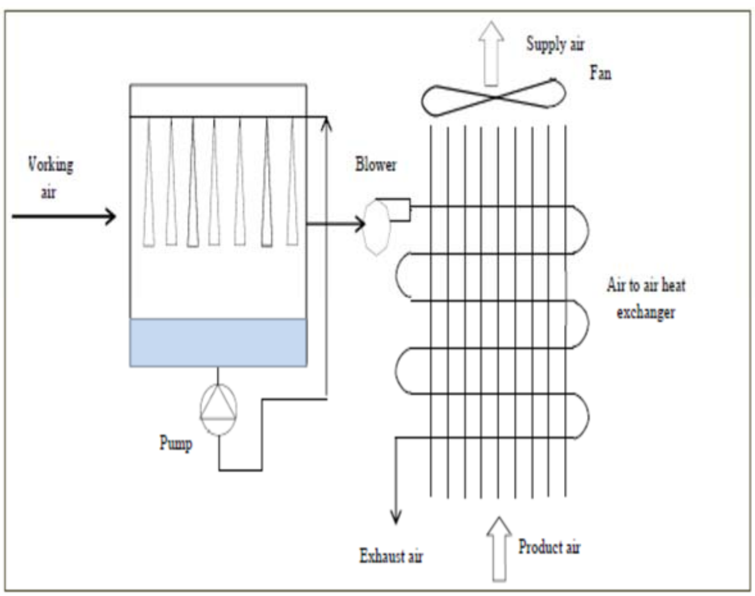

Figure 3. In-direct evaporation cooling method [2]

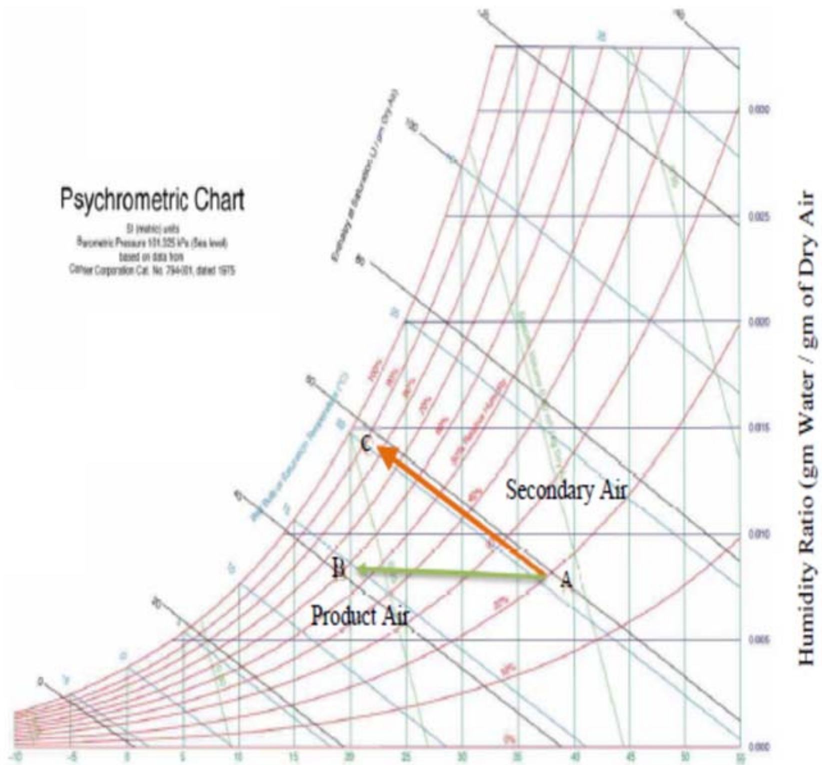

Figure 4. In-direct evaporation passive cooling method on psychrometric chart [4]

3. DESIGN OF IN-DIRECT EVAPORATION TYPE PASSIVE COOLING SYSTEM

As a study case, the Sanjivani hospital in Bellary, Karnataka, India was chosen. The overall floor area of the structure is 4143.4 m^2.The building's ground floor has a floor area of 1381.13 m^2. The wall is 3.33 meters tall. Evapcal software was used to evaluate the effectiveness of an in-direct evaporation cooling system. The total sensible and latent load of hospital's ground floor is 221.45 kW and 101.53 kW, respectively. Maximum allowable indoor temperature is 26^0C dry bulb temperature with a relative humidity 70%. After calculation by Evapcal it has been observed that, supply air temperature by indirect evaporative cooling system will be 25.4 ^{0}C, supply air relative humidity 53%, required air flow rate 733634 CFM and peak water requirement 4887 LPH. The summer season, which runs from February 1 to May 31 (2880 hours), has been taken into account in the calculations. It has been found that for 60% of operational hours, the system will provide a comfortable environment within the design range.

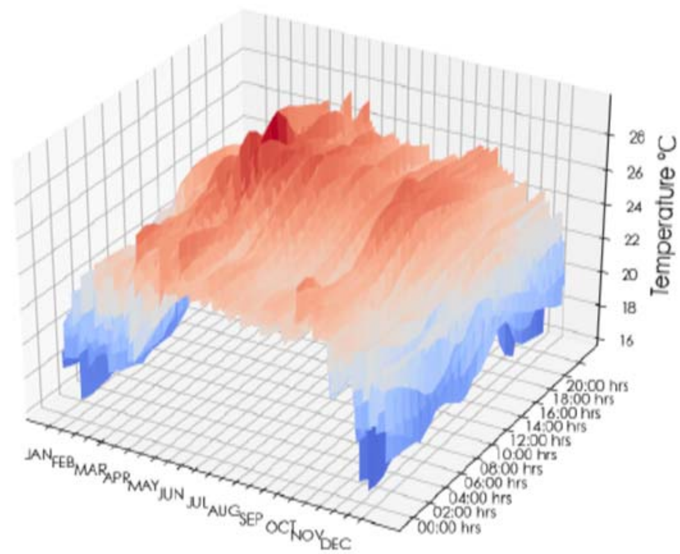

Figure 5. Dry bulb temperature inside the room

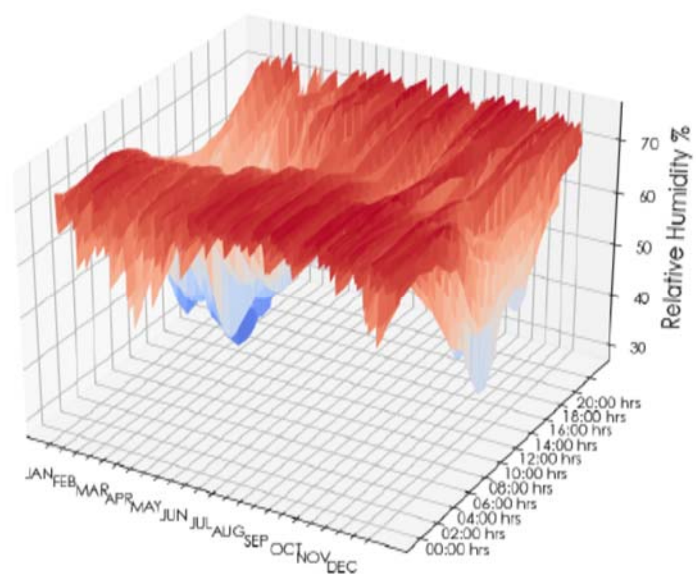

Figure 6. Relative humidity inside the room.

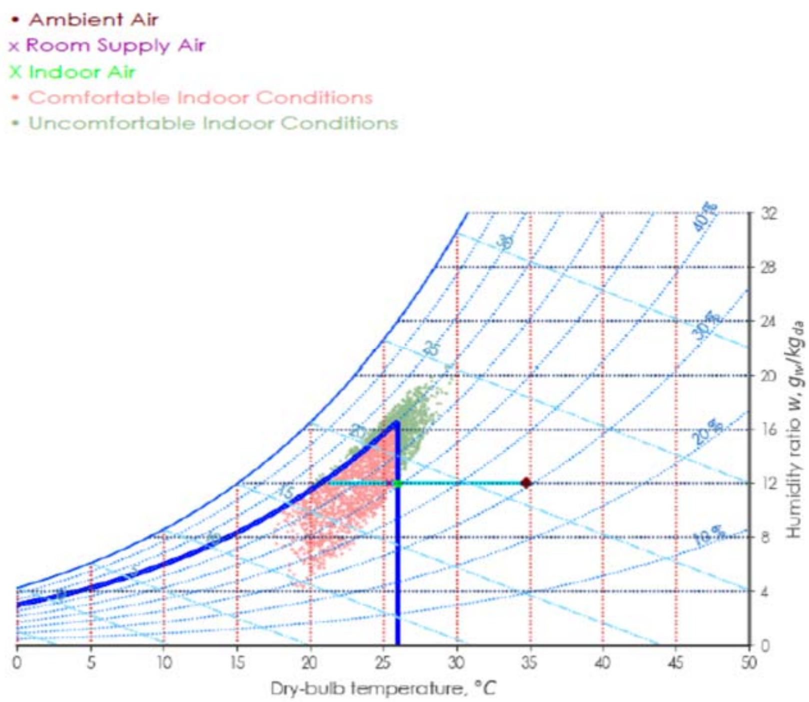

Figure7 Psychrometric comfort analysis.

4. CONCLUSION

An overview and design of an in-direct type evaporation passive cooling method was completed using Evapcal software, assuming that the indirect evaporative cooler's cooling load and efficiency remain constant throughout operational hours and that heat exchange between output air and working air is equal to heat exchange between water film and working air. With a dry bulb temperature of 25.4°C and a relative humidity of 53%, an in-direct evaporation cooling system will provide a comfortable environment for 60% of operational hours during the summer season. One of most key techniques for saving electricity in cooling is indirect evaporative cooling.

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Biographies

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Implementation of Energy Efficient Burnishing Process for Surface Integrity Improvement of Hole Finishing Tool

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Abstract.

Burnishing is a well-known cold working technique for improving the surface integrity. It is a very cost-effective and efficient approach for improving surface finish and hardness. Use of burnishing to replace current heat treatment and grinding processes on reamer shank is offered as a unique strategy for reamer shank processing. This change in processing reduces cycle time and resources while also conserves energy required for processing during heat treatment and grinding. In this work Taguchi optimization technique is used to determine the optimum parameter values of burnishing process to attain required surface finish and hardness to fulfil all functional requirements of shank. Test outcomes are convincing which shows that suggested process has capability to replace current heat treatment and grinding process, thus conserves energy.

Keywords. Energy conservation, Burnishing, reamer, shank, taguchi optimization.

1. INTRODUCTION

Energy is critical to the world's evolution, development, and existence. Rising energy consumption has a negative impact on the environment as well as increased government pressure. For a developing country like India, the energy criteria determine the country's growth. As the third biggest power generator, the country is ruled by energy shortage and need. Our country's energy consumption is expanding at an alarming rate. Energy conservation may be the greatest response to rising energy needs. Energy conservation is the practise of minimising energy consumption by utilising less of an energy service. Energy auditing is one of the most essential techniques to increase energy saving. It is a difficult effort to conserve energy without reducing consumption. The paper highlights the importance of conserving energy by substituting the processing technique used for reamer shank manufacturing, taking into account the energy consumed by the current manufacturing process, and suggesting a new efficient yet simple optimization based method, namely taguchi, to improve energy efficiency and compare results.

The cutting side of two-piece reamers is generally composed of H.S.S., while the shank side is constructed of a low-priced carbon alloy steel like EN31 to lower tool's cost.

EN31 steel attains more hardness after heat treatment, as well as strong abrasion resistance. As a result, this method is used to make reamers, drill bits, taps, ejector pins, bearings, and wear-resistant machine and press tool components, among other things.

Rotary friction welding is commonly used to attach the cutting and shank sides of reamers, since it is the most appropriate technique for combining divergent materials. Friction welding, on the other hand, causes thermal strains in TMAZ and HAZ. Air quenching hardens the HSS material (cutting side) in these zones. To enhance machinability, friction welded components are normalised and annealed, respectively. After rough turning, different heat treatment cycles are utilised for both sides because of differing material properties of the cutting and shank sides, as shown in Table 1. Heat treatment, on the other hand, is consumes lot of energy/electricity [1], necessitating careful adherence to energy conservation and environmental laws. This method is also not economically possible in today's competitive market [2]. As a result, the major focus of this research is on eliminating the heat treatment procedure by including the burnishing process into the reamer manufacturing process plan. Surface integrities, such as surface finish, hardness are enhanced during the burnishing process [3–5].

Cutting side hardness is in between 760 to 900 HV, while the hardness of the shank side is in between 180 to 450 HV, according to Indian Standard IS 5443 1994 Reff2021 of technical supply requirements for reamer [6]. Burnishing can increase the initial hardness by up to 45% [7]. Cutting side hardness is 247 HV, while the shank side is 178.3 HV before heat treatment. If heat treatment is substituted with burnishing, cutting sides' hardness can be increased to 356 HV and shank sides' hardness can be increased to 260 HV, respectively. As a result, it's clear that the burnishing technique can be used only for shank processing. As previously indicated, the burnishing technique may increase surface finish which can eliminate finish-grinding procedure in the traditional shank production process. Because of the removal of costly heat treatment and grinding processes, suggested technique will lower the cost of reamer production. In addition, the recommended strategy guarantees a secure working environment. As a result, in this study, an examination is carried out to evaluate the viability of the suggested shank process plan, as well as to compare its performance with traditional one.

Heat treatment for the shank section is therefore replaced with burnishing, a surface improvement method in current study to obtain the necessary characteristics. As a plastic deformation method, burnishing utilises the pressure of a hard roller or ball to deform the asperities on a workpiece's surface [7-9], producing a high-quality surface finish with increased hardness. To further understand how burning affects performance, several studies have been conducted [10-12].

Burnishing has been extensively studied for its influence on surface quality of steel materials including AISI 1045 [9,13,14], AISI 4140 [12] and AISI D3 [15], as well as O1 [16] and PDS5 [17]. Additionally, Shankar et al. [18] found that roller burnishing improved surface finish and hardness of Al(B4C)p MMC. Burnishing was used by Travieso-Rodrguez et al. [19] to enhance the surface quality of aluminium A92017 and steel G10380.

Burnishing can be used on the shank section of the reamer to increase surface hardness while lowering processing time and cost, according to the literature study. However, in order to effectively apply burnishing technique to reamer shank manufacturing, it is necessary to first identify most important burnishing process parameters; then, to form their relationship with process' outcomes(hardness and time required for burnishing), a taguchi optimization technique can be used..

2. MATERIALS AND METHODS

Like previously stated, the burnishing technique has the ability to eliminate the need of heat treatment for processing reamer shank. In addition to the present process plan (Fig. 1(a)), a novel process plan incorporating burnishing is offered (Fig. 1(b)). Heating and shank straightening operations are removed in the suggested process design, as indicated in Fig. 1, moreover burnishing substitute finish-grinding process also.

Dominant burnishing factors, like burnishing speed (v), burnishing feed (f), burnishing force (F), and no. of passes (N), are taken into account for successful integration of burnishing in current application, and one's impact on surface hardness (Hv) is studied with the help of taguchi optimization technique.

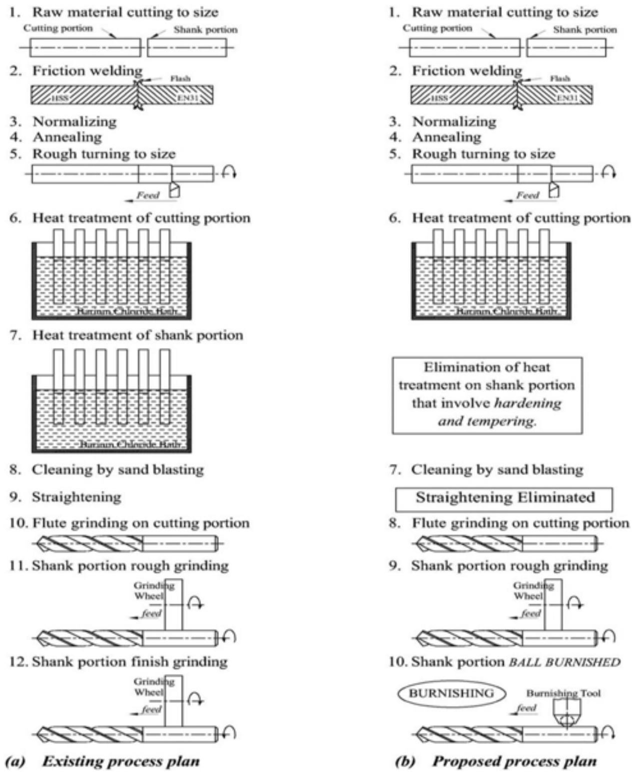

Figure 1. Process plan (a) Current (b) Suggested.

Hole-forming devices require a high degree of surface hardness. Burnishing time consideration is also essential to obtain the requisite rate of production. It's well-known that when burnishing speed increases, surface hardness decreases, while burnishing time decreases. Burnishing feed enhances surface hardness while decreasing burnishing duration. Increasing burnishing force results in surface flecks, which increase surface hardness. As burnishing duration rises, surface hardness improves. As a result, all process factors impact performance metrics in a contradictory manner. This is why the taguchi optimization approach is utilised to optimise the burnishing process for all answers.

Now, straight-shank reamer with size of Ø12 mm is taken into consideration in order to validate the suggested approach. EN31 bar used for shank side having diameter 14 mm and length 55 mm and HSS bar used for cutting side having diameter 14 mm and length 75 mm are connected by friction welding. Specimens are manufactured up to rough turning as per suggested plan as shown in Fig. 1. These components' shank section is then burnished in accordance with the experimental design.

Fig. 1(b) shows a suggested process design that eliminates heat treatment and straightening operations from the current process plan and replaces grinding with a burnishing process. As a result, main aim of current research is to determine most suitable burnishing process variables for this application and confirm that they are in line with reamer specifications.

Table 1. Process variables and their levels.

Process variables	Code	Unit	Levels				
			1	2	3	4	5
Burnishing Speed (v)	A	m/min	13	18	30	48	75
Burnishing Feed (f)	B	mm/rev	0.045	0.071	0.112	0.18	0.28
Burnishing Force (F)	C	Kg	10	25	40	55	70
No. of passes (N)	D	-	1	2	3	4	5

When determining the best burnishing parameters for a particular shank, the taguchi method is employed to see how closely process parameters correlate with the shank's performance. A total of 25 trials are performed, each with four parameters at five different levels, as indicated in Table 1. A burnishing tool is being used to burnish the shank section (which has an initial hardness of 180.4 HV on average).

The burnishing tool used during study features a 10 mm diameter tungsten carbide ball that is supported by a ball bearing that is attached to the fork arm. Using a spring-loaded subassembly, the required burnishing force may be applied to the workpiece. Fig. 3 shows how the burning tool shank fits on the tool holder of a lathe with ease.

Figure 3. Burnishing tool attached to lathe tool post.

3. RESULTS AND DISCUSSION

3.1 Analysis of means and Analysis of variance

The objective of this study is to see how burnishing factors affect hardness (Hv), as well as to optimise hardness during the burnishing process. Hardness has been assigned to the "larger the better" category. Eq. (1) is used to calculate the corresponding S/N ratios of objective functions for every test of OA. Table 2 shows the respective S/N ratios for every test of the L25 orthogonal array.

$$nij = -10log_{10}\left(\frac{1}{n}\sum_{j=1}^{n}\frac{1}{y_{ij}^{2}}\right) \qquad (1)$$

Where yij represents the ith experiment at jth test, n represents total no. of readings for given (jth) answer, and s represents the standard deviation.

Table 2. OA, parameters level and respective S/N ratios of measured responses.

	Process Parameters Results				Results	
Exp.	Speed (m/min)	Feed (mm/rev)	Force (Kg)	No. of Passes (N)	Hardness, H (Hv)	S/N ratio for Hardness
1	13	0.045	10	1	227.00	47.1205
2	13	0.071	25	2	233.50	47.3657
3	13	0.112	40	3	246.50	47.8363
4	13	0.18	55	4	250.00	47.9588
5	13	0.28	70	5	252.00	48.0280
6	18	0.045	25	3	219.50	46.8287
7	18	0.071	40	4	252.00	48.0280
8	18	0.112	55	5	260.50	48.3162
9	18	0.18	70	1	244.50	47.7656
10	18	0.28	10	2	222.00	46.9271
11	30	0.045	40	5	250.00	47.9588
12	30	0.071	55	1	247.00	47.8539
13	30	0.112	70	2	251.50	48.0108
14	30	0.18	10	3	209.50	46.4237
15	30	0.28	25	4	234.50	47.4029
16	48	0.045	55	2	238.00	47.5315
17	48	0.071	70	3	244.50	47.7656
18	48	0.112	10	4	228.50	47.1777

Exp.	Process Parameters Results				Results	
	Speed (m/min)	Feed (mm/rev)	Force (Kg)	No. of Passes (N)	Hardness, H (Hv)	S/N ratio for Hardness
19	48	0.18	25	5	235.50	47.4398
20	48	0.28	40	1	210.00	46.4444
21	75	0.045	70	4	251.50	48.0108
22	75	0.071	10	5	229.50	47.2157
23	75	0.112	25	1	222.00	46.9271
24	75	0.18	40	2	216.50	46.7092
25	75	0.28	55	3	248.50	47.9065

Tables 3 show the contribution of various process parameters on surface hardness i.e. ANOVA.

Table.3 ANOVA for hardness

Parameter Code	Degree of Freedom	Sum of Square	Mean Square	F value	P value	% contribution
A	4	0.2602	0.0651	0.48	0.748	3.90
B	4	0.8780	0.2195	1.63	0.258	13.17
C	4	2.0582	0.5146	3.82	0.051	30.86
D	4	2.3945	0.5986	4.44	0.035	35.91
Error	8	1.0775	0.1347	1.00	-	16.16
Total	24	6.6684	-	-	-	100

Burnishing force (30.86 %) and no. of passes (35.91 %) are vital for optimising hardness, but burnishing speed (3.90 %) and burnishing feed (13.17 %) have no apparent influence on hardness, as shown in the ANOVA table.

3.2 Conformability with reamer standard

Ball burnishing increased hardness, according to the results of the investigation. IS 5443 reamer standard must be met for the improved quality attributes to be effective on a dependable hole finishing tool shank. The reamer standard IS 5443 is used to assess and certify quality attributes. The suggested approach saves time and energy while manufacturing the reamer shank part.

3.3 Hardness of shank side:

The optimal set of settings for burnishing the shank section is solution No. 8. The hardness of surface improves from 180.4 to 260.50 HV when this parameter is used. This is because at a modest feed rate, plastic deformation is more effective (since the contact time between the ball and the surface is appropriate), leading to larger hardness improvement. Increased burnishing force increases work hardening, resulted in enhanced hardness.

3.4 Time and cost:

The traditional technique of shank processing includes procedures like as hardening and tempering, which consume a significant amount of time during tool manufacture. It takes 219 minutes to heat treat 30 tools in a fixture. In other words, it takes 7.3 minutes to heat treat a shank part of a tool. To harden and temper the item, a lot of power is needed, which increases the expense and danger of the heat treatment process as a whole. Straightening requires 2 minutes and finishing grinding requires a 1.2 minutes after heat treatment. This set of three operations took a total of 10.5 minutes to complete. As per present method's requirement due to different heat treatment procedure for cutting section and shank section at dissimilar temperatures (as mentioned earlier), different tensions are generated, resulting in part bending. As a result, the component also requires a straightening procedure. However, in the proposed technique, the absence of the heating of the shank part decreases this issue and removes the operation of straightening. Heating, straightening, and finishing grinding on the shank part may be substituted by a burnishing process that requires just 23.5 s to process shank which saves 606.5 seconds per piece.

For a certain reamer size, the cost of heat treatment is Rs. 3.50 and final grinding is Rs. 6.00 per piece, but the cost of burnishing process is just Rs. 1.50 per piece when taking these prices into account. By using the burnishing technique, you may save around Rs. 8.00 each item.

4. CONCLUSIONS

Taguchi optimization is used to produce the appropriate hardness on the surface of the shanks in order to satisfy all functional needs. Taguchi's solutions may be utilised as a ready-to-use guide for choosing burnishing settings to attain the necessary quality attributes required by the process planner.

- Burnishing produced a surface hardness of 260.5 HV, which is within the specified limit in IS 5443.
- Heating, straightening and finish grinding take around 630 seconds using the traditional method. Burnishing (processing time 23.5 s) eliminates these steps, resulting in a processing time reduction of roughly 606.5 s.
- The burnishing method not only avoids the dangers of heat treatment, but it is also cost-effective, saving up to Rs. 8.00 each piece.
- Burnishing process will conserves energy by replacing heat treatment with burnishing.

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Biographies

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A Review on HVAC Controller for High Energy Efficiency Commercial Building

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Abstract

The ever-increasing population and advancing municipal business demands for new building construction are often regarded as the most significant contributors to energy management. For many practical applications, machine learning is a promising method. In this perspective, we demonstrate machine learning development and application. One best way of decreasing energy usage in new buildings is to look at energy efficiency at an early stage in the design. Efficient power management and intelligent renovation can improve existing stock's energy performance. For optimal decision-making, all of these systems include an exact energy forecast. In recent years, machine learning (ML) and artificial intelligence (AI) technology have been introduced to predict building energy consumption and performance in specific terms. This article addresses hard, soft, and hybrid control systems, as well as machine learning techniques including artificial neural networks, clustering, and support vector machines which are frequently utilized in building energy performance forecasts and improvement. The hybrid approach suggestion significantly expands machine learning applications.

Keywords: HVAC, Demand Response, PID, Artificial Neural Network (ANN),Energy Management, Machine Learning .

1 Introduction

Buildings will play a leading role in ensuring that the future energy system operates securely and efficiently, representing around 40% of world energy use annually. Flexible loads, control on the side of demand, and peak scrub are not new notions; demand response was employed in certain grids in the 1970s [8]. For the robust home energy management and heating, ventilation, and air conditioning control (HVAC) systems scheduled to be developed for smart home appliances to improve building energy versatility, the development of advanced requirement side management controls has an essential role [20]. In addition, precise predictions of energy demand in the face of uncertainty are important to district management of urban energy systems through the application of a hierarchical methodology [6]. There is no universal flexibility quantification approach for sophisticated building energy systems that considers thermal-electric energy sources, Cooling, heating, and electrical energy storage, also adaptive energy management methods are all specimens of solar to electric and electrical to thermal conversions. Second, advanced nonlinearity and complexity of energy predictions, such as modeling generation and computing load, not been able to effectively and efficiently addressed, mainly when multi-level uncertainty factors are considered. Accurate forecasts of building energy with simpler prototypes and machine learning techniques have a lot of possibilities for aiding energy-efficient structures. Third, no academic research has been performed on the progress of sophisticated controllers for small duration building energy forecasting under complex scenario uncertainty. The influence of sophisticated controllers on the energy flexibility of buildings should be fully examined. Meteorological factors, Temperatures of cold water supplied and returned, interior air set point temperature, and other variables are all linked to real-time system functioning. At initial stages building energy consumption is found by using evaluation technique which is an instructive tool for giving decision-makers an energy efficiency comparison index. Commonly, during a certain time formed by floor area, the energy consumption of buildings is utilized to describe an enactment (kWh/m2/period) known as the EPI or energy intensity (EUI) The energy evaluation of buildings is divided into four primary groups: Engineering, Simulation Benchmarking and Machine Learn and Statistical Modeling (ML). Technically the rules of derivation of construction energy consumption on the entire or subsystem level are employed in engineering methodology. Internal and external characteristics are considered for all construction components also the complicated mathematics or building dynamics employ the most exact methodologies for the derivation of correct energy use [18]. Simulation of power efficiency building comprises performance simulation tools and computer models with a predetermined status. Computer simulation may generally be utilized in several areas, for example in lighting and HVAC system design. The use of updated methodologies to evaluate energy performance has been made possible by the availability of building energy data. The methods of statistics employ historical data on buildings and commonly use regression in models of building energy consumption/performance [18].

2 Related Work

Dynamic processes with temporal delays cannot be controlled successfully by on or off controllers. Only if operating circumstances do not differ from tuning settings [1] is a satisfactory performance of the PID controller guaranteed. PID Gain-Scheduling shows increased stability compared with regular PID controllers, however, the linear areas must be identified and logic to switch regions must be developed. The PID controller needs to be manually tuned and might be tough. In the evaluations of [13] [15] and [12] many metrics have been taken to compare the results of various controls. However, they do not take into account fully the possibility for flexibility. In the recent decade, MPC research has accelerated. The fact is the control approach can save energy while preserving or even increasing thermal comfort in buildings is widely recognized and demonstrated. To utilize demand-side flexibility that construction could give, researchers are showing alternative ways to employ MPC in building control systems in conjunction with thermal energy storage systems. The temperature of the zone is also the standard experimental control variable. [9] An MPC was integrated into an HVAC system and the robustness of the MPC was enhanced as well as the tracking performance of the PID controller. This case study investigates and compares the usage of a revolutionary deep reinforcement learning algorithm for controlling building space heating in a computationally efficient method. In a simulated scenario, the suggested method beats rule-based control by 5-10% for a variety of price signals. We find that, while not optimum, the proposed approach has significant practical advantages over other well-established methods, such as quicker calculation times and improved resistance to non stationarity in building dynamics. Reinforcement learning (RL) [13] has emerged as a viable alternative to MPC in several fields in recent years. The attraction of RL is its potential to approach or exceed the optimum degree of control given by predictive model controls while learning from sensor data directly, that is, without the presence of a model beforehand. ANN may be used to determine energy performance evaluation criteria for buildings. [11]proposes a pre-determination technique for the coefficient of total heat loss, total heat capacity, and the recovery factor, which are the important factors for energy efficiency calculation. [5] ANN uses 6500 energy labels in Italy as a method for evaluating the correctness of energy building certifications. A new combination of input variables is investigated in the study to decrease the number of training features. Using the ANN output, a new index for the correctness of energy certificates declaration data with a low 3.6 error is presented. The scholarly scholars did an unclear study of the needs of construction and of renewable. The multi-target optimization was carried out in the viewpoint of renewable generations [17], integrating uncertainties in renewable energy and forecasting demand projection errors. From its results, the suggested technique to optimization has been efficient in optimizing several targets with uncertainties and lowering local emissions of pollutants. A complex multi-sector target program has been designed to give building owners additional flexibility to supply In unpredictably and imprecise situations, an efficient renewable energy strategy of different renewable energies [17]. From the outcomes of the suggested approach, sustainable development has been achieved effectively. About energy demand in buildings [10], the uncertainty on overall energy consumption in buildings was around 14%. [4] The insecurity study was performed with the Monte Carlo technique, on the behavior of the people and on building envelopes.

3 Methodology

Control strategies may be classified into two parts: (1) single component control (local control) and (2) Entire energy system control. The total functioning of the energy system is smooth because the local controller guarantees that the process is in control and that the proper set point is maintained at all times, while the monitoring controller organizes all of the local controllers. [16] Hard control, soft control, and hybrid control are the three types of control mechanisms. Classical controls are included under hard controls by Naidu et al. [16], but classical controls are considered a separate category of HVAC control systems by [1]. [7] Only differentiate b, on the other hand, Figure provides an overview of several HVAC control methods.

Figure 1 HVAC Control System

Classical Control

For the most part, PID pertains to the most frequently used control methods, such as the ”on/off,” ”P,” ”PI,” and ”PID” strategies. An on/off controller manages a process so that it stays within set lower and upper thresholds. P, PI, and PID controllers use error dynamics to modulate a controlled variable and provide precise control. PID controller Auto-tuning or optimal tuning techniques for these systems are the subjects of investigation [1].

Hard Control

MPC -Hard controllers use optimum control, robust control, nonlinear control Model Predictive Control (MPC), and adaptive control to control systems [14], [13]. Hard controllers are typically very simple to interpret. Because of their predictability and consistency, and the computing load of practical methods is usually low to moderate. Fuzzy logic, neural networks, and evolutionary algorithms are used in soft control systems. Hybrid controls are a mix of harsh and soft control techniques that make use of the benefits of each. Even though MPC may be utilized for supervisory control, soft control is generally used for supervisory control while hard control is used for local control [13]. MPC Points of Strength and Weakness Nonlinear dynamics supervisory control, time-varying disturbances, and, time-varying dynamics are some of the primary problems that an HVAC system faces. MPC is a form of control that solves these issues. [13] The summary of MPC's major features are:

1 - MPC is a system evolution predictor, not a remedial control.
2 - An incorporated disturbed model can explicitly manage disturbances.
3 - It is capable of openly dealing with uncertainties and restrictions.
4 - It is capable of coping with time-delayed procedures.
5 - Energy conservation methods can be incorporated into the controller design.
6 - Using appropriate cost function formulations, several objectives can be met.
7 - MPC may be utilized for both supervisory and local control.
8 - Explicitly incorporates passenger behavior, equipment usage, and weather forecasting.

Soft Control

Artificial neural networks

The use of neural networks for estimating the energy consumption of buildings has become increasingly common. Building energy estimate has long been a popular use of neural networks, which are the most widely used ML approaches in this field. They've been used to simulate non-linear issues and complicated systems with great success. ANNs may be resistant to faults and noise while learning important patterns in constructing systems by employing a variety of approaches. The ANN's basic concept comes from the realm of microbiology. Recurrent networks, Radial Basis Function Networks, and Feed-Forward Networks are examples of ANNs that have been proposed for various purposes (RNN). Each ANN is composed of numerous layers of neurons and activation functions that link them together (at the very least two layers). Some of the most often utilized functions are linear, sigmoid, and hard limits. In FFN, there are no cycles between input and output neurons which were the earliest and simplest NN architecture. Pieces of information travel in one way in the network. Figure 2 shows the basic structure of FFN, which includes input, output, and one hidden layer. By enabling loops from output to input nodes, RNN leverages its internal memory from which to learn previous encounters. Several architectures, together with fully linked,

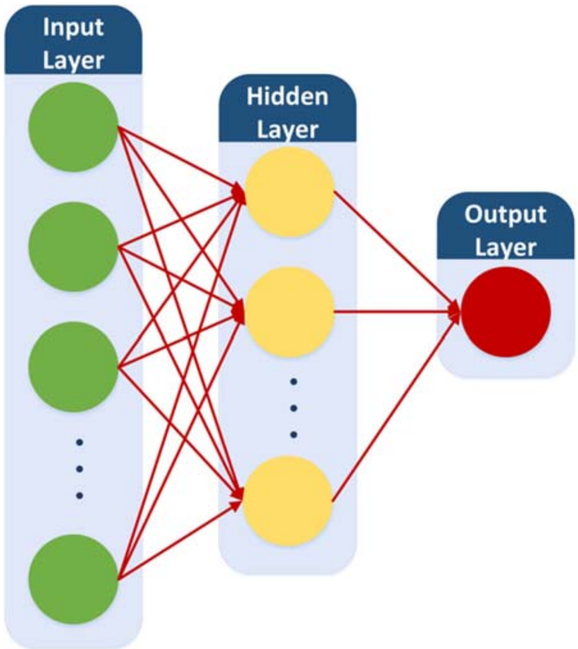

Figure 2 General Structure of Neural Network

recursive, and long-term memory have suggested RNNs and multi-layer architectures. The following are some of the advantages ANNs give over more traditional engineering solutions:

1 .They can quickly construct models with non-linear data connections.
2 .They forecast fast: the training process is long, but predictions are predicted in milliseconds after they are trained.
3 .If they have a class example for an area, they can generalize better than traditional models: they do well to evaluate structures never seen by the model since the model was trained with an example that is comparable to the one that has never been seen.
4 .They are capable of handling enormous amounts of data.

The aim of this initiative is to an ANN-based approach for measuring a building's energy efficiency. To do so, by analyzing the energy efficiency of several of the buildings in northern Spain, we produced a dataset, with an emphasis on residential structures. We trained and evaluated many alternative ANN designs using this dataset. The process is described in the following sections [2].

Other Control Techniques

3.4.1 Reinforced Learning

The building simulator described in [15] is used for testing and benchmarking of Proposed Reinforced Learning (RL) algorithm's learning features and abilities. The simulator is an ETP model written in Python that mimics the heating and cooling of the inside building, depending on a restricted number of lumped factors, including external temperature and heating features. It is a predetermined second-order model that takes the heat in the envelope into account and cools it in cases of external reduction or lack of thermal energy. The simulation is modeled according to the normal high-level heat reaction of Belgium and the Netherlands structures, adopting the entire structure as a single thermal zone. A heat pump for room heating that modulates air source is assumed to be the equipped building; Figure 3 shows a display of the control environment.

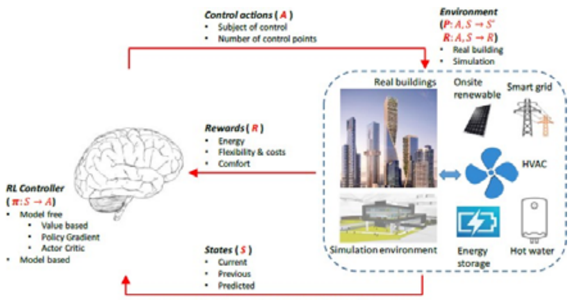

Figure 2. Reinforcement learning for building controls

Figure 3 Reinforcement learning for building controls [19]

Hybrid Control

In hot climate locations, occupant behavior patterns uncertainty was a major factor, but in cold climate regions, building envelope characteristics were a major factor. [21] Under high-level uncertainty, suggested an algorithm for optimizing total performance using optimal solutions in design. According to their conclusions, using the new strategy reduced the number of simulations by 97.8 percent of Monte Carlos, with less than 3.5 percent of projected imprecision. Given the significant amount of unpredictability in building energy systems, it's worth mentioning. Only a little research has concentrated on developing demand-side controls to increase flexibility of building energy. Quantifications of energy flexibility in Building energy systems that are integrated (including thermal storage systems, electric systems, and renewable energy, and building services systems) a collection of multi-dimensional indicators of energy flexibility. Simpler models for short-term building energy are being developed projections that are both efficient and accurate. The creation of sophisticated controllers, as well as the application of short-range building energy forecasts, for the increase of building energy suppleness. This study's uniqueness may be described succinctly as follows. 1) Integrated building energy systems' energy flexibility has been measured using several flexibility indicators that take account of different energy types, sophisticated energy conversions, varied energy storage systems, and flexible methods. 2) The sophisticated non-linearity and complexities of building energy predictions were created to simplify the replacement model. The technique of supervised machine learning is the method chosen for the substitute model. The substitute model aims to increase calculations efficiency without losing accuracy since the TRNSYS 18 building energy systems were highly complex in both the modeling and simulation procedures. 3) The anticipated control signal in the real-time energy management system was adopted to increase the flexibility of building energy, by moving the substitute model for interim prediction of building energy performance. Advanced controller's motive and concept are to correspond with renewable generation and demand of construction energy via the intelligent building equipment operations, HVAC systems, and interior air temperatures.

4 Discussion

The cargoes must maintain adequate service quality and fulfill their key objectives whilst offering control measures. AI can thus only be supplied with loads with variable requirements. Different load categories were found as appropriate for AI provision. The current situation for thermally controlled building energy charges, plug-in hybrid electric carloads, and interruptible industrial and household loads, among other things. Electric batteries can also help to increase grid flexibility, but they do have certain inconveniences, such as being costly, not being too environmentally friendly, and restricted functionality. The HVAC systems are particularly suitable to provide services on the demand side since they use substantial quantities of power and have the flexibility to demand. They are also suited to provide high-demand services. Furthermore, a building management system is installed in most commercial buildings, making it simple to implement the complex control techniques required to deliver AI services. The fundamental goal of building control is to keep occupants comfortable while reducing operational expenses. A building's thermal capacity allows it to have a variable electricity requirement. This flexibility may be used to either shift the building's usage from peak to off-peak hours or to directly give flexibility to the grid (e.g., secondary frequency control service).

5 Conclusion

Construction and building energy usage optimization have gained considerable efforts have been devoted to this sector in recent years since it is recognized to be the major source of air pollution and fossil energy use.

By use of intelligent controls or sensors or upgrades, guidelines and increasing fuel prices have obliged owners to decrease their energy consumption. This issue has grown increasingly pressing in the large constructed sector, where huge amounts of energy are lost owing to poor management.

As a result, many smart solutions for energy conservation have been implemented. The fast growth of contemporary technologies such as data collection has resulted in an enormous amount of sensors, wireless network connection, cloud computing, information and smart devices. 1.Conventional modeling is needful for fast and accurate predictions that are important for strategic decision systems is not met by software and statistical technology producing energy. 2. ML models have demonstrated tremendous promise as an alternate option for energy modeling and evaluation in many types of buildings. Several studies compare the suggested ML technique against traditional regression models or another basic ML model without giving enough structural information. Consequently, it is advised to thoroughly examine these approaches with tuning models to simplify decision-making for experts picking MLS to anticipate energy.

In addition to building energy modeling, buildings based on different input parameters make energy benchmarking far easier and better. Intelligent identification of reference constructions leads to more exact labeling of energy compared to the traditional definition of conceptual structures. In addition, an estimation of the reference structures for future instances is possible through a mix of clustering and classification.

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Biography

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Path to Urban Sustainability by use of IoT

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Abstract.

As the demand for good governance and smart cities has grown, so has the desire for the use of new technology, software, and procedures to achieve a more effective approach. The Internet of Things (IoT) is one such example of a driving scientific approach to smart city implementation. This paper will cover the IoT, smart cities, and technological advancements such as Big data and other analytical tools in order to synergize and optimise their use in decision making process. Moreover, the existing usage of IoT around the world will be discussed and the challenges associated with it. As urban planning has vast umbrella of domains which comes into conjunction of people, services, decision makers and the many more, there is a high chance of dynamic data and changing of technologies. Thus, a more efficient way in progress of such application in sustainable manner with real time scenario has to be envisaged. Studying of opportunities and challenges in sustainable urban development and IoT shall facilitate conjunction of various sectors with urban planning.

Keywords. Internet of Things, Big Data, Smart Cities, Sustainability, Urban Planning.

1. INTRODUCTION

Sustainable urban and rural planning is a given. The notion of sustainability has evolved to a new degree of development with the rapid expansion of articles related with the Internet and growing awareness of IoT. Many critical issues of urban upkeep, for example, waste management and climate change, may be resolved with IoT for the benefit of humanity [1]. Surprisingly, the number of themes popular in cyberspace has overtaken the global population. The number is predicted to reach 50 million by 2020, as new technology enriches the digital environment [2]. It is a novel idea that combines several achievements to give a holistic foundation for urban regions. This paradigm envisions focusing on personal and resident pleasure. This portion of Smart Cities focuses on the sustainability objectives in metropolitan areas. It also helps individuals in sectors like medical services, transportation, and crisis response to man-made and apocalyptic catastrophes when humans struggle to determine. "**Concept of Internet of Things (IoT)"** – is a rich amalgamation of a wide variety of gadgets like computer peripherals, sensors along with other software mechanisms which endows an advanced substitute to the standard guidelines and associations. "**Pathway to Smart Cities through IoT" –** By the implementation of IoT and services, a smart city can be accomplished. Suppose, with the use of Iot fundamentals, at the cheapest rate a smart city can be designed having the utmost possible efficacies.

IoT allows an object to hear, see, tune in, and communicate all of these capabilities. Making common items smarter by linking their ubiquitous and indispensable processing to installed devices (such as mobile phones or tablets), communication advances and sensor networks together with Internet protocols and applications. This alters behaviour. Currently, the Internet is not considered a computer network. It will be linked to billions of smart devices and implanted frameworks. Because of this, the Internet of Things (IoT) will expand in size and breadth, presenting new possibilities and difficulties. Many countries have created long-standing public IoT execution systems after completing the elusive administrative level. So, for example, Japan's internet connection allows for the development of a correspondence office [3]. We plan smart cities' characteristics and key components like intelligent lighting and smart water supply. Infrared cameras, GPS systems, and other devices will be utilised to progress the city. Information security is one of the smart city problems [4].

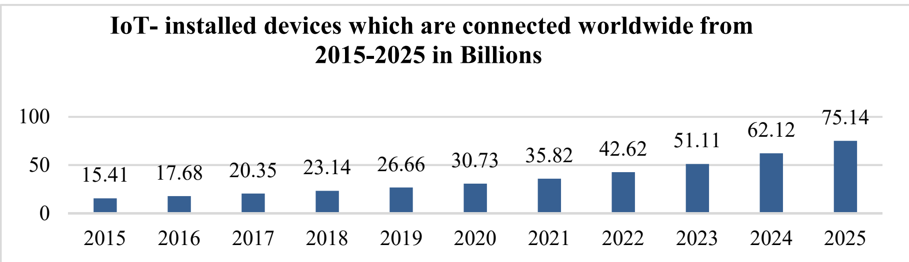
2. BACKGROUND

This section introduces ideas for future standards like IoT and Smart Cities. It contributes to the notion of sustainability by describing how computing connects IoT and Smart Cities.

2.1. Smart Cities and IoT

During 1990's, the phrase "Smart City" was coined. At that phase, the concentration was on the influence of innovative IT guidelines on the existing city guidelines [5]. *"The label "smart city" is used interchangeably with similar terms like "intelligent city" or "digital city"* [6]. The notion of Smart Cities has recently garnered significant appeal owing to its potential to help citizens and humankind as a whole. ITC research defines a "smart viable city" as one that integrates both ICTs and other planning techniques, yielding over 120 definitions. To better fulfil oneself, one must also improve one's knowledge of urban activities and government, while addressing current and future financial, social, and environmental issues [7]. The following figure shows that the quick expansion will expand the utilisation of Internet of Things (IoT) by several folds up to 75% till 2025 [8].

Figure 1: IoT- installed devices connected worldwide.



About half of the all-out total populace lives in metropolitan regions forecasted to rise about 70% in 2050 [9]. So, as the urban population grew, the administrations provided to them diminished in both quantity and quality. With a growing population, governments must find ways to provide future places for citizens. So they centre their financial improvement strategies on establishing advanced frameworks to compete. In addition to legislators, citizens are concerned about their future personal fulfilment [10]. For a smart city, existing research shows distinct transportation viewpoints that should be implanted. A cohesive structure and framework should be created by integrating information into sub-frameworks such as education and waste management [11] & [12]. Cities are also awash with big data, which is derived from sensor data. The Hadoop frameworks are used to manage the data. This section's findings give a detailed technical description of how sensors are deployed and how they produce data. Our suggestion focused on explaining the framework's framework-tier architecture and structure execution [13].

2.2. The Sustainability concept:

"The Sustainable Development Goals are the blueprint to achieve a better and more sustainable future for all. They address the global challenges we face, including poverty, inequality, climate change, environmental degradation, peace and justice. Learn more and take action" The United Nations set 17 goals with 169 targets as part of its sustainable development programme, succeeding the Millennium Development Goals [14] . The concept of "sustainability" is well-known in urban planning. A few definitions and explanations have been written. Despite this, no universal definition exists [15]. Given that this part is about sustainability and the use of IoT to achieve it, focus on the perspective that presents urban growth as a means of improvement that balances demand and supply. Economic planning is expected to produce the following outcomes [16]:

2.3. IoT's role in achieving Sustainability

Like Smart Cities, this concept aids and extends the potentials of financial losses. It represents a major change in supporting a sustainable approach. The link between smart cities and IoT is also acknowledged. So there's a link between Smart City basics and representative procedures. Smart Cities may be seen as a continuation of reasonable sustainable urbanisation. Sustainable development aims to improve citizens' health and infrastructure while lowering costs and cultural impact [16].

3. SUSTAINABILITY CASE STUDIES IN RELATION WITH IOT

The Internet of Things (IoT) and related sciences are currently being discussed and stated. Sensors, wearables, and equipment are widely used. Mechanical technology has influenced every aspect of human existence, notably economic advancement. The IoT may help improve sustainability in several areas. [1]. To help the application region's usage of IoT, the following table provides proof of sustainability.

Table 1: Sustainability proof to help the utilization of IoT

SL. No	Cases/Uses of sustainability measures	Data on trends	Sources
1.	Smart Air-Quality-Monitoring- System (AQMS)	Air quality Data which are Real -Time can be gathered by utilising sensors designed to monitor a variety of pollutants. Sensors for detecting libelium have the same sensitivity of 0.1 parts per million.	[17]
2.	Smart Health Care	Healthcare related technological devices are taking advantage of one of the fastest emerging IoT sectors. has the potential to grow to $176 billion by	[18]

		the year 2026. One of the most well-known examples of IoT in medical services is the use of a distant patient monitoring system.	
3.	Smart Waste Management	The BigBelly Solar wise waste and reusing assortment framework consolidates an incredible administration console, programming empowered organization war room, and group of blend and match squander and reusing stations into a tool stash that empowers districts, schools and colleges, government offices, and other institutional clients to diminish the working expenses related with squander assortment by 80%	[19]
4.	Smart Water Technology & Frameworks	By using smart water systems, utilities may potentially save $7.1 to $12.5 billion annually. Using IoT in water management systems results in a 20% reduction in leakage waste	[20]
5.	Smart Streetlights	As per a Navigant Research conducted by a concentrate, an additional saving of about 20% is attained by the usage of regular alteration of light and information.	[21]
6.	Smart Lighting solutions	Smart-LED lights eat half of the electricity utilised by ordinary lighting systems,enModus revealed that sensible frameworks that usage Smart LED lighting can reduce energy utilisation by as much as close to 100 percent	[22] & [23]
7.	Smart Meter	Giving constant information to clients about their utilizations is assessed to affect 40% of utilization designs for a structure	[24]
8.	Smart Grid	The Natural Defence Fund estimates that Smart Grids will reduce air pollution by 30%. Using smart matrices can save energy equivalent to 70 million journeys across the world.	[25] & [26]

4. CHALLENGES OF IOT IMPLEMENTATION

Without a doubt, IoT can significantly improve urban sustainability. But this journey isn't without challenges. This section describes the challenges of using IoT for urban sustainability and provides examples of some solutions [27].

4.1. Span in IoT

If the data quality is poor, it will generate needless disruptions and raise labour costs. Locations are decided by application. Policymakers, experts, technologists, and planners will need to approve and advise on inclusion. Consider the IoT's present economic condition to grasp its long-term function. IoT helps collect information to examine framework limits and deliver predictive or prescriptive solutions for framework needs. So IoT is still acquiring data inside the framework, which is crucial since bad data leads to hopeless inquiry.

4.2. Security

The IoT platform is more concerned about the platform's safety and security. As the cyberspace expands, so will the dangers. Because data may be readily infiltrated from a single location, organisations involved in backend and programme development for IoT based systems are working to plug the gaps. These expeditions potentially endanger people's lives. [28].

4.2.1. **Adding security during configuration stage:** At the starting of the policy framework for IoT, the safety and security measure must have to be present. The provision from end-to-end secure environment and high-level approach to security device must be achieved, this must be made default in every guideline of the policy framework.

4.2.2. **Login qualifications ought to never be hardcoded:** Before allowing the device to work, engineers might ask clients to renew their certifications [29]. Clients should renew their accreditations using strong secret word or biometrics. For example, most switches have "administrator" login credentials that many users don't update, leaving them vulnerable to security breaches.

4.2.3. **Character/identity of the users:** Detecting and recognising every device immediately is essential to understanding what it is, how it behaves, what other devices it connects to, and what security precautions it requires.

4.2.4. **Equipment security:** Making well-designed gadgets will be priceless. The same goes for making electronics alter obvious so they may be easily identified when tampered with. When the systems are used in severe and remotely controlled environments where its very tough to check and keep a need for protection then these components of the following are kept in place of use for better protection and approach.

4.2.5. **Networking security:** Ports not kept open, top notch encryption, not sending the port & IP’s, port security measures are some of the mentionable approaches for the betterment of IoT, protection of the systems with advances in the firewall, antivirus, and stopping of unwanted and illegal IP’s sets a good example that how to take smart security measure for smart business options [30].

4.2.6. **Educating the Consumer:** Educating customers on the dangers of IoT and how to stay safe. Clients of IoT play a critical role in keeping devices safe. Taking the espresso machine as an example, a smart client would know not to install an unreliable gadget on the same company as well-known gadgets.

4.3. Privacy

The Internet of Things has extreme security challenges. It outperforms client information security, which is today's main issue. That's why IoT user training is vital. It expands in scope when it comes to delivered client gadgets. Because IoT deals with so much sensitive data (personal, business, etc.) and can regulate the climate, security and protection issues should be taken seriously. Cyber-attacks should be prevented at all costs. [31].

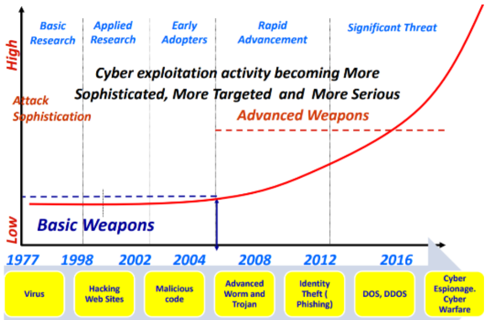


Figure 2: Scenario and Advancement of cyber activity around the world.

UNION BANK OF INDIA HEIST

Through a phishing email sent to an employee, hackers accessed the credentials to execute a fund transfer, swindling Union Bank of India of $171 million, Prompt action helped the bank recover almost the entire money

WANNACRY RANSOMWARE

The global ransomware attack took its toll in India with several thousands computers getting locked down by ransom-seeking hackers. The attack also impacted systems belonging to the Andhra Pradesh police and state utilities of West Bengal

DATA THEFT AT ZOMATO

The food tech company discovered that data, including names, email IDs and hashed passwords, of 17 million users was stolen by an 'ethical' hacker-who demanded the company must acknowledge its security vulnerabilities-and put up for sale on the Dark Web

PETYA RANSOMWARE

The ransomware attack made its impact felt across the world, including India, where container handling functions at a terminal operated by the Danish firm AP Moller-Maersk at Mumbai's Jawaharlal Nehru Port Trust got affected

Figure 3: Some Major Cyber-attacks in India (2017).

Cybersecurity breaches is not necessarily computer-related, although it is carried out using computer networks and electronic communication channels. It's tough to tell if someone has been hacked, yet hacking can be done simply beyond boundaries. Cyber thieves may now easily conduct crimes from the comfort of their own homes, thanks to technological advancements. The unforeseen threats cannot be removed totally form the cyber space in many ways the cyber space can be misguided, thus need to create a more sophisticated and secure environment for users. In the lower figures we can see from the report of NITI Ayog in 2017, that how the evolution of the threats has increased in decades [32]. Some facts about internet users about India are it ranks 3rd in terms of users after USA and China with annual compounded growth of about 44%, also India is among the top ten spam sending countries among the rest of the world parallel to USA [32]. India comes in top five in the world in cybercrime hit-list to be affected by cyber-crime by a report of top cyber security company "Symantec Corp" [33]. Some noted examples are given below of major cyber-attacks in India of the year 2017 [32].

4.4. Development and Regulation

Like security, there are a few administrative challenges around the Internet of Things that require valid and smart local consideration. The pace of innovation is faster than the administrative advisory groups can keep up with. This causes the supervising and administrative councils to not think of long-term guidelines. The opportunities in the third world nations which are still under development phase and having economic potential are possible nodes and entry points for the development of ICT & IoT making them smart. Through the measures such as skill development, training of the unskilled, creating more training opportunities and to devise plans for using the full potential in IoT [34].

The table below showcases few examples of cyber related laws and regulations in India:

Table 2: Cyber Regulations in India.

Sl.No	Laws/Regulations	Year
1.	Indian Penal Code (IPC) Specific Sections- 383,420, 463, 499, 500, 503, 507	1860
2.	Indian Telegraph Act	1885
3.	Indian Evidence Act	1891
4.	The Companies Act	1956
5.	Copyright Act	1957
6.	Code of Criminal Procedure	1973
7.	The Consumer Protection Act	1986
8.	Information Technology Act (IT Act)	2000
9.	Information Technology Act (Amendment of the IT Act, 2000)	2008

There are many revisions and amendments in the laws and regulations in cyber space and information technology, but we have to keep in mind that the technology is ever changing and its dynamic in nature. Few points are mentioned below which contains lacunas and loopholes which should be addressed in the IT act [35]:

- The Information Technology Act of 2000 is focused with both the correct enforcement of intellectual property rights for electronic data and information. It's indeed divisive, but a key issue related to copyrights, trademarks, and patents has been overlooked by the law, leaving many loopholes.
- It pays no attention to the difficulty with the domain name. It's doesn't address the rights and duties of website domain owners (responsibilities)
- It excludes other types of cybercriminal activities and its manifestations, such as: Cyber Stalking, Theft, harassment, defamation, deformation, cyber frauds, cyber or social media abuses, credit/debit card misuse etc.
- It does not resolve the antitrust issue.
- The rules for electronic payments aren't really clear.

Globally, coordinated work is necessary to address regulatory gaps. This will make fighting cybercrime considerably simpler, since comparable jurisdictions will be able to work together more efficiently. When employing technology, it is vital to understand the issue and establish a safe environment.

4.5. Standards

The IOT space lacks documentation and local standard practises. This has a huge impact on the Internet of Things, limiting their development and limiting their potential. Lack of a genuine standard encourages unethical IoT device engineers. Without legitimate regulations and guidelines on makers and their assembly procedures, engineers may end up designing goods that operate poorly with little regard for the effects on other devices or customers.

4.6. Lack of Incentive

It is possible to conclude that the smart city programme is a business-government collaboration. Given the compelling benefit capabilities of such apps, this implies a lack of incentive on the side of the endeavours. To overcome these issues, diverse sectors must work together to create workable foundations. [36]. Smart homes, smart buildings and ultimately smart cities are built by the policy makers, engineers, architects and urban planners who work closely to optimise every resource and accelerate the sustainable development process through IoT in the cities to be called as ‘Smart’.

4.7. Adversative Technological Effects

Infrastructures prepared for me urban sustainability envision resident benefits and place them in high demand. However, such frameworks may have unfavourable effects. First, developing sensor networks may require a lot of energy. Using these sensors may also result in increased energy and cost usage [37].

5. FUTURE ASPECTS OF IOT AND SMART CITIES

With the increasing number of sensors and connection options, it is conceivable to expand the IoT organisation even if private clients do not profit from many of the advantages. Many IoT start-ups are still in their infancy, with few sensors, wireless developments like 5G, and other breakthroughs in the pipeline. It's too early to tell which technical advances or organisations will gain the most from IOT adoption. Without adequate legislation, security may remain an issue for some time. [38]. In the near future, smart devices linked to IoT framework will be observed in workplaces and residences, and this development will be welcomed progressively by city people. As a result of the global pandemic of urban sprawl and population growth, cities must adapt their governance and enhance their efficacy. Service delivery, coordination, and management system resilience need a bottom-up strategy that incorporates new concepts and technologies such as IoT.

6. CONCLUSION

7. The Internet of Things (IoT) is the most important advancement in information science and artificial intelligence (AI). While IoT design prioritises data collecting, the numerous and increasing technologies that manage findings and their accuracy put a premium on information accessibility and quality. Many improvements may be used to create assistance-oriented smart cities. A resident administration is required to achieve an urban sustainability plan. Both Smart Cities and metropolitan sustainability seek for a sustainable future. The Internet of Things is being utilised to help create sustainable cities. Internal failure, range, information ownership, and institutional obstacles all arise. The cost savings trade-off associated with IoT deployment will be assessed in future study. In conclusion, smart cities are a terrific idea that benefits everyone if handled carefully. The IoT's issues are usually intertwined. It's easier to deal with them as a whole than Given the complexity of the development process, including commercial, innovation, government, and financial challenges.

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Demand Side Energy Management in Deregulated Environment: A Review

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Abstract.

Demand for Electric Power is elevating because of increasing consumers in the market. With the rise of Smart Grids, customers can also actively get participated in Energy Management Schemes. These schemes are called Demand Response Programs which can reduce the electricity bills and can also give them incentives or perks. The primary intention of DRPs is to diminish energy utilization in course of peak hours and improve the load factor. Also, Renewable Energy Sources do act as an adjunct source besides the grid but it further complicates the system. Certain challenges are there in implementation of DRPs which make Demand Side Management still a faraway dream. The paper presents a review of that and the challenges associated with it.

Keywords. Demand Response, Demand Response Program, Demand Side Management, Smart Grid

1. INTRODUCTION

Low carbon methods along with the energy efficiency have gained the attention of the world for a better world. Researchers all over the world have proved that demand response programs are efficient in decreasing the content of carbon dioxide as it is directly dealing with lesser use of Thermal Power Plants. Factors like unpredictable weather; integration of RES with the Grid among other complicates the DRP. The argument continues to the fact that this complication is not at site level but at organizational level. Commercial huge firms, public sector units, lot of smaller level stand alone electricity loads , complicated decision-making, etc. can halter the uptake of DSR. Participation prices which are hidden, issues of bounded rationality and energy application type for different organisations limit the organization ability to participate in DSR also.

2. COMMON ENERGY MANAGEMENT STRATEGIES

Program in [1] provides a captivating incentive for industrial consumers by managing smartly during energy crisis duration. A system with an energy storage unit connected behind-the-meter with a big-scale wind power generator is mentioned in [2]. Analysis of BTM benefits along with resiliency capability of the energy storage units is discussed in

[3]. [4] Shows how exciting opportunities are possible with digitization of BTM assets and optimization can be completed using AI and ML. Bi-level optimization exploiting genetic algorithm and linear programming is discussed in [5]. In paper [6], hydrogen energy storage is used for attenuating the irregularities of renewable .Study in [7] examines the bio mimetic energy management along with scope for construction industry reinvention. [8] Highlights the economic approaches in regulations and policies which support sustainability in energy and building.

3. DEMAND SIDE ENERGY MANAGEMENT

[9] Presents two simulation concepts to combine DR strategies into EMS. In [10] quality and quantity of DR were governed by customer experiences affected directly by connectivity, control and care. Findings of literature in [11] has deeply targeted on DR potential along with economic, theoretical and achievable potentials. [12] aims to study market of DR - risk nexus. Design along with operation optimization is addressed in [13] to gain the complementary benefits of sub-systems while advancing individual systems. [14] Effectively handles interoperability along with integration in various heterogeneous devices at consumer end which comes along with plug-play feature, zero configuration coherent networking. In [15] integrated demand response (IDR) is discussed where all types of energy customers (electricity, heat, natural gas, etc.) partake in DR. [16] formulates conflicting yet co-operative liaison between the utilities and end-users as a Stackelberg game where equilibrium points are attained by backward induction method. At the equilibrium, the utility company adopts real-time pricing scheme. [17] Scrutinizes history of DRPs and the practices of DR in the US, other nations in Asia and Europe which proves that DRPs is a hit in lot of nations for decrement of outage. However equipment price and standardization lacking still causes setback.

4. DEMAND SIDE ENERGY MANAGEMENT OF POWER SYSTEM

The model in [18] expresses that genetic-based heuristic updates accuracy of energy demand prediction whereas intra-day prediction refinements further decreases day-ahead prediction error. An online droop-based DR, generalized is popularized for application in islanded MGs frequency control in [19]. [20] Addresses issues which are related to bumpiness of supply, PV penetration, back-feeding, etc. In [21] recent use of deregulation in Indian Power Sector has been described [22] Proposes a simple solution by reducing proper management of Electricity distribution .Use of convoluted PV Model, Wind Turbine and home needs, developed in Simulink in [23] by Load Shifting method for HEMS controller. An energy detection algorithm depending on generalized stochastic resonance is adopted in [24] to improve the spectrum sensing accuracy with the conditions of low signal-to-noise ratio without alleviating the system overhead. In the proposed method of [25], loads which are in controlling nature are relocated to time when the difference between load and RE generated power is maximum which is in consideration to the consumers' welfare. In [26] by application of probability theory uncertain optimization model is transformed into a complicated optimization problem. EMS framework which is of three stage is proposed in [27]. Detailed reviewing of 34 power-to-heat demand response projects of large scale of is done in [28]. The literature review suggests that period of energy sector restructuring popularized uncertainty to energy companies regarding P2H DR. In [29] to resolve the issues of setting UFLS parameters stochastically, a MILP formulation is used for optimization framework. In [30], a distributed optimization method which is based on alternating direction method of multipliers algorithm with Gaussian back substitution is proposed. In [31] The electrode boiler is steered based on the predicted imbalance price, making use of the price volatility and single imbalance pricing mechanism as used in Belgium. In [32] novel online generalized droop control is introduced to apply in islanded MGs frequency control. [33] Propose an energy prediction model using genetic heuristic. The article [34] aims of optimizing the energy costs that will be transferred to users depending on its stratum. Implementation of an efficient hybrid energy trading market along with reduced price and peak to average ratio of electricity is done in [35]. Optimization problem with lot of constraints is solved using heuristic algorithms in [36]

5. OPTIMIZATION TECHNIQUES OF POWER SYSTEM

Power systems are very large and complex so its optimization problems are difficult to solve. [37] Proposes a system with multi energy inputs and outputs, 2m + 1 point estimation probabilistic scheduling scheme [38] overviews mathematical optimization methods.[39] has work on Optimization of Reactive Power Dispatch[40] Explores potential of metaheuristic methods and an improved salp swarm algorithm is proposed .In [41] Information gap decision theory technique is proposed. A microgram reactive power management approach in iterative nature and power-electronic converter depending renewable technologies is proposed in [42].

[43] Shows how Electricity prices on market are becoming volatile. There is a chapter which describes various algorithms used in optimization methods in [44]. In [45] Researchers have proposed novel bi layer Volt-Var based control strategy. In [46] an index of loss of power supply probability and of heat supply probability is formulated. Some authors have worked on Hybrid approach [47] which is based on marriage of firefly algorithm and adaptive fuzzy PSO. There is a work which reports a Volt/Var algorithm in [48].Parameters like frequency or voltage can be used as a factor for design of advanced metering infrastructure in SGs as in [49] like under-frequency load shedding. In [50] ORPD issues are solved by formulating smart controller with effective monitoring the real power loss of SGN. Elephant herd optimization which is a firefly evolutionary algorithm is used and power flow is limited in transmission network and summation with DGs. Various combinations of multi objective PSO and fuzzy decision making methodology is utilized in [51].

Steady state voltage stability index called by load margin, can be selected as network performance indicators as done in [52] with a PSO used to modify DSM program in the time steps of planning horizon and load margin is reduced. In [53] a decoupling optimization framework is devised which solely treat problems sequentially from the demand to generation can side with benefit caused by DR is allocated between users using cooperative game theory. Classic DSM technique implemented in [54] for IEEE 33 bus system .An exclusive literature review on impacts of DSM on trustworthiness of power systems discussed in[55]. Linear model for resource scheduling of Micro Grids and algorithms attached to it are attracting focus currently due to simplicity and fast computation as discussed in [56].

6. CONCLUSION

There is a need of development for a fair, centralised and 24-hour analysis control based system using local measurements for consumer and utility with a secure, and organized bidirectional communication which involves the consumer engagements and perks, without increasing the complexity of the system and lasting equity between supply and demand is needed.

Objective functions for research work should consider following parameters:

1) Minimization of Uncertainties (Load, Price, Voltage Deviations, Forecasting), Active Power losses, Violation limits
2) Maximization of exceptional amalgamation of distinct variables in optimization problem, Input Output control, Self Maintenance, Reactive Power dispatch
3) Scheduling of Battery storage, type of market, interoperability, integration and penetration of RES, data acquisition, storage and processing.
4) Maintain balance of actual time and its control effects and results os optimization, system flexibility with increase in the degrfes of freedom, standardization

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Multi - agent system based Energy Management of Distributed power sources in Domestic Cooking

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Abstract.

As we are using many homes appliances day by day, the energy consumption is increasing. As Fossil fuels are depleting and demand is increasing, it is important to move towards Renewable Energy even in domestic areas. Energy used for Cooking is in large amount in developing countries. Almost 80% of energy which among household is used as cooking energy in rural areas. Biofuels such as fuel wood, charcoal, agri-residues, and dung cakes are used to replace this requirement for cooking. In India, several attempts have been made to utilise biofuels and renewable energy for home cooking. In this project, solar power is used to power an induction cooktop. Because of its excellent efficiency and safety, the induction stove has been more popular in recent years. The concept of Electromagnetic Induction is used in induction cooking. The coil is stimulated in the ferromagnetic material by creating eddy currents in the coil, which causes heating [1]. An induction cooktop driven by solar panels and supplemented by mains electricity is being developed utilising a half bridge design. The operating frequency may be changed in simulation and in hardware, allowing for more control over power output.

Keywords: *Microprocessor-controlled induction cooking, solar power, a half-bridge circuit with microcontroller, and a battery charging circuit MATLAB-SIMULINK, PROTEUS.*

1. INTRODUCTION

Solar Energy is a clean form of energy that will help the globe avoid using non-renewable energy sources such as coal and other fossil fuels. Induction heating is commonly employed in domestic applications. It's also eco-friendly, efficient, low-cost, and results-oriented [2]. Induction heating is mostly utilised in the manufacturing industry for melting, brazing, and hardening [3]. Solar cookers are now the only household cooking option. Even though many research papers have reported, biogas plants and cookstoves with new features are still far away from their respective potential. Solar cookers are also contributing their part inmeeting domestic needs. It is ideal to improve the technology of solar cooker as India is blessed with sunshine and can meet the requirements of energy. An effort has been made in this reference to assess the technology's potential for use in household cookery in India, which helps in assessment of their future potential of planning energy sector in country. It's memorable's pivotal that as the quantity of homes in the nation develops and as biomass feedstock and other inexhaustible assets become all the more promptly accessible, the genuine capability of environmentally friendly power gadgets for home cooking might change.

In general, low temperatures are required for the majority of the cooking energy. So solar cookers are known to be very good source of having low thermal energy. The yearly mean daily sun radiation received by average nations is in the range of 5- 7kwm2/day [9]. The box type solar cooker is the one that is specified [8] in India for boiling and baking meals.

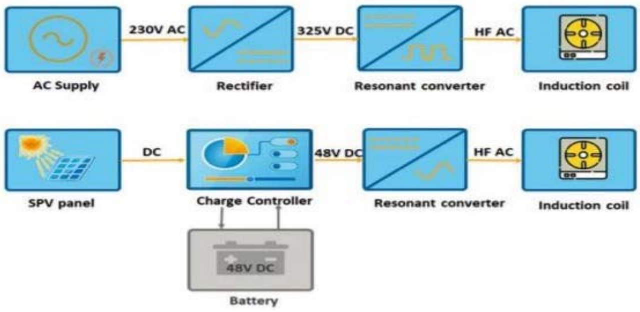

Fig. 1: Number of box-type solar cookers in use throughout time in a given nation

In this article, a few homes are assumed to be using a box type solar cooker for domestic cooking. The following calculation is based on the assumption that although solar cookers cannot totally replace current cooking alternatives, they may save a significant amount of fuel when utilised for home purposes. In other words, it is expected that if all of the above-mentioned cooking equipment criteria are met, solar cookers will be possible consumers.

2. INDUCTION HEATING

Induction heating is being used now a days for domestic appliances, as it is clean, gives high efficiency and is low-cost advanced semiconductor device, it gives high performance [6]. Enlistment warming is utilized for brazing, solidifying, and dissolving in industry [7]. 80% of the attractive field produced between the loop and the skillet is moved to the curl. Domestic and commercial cooker will give quick warming by saving energy with different range of temperatures [9]. Induction heating is done by electromagnetic induction in which the ferromagnetic materials are heated electrically. Cooking is one of the numerous uses for Induction. Induction cooking works on the concept of magnetic induction, in which eddy currents are created in the coil, which then stimulates the ferromagnetic materials, causing them to heat up. Many converter topologies are their which can efficiently produce time varying magnetic field that is needed for induction heating.

In this paper, principle of working of induction heaters/cookers is presented. Different topologies of solar electricity-based DC induction cookers like resonant converter and the voltage source inverters of full bridge inverter, and quasi resonant topology has been reviewed.

3. PRINCIPLE OF OPERATION OF SOLAR INDUCTION

A solar panel charges the battery by providing fluctuating DC to the solar induction cooker. The DC from the battery is transformed to high frequency AC power with the help of an inverter circuit. The alternating flux created in the magnetic core causes eddy currents and hysteresis losses. Induction cooking is becoming more popular due to its great efficiency and safety.

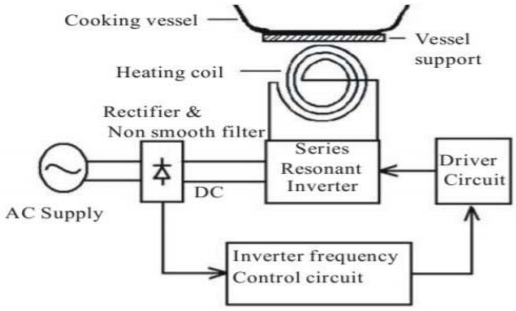

Fig 2: Basic circuit of Induction cooking

Induction cooker is initially supplied with energy as fuel from solar panel and solar panel is controlled using a controller. The energy from Solar panel can be used immediately for induction cooker or store in the form of DC for future use. To utilise the conserved energy later, the stored energy may be transformed into high frequency AC form using an inverter. There is an exchanging attractive field produced by this high recurrence current in the enlistment loop. Inducing eddy current in a pan by positioning it near to an induction coil. This results in production of heat on pan surface. In this way internal resistance of the pan will result in dissipation of heat. Finally, it is the pan which helps in heating and cooking process but not the heater.

Benefits of Using an Induction Cooker:

- The sole source of heat radiation is an induction cooker
- Coil stays cool, so it will be safer
- High efficiency, so gives low electricity bills
- Gives constant power output
- No danger of electric shock in cooking pan
- Has flexible temperature control
- When compared with microwave-oven induction cooker is cheaper
- No need of any special utensils, regular kitchen steel utensils are enough

4. Energy Management System of Solar Induction Cooker

There are three different kinds of cooktops on the market: Gas, electricity, and induction are all options.

• Gas: It features a burner on top that burns gas (LGP or PNG) to create a flame that cooks food.

• Electric: A coil warms up as a result of resistance. It heats and cooks food by generating energy.

• Induction: This method utilises electricity and the magnetic properties of steel to heat the cooking pots directly.

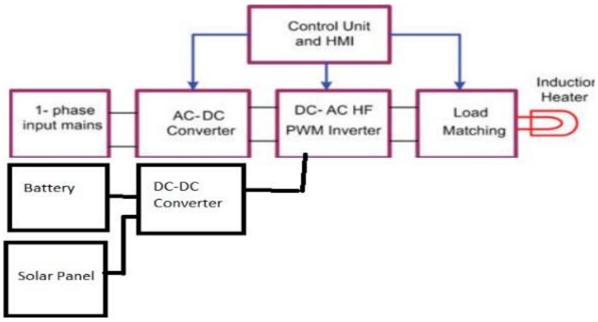

Fig 3: Solar Induction Cooking Block Diagram

In this paper, it is also explained regarding the thermal storage, which is present in food also, even if battery is not used. As a result, the chef may use the kitchen equipment inside the home as well. As a result, even without a battery, the solar e-cooker system offers several benefits over a traditional solar cooker.

The expenses of 500 Wp roof top panel with its fitting and fixing

$$C(PV) = 300[0.1/ (1 - (1 + 0.1)^{-20}) + 0.05] = \text{Rs } 3500 \text{ per year (approx.)} \quad (1)$$

Amount of energy generated by a panel over a daily insolation average of 4.5 kWh/ m^2 (assumptions of insolation are considered from paper studies) is 821.25 × 0.8 = 657 kWh

Cost of energy is approximated to

$$C \text{ (solar PV electricity)} = 50.23/657 = \text{Rs } 5.355 \text{ /kWh} \quad (2)$$

The cost of energy production will depend on sunshine and interest rate. Cooking is supposed to take 4 hours a day on average, for cooking, the monthly expenditure of energy is estimated to be about 300 watts on an average

$$C(\text{cooking}) = 0.0765 \times 0.3 \times 4 \times 30 = \text{Rs } 192.78 \text{ /month} \quad (3)$$

5. SIMULATION MODEL AND RESULTS

The essential goal of this exploration is to create a multi-specialist framework for family cooking energy the executives utilizing environmentally friendly power . Many problems that a single agent or monolithic system cannot address may be solved with the help of multi-agent systems. Intelligence strategies for forming decisions include procedures such as algorithmic search and reinforcement learning.

The major goal of this project is to create an intelligent habitat system by determining which components will be able to make choices and optimise energy use through intercommunication. The method should not affect the inhabitant comfort with respect to the application.

In addition, the use of a Multi Agent System (MAS) as a crucial technology for providing distributed adaptable micro-network control was examined. Each function of the system will be allocated to a different agent in the multi-agent approach, which allows more flexibility and autonomy than the typical solar-based induction cooking system. These agents will closely link and communicate with each other.

The initial analysis of the solar based cooking system is done by using 555 timers. The driver circuit for induction cooking is also developed with the help of the same 555 timer. Simulation of driver circuit using 555 timer is done by MATLAB-Simulink.

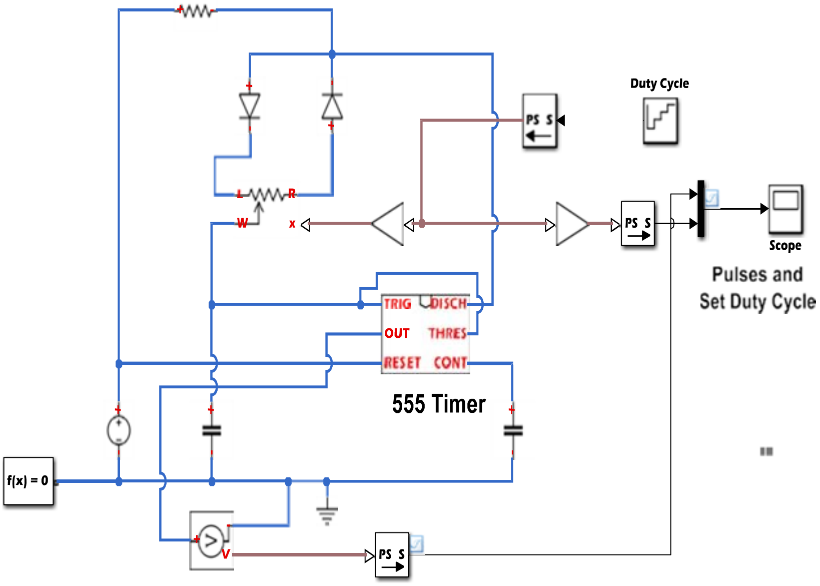

Fig 4: 555 Timer circuit diagram to generate PWM pulses

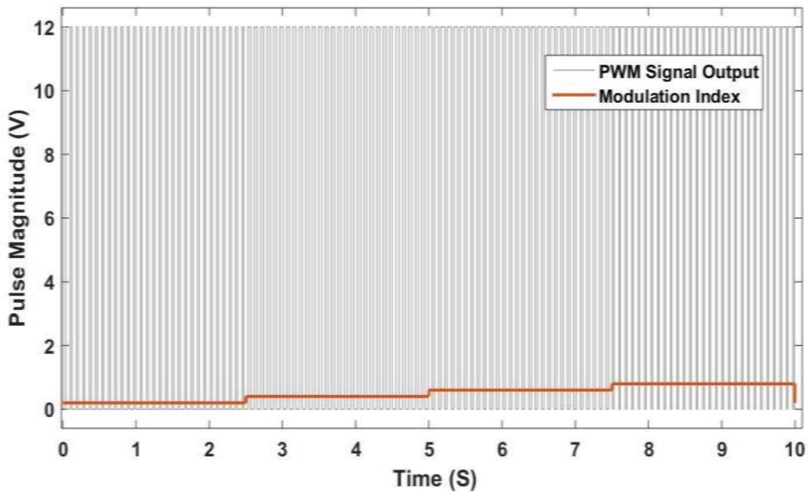

Fig 5: 555 Timer PWM pulses for different Modulation Index.

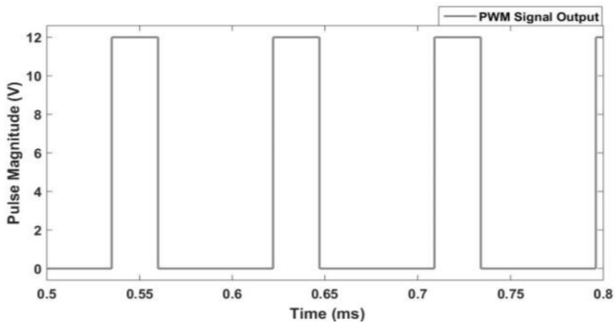

Fig 6: 555 Timer PWM pulses for 25% Modulation index.

The MOSFET will be ON for 20% of the cycle and OFF for 80% of the cycle. The graph is recorded for every 20Khz frequency. The simulation results of Multi Agent System is shown below. The main circuit is simulated with three sources solar battery and a adopter, which are used for domestic cooking purpose.

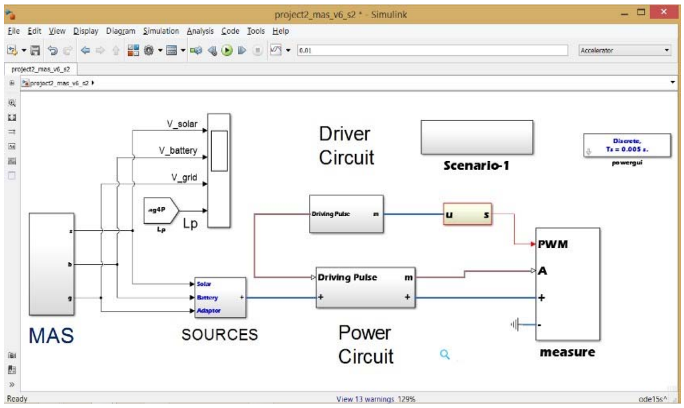

Fig 7: Main Circuit

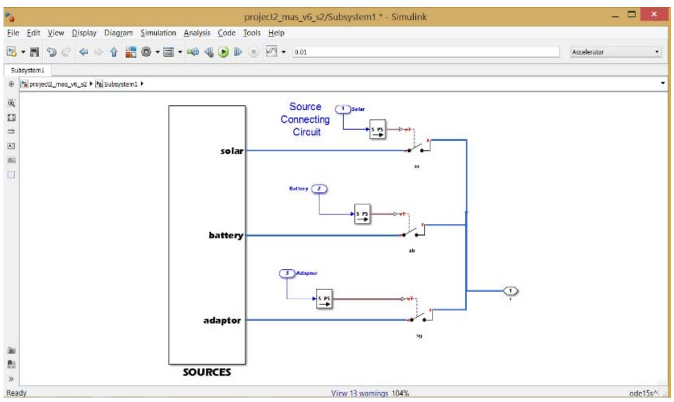

Fig 8: Connection of sources to main power circuit

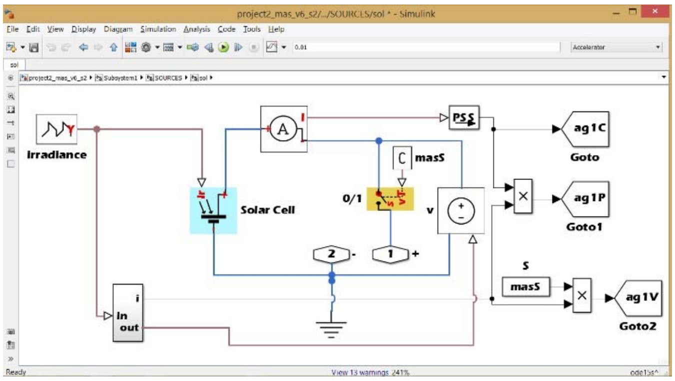

Fig 9: Subsystem of Solar source

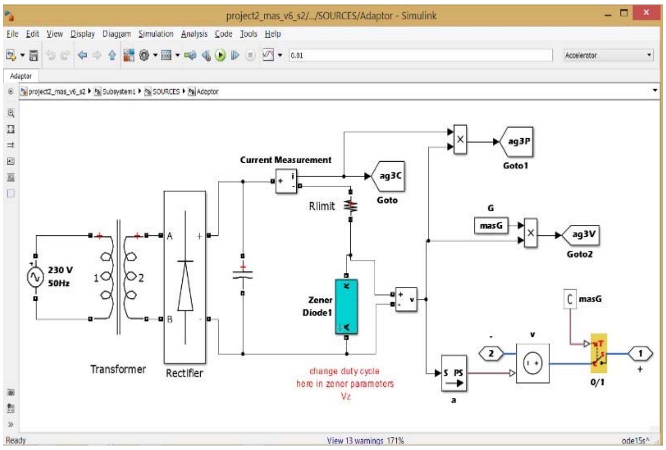

Fig 10: Subsystem of adaptor circuit

Considering load is constant at 4000 watts as peak, also grid is not available, solar power and battery are available. A threshold value of 5000-watt peak is considered and categorized as low power and high power (If the value is less than or equal to 5000 peak then it is low power, if value is more than 5000 peak then consider it as high power).

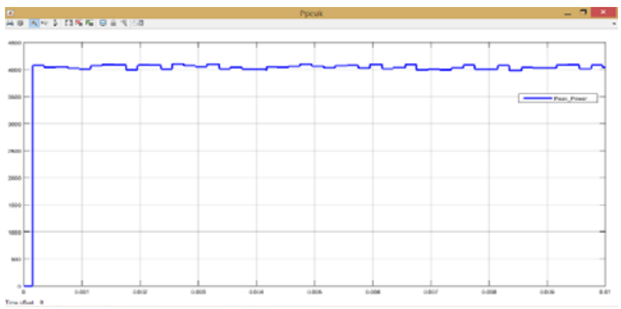

Fig 11: Load power requirement

Solar power has been delivered at 48V and battery also has the terminal voltage at 48V whereas grid voltage is zero as it is not considered in this scenario. Fig 11 shows the load response to the first case executed in the simulation.

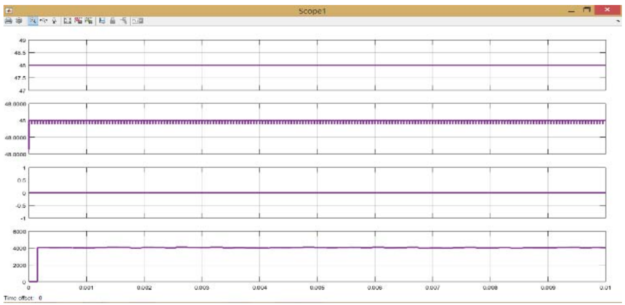

Fig 12: Voltage profile of sources and load power

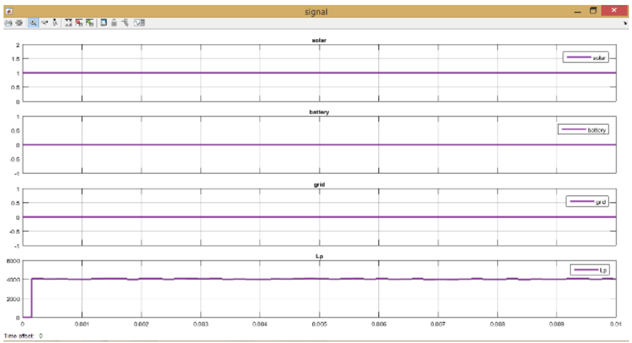

Fig 13: Load Response to first case executed in the simulation

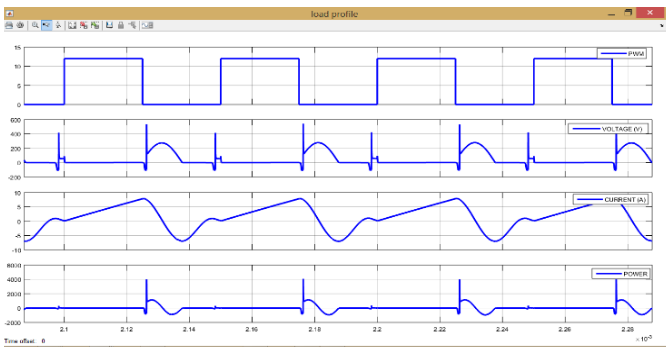

Fig 14: MAS output, switching ON/OFF sources

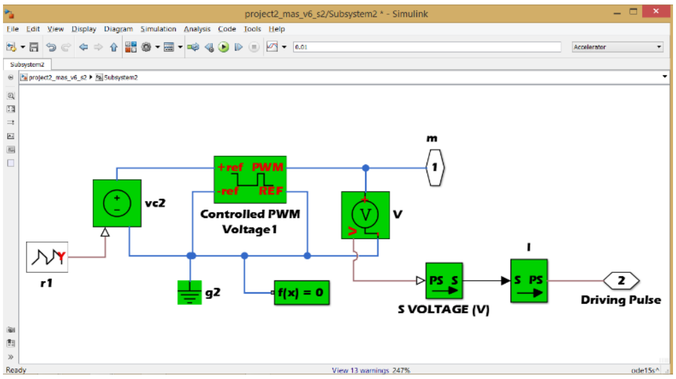

Fig 15: Driver circuit

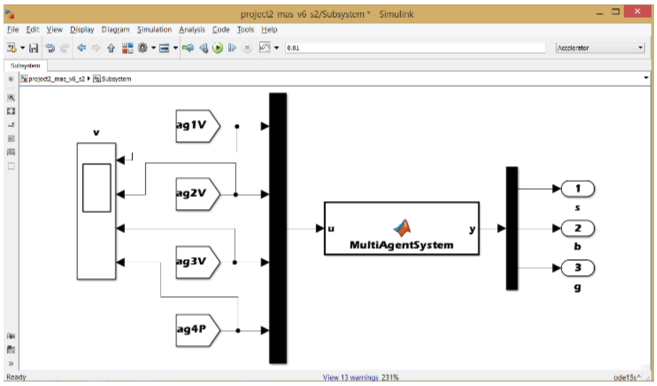

Fig 16: Multi Agent System Central Controller

Input information is taken by Multi Agent system and given to the central controller. The central controller unit will take decision depending on the algorithm output. The decision will be in the form of turning a particular source as ON/ OFF.

Table 1: Solar parameters

From time (ms)	To time (ms)	Insolation (H in Watts/m^2)
0	3	500
3.01	6	1000
6.01	10	1000

Solar source parameters (1=ON or 0=OFF)

MAS to Solar=1; MAS to Battery=1; MAS to GridG=1

Table 2: Drive Duty cycle parameters

From time (ms)	To time (ms)	Duty Cycle (%)
0	3	75
3.01	6	50
6.01	10	75

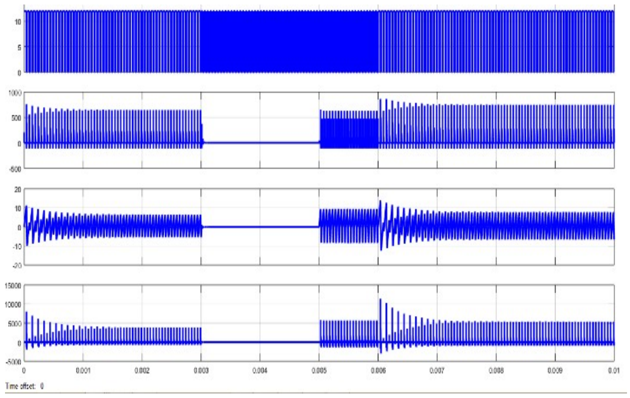

Fig 17: Voltage, Current and Power at the load side.

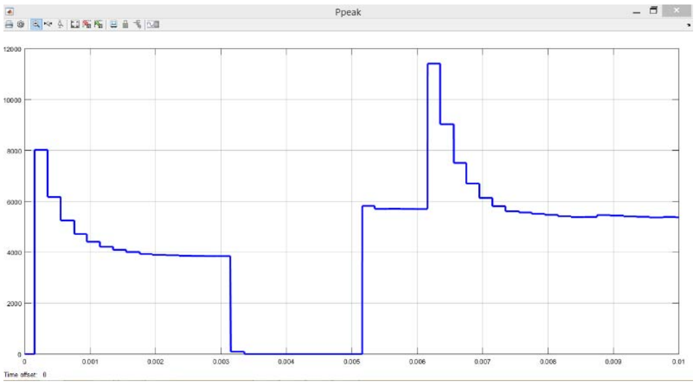

Fig 18: Load power vs Time

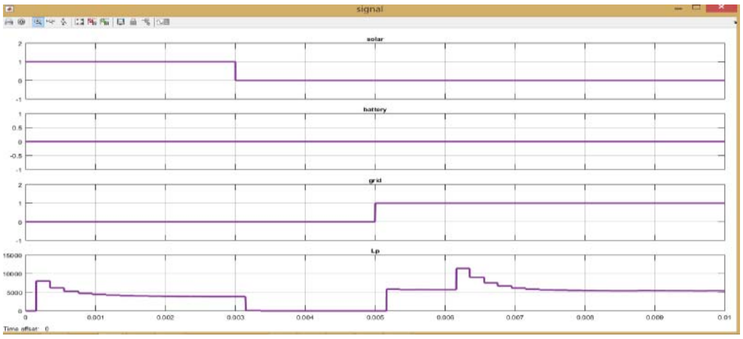

Fig 19: MAS decision making output: sources

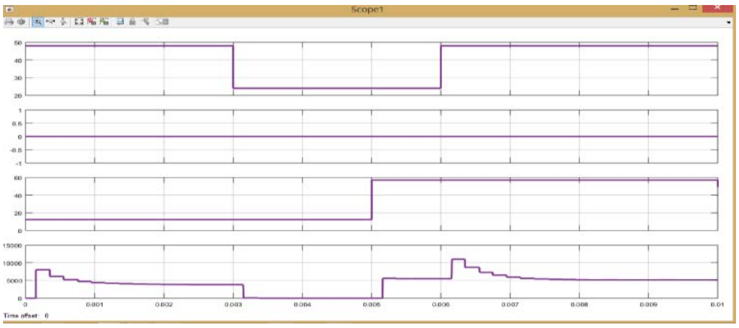

Fig 20: Voltage levels of sources connected to the system

Table 3: Solar parameters

From time (ms)	To time (ms)	Insolation (H in Watts/m^2)
0	3.33	1000
3.33	6.66	1000
6.66	10	500

Solar Control parameters (1=ON or 0=OFF) MAS to Solar =1;

MAS to Battery=1; MAS to Battery =1; MAS to GridG = 1;

Table 4: Driver- Duty cycle parameters

From time (ms)	To time (ms)	Duty Cycle (%)
0	3.33	50
3.33	6.66	75
6.66	10	50

During the time t=0 to 0.006s, it is observed that solar power which is generated is sent to the load, as the requirement are below the threshold values in 5000 watts type. In this period the input to solar PV is kept at 1000 watts per meter.

At time t is equal to 0.006S solar insolation level drops to 500 watts per meter square and hence power needed by the load cannot be generated, the same is communicated to central Multi Agent system. The grade is used as second option in Multi Agent System, the volage across the adapter will cross the threshold limit of 47V. The power levels will increase because the adapter output is 52V, it means more power can be generated from the source.

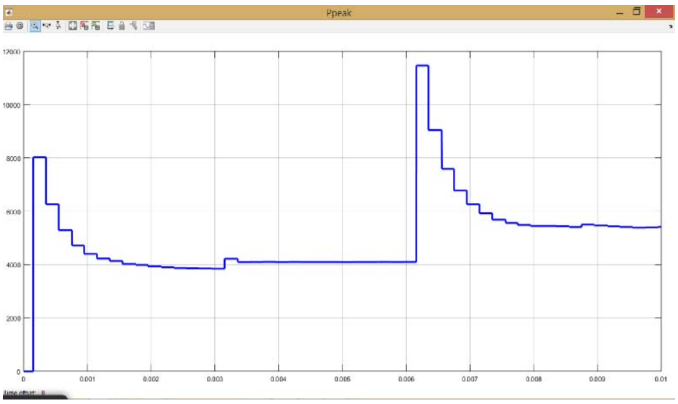

Fig 21: Power requirement of load

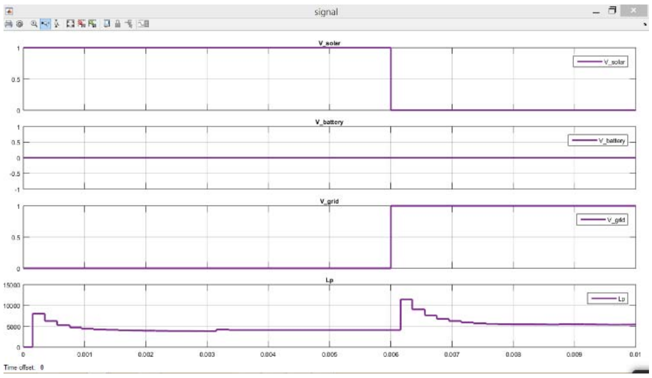

Fig 22: MAS based decision made, based on source availability and load power required

6. CONCLUSIONS

The key issues of solar e-cooking in terms of energy costs, usage, and conservation are discussed in this research. The energy cost for cooking is very low in insulated stoves and pans and these can be used in applications of both grid and off-grid case. Cooking meals with minimal power and in an acceptable amount of time is the key technological difficulty for this study, as well as the problem of changing cooking habits. Rice, vegetables, and meat can all be cooked the same way, based on what we've learned, but frying is going to be more difficult because of our limited understanding. For sun oriented e-cooking, expanding the size of the PV board and the battery might be more financially savvy, as indicated by this expense research. Furthermore, boosting the solar home system's power capacity allows homes to utilise additional equipment, such as fans for cooling, tiny freezers, and so on. This enhances the quality of life of users. The results obtained are verified with compact and low cost efficient 500watts prototype design. In the comparison process it is found that efficiency of the proposed converters exceeds more than 92% with full load condition due to reduction in THD.

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Efficiency Improvement by Thermo-Mechanical Coupling

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Abstract:

Electric motor or generator when running on load becomes hot due to the heat produced by the energy that is lost in the process of the electromechanical conversion of energy. There are suitable cooling and ventilation system to dissipate the heat, thereby putting a limit to the rise of temperature of the machine. Additional cooling measure by way of using thermo-mechanical coupling in torque transmission between the driving-shaft and the driven-shaft may facilitate faster dissipation of heat from the machine, thereby reducing somewhat the maximum temperature rise of the machine bringing in improvements in many aspects of performance of electrical machine.

Keywords. Performance, efficiency, temperature, coupling, cooling

1. INTRODUCTION

Electric motor upon running on load for some length of time appears hot, temperature being considerably higher than the ambient temperature. There are various cooling methods for purpose of cooling and ventilation of the machine. The source of heat and the necessity and the way of cooling thus appear important features in matters of electric dynamo, more particularly of performance, analysis, design and construction aspects.

The electric dynamo operates on the principle of electromagnetic energy conversion which is necessarily accompanied by a certain amount of irreversible conversion of energy to heat in the conversion device e.g., electric motor or generator. In each time of energy conversion process, say electrical to mechanical or mechanical to electrical, some of the energy is used up to meet the losses in the conversion process. These losses are converted into heat and are lost from the system for ever. Thus, electromechanical energy conversion is a reliable process except for the losses in the system.

It becomes a necessity to arrange to dissipate the heat produced in the machine. There are developed cooling and ventilation system of various types. Heat is dissipated by way of radiation from the surface of the machine and by way of convection by circulation of air by fan which itself consumes some power. There are too many applications of electric motor to act as prime mover to drive some mechanical equipment viz. pump, gearbox. In many a situations mechanical coupling e.g., flange coupling, gear coupling are used to connect driving shaft with driven shaft for torque transmission. Some modified coupling, say thermo-mechanical coupling may provide additional scope of dissipating heat by conduction which may help reducing the maximum temperature rise of the electric machine. Thus, lesser rise of temperature of the machine in steady-load service remain beneficial for the electrical machine.

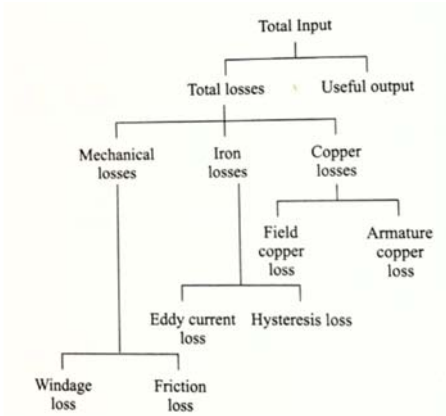

Figure 1: Different types of losses in motor

A. Energy losses and efficiency

The energy losses arise in electromechanical conversion process because of several reasons, e.g., circuit resistance (copper or electrical losses), existence of alteration of fluctuating magnetic fields (core or iron losses) and mechanical losses (friction and windage). Although they play essentially no basic role in the energy conversion process, these are nevertheless important factors in practical application of machines.

These machine losses are important for basically three reasons.

i) Power losses determine the efficiency of the machine and appreciably influence its operating cost.
ii) Power losses determine the heating of the machine and hence fix the rating of power output that can be obtained without deterioration of the insulation because of overheating.
iii) The losses associate with voltage drops or current component used to be accounted for in a machine representation for desired analysis of electrical machines.

B. Efficiency

The efficiency (η) of an electrical machine, like that of any other apparatus, is defined as the ratio of useful power output to the input power.
Machine efficiency, η = output/input
or, η = output / (output + losses)
or, η = (input – losses) / input
or, η = 1 - losses/input ……………………………………………………..……………... (1)
Considering various power stages in dc generator represented as in figure 2

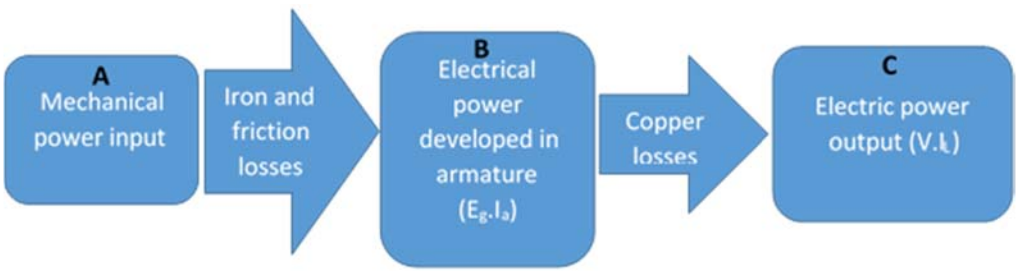

Figure 2: Schematic power stages in a dc generator.

a) Mechanical efficiency, $\eta_m = \frac{B}{A} = \frac{E_g.I_a}{mechanical\ power\ input}$ ……………..…………...……... (2)
b) Electrical power efficiency, $\eta_e = \frac{C}{B} = \frac{V.I_L}{E_g.I_a}$ …………………………........................... (3)
c) Commercial efficiency, $\eta_c = \frac{C}{A} = \eta_{m*}\ \eta_e = \frac{V.I_L}{mechanical\ power\ input}$ .... (4)

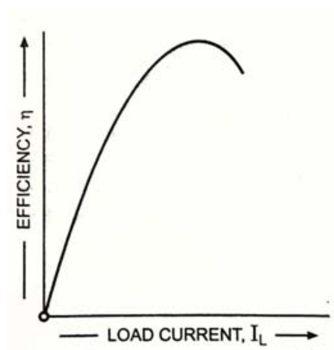

Figure 3: Load current vs efficiency curve

Rotating electrical machines in general operate efficiently at light loads. The full load efficiency of average motors, for example, is about 74% for 0.75kW size, 89% for 37kW, 93% for 375 kW and 97% for 3750kW. The efficiency of slow speed motors is usually lower than that of high-speed motors, the total spread being 3-4%. Load current vs efficiency curve appears as in figure 3.

For electrical machines, efficiency is most commonly determined by measurement of losses instead of directly measuring the output and input under load. Loss measurement have the advantage of conversion and economy and of yielding more accurate and precise values of efficiency because a given percentage error in the measuring of losses cause only about one-tenth ($\frac{1}{10}th$) of their percentage error in the efficiency. Efficiency determined by the measurement of losses can be used in comparing machines if exactly the same methods of measurement and computation are used in each case.

C. Constant and Variable losses

The losses in electromagnetic conversion process, say for a dc generator or motor can be subdivided into i) constant losses ii) variable losses.
i) Constant losses: - Those losses in an electrical machine which remain constant at all loads are known as constant losses. e.g. - a) Iron losses b) mechanical losses c) shunt field losses.
ii) Variable losses: - Those losses in a dc generator/electrical machine which vary with load are called variable losses. e.g. - a) Copper losses in armature winding ($I_a^2R_a$) b) copper losses in series winding ($I_{se}^2R_{se}$)
Total losses = Constant losses + Variable losses.
$P = P_c + P_v$ ……………………………………..….. (5)
The point at which the variable losses are equal to the constant losses determine the maximum efficiency. The value of load current (I_L) corresponding to maximum efficiency can be determined as,
$I_L = \sqrt{\frac{P_C}{R_a}}$
The efficiency of an electrical machine, say of a dc generator, will be maximum when the load current is such that Variable losses = Constant losses.

D. Temperature rise in electrical machines

For the losses in various parts, heat is developed causing the temperature of that part to rise. This temperature rise continues until all the heat generated is dissipated to the surroundings by one or more of the natural modes of heat transfer like conduction, convection and radiation.
Ultimately then, under steady load, each part achieves final temperature, the magnitude of which depends on balances between the rate at which heat is developed in that part (or received by conduction from a hotter part) and the rate at which heat can be dissipated which is determined by effectiveness of the cooling method.
The temperature rise depends on

i) The amount of heat produced
ii) The amount of heat dissipated per ℃ rise of temperature from the surface of the machine.

According to Newton’s law of cooling the rate of loss of energy of a hot body is proportionate to the difference in temperature between the body and the surroundings. This law is approximately true for moderate temperature difference (up to 100°C) and for the bodies dissipating heat by radiation and natural convection. It means that the amount of heat dissipated per 1°C rise of the surface of a machine depends on the surface area of cooling.

E. Size of motor

The size of motor for any service is governed by the maximum temperature rise when operating under the given load condition and the maximum torque required. The form is more important because if the motor operates satisfactorily at maximum temperature rise it will usually provide the required maximum torque except in special cases where the load consist of heavy peaks followed by relatively long intervals of no load. Electric machines are therefore designed for a limiting temperature rise.

F. Insulation

In fact, continuous rating of a machines is the rating for which the final temperature rise is equal to or just below the permissible value of temperature rise for insulating material used in protection of motor windings. In any situation if the temperature rise of 50°C can be brought down to a limit of 40°C, then insulation A can be utilized for 40°C temperature rise instead of utilizing insulation B which is applicable for 50°C temperature rise. When the machine is overloaded for such a long time that its final temperature rise exceeds the permissible limit, it is likely to be damaged. In worst cases, it will result to an immediate thermal breakdown of the insulating material which will cause a short circuit in the motor thus putting a stop in its functioning. The short circuit may also eventually lead to a fire.

In less severe cases, immediate thermal breakdown of insulating material may not occur, but the quality of insulation will deteriorate such that the thermal breakdown with future overloads or even natural loads might soon occur, thus shortening the useful life of the machines. The temperature rise to which a motor be allowed to rise is limited by the insulation employed.

2. HEATING TIME CURVE

The maximum temperature rise which should not be exceeded by different types of motors are fully set out in the relevant IS. Since temperature rise is one of the chief features in fixing the size of a motor, its calculation become a matter of importance.

For determination of an expression for the temperature rise of an electric machine after time t seconds from the instant of switching it on, let

Power converts into heat = P joules/s or watts

Mass of active part of machines = m kg

Specific heat of material = C_p joules/kg/°C

Surface area of cooling = S metre^2

Coefficient of cooling = α in watts per metre^2 of surface per °C of difference between machine surface and ambient temperature.

Assumptions made

i) Losses and heat produced remain constant during the temperature rise.
ii) Temperature of cooling medium remain unchanged.
iii) Heat dissipated is directly proportional to the difference in temperature of the machine and cooling medium.

Suppose a machine attains a temperature rise of θ℃ above ambient temperature after t seconds of switching on the machine and further rise of temperature by dθ in very small time dt.
Energy converts into heat = Pdt joules
Heat absorbed = $mC_p d\theta$ joules
Heat dissipate = $S\theta\alpha dt$ joules
Since, energy converted to heat = Heat absorbed + Heat dissipated
Therefore, $Pdt = mC_p d\theta + S\theta\alpha dt$
or, $(P - S\theta\alpha)dt = mC_p d\theta$
or, $\frac{dt}{\text{m Cp}/S\alpha} = \frac{d\theta}{P/S\alpha - \theta}$ .... (6)
When final temperature (θ_F) is reached, there is no absorption of heat, whatever heat is generated has to be dissipated.
∴ $Pdt = S\theta_F \alpha dt$
or, Final temperature rise, $\theta_F = \frac{P}{S\alpha}$ .... (7)
Substituting $\theta_F = \frac{P}{S\alpha}$ in equation (6)
We get, $\frac{S\alpha dt}{mCp} = \frac{d\theta}{\theta_F - \theta}$
Integrating both sides, we get $\frac{S\alpha}{mCp}$ t = - $\log_e(\theta_F - \theta) + K_1$..(8)
K_1 = Constant of Integration
Substituting t = 0, $\theta = \theta_I$ in equation 8, initial temperature rise from initial condition, we have
$0 = -\log_e(\theta_F - \theta_I) + K_1$
or, $K_1 = \log_e(\theta_F - \theta_I)$
So equation (7) becomes
$\frac{S\alpha}{mCp} t = -\log_e(\theta_F - \theta) + \log_e(\theta_F - \theta_1)$
or, $\frac{S\alpha}{mCp} t = \log_e \frac{\theta_F - \theta}{\theta_F - \theta_1}$
or, $e^{-\frac{S\alpha}{mCp} t} = \frac{\theta_F - \theta}{\theta_F - \theta_1}$
or, $\theta_F - \theta = (\theta_F - \theta_I)\, e^{-\frac{S\alpha}{mCp} t}$
or, $\theta = \theta_F - (\theta_F - \theta_I)\, e^{-\frac{S\alpha}{mCp} t}$ .... (9)
or, $\theta = \theta_F - (\theta_F - \theta_I)\, e^{-\frac{t}{\tau_h}}$ ....(10)
$\tau_h = \frac{m\,Cp}{S\alpha}$ is known as heating time constant.
If motor is at ambient temperature $\theta_1 = 0$
$\theta = \theta_F - \theta_F\, e^{-\frac{t}{\tau_h}}$

or, $\theta = \theta_F(1 - e^{-\frac{t}{\tau_h}})$ ………………………………...…....... (11)
Heating time constant is defined as the time taken by the motor in attaining the final steady value. If the initial rate of rise of temperature were maintained throughout the operation.

Substituting t= τ_h in equation (11), we have $\theta = \theta_F$ (1-e^{-1}) = 0.632 θ_F ....……… (12)

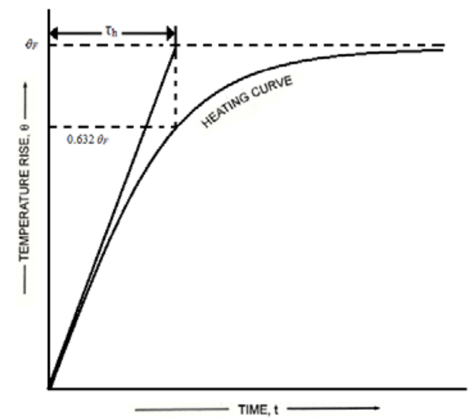

Figure 4: Heating time curve

So, heating time constant may also be defined as the time duration in which the machine will attain 63.2% of its final limit rise above the ambient temperature the corresponding heating curve has been shown in figure 4.

From equation 7, i.e., θ_F = P/Sα, it is obvious that θ_F is directly proportional to the power losses and inversely proportional to the surface area S and specific heat dissipation α. For poorly ventilate machines, it will attain a higher final temperature rise.

Heating time constant τ_h, being equal to mCp/Sα, has small value for well ventilated machines and large value for poorly ventilated machines.

Large size machine has large heating time constant because with the increase in size of machine, the volume hence the mass increases in proportion to third power of linear dimensions and surface area S is proportional to second power.

Typical values of heating time constant lie between about one and half hour for small motors (7.5 kW to 15kW) up to above five hours for motors of several hundred kW.

3. COOLING TIME CURVE

After reaching steady temperature rise θ_F and operation of the machine, during which period heat production due to losses get dissipated equally, when machine is switched off, no heat is produced.

So, Heat absorbed + Heat dissipated = 0 and τ_c = mCp/Sα' is cooling time constant.

$\theta = \theta_F\, e^{-1} = 0.368\, \theta_F$ ……………………………………………………………(13)

I.e. cooling time constant may also be defined as the time required for cooling machine down to 0.368 times the initial temperature rise above ambient temperature. It has been shown in figure 5.

The heating and cooling curves follow an exponential law. Heating time constant and cooling time constant may be different for the machines as the ventilation condition in the two cases may not be same.

The cooling time constant of a rotating machine is usually larger than its heating time constant owing to poor ventilation condition prevailing when the machine cools.

In self-cooled rotating machine, the cooling time constant is about 2-3 times greater than its heating time constant because cooling condition are worse as the machine stands still.

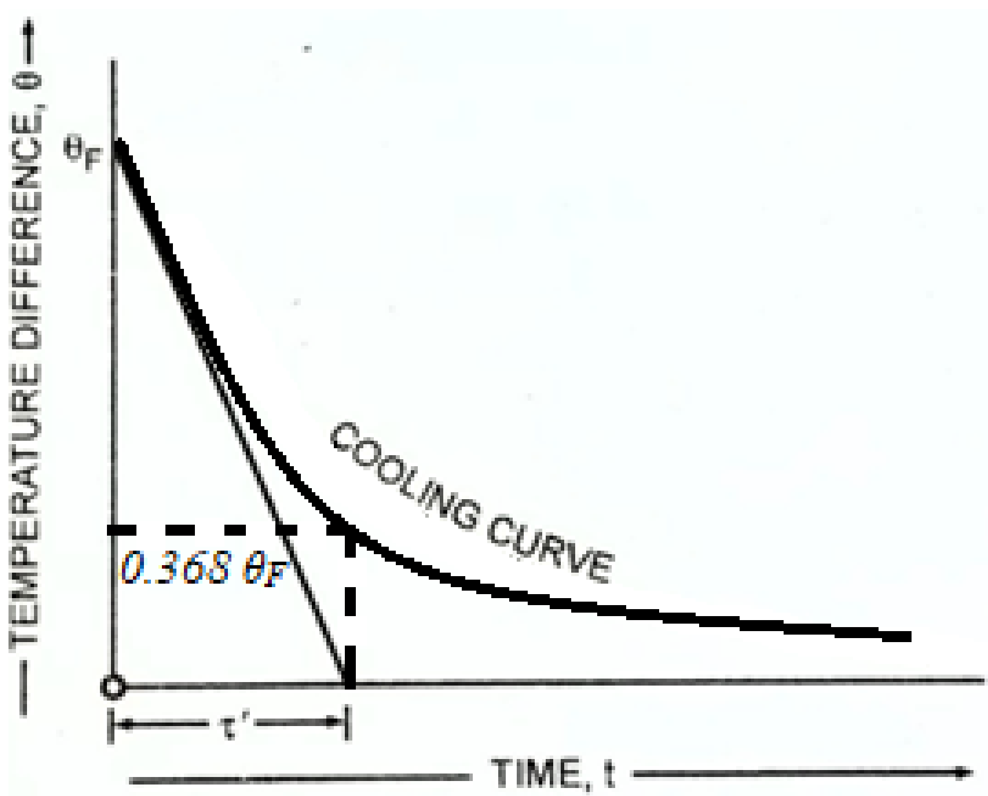

Figure 5: Temperature difference-time curve

4. COOLING AND VENTILATION OF ELECTROMECHANICAL MACHINES

It is necessary to provide suitable ventilation and cooling for the machines so that temperature rise at any part of the machine does not exceed the permissible limit governed by the types of insulation employed in the construction. The cooling of electrical machine by means of air stream is taken as ventilation.

There are various methods of such ventilation and cooling like natural cooling, self-cooling and separate cooling, open-circuit ventilation, surface ventilation and others. Alongwith also comes types of enclosure for protection of man and machines both and IS-4691 provides the IP codes. The types of enclosures corresponding to the service condition and vicinity of location of the machine include open type, protection type, screen-protected type, totally enclosed fan cooled type (TEFC), pipe ventilation type and other types.

5. ADDITIONAL COOLING

Important relations below indicate that increase in the heat dissipation brings down the value of parameters like temperature rise, heating time constant and influence the heating curve well.

$\theta_F = p/S\alpha$, $\tau_h = mCp/S\alpha$, $\theta = \theta_F\,(1 - e^{-\frac{t}{\tau_h}})$

In general, $S\alpha$ represents heat dissipation from the surface area of the electrical machine that radiate heat to the atmosphere. In well ventilated fan cooled machine heat dissipation takes place also by convection by flow of air.

There are too many applications of the electrical machine in driving the mechanical equipment. Coupling is employed to connect the driving shaft of motor with the driven shaft of the mechanical equipment and torque is transmitted from motor shaft to the shaft of mechanical equipment e.g., gear box, pump.

Such mechanical coupling, say flange coupling of improved concept and design may give scope to dissipate heat by conduction from motor shaft to the driven shaft of mechanical equipment which apparently become heat sink and the temperature of such driven-equipment may not change appreciably and remain near ambient temperature. Heat dissipation from electrical machine by application of such coupling in transmission of heat from prime mover to utility equipment may facilitate reducing the temperature rise θ_F and the heating time constant τ_h and in turn, improve the relevant features like rating, life, insulating matters.

Considering additional heat dissipation by conduction by way of use of thermo-mechanical coupling of suitable design the heat balance equation develops to

$$Pdt = m\,C_p\,d\theta + S_1\,\theta\,\alpha_1\,dt + S_2\,\theta\,\alpha_2\,dt \qquad (14)$$

Where $S_2\ \theta\ \alpha_2$ dt is the equivalent of heat dissipation by conduction through thermo-mechanical coupling indicate here in afterwards.

The final temperature rise θ'_F at steady-state operation appears,

$\theta'_F = \frac{P}{S_1\alpha_1 + S_2\alpha_2}$

or, $\theta'_F = \frac{P}{S_1\alpha_1(1+\frac{S_2\alpha_2}{S_1\alpha_1})}$

or, $\theta'_F = \theta_F \cdot \frac{1}{h}$

where $h = (1 + \frac{S_2\alpha_2}{S_1\alpha_1}) > 1$ ………………………………………………………………………….. (15)

Also the heating time constant τ' in such case reduce to

$\tau' = \frac{mCp}{S_1\alpha_1 + S_2\alpha_2}$

or, $\tau' = \frac{mCp}{S_1\alpha_1(1+\frac{S_2\alpha_2}{S_1\alpha_1})}$

or, $\tau' = \tau_h \cdot \frac{1}{h}$ where h>1

The corresponding heating curve follows (in figure 5)

$\theta = \theta'_F - (\theta'_F - \theta_I)\ e^{-\frac{t}{\tau'}}$

When θ_1 being ambient temperature, $\theta_I = 0$

$\theta = \theta'_F\ (1 - e^{-\frac{t}{\tau'}})$ ………………………………………………………………………… (16)

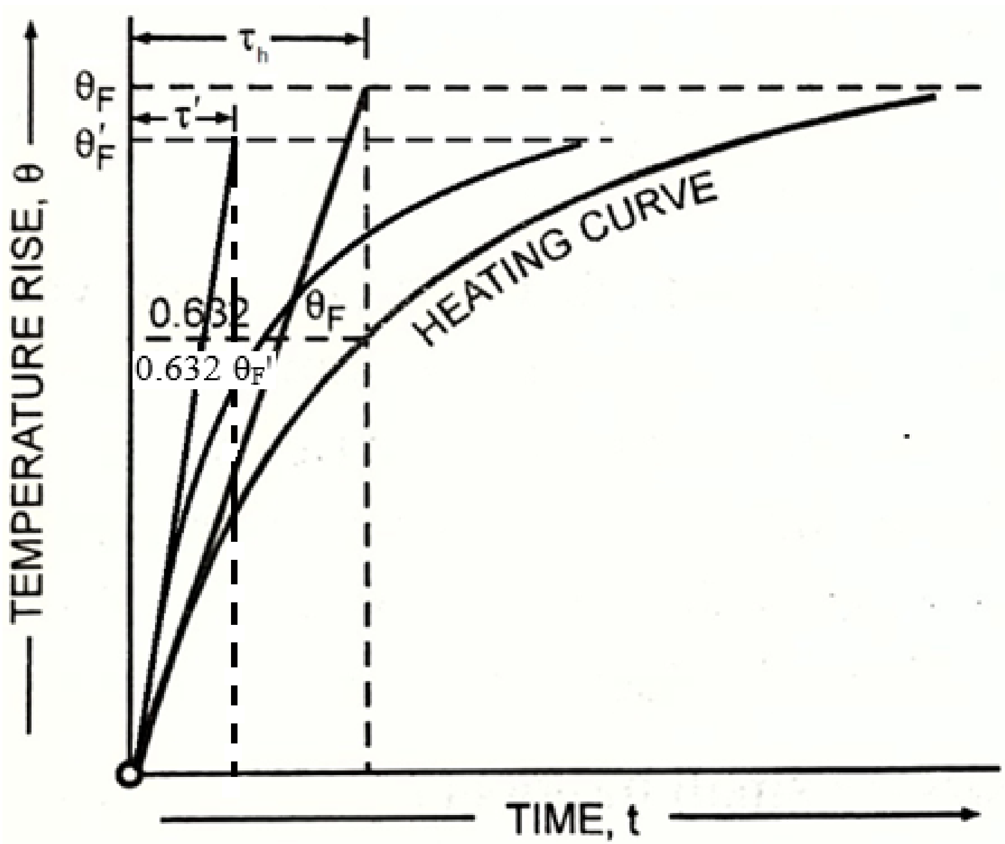

Figure 6: Temperature rise-time curve

6. THERMO-MECHANICAL COUPLING

Generally, a flange coupling of Cast Iron, used in connecting shafts manufactured separately for transmission of torque looks as in the figure 7.

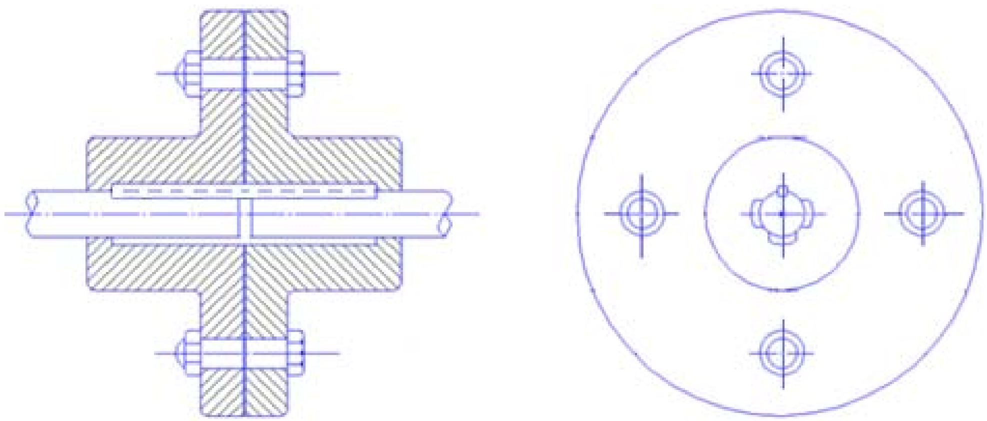

Figure 7: Flange coupling of Cast Iron

With such basic construction and design modification a thermo-mechanical coupling may be considered in figure 8.

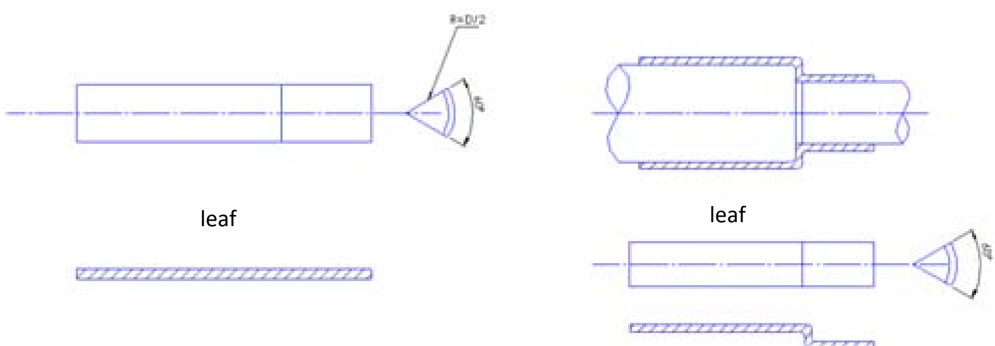

Figure 8: Thermo-mechanical coupling

The heat transmission leaf of suitable material like Cu, Al or Zn need be of required shape and dimension with due design and maintenance considerations, may be in multiple numbers. This leaf is accommodated into the suitable designed groove of the hub of the flange of the coupling.

The two shafts (driven and driver) are connected by such heat conducting leaves inserted into in the groves of the pair of flanges so as to have contact with the surface of both the shafts thereby can dissipate heat by conduction from hotter shaft to colder one. The leaf should not disturb the natural alignment of the shafts while the coupling transmits torque. This type of coupling continues to dissipate heat when the machine is switched off thus improves the cooling curve of the machine.

7. DUTY CYCLE

The nominal duty of the drive motor is the duty corresponding to the service condition and performance marked on its name plate. There are three types of duties viz

1) Continuous duty
2) Short time duty
3) Intermittent duty or intermittent provided duty

Continuous duty is that duty when the on-period is so much long that the motor attains a steady-state temperature rise. Figure 9(a)
The heating and cooling curves for short time duty motor are given in figure 9(b). The short time duty motors operate at a constant load for some specific period which is then followed by a period of rest. The period of run (or load) is so short that the machine cannot attain its steady temperature rise while period of test is too long.

The heating and cooling curves for intermittent periods, duty motors are illustrated in figure 9(c). On intermittent duty the periods of constant load and rest with machine de-energized alternate. The loading periods are too short to allow the motor to attain its final steady-state value while periods of rest are too small to allow the motor to cool down to ambient temperature.

Intermittent rating of a machine as the load which is applied during a certain fraction of time of a load cycle and the temperature rise limit is not exceeded.

The heating and cooling curve for maximum temperature rise of i) θ_F ii) θ_F', where $\theta_F > \theta_F'$ for various types of duties become modified as given in schematically figure 5.

The duty cycles for various motor duties appear as in figure 10.

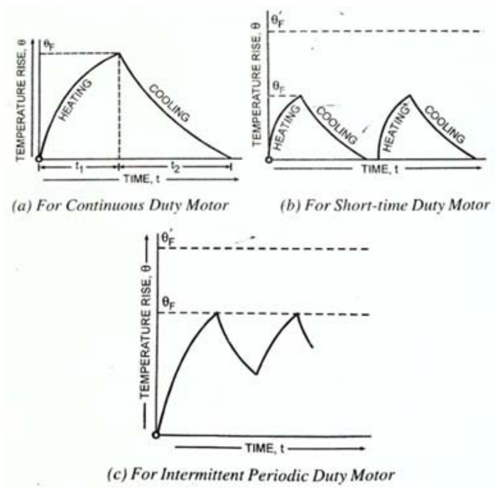

Figure 9: Temperature rise-time curve

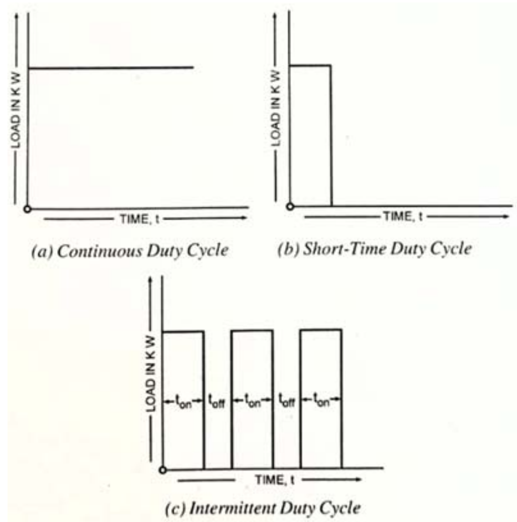

Figure 10: Temperature rise-time

8. RATINGS OF MACHINES

The rating of a machine must give the necessary information to safeguard the application of the machine from condition of operation which (i) would result in unsafe mechanical or electrical strains upon any part of its structure or (ii) would result in excessive deterioration of the mechanical or electrical characteristics of materials of construction. To give the information related to an electric machine should include the output voltage, speed and any other information that may be necessary for the proper operation of the machine.

Electric generators and motors are rated in terms of kVA or kW output at a given speed and voltage. The size and rating of an electric machine for some service is mainly governed by the factor ‘temperature rise’. The maximum temperature to which an electric machine is allowed to reach is limited by the type of insulation employed.

The maximum temperature rise permissible with insulation A and insulation B may be 40℃ and 50℃ respectively. Overloads are permissible generally for short period of time but when machines are required to carry greater loads than those specified, they must be kept under inspection to see that the temperature does not rise too much and that severe sparking at the commutater does not occur.

The type of service to which a machine is subjected to is of great importance. The machine operating continuously at rated (or near rated) load are physically larger than those working at intermittent loads. Also, electric machines that are not enclosed and are, in addition, well cooled by fans are likely to have higher ratings than covered up machines or those machines located where air does not circulate freely through or over them. High speed machines employing mica glass tapes and the new silicon insulation can generally be physically smaller, in given ratings than the low-speed machines employing standard insulation.

9. TESTING OF MOTORS

Electrical machines, particularly generators and motors are likely to undergo various tests for quality performance and life of the machine e.g., load, efficiency, insulation rating. There are various situation-specific testing methods like direct, indirect, regenerative method and others.

Heat run test or temperature rise test indicate the maximum temperature attainable by the machines while operating under certain load condition.

Heat Run test or Temperature Rise test

The life of insulation of electrical equipment depends upon the maximum temperature attained during operation. The objective of the test is to find out the actual maximum temperature attained while the machine is operating under certain load condition.

The back-to-back load is performed for the temperature run also. The normal duration of the hot run test for large machine is about 6 hours. In some cases, to avoid waste of energy during testing and to reduce testing duration (which is normally till the temperature rise attains a steady value), short time test is carried out and ultimate temperature rise of the machine is determined from the data obtained from these tests.

The equation for temperature rise is given by, $\theta = \theta_m (1- e^{-\frac{t}{\tau}})$

Where θ = the temperature rise at time t, θ_m = maximum temperature rise, τ = heating time constant depending upon the thermal capacity of the insulation and the rate of dissipation of heat.

The above equation being simplified by substituting $e^{-\frac{1}{\tau}}$ by k. we get $\theta = \theta_m (1\text{-}k^t)$.

When t = 1, $\theta_1 = \theta_m (1\text{-}k)$. t = 2, $\theta_2 = \theta_m (1\text{-}k^2)$. k^2

Then $\frac{\theta_2}{\theta_1} = \frac{1-k^2}{1-k}$ or, $k = \frac{\theta_2-\theta_1}{\theta_1}$

And the maximum temperature rise, $\theta_m = \frac{\theta 1}{1-k}$ ……...…………... (17)

It will thus be possible to determine the maximum temperature rise by taking two or more readings at regular intervals of time, i.e. $k = \frac{\theta_2-\theta_1}{\theta_1-\theta_0} = \frac{\theta_3-\theta_2}{\theta_2-\theta_1} = \frac{\theta_4-\theta_3}{\theta_3-\theta_2}$ and so on.

The interval of time during the test for measurement of temperature may be taken as 30 minutes or even smaller.

Example: in a heat run test on a dc machine, three consecutive readings taken at 30 mints time intervals were 35℃, 45℃ and 50℃.

So, ratio of temperature rise during successive intervals of time,

$k = \frac{\theta_2-\theta_1}{\theta_1-\theta_0} = \frac{50-45}{45-35} = 0.5$

Maximum temperature likely to be attained, $\theta_m = \theta_0 + \frac{\theta_1-\theta_0}{1-k}$

When k = 0.5 we get $\theta_m = 35 + \frac{45-35}{1-0.5} = 55°C$

10. CLASSIFICATION OF INSULATING MATERIALS

The temperature rise which electric motor can safely withstand is determined by thermal stability (limiting temperature) of the insulating materials used in them. By using materials of higher thermal stability, motors of the same physical size may be rated for larger power output.

Different insulating materials have different limiting temperature. For example (ref. IS-1271), Class y (90℃), Class A (105℃), Class E (120℃), Class B (130℃), Class F (155℃), Class H (180℃)

11. CONCLUSION

Arrangement for additional heat dissipation from electrical machines by using thermo-mechanical coupling in torque transmission appear to be beneficial to various aspects of such machine e.g. improving the heating curve, cooling curve, lessening power consumption in cooling and ventilation by fan, increase in effective output power, reducing the heating time constant vis-a-vis maximum temperature rise, reducing cooling time constant, enduring insulation, improving the rating vis-a-vis reducing size or frame size of machine and reduces temperature dependent losses indicating more efficient performance of the machine. The machine may perform in relatively tougher service condition. In case effective output power increase even by 0.1%, in the power consumption order of 1 TW in the corresponding application, the saving of power ranges to 1000 MW which remains not negligible.

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Power Management Strategies in Hybrid AC/DC Microgrid: A Review

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Abstract.

The future of power system is 'Smart Grid' for which microgrids are the building blocks. Renewable energy sources, such as solar, wind and various distributed generation (DG) units, and as well various energy storage systems (ESS) are encouraged to integrate with grid. Since they incorporate the benefits of AC and DC distribution networks and which do not entail any unnecessary changes to the distribution network, which emerge hybrid microgrids as a promising solution. They need more complex control techniques, though, since they must handle the alternating current and direct current networks at the same time as well as interface the power converters. This paper examines power management strategies in grid-connected and grid-disconnected operational modes in hybrid microgrids with renewable energy sources.

Keywords. Hierarchical control, Hybrid Microgrids, Interconnected converters, unidirectional/bidirectional power flow, Distributed Energy Resources, Energy Storage Systems.

1. INTRODUCTION

The definition of micro-grids with classification schemes, including controllable loads in addition with energy storage systems, are found in several literature, for instance in [1] – [4]. Microgrids are operated in a dependently when connected to grid and independently when isolated from grid.

There are three microgrid structures available: AC microgrid, DC microgrid, and hybrid microgrid [5], [6]. While AC system is the most prevalent configuration of micro-grids, there has been a lot of interest in DC micro-grids because of some advantages, such as the lack of the requirement for reactive power or synchronisation, also the growing number of electric vehicles, smart DC devices and DC loads that are available. The hybrid micro-grid, on the other hand, combines the greatest features of both designs. A hybrid microgrid is a design that merges a greater number of separate AC microgrids and DC microgrids using bidirectional power electronics interlinking converters (ICs). Here, ICs provide power management with neighbouring AC-DC microgrids. The DC microgrid is connected to the main utility grid by voltage source or back-to-back converters [7], [8] and it is adjacent to AC subgrids via bidirectional ICs. The IC serves as the foundation for hybrid microgrid management and control. IC is largely accountable for the efficient regulation of transmission of power between the AC microgrids and DC microgrids. The IC controller may also be set to function in island mode to guarantee identical loading of the AC microgrid and DC microgrid based on their capacity, minimum load peeling and renewable power reduction in the hybrid microgrid as a whole in addition appropriate reserve and loadability buffer intended for the overloaded microgrid.

Advanced hybrid microgrids can also balance renewable energy demand, plan resource dispatch, and maintain system dependability. It is also capable of controlling the inter connection and interactivity of complicated distributed generation arrangement, demand response, storage as well controlled loads, and energy management systems [9]– [13]. The operation of hybrid micro-grids comprises secure and suitable power management strategies, mostly based on droop control, to govern load contribution between AC and DC sources.

The layout of the paper is divided as follows: Section two is a concise description of the hybrid microgrid definition, here the key characteristics as well as related control and operation issues are stated. In section three, challenges and research findings are discussed.

2. HYBRID MICROGRID CONTROL

An AC microgrid and a DC microgrid, as well as an interface between the two power converters that regulates power flow connecting these microgrids and the main grid comprise hybrid microgrids. The AC microgrid mostly have AC dispersed energy resources (DERs) and AC loads in the hybrid structure, whereas the DC microgrid primarily consists of DC dispersed energy resources and DC loads [7]. Every extra energy generated in a DC microgrid is normally stored in storage systems, such as batteries. Simultaneously, excess energy generated in the AC subgrid can be stored in AC ESSs such as flywheels. In Fig. 1, A typical hybrid microgrid arrangement is shown as both AC microgrid and DC microgrids connected through interlinking bidirectional converters to the utility grid [14].

The hybrid AC-DC microgrid's topologies and power management strategies are discussed in [15]– [17]. The hybrid AC-DC microgrid plan and design representation is suggested in [18], [19], which can evaluate the dispersed energy capability, and study the effect of the load ratio of AC-DC. Here, in aforementioned literatures, however, the work is focused on the single optimization problem of AC-DC hybrid microgrids, except there is a short of efficient coordinated optimization idea in terms of economics, dependability, and other difficulties.

The organized approach that administers all such devices connected to the network is one of the mainly distinguishing types that distinguish microgrids from traditional distribution networks. Because microgrids are distributed, this strategy is crucial for effective management [20].

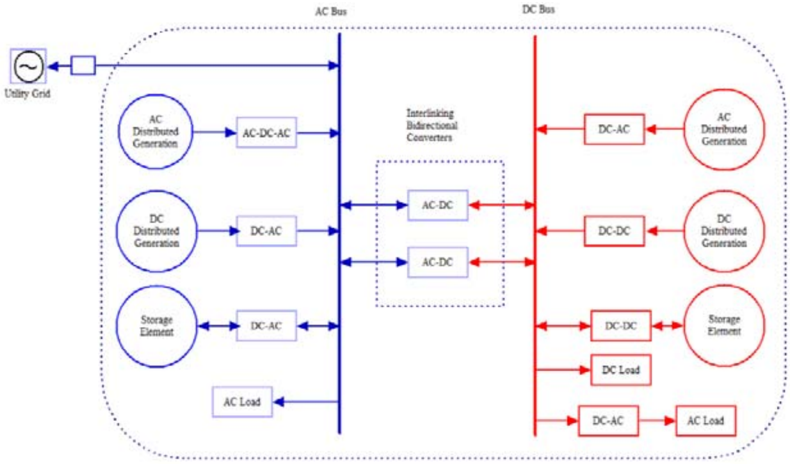

Figure 2.1. A Typical Hybrid AC-DC microgrid

Microgrids may function in both grid-tied and grid isolated operational modes, allowing for the effective integration of Dispersed Energy Resources (DER).

The microgrid control structures have following major roles [21]-[28]

- Microgrid synchronization with utility grid;
- Power transfer between the microgrid and utility grid;
- Active and reactive power management of microgrid at different operating modes;
- Smooth transition among different modes of operation of microgrid —i.e., grid-connected to isolated mode or island mode to grid-tied.
- Proper coordination between DER and load;

These requirements have different definitions and time scales, and thus require a hierarchical management system to handle each requirement in a different hierarchy of management. There are three level of hierarchical power management policy, namely primary, secondary, and global/tertiary controls.

2.1 Primary Control

The primary control is a self-regulating main/local control approach which permits each DG unit to function separately. It is essential to offer unique active and reactive power contribution regulations for DERs in the existence of both linear and nonlinear loads. Furthermore, power sharing regulation limits the circulation of undesirable currents. This main level of control consists of simple control circuitry, sometimes referred to as zero-level, that contains DERs' internal voltage as well current control loops. In the literature primary management strategies implemented are namely grid-feeding and grid-forming as expressed in [29], [30]. While some research on main control mechanisms is available, it typically focuses on AC microgrids or DC microgrids [4], [31]. In this case, grid-forming as well grid-following management approaches are being examined for execution [32].

2.1.2 Grid-following control

To be grid-connected, the microgrid must adhere to the network's distribution requirements. Local control, which comprises fundamental control hardware such as DG inner voltage as well current control loops, keeps DGs stable by sensing and adjusting local signals. It is essential to supply autonomous active and reactive power contribution management for DGs/RESs in addition to limit undesirable circulating currents using the accessible current, voltage, and frequency feedback signals. While in grid-tied operation mode, the main grid sets the voltage as well frequency of microgrid, so that local DER device controllers generally function in current-control mode to take out maximum power as feasible from energy resources [4].

2.1.2 Grid-forming control

In the case of any aberrant operation or situation affects the grid, the microgrid should be unplugged and switched to grid-isolated operating mode. During these situations, DG and ESS systems must maintain balance of active and reactive power of the microgrid's AC and DC networks. In this case main control provides reference inputs to the voltage and current control loops of DERs referred as zero-level control. To accomplish zero-level control, PQ or voltage control modes are typically employed [31]. Depending on the needs, several DG units may operate to regulate voltage of the network, i.e., in grid-forming mode, and the remaining will remain in the grid-following mode [4].

2.1.2.1 Single Grid-Forming Unit

In the case of just one grid-forming unit availability in an isolated mode of microgrid, such unit stays with simpler voltage control with a predetermined reference voltage. Numerous grid-forming machines with the same specified reference voltage cannot be connected to a single distribution network. This will cause circulating currents, synchronisation problems, and inconsistencies in power contribution. Hereafter, all other units must be grid-following. The grid-forming unit will entirely remain dependable on power balance of the network [5].

2.1.2.2 Multiple Grid-Forming Units

If numerous dispatchable DG units are supplied into a microgrid, electricity must be swapped, for example, based on unit ratings. As a result, synchronisation is required for hybrid microgrid networks in such a way to assure voltage and frequency stability when performing balanced power sharing [4].

The droop control method is often utilised for main control in islanded microgrids. Droop control imitates traditional grid control in microgrids based on the well-known droop controllers of Q/V and P/f with many grid-forming DG interface converters, and did an exhaustive analysis of grid-forming control schemes [33].

2.2 Secondary control

In the case of secondary control, a communication-based approach for similar construction of DGs, provides power sharing by adjusting for voltage and frequency fluctuations induced by local control operation and load fluctuation. This type of control is meant to have a weak dynamics response than the main, that explains the decoupled dynamics of the primary and secondary control loops and simplifies their respective plans [4]. Secondary controls, also known as second layer control loops, help inner control loops by minimising steady-state defects and increasing power quality inside MGs. They work closely with both local and central command units. In grid-tied mode, all DGs and inverters in microgrids utilize grid electrical signals as references for voltage and frequency regulation. The DGs, however, lose the main grid's reference signal when operating in the islanding mode. In this circumstance, they could collaborate to handle a simultaneous operation using single/multimaster operation approaches. Some of the secondary controls necessary to improve the performance of parallel operations for DGs are also included (or inverters). Many control systems for successful similar operation of DGs/inverters are known in the literature, including current or power sharing, master or slave, and generalised frequency and voltage droop control strategies [30].

Secondary control techniques are classified as either centralised or decentralised. In centralised techniques, the microgrid is administered by a tertiary control level as the microgrid central controller or MGCC [20], [25], [34]. In grid-tied mode, the secondary centralised control compensates for change in frequency and voltage in main control levels using the reference supplied by the higher tertiary level. In contrast, after an islanding process occurs, these references are generated internally [22]. The authors suggest a centralised secondary control mechanism for both hybrid microgrid networks.

Power management duties in generating and storage units are recalled in non-centralized control schemes. This suggests that they are included into the local controller rather than the MGCC, so that bypassing the communication network with higher-level control mechanisms [35]. The fundamental benefit of these control systems is that if a problem increase, the remaining part of the microgrid may continue to function normally after the malfunctioning unit is unplugged. Because it provides a simpler communication network with plug-and-play device connections, the non-centralized control method is considered as an interesting choice for microgrid integration at the power distribution level [20], [34], [35].

2.3 Tertiary control

Topmost degree of power management of numerous linked MGs and communicating needs with the utility grid is tertiary control. The tertiary control system, for example, might include coordination capabilities for active/reactive power control of a grid comprised of the utility grid and interconnected MGs [22]. In grid connected mode, the power transfer between the microgrid and the utility grid may be adjusted by varying the amplitude and frequency of DERs voltages. Tertiary control is the highest level of management coordination for the operation of many connected MGs and communicating demands with the utility grid. For example, the tertiary control system might incorporate coordination capabilities for active/reactive power control of a grid comprised of the utility grid and linked MGs [36]. In contrast, from a tertiary control standpoint, the MG may be programmed to cooperate with the distribution network as a dispatchable and constant impedance load.

Tertiary level control is concerned with aspects of an MG's overall responsibilities, such as power transfer between the utility grid in addition/or other linked MGs. In general, the most important tertiary control objectives are generation schedule optimization, improved overall system management and dispatch services, energy disparity correction, and spinning reserve function. MGs can also be coordinated with the MGCC to provide various ancillary services aimed at improving the utility grid's performance [4].

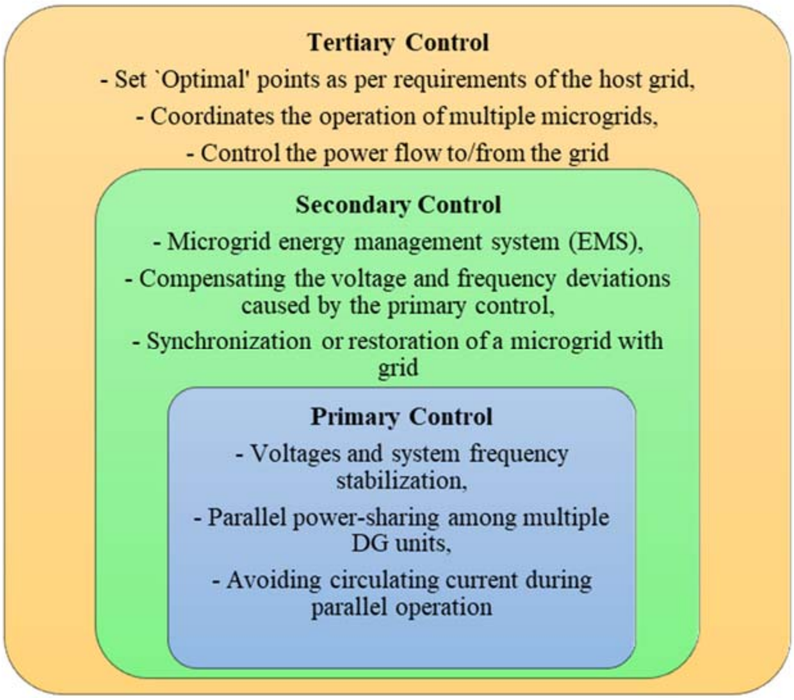

Figure 2.2: Hierarchical microgrid control structure

Furthermore, by including ESSs into the MG, these services might be expanded even further. In this circumstance, tertiary management will give functionalities like effective reserve capability extension, largely peak shaving, frequency regulation, backup of determined electrical islands, and increased control of day-by-day renewable energy cycles [37].

3. CHALLENGES ASSOCIATED WITH HYBRID MICROGRID

Microgrid protection and control systems must overcome operational problems in order to maintain adequate levels of dependability and take out possible benefits from DER. Some of the issues originate from incorrect assumptions, which might lead to system instability. When it comes to replicating power system control within a microgrid, the majority of the problems originate from the traditional distribution and transmission systems that still exist in today's power networks. The following are some of the microgrid control challenges [38]-[40]:

- *Bidirectional power flows:* The existing power system, as well as the distribution feeders that go with it, are built for unidirectional power flow. In such system use of DG units in low voltage networks is projected to necessitate bidirectional power flow, with customers acting as prosumers. If existing feeder systems are maintained during availability of DG units in distribution networks, complications like as reverse power flow, unexpected power flow patterns, imbalanced voltage levels, and fault current flow may occur.

- *Low inertia*: Solar modules and fuel cells like renewable energy sources have no inertia, while others, such as wind turbines, have a low inertia. In contrast to huge power systems with thousands of synchronous generators assuring high inertia, these power electronic based DG units in microgrids have low inertia characteristics. In spite of the fact that power electronics-based DG units have higher dynamic performance; their low-inertia features may cause frequency variations in the islanded operation mode if proper administration mechanisms are not implemented.
- *Stability issues*: Because of the interaction between the different control dynamics of the DG units, local oscillation may develop. A comprehensive small signal and transient stability study is also required for a smooth transition between microgrid grid-connected and isolated mode of operation.
- *System modelling*: In a typical power system at the transmission level, assumptions such as a low X/R ratio, balanced three-phase condition, and steady power loads might be assumed valid. However, when considering a microgrid with low voltage distribution networks, these assumptions are incorrect. As a result, new modelling is necessary.
- *Cyber-physical security*: Because prosumers and DG units are scattered, controllers must connect through communication networks. Malware and data theft are both threats to cyber networks. Cyber-physical security is becoming increasingly essential as the number of microgrids and their related controllers grows.
- *Uncertainty*: The most renewable DG units are linked with uncertainty, intermittency, non-linearity, and unpredictability. To enable effective and consistent microgrid operation, specific levels of coordination across multiple DG units are necessary. Especially in the isolated mode of microgrids, where maintaining generation-consumption balance is more difficult owing to the high incidence of component failures and the unpredictability associated with load profile and weather prediction. Due to the presence of strongly correlated output fluctuations of available energy sources, known as the restricted averaging effect, the unpredictability rate in a microgrid is actually higher than in a big power system.

4. CONCLUSION

The review focused on current work on hybrid microgrid integrated with renewable energy sources. The primary problem, especially for those operating in the islanded mode, is power management and control strategy. This is mostly owing to the microgrid's necessity to control voltage, frequency, and power delivery in addition to power supply. In the literature, many methodologies for analysing power-sharing possibilities for AC and DC microgrids have been given. The authors highlight three major study areas: hybrid microgrid convergence, system control, and distribution network modelling. This research investigated power management strategies in hybrid microgrids, as well as the benefits, difficulties, and solutions interfaces together AC microgrids and DC microgrids. Such systems' unidirectional/bidirectional power flow capabilities, as well as changes in frequency and methods, were explored.

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Review of Matrix Converter Application

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Abstract

Over the last few years matrix converter gain popularity due to system become less bulky, compact in size or shape, more efficient & reduces stages of conversion process. The major influence in the research filed of electrical engineering by electric vehicle charging station in which using renewable charging station such as wind energy system VFD force control. It includes the very deep utilization in single phase or three phase matrix converter & its future in upcoming EVs charging station. This paper is a review paper of single phase & three phase of AC to AC Direct converter. Consideration about the practical implementation & constructional Bidirectional switches of matrix converter, no restriction on input & output. For single phase it will operate on 4- quadrant.

Keywords. Matrix converter, Direct Converter, MC

1. INTRODUCTION

Direct converter is successful arrangement for power conversion. It accommodates changes in force with the high effectiveness, no need of DC link capacitor for storing. At first Gyugyi proposed this technology in terms of topology in 1976. Single phase matrix converter first launch by Zuckerberger in the year of 1997 as a direct power conversion by single phase AC to AC [1, 2] with the capacity to vary the steps in that. The whole process is a single stage in direct matrix conversion that becomes the system more stable, less bulky, compact as well as high efficient.

In the future, the matrix converter use will be the need understanding of a few distinctive converter geography, now days we are utilizing. The property simple & single stage power conversion fulfill with practically everything on electric vehicle charging. Manually controlled on input as well as output side control strategy is known as sinusoidal PWM [3, 4] the converter topology is dependent on input side as of using bidirectional switches having the pair of thyristor & Diode. For medium power, circuit having IGBT OR MOSFET & for high power, circuit will have SCR. Load phase can be controlled through any input phase with the help of bidirectional switches. As full matrix converter

Could be cover completely as a varying function of AC-DC Rectifier & DC-AC inverter. With an reliable structure of the system.

The whole system may be act as revolution power electronics component uses [5, 6] for solar system in battery charging & then supply to AC load it act as rectifier & inverter mode without dual stages Straight from matrix converter. To drive EV DC motor in both directions can possible by variation in input parameters.

2. MATRIX CONVERTER CONNECTION

The switches of bidirectional matrix converter are basically containing the switch pair of two IGBT & two diode switches. There are Total four number of switching for single stage matrix converter arrangement as shown in Figure 2.1

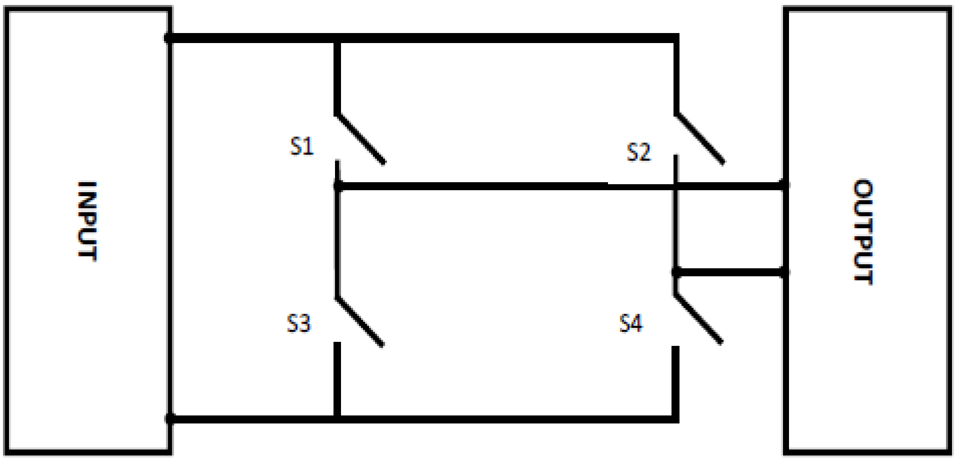

Figure 2.1 Matrix Converter Topology

The matrix converter connection is having Bidirectional switches as shown in figure and its applications depends on particular power transformation field.

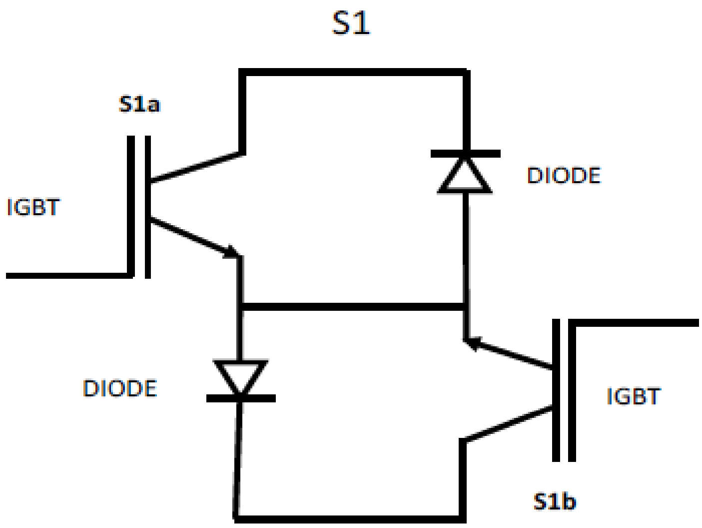

Figure 2.2 IGBT & Diode pair Bidirectional switch of Matrix Converter

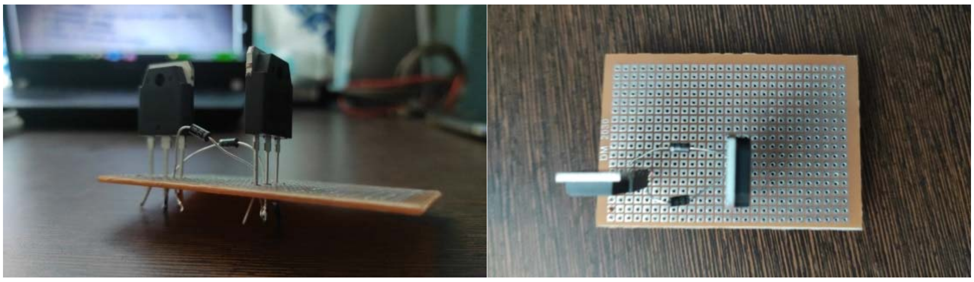

Figure 2.2 Practically Design Matrix Converter Bidirectional Switch

3. SWITCHES SEQUENCES

S. No	Input	Exchanging Arrangement	Converter Function
1	AC	1a, 4a 2b, 3b	Rectifier
2	AC	1a, 4a 2b, 3b -------------------------- 2a, 3a 1b, 4b	Dual Converter
3	DC	1a, 4a 2a, 3a	Inverter
4	AC	1a, 4a, 2b, 3b 2a, 3a, 1b, 4b	Cyclo-converter
5	AC	1a, 4a 2a, 3a 2b, 3b 1b, 4b	Cyclo-inverter

TABLE 3.1 MATRIX CONVERTER PERFORMANCES

3.1 Matrix converter as a Rectifier Mode

The Converter is functional as Rectifier for solar system by providing charging to the battery & supply to the load. In this system proper isolation is providing between AC load & battery via inverter & rectifier mode of operation. Input supply to the converter as shown in figure 2.1 for early half cycle of the input of AC, the switches 1a & 4a will be operates as mentioned details on table.

Other switch 2b & 3b will be operating for –ve cycle which is also address in MATLAB Simulink. The figure 3.2 showing MATLAB Simulink result of operate as an rectifier with AC input supply of 230 V. the review is done for resistive limit.

3.2 Matrix Converter as a Dual Converter

The converter is ac as a dual converter. The converter is shown in figure 3.5. It having the bidirectional switches. For early +ve cycle, the switches 1a & 4a will be operate & for –ve cycle 2b, 3b will be operate as mentioned on table. The MATLAB Simulink result address in the figure 3.6.

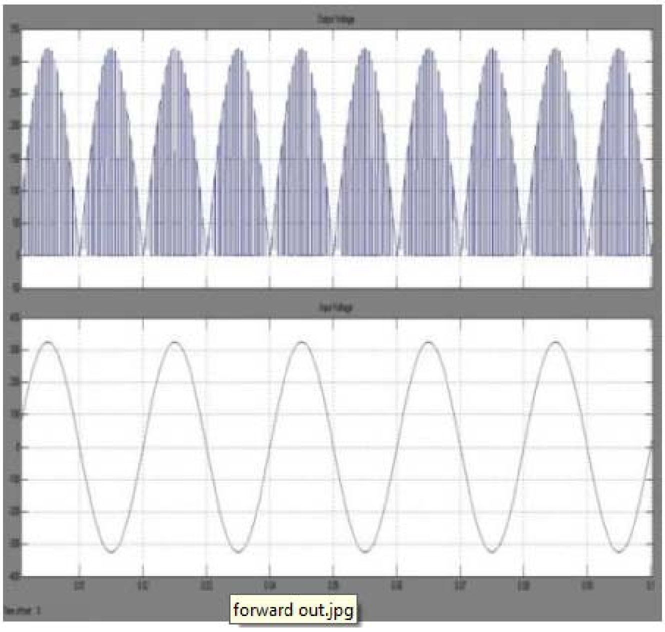

Figure 3.1 Rectifier mode of Matrix direct converter as Input voltage vs Output voltage

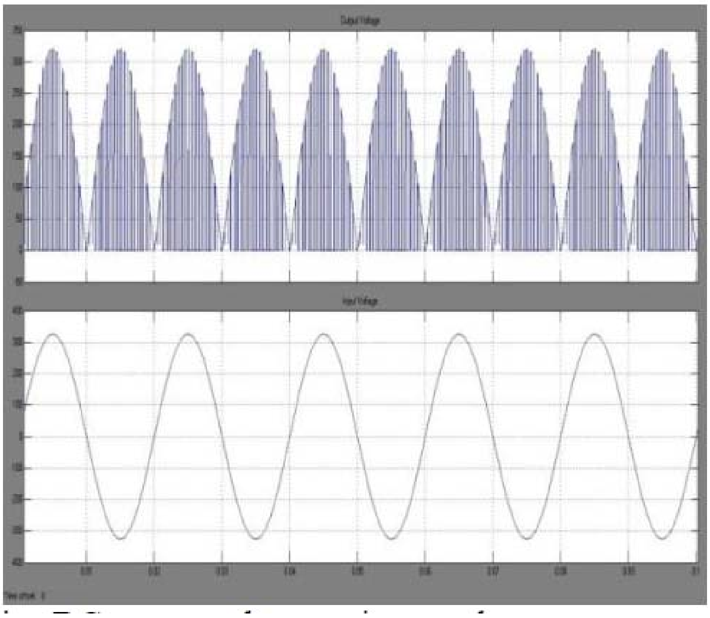

Figure 3.2 Positive DC output voltage vs input voltage

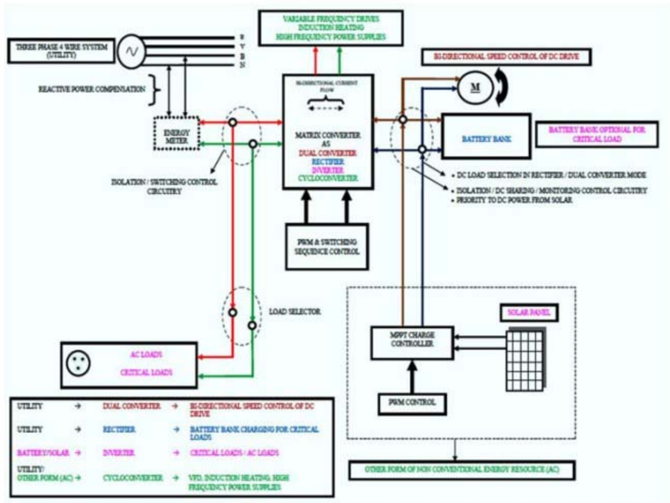

Figure 3.3 Birds' Eye view of Matrix Converter applications

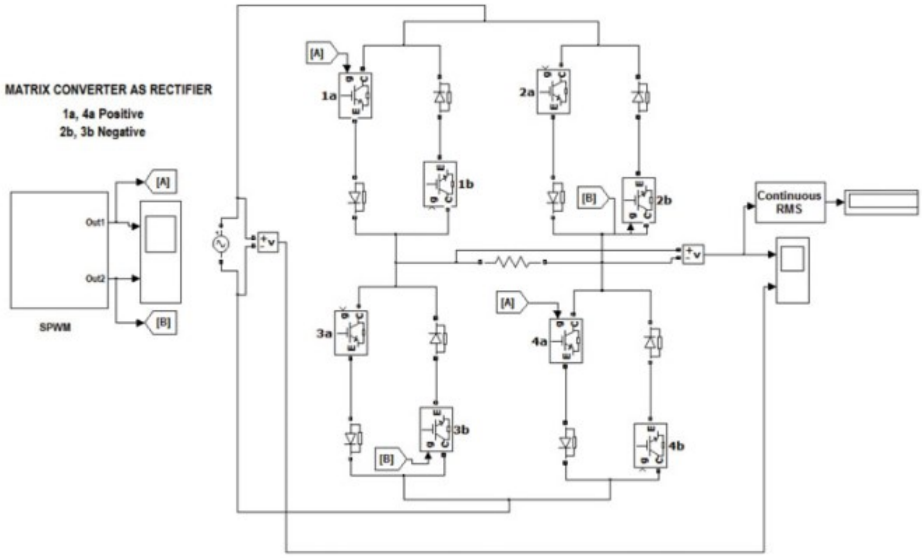

Figure 3.4 Circuit of Matrix Converter Simulation as Rectifier

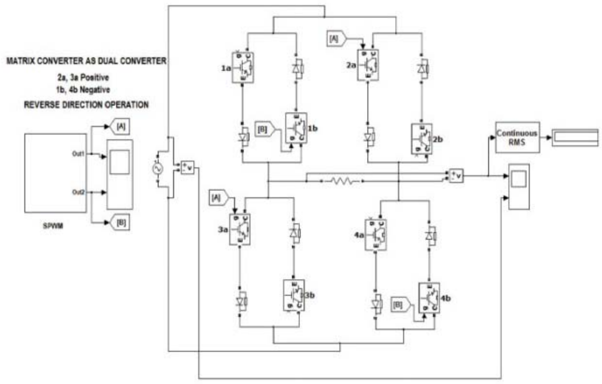

Figure 3.5 Circuit of Matrix Converter Simulation operating as dual converter

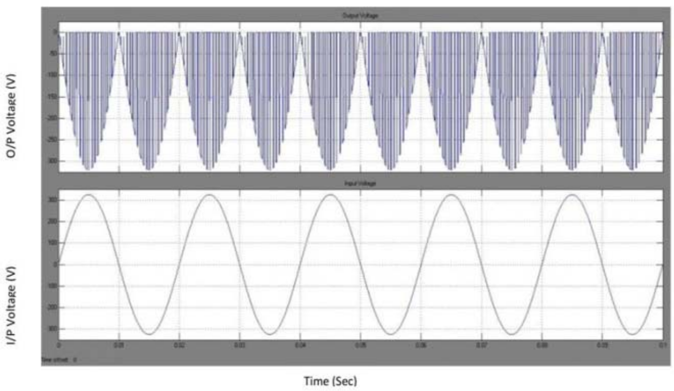

Figure 3.6 Negative DC output voltage vs input voltage

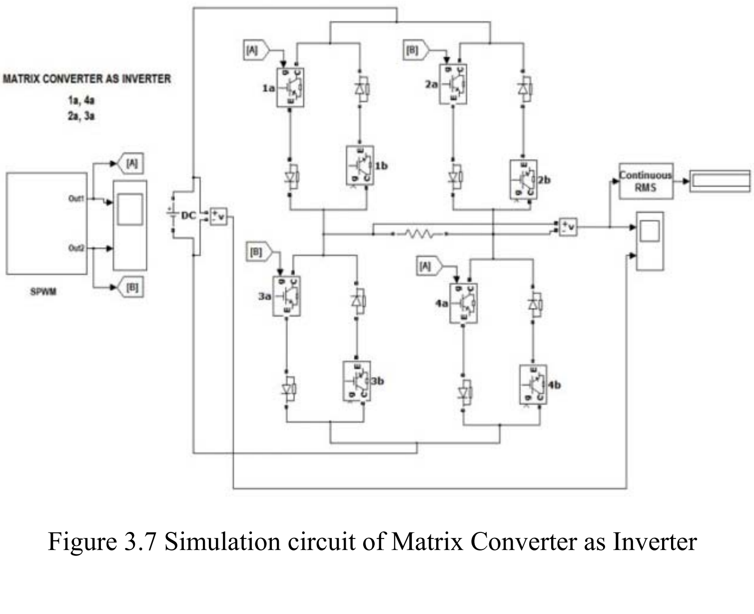

Figure 3.7 Simulation circuit of Matrix Converter as Inverter

3.3 Matrix Converter as Inverter

The Matrix Converter as inverter keep possibly be made to drive AC motor with its flexible frequency inverted AC output as speed control of AC drive via changing the frequency. If input to the matrix converter is DC & switching sequence details mentioned in table 1a, 4a, 2b & 3b will operate inverter as giving Alternating output of the frequency of PWM frequency. The MATLAB Simulink result is mentioned in the Figure 3.7 and Figure 3.8.

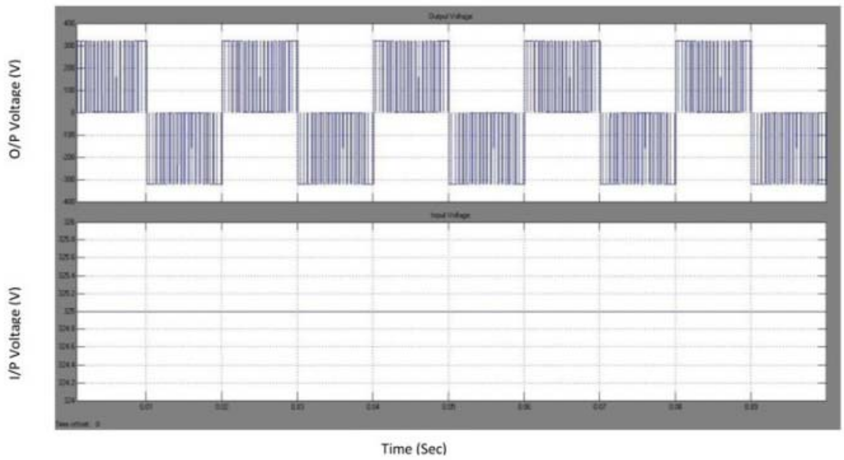

Figure 3.8 Simulation output of Inverter operation by Matrix Converter

The inverter operation of Matrix Converter could be applied to produce the AC voltage output of the required frequency by varying the frequency of the pulse width modulation. This operation could implement for controlling the speed of AC drive via variation in frequency. The input DC to the converter with that of the reference cycles. This operation could be implemented for controlling the speed of AC drove via variation in frequency. The storage system is use for emergency operation for load, therefore by solar system AC supply can be received by DC input.

3.4 Matrix Converter as Cyclo-converter

As mentioned in details table, the switching operation will be for +ve half cycle is 1a, 4a, 2b & 3b. for –ve half cycle it will be 2a, 3a, 1b & 4b. the MATLAB Simulink result is mention in figure 3.10 and MATLAB designing circuit as shown in figure 3.9.

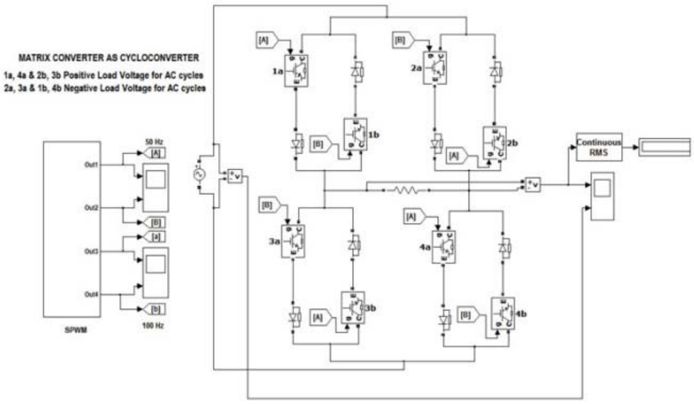

Figure 3.9 Simulation circuit of Matrix Converter as Cyclo-converter

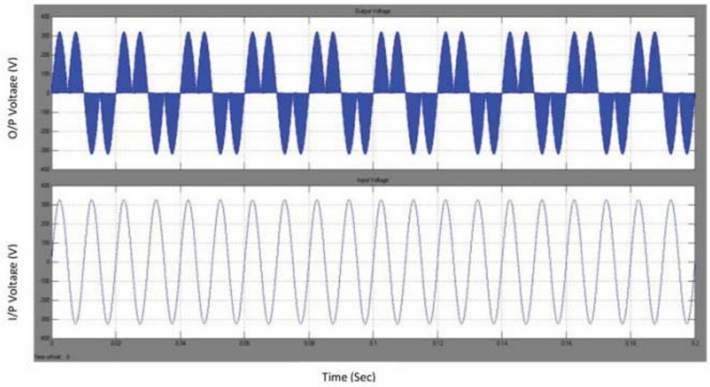

Figure 3.10 Simulation output of Cyclo-converter (100Hz input vs 50Hz output)

Here, the output frequency is given by, fo = fin/Nr, 50=100/2, in which the desired output is accomplish by the SPWM pulses of the reference frequency of 50Hz. Figure.12 shows the AC output voltage of 50Hz for the 100Hz AC input waveform.

3.5 Matrix Converter as a Cyclo-inverter

As a switching mentioned in table, the switching will be operate for +ve half cycle is 1a, 4a, 2a & 3a. for –ve half cycle it will be 2b, 3b, ib & 4b. the MATLAB Simulink result is mentioned in figure 3.12 by designing circuit as shown in figure 3.11

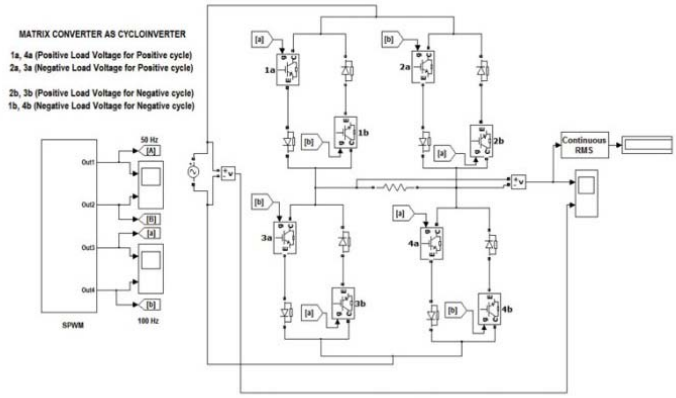

Figure 3.11 Simulation circuit of Matrix Converter as Cyclo-inverter

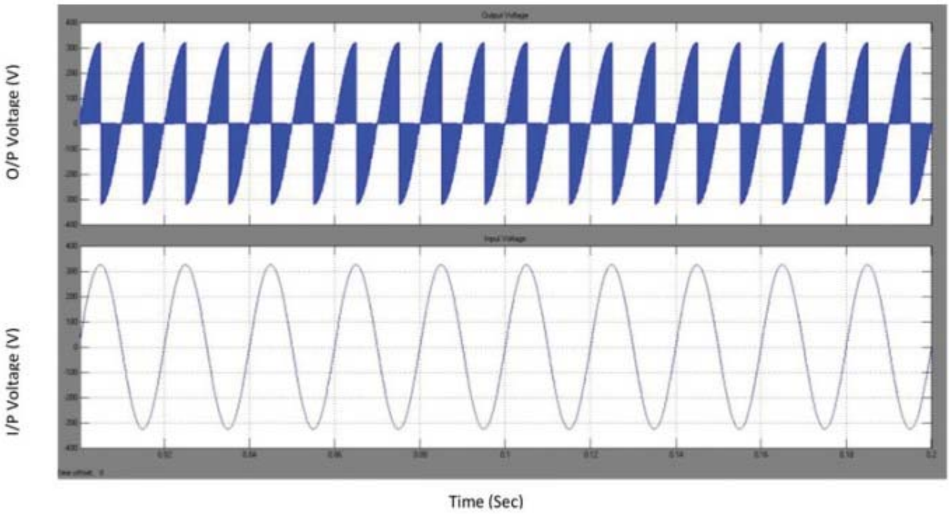

Figure 3.12 Simulation output of Cyclo-inverter (100 Hz vs 50 Hz)

4. MODULATION TECHNIQUES

A. Sinusoidal Pulse Width Modulation (SPWM) PWM is a recent technique, made practical by modern electronic power switches.The main benefit of carrier based SPWM is that the complication is very low and the dynamic response is also good for Matrix Converters [11].

5. THE FAMILY OF MULTI LEVEL MATRIX CONVERTER

Matrix conversion is having the ability of direct power conversion. Also increasing the efficiency as well as magnitude of the circuit by using extra level topology as per detailed table 5.1 is mentioned.

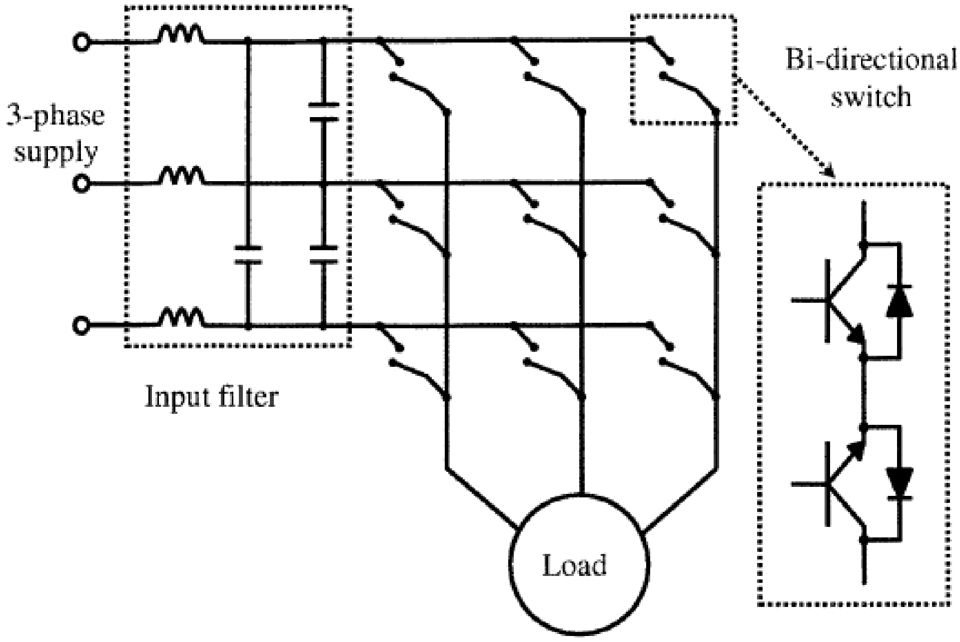

Figure 5.1 AC-AC Matrix Converter

Family of Multi-level Matrix Converter Topologies

Matrix Converter Topology	Multi-Level Converter Topology	Resulting Multi-Level Matrix Converter Topology
Two Stage Matrix Converter	Diode Clamped Multi-Level Converter	Two Stage, Three Level Matrix Converter
Standard Matrix Converter	Capacitor Clamped Multi-Level Converter	Flying Capacitor Multi Level Matrix Converter
Standard Matrix Converter	H-Bridge Multi Level Converter	H-Bridge Multi Level Converter

Table 5.1 the Family of Multi-level Matrix Converter Topologies

6. THREE LEVEL MATRIX CONVERTER BY TWO STAGES

In direct matrix conversion by two stage as shown in figure 6.1 to connection of diode & output step is given to the three level inverter by midpoint through the neutral for providing extra voltages.

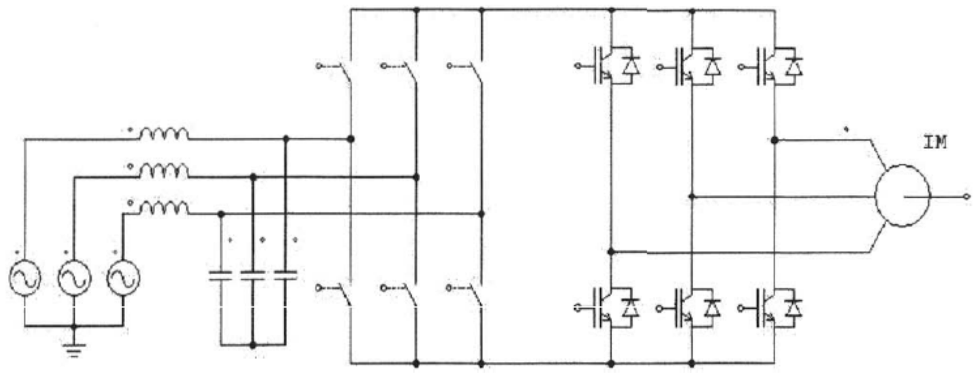

Figure 6.1 Three level Matrix Conversion by Two Stages

In order to modulate the converter a combination of space vector modulation techniques for Matrix Converters and Multi-level converters has been established.

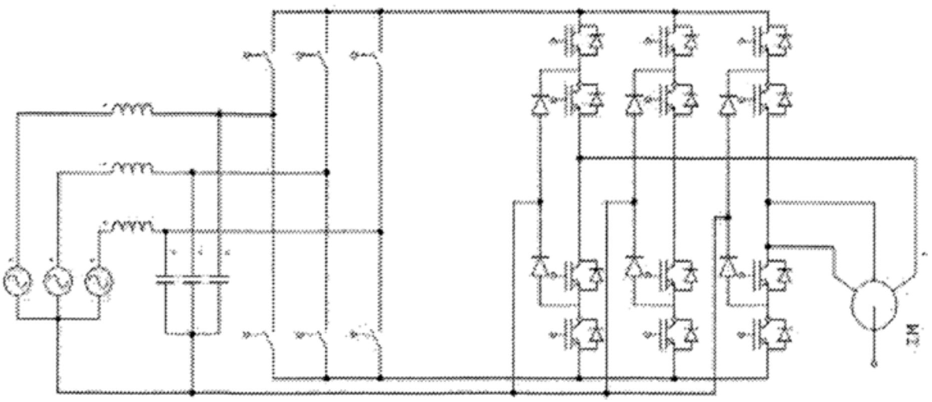

Figure 6.2 the Three-level-output-stage Sparse Matrix Converter

7. CONCLUSION

The review of SPMC and analysis then it is proportional system for direct conversion as well as indirect conversion for particular application which reduces the system become bulky, losses are less etc. the output load can be controlled by varying any input phase which is link to many bidirectional switches. In three phase matrix converter it is having nine number bidirectional switches, with that any load supply can be controlled through any input phase & also having the possibility to control the load frequency by different switching operation as well as in SPMC.

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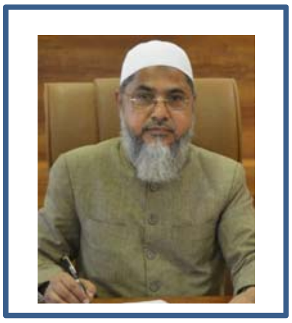

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Ecological Footprint Assessment of Small Residential RCC Building

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Abstract.

The aim of this paper is to evaluate the environmental imprint of single-store RCC buildings on the planet, through the use of the Ecological Footprint (EF) indicator. Urbanization requires a significant amount of energy, materials and resources for building construction. Energy, materials and resources consumption are responsible for greenhouse gas emissions that affect the ecosystem of the planet. To find the effect of this activities on ecological system this study becomes more important. The natural impression of building development can be decreased by utilizing ecologically modest materials, environmentally friendly power assets, and by improving bio productive land use through the development of small residential RCC building structures.

Keywords. Ecological footprint, Embodied Energy, Sustainable Construction, Sustainable building, Environmental Assessment.

1 INTRODUCTION

The construction sector is accountable for about 40% of the worldwide primary energy utilization as well as one-third of the total greenhouse gases (GHG) emissions [1]. The Indian construction sector has been raised at the rate of double digits during the last decade. The dwelling stock in India has been increased from 250 million to 330 million units during the period of 2001 to 2011[2]. In India, the primary energy consumption for building materials manufacturing is approximately one-fourth of the total primary energy consumption, and the building materials demand is surpassing 2 billion tonnes per year. Simultaneously, the GHG emissions due to construction are responsible for 30% of the total GHG emissions of the country [3, 4].

Various researchers worked on sustainable building construction [5, 6, 7]. Ramesh et al. examined the life cycle energy (LCE) of different residential buildings. The LCE of a residential building is in the range of 240 - 380 kWh/m^2, however, the construction phase consumes 10-20 % of the total LCE of the building [8]. Pinky et al. examined that the building construction responsible for 22-36% of the total LCE depends upon the lifecycle of the building [9]. Husain and Prakash experimentally investigated on the constructional Ecological Footprint (EF) of the conventional fire ash brick wall and conventional RRC roof, have concluded that for fire ash brick wall (EF) is 0.0074 gha/m^2 and for RRC roof (EF) is 0.0074 gha/m^2, respectively [10]. The EF of a constructional phase of the building is 36.16% of the total life cycle EF of the building [11].

1.1. Ecological Footprint (EF) Indicator

The EF indicator was developed by Mathis Wackernagel and William Rees in the mid-nineties [12]. This indicator can be utilized for study as well as for estimating the various types of sustainable measures such as the viability of proper distribution of resources of the planet. It includes all resources as input parameters and transforms them into a single output (i.e., bio productive land). The unit of EF (i.e., global hectare; gha) define as "One gha is equivalent to one hectare of bio-productive land with world average productivity".

This case study emphasizes assessing the environmental imprint of a typical residential RCC building on the planet. In coming decade there will be massive development in infrastructure to improve the lifestyle of people and hence the EF assessment of the residential building become more important. However, the natural resources (i.e., EF) demand has exceeded the existing bio-capacity (i.e., bio productive lands) of the country. This study helps to assess the total bio-productive lands requirement for building construction in India. The study may also be helpful for exploring the feasible EF reduction opportunities in the construction sector.

2 METHODOLOGY

The bio productive lands are significant factors for building construction. In this study, the constructional EF of small residential building are examined. The details of the EF assessment of small residential building construction are as follows:

2.1 Ecological Footprint of Building Construction (EFB):

The Ecological Footprint of a small residential RCC building has been estimated in this study. The Ecological Footprint assessment of a small residential building comprises four components: (1) Raw materials & Manufactured materials (2) Energy/ Machinery Use (3) labor and (4) Physical land. The transportation of materials is not considered in this case study. The system boundary for the EF assessment of small residential building construction is shown in Figure 1

2.1.1 EF of Building Materials (EFm)

Building materials of small residential RCC building are accountable for significant resource consumptions, therefore, the environmental impact of building materials should be examined. The EF_m has been calculated by Eq. 1 [10]:

$$EF_m = \sum\left(\frac{C_i.E_{mi}}{A_f/_{(1-A_{oc})}}\right) e_{CO2\,land} + \sum\left(\frac{C_{wi}}{Y_{wi}}\right).E_i \quad (1)$$

manufacturing impact   natural impact

Where, C_i is represented material consumption of the material, E_{mi} is embodied emission of the material, the average world forest carbon sequestration rate is estimated to be 0.73±0.37 tC/ha [13]. Therefore, A_f absorption factor of forests is considered to be 2.7 tCO_2/ha, A_{oc} is fraction of annual oceanic emission sequestration (i.e., 0.3 [14]), C_{wi} is consumption in the natural material, and Y_{wi} is materials productivity. The ei is equivalence factor (gha/ha) of different land types {i.e. $e_{cropland}$ (2.52 gha/ha), $e_{pasture\ land}$ (0.43 gha/ha), $e_{forest\ land}$ (1.28 gha/ha), $e_{CO2\ land}$ (1.28 gha/ha) and $e_{marine\ land}$ (0.35 gha/ha) etc.}[15].

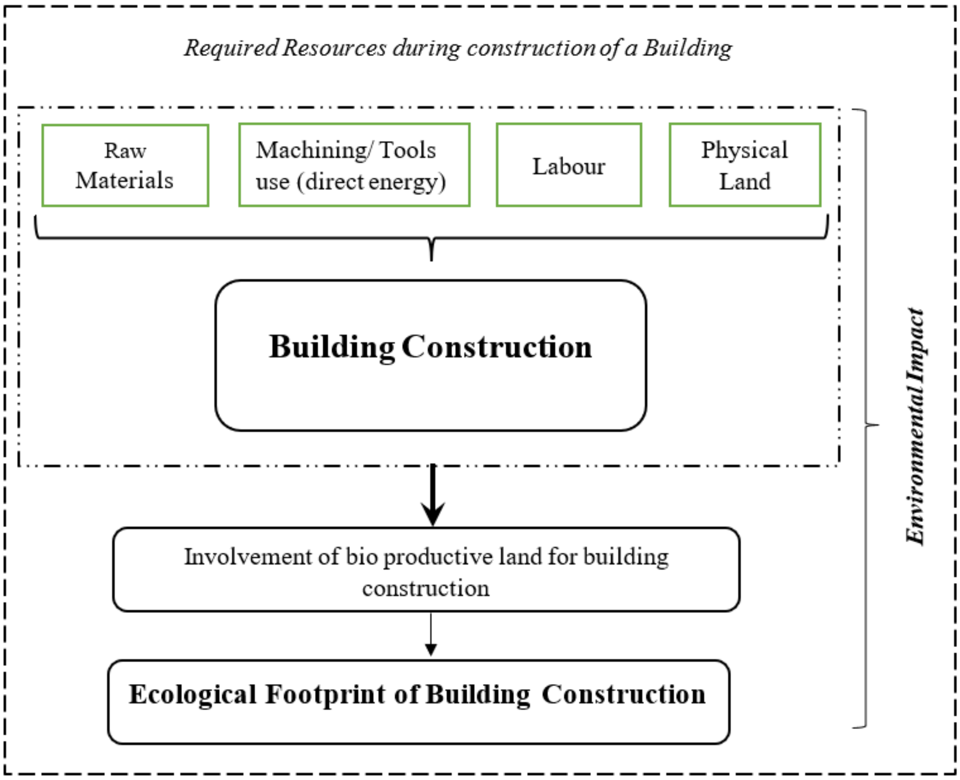

Figure 1 System boundary of a building construction

2.2.2 EF of Energy/ Machinery Use (EFe)

The EF_e depends on machinery used and labour required during the construction.

The estimation of EF_e is given by Eq. 2:

$$EF_e = \sum(Ei.ai).(\frac{1-Aoc}{Af}).\ e_{CO2\ land} \quad (2)$$

Where, E_i is the amount of energy/fuel consumed during the use of machineries; α_i is theemission factor of energy/fuel sources.

2.2.3 EF of Labour (EF$_l$)

The EF_l is associated with the metabolic rate of labour/manpower for the different type of activities [6]. The total labour requirements during building are estimated in terms of full time equivalent (FTE). The EF_l is determined by Eq. 3

$$EF_l = FTE.(annual\ EF\ of\ labour) \quad (3)$$

The EF of labour for one working-day (8 hr) is 0.0009 gha/day [16].

2.2.4 EF of Physical land (EFp)

The environmental impact of physical land engaged by the residential RCC buildingis considered in this section. The EF_p is calculated by Eq. (4):

$$EF_p = A_p.e_{built\text{-}up\ land} \quad (4)$$

where, A_p is the total physical land (hectare) and $e_{built\text{-}up\ land}$ represents the equivalence factorof built-up land (i.e., similar as cropland).

Figure 2 Building and Google Map image.

3 Building Description

This study is done on one of the small residential RCC Building located in Dhule District of Maharashtra, India. The total built-up area is about 60.78 m^2. It consists of a Hall, Kitchen and 2 Bedrooms, Floor to Ceiling height of the building is 3 m. This building is located in a hot and humid climatic zone of India. The building and Google image are shown in Figure 2.

4 Results

4.1 *Ecological Footprint of Building Construction (EFB)*

For the estimation of the EF_B, all parameters such as EF_m, EF_e, EF_l, and EF_p are assessedexclusively and after that added to evaluate the EF_B of the small residential RCC building. The details of all the construction works and building materials use this building are shown in the Table. 1. The EF distribution of different construction works of the building is shown in Figure 3. The EF_B of the small residential RCC building is about 7.011 gha (i.e., 0.115 gha/m^2 floor area of the building).

The constructional EF of the small residential RCC building depends upon the building material consumptions, resources and constructional activities involved during the building construction. The EF of small residential RCC building is estimated as follows:

4.1.1 EF of Building Materials (EFm)

The EF_m of the small residential building as calculated by the Eq. 1 is 6.738 gha (i.e.,96.1% of the total EF of the building).

4.1.2 EF of Energy/ Machinery Use (EFe)

The environmental impact of direct energy/machine use during the buildingconstruction is about 0.021 gha (i.e., 0.26% of the total EF of the building).

4.1.3 EF of Labour (EFl)

The total labour requirement is 282 labour-days. The EF_l as estimated as 0.250 gha (i.e., 3.5%of the total EF of the building).

Table 1 EF of different types of construction works and building materials.

Description	Quantity of Item	Construction materials			Labour (Working-day)	Brick (Nos)	Machine use	EF (gha)
		Cement (50kgbags)	**Sand (m^3)**	**Aggregate (m^3)**				
Earth work in excavation	14.04 m^3				4.68			**0.004**
PCC in Foundation	1.17 m^3	10	0.646	1.293	4			**0.060**
RCC	21.249 m^3	168	8.808	17.617	30		Concrete Mixer-1Day	**1.070**
Brick work	27.20 m^3	39	8.16	0	70	13604		**2.315**
Internal Plaster	272.951 m^2	30	4.258	0	34.11			**0.218**
External Plaster	182.238 m^2	20	2.84	0	22.77			**0.145**
Plinth Filling	48.625 m^3				12.15		Dumper-2 Days	**0.025**
Plinth PCC	6.078 m^3	48	3.359	6.719	4			**0.300**
Flooring	60.782 m^2	31	7.90		10.13			**0.202**
Internal Painting	41.9 litre				10.91			**0.019**
External Painting	28.03 litre				7.28			**0.012**
Steel work	2791.68 kg				30			**1.882**
Wiring	50 m				6			**0.006**
Ply Door	15.12 m^2				5			**0.340**
Wooden Door frame	37.05 m				2			**0.152**
Aluminium sliding Window	9.09 m^2 (approx. 5kg/m^2)				6			**0.065**
Wall Tiles	26.59 m^2				6			**0.136**
Tap	9 Nos				1			**0.007**
Plumbing Pipe	25 m				4			**0.005**
Drainage Pipe	18 m				4			**0.015**
Kitchen Platform (Granite)	4.5 m^2				3			**0.011**
Land	60.78 m^2							**0.015**

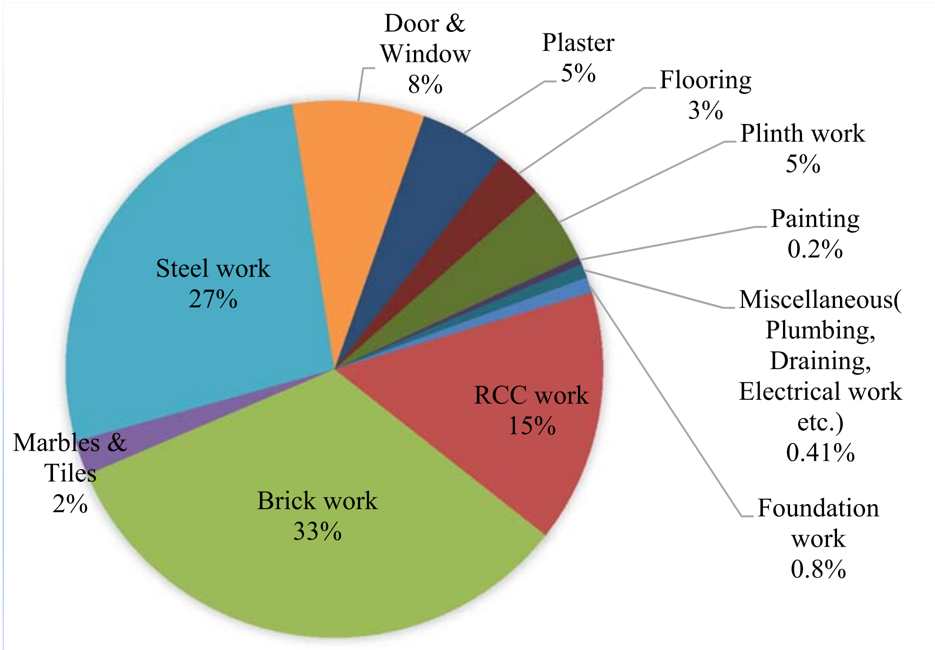

Figure 3 The EF distribution of different construction work of the building

4.1.4 EF of Physical land (EFp)

The total land expended must be considered that are used for the small residential building. The EF_p of the building calculated by using Eq. 4 is about 0.015 gha (i.e., 0.22 % ofthe total EF of the building).

5 CONCLUSIONS

The total construction EF of a small residential building is about 7.011 gha. The EF of a small residential building per floor area is about 0.115 gha. The results indicate that materials impact is most significant than the rest of other parameters like machine use, labour impact and physical land etc. The environmental impact of cement is maximum (i.e., 2.13 gha) for the building followed by brick impact (i.e., 2.01 gha). The EF of brickwork contributes the highest impact among all the construction work of the small residential building.

The lower constructional EF should be accepted for achieving the United Nations Sustainable Development Goals; therefore, the sustainable building materials may help to reduce the environmental impact of a residential building.

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Network Reconfiguration using Fuzzy Logic for Power Flow Balancing in IEEE 30 Bus System

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Abstract -As the existing power systems is gradually moving from a traditional power transmission system to the more highly developed smart grid our objective in this research work is to make the power flow control more intelligent. In this paper an old problem of phase balancing for power flow control is considered and solved by network reconfiguration technique using the fuzzy logic. Network reconfiguration is required as a solution to the problems associated with power distribution system such as planning, power loss and power flow unbalancing. The proposed technique is implemented in IEEE 30 bus system to balance the power flow in under loaded or overloaded lines. The total load per phase of the lines is considered as input to the fuzzy system and load required to inter changing unbalanced lines is the output. The fuzzy logic system's suggested load values, both negative and positive, are to be considered as input to the load changing system. Load flow analysis, which can be used to compute the electric potential build and the difference in vector positions of the active values at each bus, as well as the consumption of energy expressed as curves in individual transmission circuit, is at the core of modern power systems**.** The objectives of this research can be used to define the system's most important lines, leading to better production scheduling and the reduction of the risk of voltage instability.

Keywords-Feeder load balancing; Fuzzy logic control; Network reconfiguration

1. INTRODUCTION

Energy efficiency has always been an issue in the electricity supply system. With the rising electricity demand, the challenge is to condense the system failure and to get better the system efficiency. However, it is also desired for the system to be able to deliver help when one or more of the system's lines fail .Numerous of the faults to facilitate arise at by chance in a transmission line can be dangerous**.** To resolve this concern, tolerable automation of the power distribution system is required. Distribution automation preserve be characterized as the concept of an integrated system, which involves monitoring, controlling and, sometimes, the choice to transform any type of load. The automatic distribution system provide instructions for automatic switch reclosing and remote monitor of the loads that relate to the phase balancing process. In order to diminish distribution feeder losses and get better system safety, phase balancing becomes very important .In a distribution system there are various switches that required being open or close. By adjusting the unpredictable position either open or closed connected to the switches thus connected to the feeder, with load currents there is a possibility for transmissibility of feeder connection. It can be transferred to less loaded feeders instead of connecting them to the heavily loaded. To minimize the unbalanced flowing feeder current, the connecting phases of some feeders are altered manually after thorough analysis of the situation in a simulated environment using a software. This study proposes the use of fuzzy logic based load changing system as problem solving technique to balance the feeder load. Fuzzy logic has risen in importance in this field because it is a realistic, effective, and adaptable technique. The concept of fuzzy sets provides a suitable method for converting design, operator's knowledge into dynamic control systems that is simple to fix instantaneous applications. The fundamental contribution of this study is to identify the majority fault finding transmission line in IEEE 30 bus system, its breakdown potentially cause the system to fail completely. In this paper make comments how to get better grid's procedure by making ideas operating how to improve the process of such lines. After considering the load flow analysis results, those dangerous transmission lines will be identified. Although in some cases change the current phase imbalance, this method is more timely and fallacious. In this study Newton Raphson method is used in calculation of power flow in IEEE 30 bus system.

For feeder reconfiguration, Baean and Kelly utilized the state estimate methodology[1].Various research have been conducted on loss minimization of feeder distribution [3-4].With the advancements in the fields of artificially simulated intelligent systems and high voltage electronic equipments in power systems, it has become much easier than before to analyze the phase and load balance problem. Customers will benefit from advanced automation that is also cost-effective [4]. The estimated load current that the feeder can handle could be used as a reference. The IEEE 30 bus system has been the focus many studies on a variety of topics. We present a number of similar research in this part, all of which are appropriate to our work[5].The author [5] get a load flow analysis with the goal of determining the converge bus voltages used Newton-Raphson method, as well as comparing the two statistical methods in conditions of difficulty and meeting charge. M.Sugeno, Industrial applications of fuzzy control[8]. Performance curve of Newton-Raphson method in Load Flow Analysis using MATLAB, Nivedita Nayak and Dr. A.K. Wadhwani. Review of load-flow computation methods [10], by B. Stott.Ulas Eminoglu and M. Hakan Hocaoglu for radial distribution systems, a new power flow method with voltage dependent load models has been developed [15].

2. FEEDER DESCRIPTION

Distribution feeders usually are 3 phase 4-wire star connected system with an interconnected system. It is required to understand the conductors' current capabilities while avoiding any tapping. The connection between the distribution transformer and the distribution feeder has been rearranged properly to enable for a balanced state. There are four distribution feeder systems viz. radial, parallel feeders, ring main, and mash connected system. The mash connected system method is the simplest and most economical to work with, from the point of view of construction and security. For the difficulty in this paper, we take for granted IEEE-30 bus test system. IEEE-30 bus test systems are widely used by researchers to execute new thoughts and concept .The IEEE-30 bus test system is described in detailed technical note point. It has 30 buses, 41 transmission lines plus different transformers and synchronous condensers make the IEEE-30 bus test system. The system is demonstrated in Figure 2.1 below.

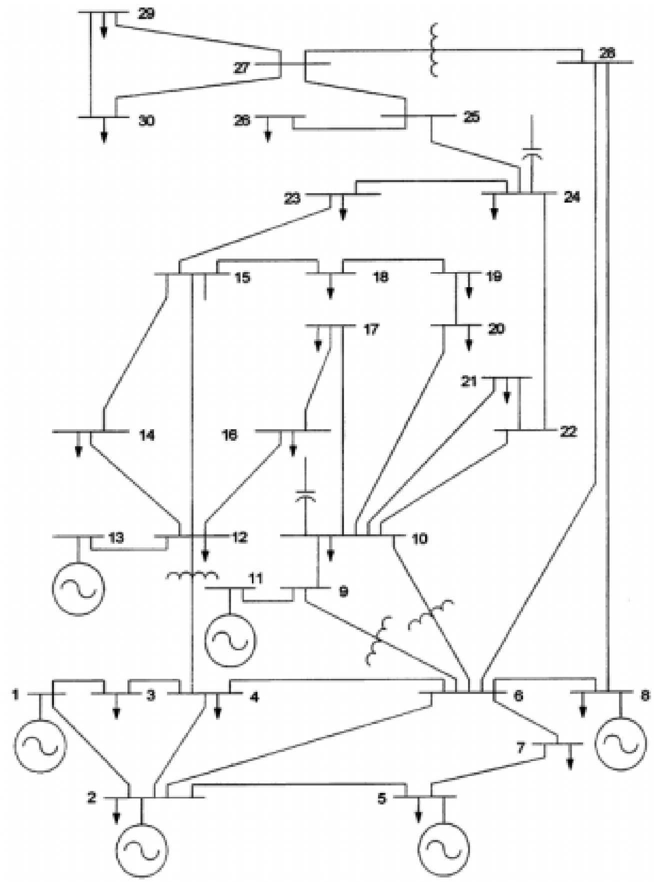


Figure 2.1 SLD of IEEE-30.

3. METHODOLOGY

The process of estimating the magnitude and phase angle of voltage at each bus in a power system under balanced 3-phase steady state conditions is known as the load flow problem. This method can be used to calculate actual and reactive power loses in the transmission system and transformers, along with equipment losses. For this research, we examined load flow analysis of the IEEE-30 bus test system utilizing the Newton Rephson Method. A load flow analysis was obtained for the proposed example, in which all of the systems transmission lines are operating. The measured load flow further disconnecting one transmission line instantaneously for a total of 41 times. The major goal of experimenting this was to calculate and identify the least performing flow values in the system in the event of a single transmission line failure. In other words, a study of the IEEE-30 bus test system susceptibility to a single transmission line failure. We may also simulate the effect of voltage collapse failure in an IEEE-30 bus test system by removing the lines that overload when a single line fails and repeating the cycle. After this, process utilizes fuzzy logic for load balancing. Load balancing (also known as phase balancing) is a useful tool for reducing distribution feeder losses, boosting system safety. Load currents can be changed from highly loaded to less loaded feeders by changing the open/close configuration of the feeder switches. In this paper will see the use of fuzzy logic for the purpose of load balancing in this application study the link joining particular distribution transformer and the feeder must be properly organize to enhance the system phase voltage and current imbalances. As a result, phase balancing can include reconsidering the network layout in order to reduce total real power losses caused by line branches. Load flow equation is taken from [3]. The process of proposed intelligent system is shown in Fig. 3.1

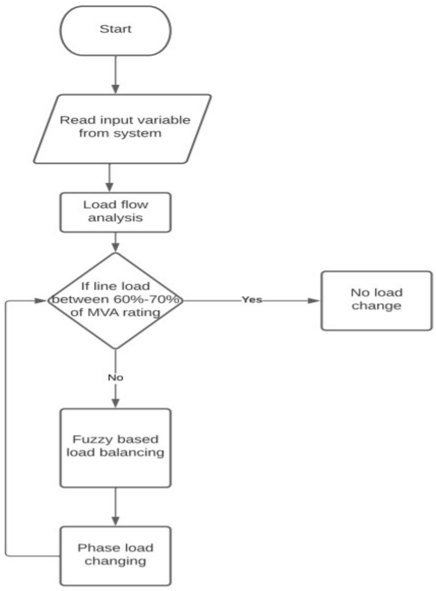


Fig. 3.1 Flowchart for load balancing

Load flow equation by Newton Repson method

$$\Delta P_i^{(r)} = P_{isp} - P_{i(cal)}^{(r)} \qquad i= 2,3......n \qquad (3.1)$$

$$\begin{bmatrix} H & N' \\ M & L' \end{bmatrix} \qquad (3.2)$$

Obtain the value of Δδ and Δ$|Vi|$ from equation shown below

$$\begin{bmatrix} \Delta & P \\ \Delta & Q \end{bmatrix} = \begin{bmatrix} H & N' \\ M & L' \end{bmatrix} \begin{bmatrix} \Delta & \delta \\ \frac{\Delta \quad V}{V} \end{bmatrix} \qquad (3.3)$$

Using the value of Δδ and Δ$|Vi|$ calculate in the above step, modify the voltage magnitude and phase angle at all load buses by the equation shown below

$$\left|v_i^{(r+1)}\right| = \left|r_i^{(r)}\right| + \Delta\left|v_i^{(r)}\right| \tag{3.4}$$

$$\delta_i^{(r+1)} = \delta_i^{(r)} + \Delta_i^{(r)} \tag{3.5}$$

$$\left|v_i^{(r+1)}\right| = \left|r_i^{(r)}\right| + \Delta\left|v_i^{(r)}\right| \tag{3.6}$$

3.1 Input and Output OF Fuzzy Controller

In this paper must first construct the input and output variables before designing the fuzzy logic controller .The output is Change, which indicates the positive or negative load change (kW) for each phase. Load is the input, which is the total phase load (kW) for each of the three phases .Table 3.1.1 displays the fuzzy categorization for the input variable, and Fig. 3.1.1 illustrates the fuzzy membership function for the input variable .Table 3.1.2 displays the fuzzy output classification, and Fig. 3.1.2 illustrates the corresponding triangular "fuzzy membership" functions for the output variable. Fuzzy nomenclature for the input and the output variables shown in table 3.1.3 The non-aligned connection between the chosen output and input variables is visualized in Fig3.1.3.

Table3.1.1. Fuzzy nomenclature for the input variable

SL. No.	Input (*Load*) Description	Fuzzy Nomenclature	Percentage range of line MVA rating
1	Very Less Loaded	VLL	45% - 50%
2	Less Loaded	LL	50% - 55%
3	Medium Less Loaded	MLL	55% - 60%
4	Perfectly Loaded	PL	60% - 70%
5	Slightly Overloaded	SOL	70% - 75%
6	Medium Overloaded	MOL	75% - 80%
7	Overloaded	OL	80% - 85%
8	Heavily Overloaded	HOL	85% - 90%

Table 3.1.2.Fuzzy nomenclature for the output variable

SL. No.	Input (*Load*) Description	Fuzzy Nomenclature	Percentage range of line MVA rating
1	Very Less Loaded	VLL	45% - 50%
2	Less Loaded	LL	50% - 55%
3	Medium Less Loaded	MLL	55% - 60%
4	Perfectly Loaded	PL	60% - 70%
5	Slightly Overloaded	SOL	70% - 75%
6	Medium Overloaded	MOL	75% - 80%
7	Overloaded	OL	80% - 85%
8	Heavily Overloaded	HOL	85% - 90%

Fig3.1.1 Fuzzy membership function for the input variable

Table.3.1.3 Fuzzy nomenclature for the input and the output variables

SL. No.	Output (*Change*) Description	Fuzzy Nomenclature	KW Range
1	High Subtraction	HS	-25% to -20%
2	Subtraction	S	-20% to -15%
3	Medium Subtraction	MS	-15% to -10%
4	Slight Subtraction	SS	-10% to -5
5	Perfect Addition	PA	0 to 10%
6	Medium Addition	MA	+5% to +10%
7	Large Addition	LA	+10% to 15%
8	Very Large Addition	VLA	+15% to +20%

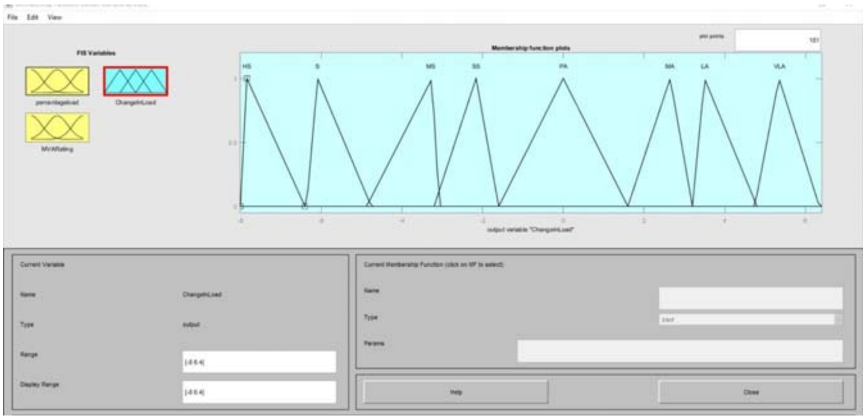


Fig3.1.2 Fuzzy membership function for output variable

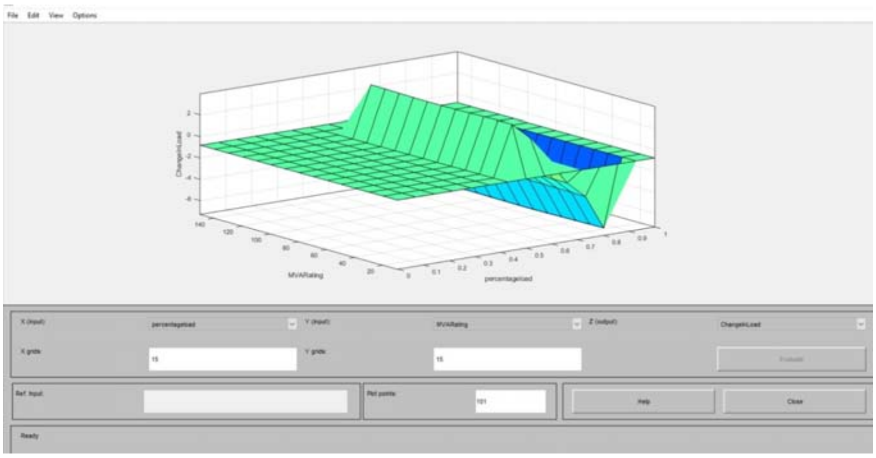
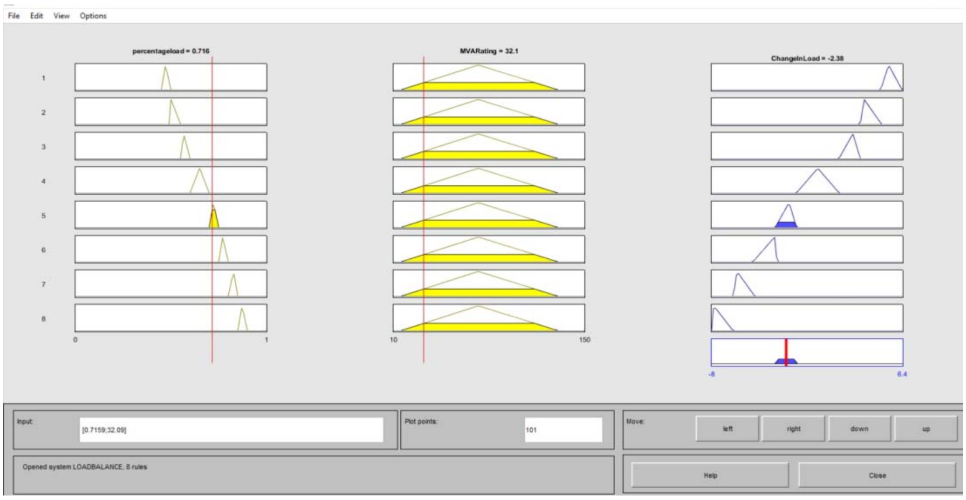


Fig3.1.2 .Non aligned relationship between the input and the output variables

4. Application Result

In this section shows the application result outcomes using the fuzzy logic load balancing technique. For the simulation, Matlab fuzzy toolbox [6] is implemented .The Mamdani [7] fuzzy assumption technique is used. Then use of 32-MVA line as an example input load configuration for one phase .Using the fuzzy controller mentioned earlier, we attempt to balance it. The eight fuzzy rules were used to create a graphical representation of (output load change) for the 3 phases that correspond this input load are shown in Fig. 4.1.The Mamdani approach [7] is used in the defuzzification process. A change in phase line 42 whose MVA rating is 32 of the output load is determined.



Output load changes Fig. 4.1

According to the output of lines is mostly very low loaded, but some lines are highly overloaded and slightly overloaded, according to the fuzzy logic rule. In this research, using of fuzzy logic and a combinatorial optimization-based implementation technique, investigate the phase balancing problem in the field of power system. As a result, the approaches and application provided in this study are based on the following assumptions. In this paper line 41 whose MVA rating is 32 is perfectly loaded is resulted by fuzzy shown in table 4.2

Line No.	**MVA Rating**	**before fuzzy system**			**after fuzzy system**		
		P flow (MW)	**Q flow (MVAr)**	**S flow (MVA)**	**P flow (MW)**	**Q flow (MVAr)**	**S flow (MVA)**
1	130	147.00464	-14.779	147.746	18.94193	120.2866	121.7688
2	130	64.15866	4.253	64.299	25.22224	62.10914	67.03512
3	65	31.89110	2.606	31.997	19.65685	31.76457	37.35478
4	130	60.08551	0.462	60.089	18.24865	59.89339	62.61176
5	130	72.45313	2.642	72.501	36.40318	33.45417	49.4406
6	65	46.24380	0.332	46.425	25.13013	40.30862	47.50061
7	90	62.34209	-10.144	63.162	25.41322	44.0644	50.8675
8	70	-18.03501	9.962	20.604	-3.7674	9.738385	10.44172

9	130	41.48121	-0.998	41.493	20.72668	6.076963	21.59919
10	32	28.01775	6.548	28.173	7.499785	17.12618	18.69633
11	65	15.64737	-7.277	17.257	12.73784	27.2345	30.0661
12	32	8.94964	0.407	8.959	11.67912	12.42233	17.0504
13	65	0.00000	-14.168	4.631	-19.9995	9.999891	22.36019
14	65	15.64737	7.138	16.874	32.74595	14.0673	35.63967
15	65	21.03856	13.629	16.197	23.08951	32.98348	40.26209
16	65	-10.00000	-6.203	11.768	-19.9994	14.99983	24.99943
17	32	5.54120	2.040	5.905	5.416038	4.432526	6.998626
18	32	14.97793	6.164	16.197	11.71724	10.51301	15.74221
19	16	9.31938	2.784	9.726	4.934937	3.827369	6.245187
20	16	2.30320	0.361	2.331	0.494732	0.769686	0.914973
21	16	5.74203	0.187	5.789	3.114955	0.500675	3.154936
22	16	6.75696	1.381	6.896	4.258271	2.767308	5.078471
23	16	3.51021	0.386	3.531	2.036365	0.77651	2.179392
24	16	-1.99721	-3.029	3.628	-4.2015	-5.79478	7.157662
25	32	4.22897	3.799	5.685	6.106298	7.128666	9.386413
26	32	0.29252	5.061	5.070	2.956522	7.281496	7.85883
27	32	9.68892	9.706	13.714	9.224285	13.71755	16.53054
28	32	4.58661	4.470	6.405	4.411683	6.418773	7.788683
29	32	-1.87073	-1.622	6.766	-0.80448	-2.12996	2.276821
30	16	6.15969	2.331	6.586	3.04751	2.925743	4.224605
31	16	2.8805	2.790	3.874	2.861699	4.268992	5.139418
32	16	2.92005	0.651	2.992	1.120424	0.359848	1.176792
33	16	0.88106	0.994	1.328	0.568758	-4.26356	4.301328

34	16	3.54393	2.366	4.261	1.353565	3.206076	3.480095
35	16	-2.6660	-1.377	3.001	-1.39373	-8.00394	8.12438
36	65	10.77672	4.891	11.835	19.0542	10.96653	21.98471
37	16	4.06548	1.519	4.340	4.14314	3.750763	5.588724
38	16	4.03588	1.472	4.296	4.842887	3.920929	6.231151
39	26	1.62654	0.564	1.716	2.64185	1.949938	3.283539
40	32	-2.07919	-4.138	4.631	1.958523	1.358664	2.383648
41	32	28.01775	6.548	28.173	11.9861	16.57891	20.45793

Fuzzy result Table 4.2

5 .Conclusion

Phase balancing is a critical and realistic procedure for reducing distribution feeder losses and improving safety. In this research, we propose a load balancing system based on fuzzy logic, as well as load change implementation system based on optimization algorithms. Total (kw) load per phase of the feeders is supplied into the fuzzy stage. The load transform values are the fuzzy step's output, with a negative value designed for load leaving a 'positive value' for load, receiving. The entire load remains constant throughout phase balancing because the sum of the negative and positive numbers is zero. The input of the load-changing system will be read by the fuzzy line .The implementation system divides the alter (kw) values by the number of load points, then chooses the appropriate load locations using combinatorial optimization approaches. It also ensures that load points are properly interchanged between the releasing and receiving phase's unbalanced 3-phase, 4-wire feeders are being used to test the load balancing system. A specific design example that uses Matlab for simulations illustrates the proposed system's application. Additional implementation results for different feeder loading configurations show that imbalance conditions have improved. The planned fuzzy logic phase balancing method and implementation systems are both practical and effective in minimizing feeder disturbance. The phase balancing technique and system described in this paper might be applied to different distribution system and feeders load configuration.

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Solution of Economic Load Dispatch Problem Using Artificial Intelligence Based Advanced Algorithms

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Abstract

Power system evidently, is a complicated task to operate. This study deals with the most common problem of power system i.e., economic load dispatch problem. Economic load dispatch (ELD) is the manipulation of power generated by generating units with a formative arrangement to get more optimal values of cost. The solution of ELD problem require the rearrangement of power being generated so as to provide the required load demand with reduced cost of energy, along with the satisfaction of all the equality and inequality constrains. The principle aim of this study is the liberation of long manual calculations, required in the process of finding the optimal values, and replacing the decisive and calculative element of this complex chore to a rather more advance and comparatively much better suited methods for finding the required end result. This study, as the decisive and calculative element utilizes four methods for finding the optimal values these are Newton Raphson (NR) method, Artificial Bee Colony (ABC) algorithm, Particle Swarm Optimization (PSO), and Cuckoo Search (CS) method. For simulating a network for a small power grid in this study, IEEE-30 bus system has been utilized.

Keywords: Newton Raphson, Artificial Bee Colony, Particle Swarm Optimization, Cuckoo Search Method, Lagrangian Function, Economic Load Dispatch

1. INTRODUCTION

The main problem faced today by the power system engineers is handling the power generated with the growing demand of the consumers. The annual report of 2020 by CEA (Central Electricity Authority) states that the overall 4,871 Mega Units of energy was not met by the overall supply, though it was seen that some parts were receiving energy surplus, the reason might be inefficient power scheduling [1].

Table [1]. Data of Power Consumption and Supplied in India during 2020-21 (CEA) (MU stands for Mega Units.)

Year	Energy Required (MU)	Energy Supplied (MU)	Energy not Supplied	
			MU	%
2020-21	12,75,534	12,70,663	4,871	0.4

Today, modern power system operation is complex than ever. The load requirement mandates maintaining in-range production of voltage and frequency to operate a reliable power production and transmission system. Along with generating sufficient energy, it is needed to keep the cost of producing that energy as low as possible. In the actual energy production and transmission system, the power generation units are not located equidistant from the centre of load and their fuel prices are dissimilar as well [2]. Also under usual operation, the capacity of energy generation is always greater than the amount demanded by the load in addition to losses, leaving a considerable degree of margin for generation scheduling. In the power system, to minimize the operating cost, the first target is the real and reactive power identification during the power production of the energy production unit and finding the power scheduling correspondingly. This statement is implying that a certain power generating unit may provide real and reactive power within a predefined range to provide requisite demand of the load and production of minimized fuel cost. The problem is known as "Economic Load Dispatch" (ELD) [3]. In the designing and the functioning of the power transmission system, Optimal Power Flow (OPF) is considered the most reliable solution for the handling of issues such as Economic Load Dispatch (ELD). Optimal Power Flow is the manipulation and minimization of the losses adjoining in the power production, making the generation of energy more economical by considering some important factors, and considering environmental benefits by reducing the usage of environment-unfriendly compounds. OPF solution produces desired output by adjusting the control variables that are required by the system while also taking the satisfaction of the constraints as well under account [4]. Present computerization for finding the solutions to these problems has become much easier, different algorithms are available today which are capable of running multitudes of tasks in parallel. These methods are generally identified as computer-based mathematical techniques [5]. Different mathematical and computational operations and algorithms are now available, for finding complex, optimized solutions for linearity or non-linearity-based functions as the OPF. Some of the methods like Gradient Method [6], Interior Point Method [7]. Optimal power flow (OPF) is not into consideration of linear or differential problems. So, solving the OPF with the usage of linearly based methods may end up the solution trapped by the local optimum value [8]. During the actual run of the solution, OPF is an extreme nonlinear programming objective containing multiples of hundreds or more variables running along with nonlinear constraints [9]. Since the '60s, the origination of this formulation, multiple optimization methods are proposed and implemented for figuring the effective solution of OPF. Among the most used solutions are; given by Dommel Tinney (the reduced gradient method), and by Carpentier (the differential injection method). Non-linear programming has to solve this problem and a comparison between the execution values of these Algorithms is obtained [10]. Although, these techniques worked as expected previously when the requirements were of only linear or expressly incremental cost curves. Now, solutions for diverse values faced today needs, algorithms that can face, non-linear curves (with valve-point effect and rate limits, etc.), and cost functions with multiple optimum points. These issues make the old methods struggle and get them to stuck on local optimum solutions. To overcome these obstacles, evolutionary algorithms can be used such as Artificial Bee Colony (ABC) Algorithm, Genetic Algorithm, Particle Swarm Optimization, and Cuckoo Search Method. These algorithms can be effectively utilized to solve non-linear functions. These algorithms though not always guaranteed to provide a perfect all usable optimal solution but can provide a near-optimal value [11-18].

2. PROBLEM FORMULATION

The MW generation is allotted to the required MW demand on the particular regional grid as allocated by the Load Dispatch Centre. Load Dispatch centre for each load manipulates frequency and voltage of its own to match parallel with other generating stations and provide the required MW load demand along with the consideration of losses [11]. OPF's main task is the control variable identification that reduces the objective quadratic function related to the power output of all the generators. The mathematical formulation:

2.1. *Problem Objective*

Fuel cost-cutting with the output considered as the Real Power;

$$f = \sum_{i=1}^{NG} a_i Pg_i^2 + b_i Pg_i + c_i (\$/h) \tag{1}$$

A single quadratic function is used to express the cost of fossil fuel used by each fuel-fired generator; the only problem is the discontinuity in the change of fuel [6]. Hence, the use of a Piecewise quadratic equation is appropriate here. Power Output with respect to fuel Cost is given by [12]:

2.2. *System Constraints*

This study follows the underneath stated equality and inequality constraints [13]:

2.2.1 Equality Constraints

$$\sum_{i=1}^{NG} Pg_i - \sum_{i=1}^{NB} Pd_i - Ploss = 0 \quad (2)$$

$$Pg - Pd - Vi\sum_{j=1}^{NB} Vj[Gij\cos(\delta i - \delta j) + Bij\sin(\delta i - \delta j)] = 0 \quad (3)$$

Where, i = (1… NB). NB is the number of buses. P_g is the generated real power. P_d is the actual power demand. G_{ij} and B_{ij} are conductance and susceptance respectively of the line between buses i and j.

$$P_L = \sum_{j=1}^{n}\sum_{i=1}^{n} P_i B_{ij} P_j \quad (4)$$

Where Bij are the elements of loss co-efficient matrix B. The Lagrangian function for the above problem of economic load dispatch.

$$L(Pg_i, \lambda) = f(P_g) + \lambda(Pd + Ploss - \Sigma Pg_i) \quad (5)$$

2.2.2 Inequality Constraints

Generator Constraints: The output power from the generation unit lies in between their maximum and lowest values:

$$Pg_i^{min} \le Pg_i \le Pg_i^{max} \text{\_\_\_}(i = 1, 2 \ldots NG) \quad (6)$$

3. SOLUTION METHODS

3.1. *Newton Raphson (NR) Method*

Named after Isaac Newton and Joseph Raphson, it had been the most used approach which is adopted as it is flexible enough to formulate power flow algorithms used for the optimization of power systems. The concept of finding optimization of any non-linear function using gradient and Hessian matrix and Newton's iterative technique together comprise the given approach. The solution for the optimal power flow by NR method requires the creation of the Lagrangian function as shown below

$$L(z) = f(x) + \mu^T h(x) + \lambda^T g(x) \quad (7)$$

Where Z = [x μ λ]^T, μ and λ are vectors of Lagrangian multipliers. A gradient which is Partial Derivative's vector of a Lagrangian function is then defined as follows:

$$\nabla L = [\frac{\partial L(z)}{\partial z}] \quad (8)$$

The Hessian matrix is the second derivative of the Lagrangian function, is then defined as follows:

$$H = \nabla^2 L(z) = [\frac{\partial^2 L(z)}{\partial z_i \partial z_i}] \quad (9)$$

The gradient of the Lagrangian function is equated to zero and finds the solution vector. At this point, the Hessian matrix should be positive definite (Eigenvalues of the Hessian matrix at that point must be positive) to ensure that the solution point is the most optimum.

3.1.1 *Steps of NR Method*

After calculating the Hessian & Gradient, OPF is attained using the iteration algorithm of Newton's.

Step 1: OPF operation starting, Initial guess vector, z (Generator's power output & all the Lagrange multipliers).

Step 2: Evaluation of ∇f , if ∇f =0, estimated λ corresponds to the optimum solution and depending on the sign, λ is increased or decreased.

Step 3: Gradient Calculation by Equation... (7)

Hessian of the Lagrangian by Equation... (8)

Step 4: Solving the following expression.

$$[H]\Delta z = \nabla L(z) \tag{10}$$

Step 5: Renew the solution.

Step 6: If this value is not obtained$\|\Delta z\|<\epsilon$ go back to Step 2**.**

3.2. *Artificial Bee Colony (ABC) Algorithm*

The ABC algorithm comes under the category of Swarm-Based Optimization Algorithms (SOAs). In SOAs instead of having one direct solution, various iterations of different solutions are contemplated for the optimum solution [14]. The Artificial Bee Colony algorithm imitates the resource-gathering tactics of Honey Bees shown in figure 1. In this algorithm there are three artificial bee groups [15]:

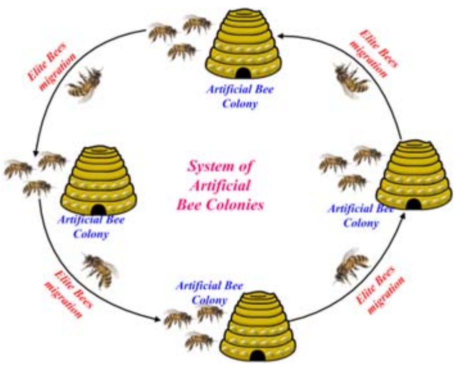


Figure 1: Artificial Bee Colony

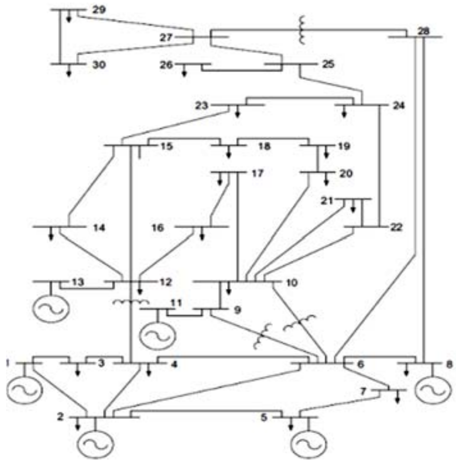


Figure 2. SLD of IEEE-30 bus system

Employed Bees: - Partial colony is distributed as the employed bee. The count of employed bees is the same as the number of resources in the system. Employed bees are responsible for resources, their details, and memorization. **Onlooker Bees:** - The other half of the colony contains the onlooker bees. Onlooker bees get their details about the present or discarded resources from the employed bees and select any one of the resources at random. **Scout Bees:** - These are the bees associated with the abandoned food sources. They are responsible for finding new food sources.

3.2.1 *Optimization Algorithm*

Step 1: Initialization: In a D dimensional problem space, a population solution is selected randomly. (X_i = 1,2,3………. D).

Step 2: Reproduction: A random food source is chosen by the artificial onlooker bee according to the expectation of that resource's provability, P_i [16].

$$P_i = {f_i t_i}\Big/{\sum_{n=1}^{N} f_i t_n} \qquad (11)$$

fiti = fitness value of the solution, i = nectar amount of food source, N = number of resources = number of employed bees. For deciding a possible food position from the previous memories following expression is used.

$$V_{ij} = X_{kj} + \phi_{ij}(X_{ij} - X_{kj}) \qquad (12)$$

k = {1,2… D} and j = {1,2… N} are randomly chosen indexes.

ϕ_{ij} = randomly selected from -1 or 1.

Step 3: Replacement of Bee and Selection: After several cycles, if a source is not providing enough or is not improving to be more providing, the source is then abandoned. The number of cycles required to abandon a food source is labeled as the "limit" for desertion [17]. Left out food source is denoted by Xi and j = {1,2… N}, new food that is discovered replaces the place of the earlier Xi. The operation is defined as:

$$X_i^j = X_{min}^j + rand(0,1) * (X_{max}^j - X_{min}^j) \qquad (13)$$

When a new possible food source is found Vij, it is analyzed by the virtual bees and after judging the new food source's produce comparison is conducted between the old one and the new one. Only if the newly found resource is found to be more productive and preferable than the last one, it is decided to keep the food source as actively retained in the memory.

3.3. *Particle Swarm Optimization (PSO) [13]*

Invented by J. Kennedy and R. C. Eberhart in 1995, Particle Swarm Optimization is an algorithmic technique that simulates the social & psychological information gathering and extrapolation methods of birds and fish. It simulates how information is gathered by people in real life by communicating with different social groups and individual people hence collecting their social beliefs and opinions. PSO behaves like a person where it converges to a decision by the experience it had gathered along with others' experiences and its knowledge as well.

3.4.1 Steps of PSO.

Step 1: Initialization: Each Particle is represented as 'i' and every 'i' represents every solution for the to be optimized function. Also, as a vector representing a decisive variable, Xi.

$$X_i = X_i^{min} + rand(\,) * X_i^{max} + X_i^{min}) \qquad (14)$$

i = 1, 2, 3, …… NP, (NP is the number of particles.)

Step 2: Velocity of Particles: PSO algorithm always gives priority to the most adequate swarm and provides access towards analytically better regions of the solution space.

$$v_{ij}^{t+1} = wv_{ji}^{t} + c_1R_1\{Pbest^t - X^t\} + c_2R_2\,\{Pbest^t - X^t\} \qquad (15)$$

V_{ij} = velocity of j^{th} member

j = member of i^{th} particle

i = number of particle at t iteration

Gbest = global best position

Pbest = local best position

Step 3: Inertial Weight: w represents the inertial weight.

$$w = w^{max} - \frac{(w^{max} - w^{min}) * iteration}{max\ iteration} \quad (16)$$

R_1 & R_2 represent the random numbers produced between 0 & 1.

C_1 & C_2 has a range of 0 to 4. Although, they are adjusted as C_1+C_2 = 4 or C_1= C_2 = 2.

Step 4: Solution Vector: Velocity 'v' is added further after every generation of iteration.

$$X^{t+1} = X^t + v^{t+1} \quad (17)$$

3.4. *Cuckoo Search Method [13]*

Introduced by Xin-She Yang in 2009, this algorithm mimics the brooding pattern of Cuckoo birds. With a lesser number of control variables, this algorithm has the potential to easily handle the optimization of any non-linear functions effectively [18]. This method has already been applied and tested for finding discrete multi-variable OPF solutions.

3.4.1 Steps of Cuckoo Search Method

Step 1: The first population is generated randomly within the limits of control parameters. After that 'Levy flight' operation is applied to the first wave of the population.

$$X_i = X_i^{min} + rand(\,) * X_i^{max} + X_i^{min}) \quad (18)$$

(i = 1, 2, 3…. NP) 'i' is the number of eggs.

Step 2: Levy flights operator describes the phonetic flying or swimming order of manner of the cuckoo birds.

$$X^{t+1} = X^t + \alpha \oplus Levy(\lambda) \quad (19)$$

The variance of step size 'α' is between 0.1 to 0.4 [12].

Step 4: The number of cuckoos and nests are taken as constants.

Step 5: Per cuckoo single or multiple eggs are selected and are dumped at randomly chosen nests.

Step 6: The quality of nests ensures the propagation to the next generation.

Step 7: Probability of identification by the parent is given by Pa whose value ranges in between [0, 1].

4. RESULTS AND DISCUSSION

In this study, IEEE-30 bus standard test system environment is used to test the efficiency of the proposed algorithm in the active power dispatch with 5 generator buses, 1 as a slack bus, and 24 load buses with 41 transmission lines. A comparative analysis of the results obtained by all the algorithms is also given in Table [2]. Table [2] shows that before optimization, the total cost of generation was 916.29 $/hr for the demand of 283.00 MW. After optimization by the NR method as a conventional optimization method the total cost of generation is reduced to 869.68 $/hr. and ABC algorithm as an AI method resulted into least cost by 805.70 $/hr. The Fitness curve for the cost optimization using the ABC algorithm is given in figure 3.

Table [2] Effectiveness of proposed algorithm in economic active power dispatch

S. No.	Parameters	Before optimization	Optimized values by			
			NR method	PSO	CS	ABC
1	Pg1	102.62	177.07	137.547	120.727	185.05

2	Pg2	80.00	48.06	54.039	64.445	46.98
3	Pg3	50.00	20.77	40.234	49.618	20.45
4	Pg4	20.00	22.18	31.580	12.835	14.89
5	Pg5	20.00	12.23	16.989	29.998	11.84
6	Pg6	20.00	12.00	12.700	15.741	15.41
7	Total Gen. (MW)	**292.12**	**292.31**	**293.08**	**293.36**	**294.62**
8	Total Cost ($/h)	**916.29**	**869.68**	**829.543**	**824.069**	**805.70**

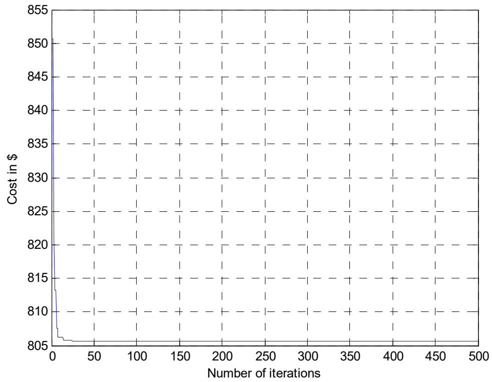
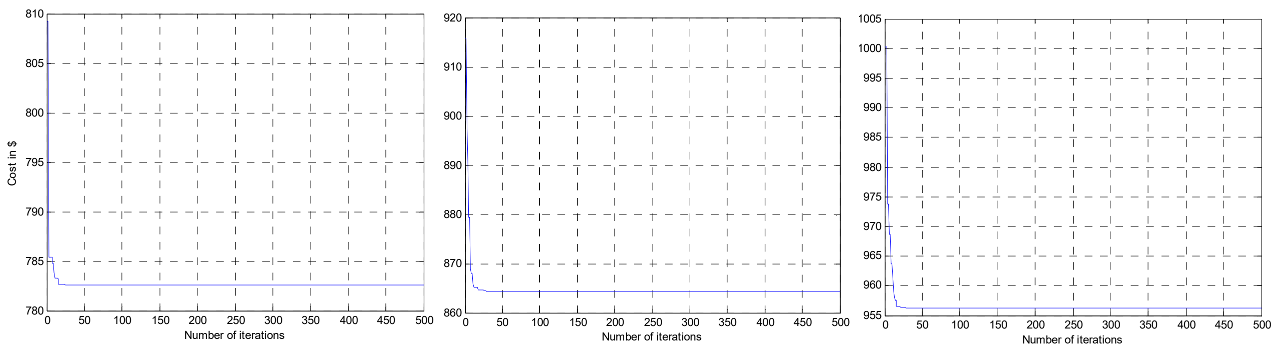


Figure 3. Fitness curve for generation cost optimization by ABC algorithm

Table [3] gives the relative comparison of generator scheduling for different demands of the IEEE 30 bus system and shows the optimized quantity of active power generation for the system. Here, the proficiency of the proposed algorithm is tested for three cases of different load demands i.e., 275MW, 300MW, and 325MW. ABC algorithm resulted in minimum fuel cost in the each case and the fitness curve for these three cases has been shown in figure 4.

Table [3]. Optimal scheduling of generators for different load conditions

S. No.	**Parameters**	**Power Demand** (MW)								
		PD= 275			**PD= 300**			**PD= 325**		
1	Un-opt. Total Cost ($/h)	838.45			947.28			1005.74		
Optimal scheduling of generators by										
		PSO	**CS**	**ABC**	**PSO**	**CS**	**ABC**	**PSO**	**CS**	**ABC**
2	Pg1	165.07	114.84	155.69	180.06	178.35	177.49	197.08	197.89	199.45
3	Pg2	48.06	62.88	46.71	51.21	50.89	52.42	52.92	49.8	44.72
4	Pg3	20.77	42.20	20.39	21.86	23.45	21.34	22.47	23.46	25.19
5	Pg4	22.18	18.64	34.87	29.35	27.96	29.75	33.25	27.50	21.67
6	Pg5	12.23	26.21	11.57	14.67	15.47	12.78	16.01	19.81	23.69
7	Pg6	12.00	17.26	14.13	13.59	14.12	16.58	14.87	17.75	20.63
8	Total Gen.	280.31	282.03	283.36	310.74	310.56	310.38	336.52	335.97	335.38
9	Opt. Total Cost ($/h)	**798.68**	**791.08**	**782.62**	**898.46**	**871.96**	**864.32**	**976.27**	**961.23**	**955.39**



(a) (b) (c)

Figure 4. Fitness curve by ABC algorithm for demands a) 275 MW, b) 300MW, c)325 MW.

5. CONCLUSION

In this paper, a conventional technique i.e., Newton Raphson along with comparatively recent techniques i.e. Artificial Bee Colony (ABC) algorithm, Particle Swarm Optimization (PSO), and Cuckoo Search (CS) method has been used to solve the problem of ELD. All the algorithms are enacted on MATLAB software and eminently applied to reduce the cost of real power generation by optimized relocating the power generating units with subjecting to load balance equation as equality constraint. The stated techniques had been tested on the standard test environment of the IEEE-30 bus system with different cases of power demand. In the case of power demand 283 MW, the conventional method of optimization minimized the fuel cost by 5.06% compared with power flow solutions. In comparison of this ABC algorithm as an recent technique of artificial intelligence resulted into highest cost saving by 12.10%. The proposed algorithm proved its efficiency in the reduction of fuel cost of power generation in all the cases of power demand under study.

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Renewable Based Hybrid Microgrid Scheduling Incorporating Demand Side Management

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Abstract.

A smart scheduling technique of a renewable integrated microgrid has been proposed and implemented in which generation side and demand side management are simultaneously utilized. Since solar and wind energy sources, which are intermittent in nature, are main energy providers in the microgrid, their variability has also been considered in the scheduling. A natural gas power plant and the grid have been considered as reserve sources. In the demand side management (DSM), a novel area based load shifting technique has been proposed along with voluntary demand reduction as load reserve. The overall aim of the paper has been set to develop a cost effective operation scheduling using generation reserves and DSM so that a balance is maintained between generation and demand over a day. The optimization has been done by cuckoo search algorithm. Simulation results demonstrate the smart scheduling satisfying the operating conditions mentioned in which substantial cost reduction is achieved.

Keywords. Demand Response, Demand Side Management, Energy Scheduling, Scenario Generation, Day Ahead Energy Cost.

1. INTRODUCTION

In recent days, environmental impacts and shortages of fossil fuels have increased interest in clean and renewable energy generation, including wind power, photovoltaic, hydroelectric power, natural gas based generation, fuel cells and micro turbines. Wind and solar energy are intermittent and unpredictable in nature and cannot be used for reliable power system operation. In a conventional system, generation follows the load pattern whereas since there is no control over renewable generation, in a renewable integrated system loads are made to follow the generation. To handle variability of renewable power generation effective forecasting method is necessary. Petre et al. described short term wind forecasting by Markov chain and Chapman-Kolmogorov equations [1]. This technique was useful to generate data even if errors may creep in which needs estimation. So, to include this variability in the power system, stochastic models were needed for safe and cost effective operation of power system. In stochastic model, uncertainty was represented by scenarios which could be generated by various methods [2]. Generally, forecast error due to variability and randomness was compensated by energy management from supply side i.e. by using energy storage technologies [3]. The demand side management (DSM) technology is the option to manage the renewable power intermittency from load end. DSM is basically voluntary demand reduction or load shifting from peak load to lean load hours to reduce power consumption during peak load period which improves system reliability. It may also support to increase consumption during high production and low demand period. To accomplish this, the first criterion is to segment the various types of loads. Different types of electricity customer namely industrial, commercial and residential customers with different electricity consumption behaviour and pattern provided operational reserves that have been modelled in separate research work [2]. As per time of the day (TOD) pricing or real time pricing (RTP), customers would pay the highest prices during peak hours and the lowest prices during off-peak hours [4]. Load shifting technique is mainly applied to the usage time of appliances of residential and commercial customers. To shift different appliances from peak load hours (high pricing period) to lean load hours (low price hours), the most important thing is to know the appliance characteristics and their operating time over a day. Different appliances were modelled in a later work whose working hours can be shifted to different time of the day [5].

Although smart energy scheduling has already been proposed in different papers, combined effects of load reduction and load shifting considering the variability of renewable resources and their effects on the cost of energy have not yet been demonstrated. In this paper, a demand side management approach has been undertaken so that difference between load and generation becomes minimized at an optimum cost with minimum computational complexity. Overall day-ahead operational cost is modelled by two-stage stochastic programming method and has been optimized by CSA. The novelty of the work lies in development of area based load shifting technique while implementing this in micro grid scheduling. Appliances are shifted from peak load period to off-peak period according to their consumption. Even if, the variability present in the system will be catered by reserve from source side such as natural gas based generation and grid, participation of load to supply load reserve is also utilized to keep a balance between generation and load. The effect of load shifting and incentive based load reduction on daily total energy cost in day-ahead scheduling of energy is implemented. The demonstrated cost comparison shows substantial reduction in case of DSM based technique.

2. DEMAND SIDE MANAGEMENT

2.1. Load shifting model

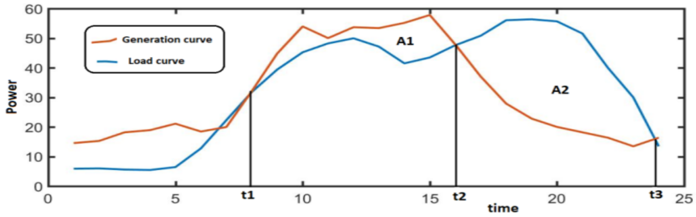

Figure 2.1. Typical generation and load curves for 24 hours

A new approach for load shifting is implemented in this work to consider the variability of renewable generation. In this work only domestic loads have been chosen for shifting with due agreement with the consumers. In Figure 2.1 between t_1 to t_2 hours, generation is more than load whereas between t_2 to t_3 load is much higher than generation. In the proposed technique operation of appliances planned between t_2 to t_3 is shifted to the time slot between t_1 to t_2, such that amount of excess energy between t_1 to t_2 is totally/partially consumed. This will help in utilizing the excess generation between t_1 to t_2 hours and reducing the load between t_2 to t_3 hours. From the figure it is also seen that generation is more than load between 00:00 to t_1 hours. But the consumption of that excess generation is already planned and included in the scheduling. Between t_1 to t_2 hours, solar generation is generally, maximum and loads are lean. Beyond t_2 hours peak load period starts and it may be difficult for the consumers to run some appliances. Rather usage of appliances between t_1 to t_2 hours may be more economically comfortable for the consumers. For that shifting of load from peak load period to lean load period has been chosen. The excess energy F may be written as

$$F = min\{area1 - area2\} \tag{2.1}$$

$$area1 = \int_{t_1}^{t_2} (f_1(t) - f_2(t))\, dt \tag{2.2}$$

$$area2 = \sum_{t=t_2}^{t_3} \sum_{app} \sum_{h=1}^{H} N^{shift}(app,h,t) \times KWhr(app,h) \tag{2.3}$$

$$P^{solar}(t) + P^{wind}(t) = P^{load}(t) \pm \sum_{app} \sum_{h=1}^{H} N^{shift}(app,h,t) \times KWhr(app,h) \times U^{shift}(app,h,t) \tag{2.4}$$

$$\sum_{t=t_s}^{t_e} U^{shift}(app,h,t) = T_{run} \tag{2.5}$$

$$\sum_{app} \sum_{h=1}^{H} N^{shift}(app,h,t) \le N_{max}^{shift} \tag{2.6}$$

The objective for load shifting is to minimize the difference between excess generation and excess load and is formulated by (2.1). Equations (2.2) and (2.3) represent each term of the objective function where $f_1(t)$ and $f_2(t)$ are considered as load curve and generation curve respectively. The number of appliances of type app to be shifted from t^{th} hour is represented by $N^{shift}(app,h,t)$ and $KWhr$ is the consumption of each type of appliance. Equation (2.4) is included to check the balance between load and total renewable generation. Run time of each appliance is described by (2.5) where U^{shift} is the on-off status and T_{run} is the run time of each appliance. If a appliance starts from t_s hour it will stop at t_e hour without any interruption.

2.2. Load shifting model

Incentive based demand reduction is one of the easiest ways to support the intermittency of solar and wind. Equations (2.7) to (2.9) are used to calculate the incentives paid to different customers for participating in the demand reduction programs.

$$IC_{ind}^{E}(i,t) = IP_{ind}^{E}(i,t) \times incen^{ind} \tag{2.7}$$

$$CC_{com}^{E}(cc,t) = CP_{com}^{E}(cc,t) \times incen^{com} \tag{2.8}$$

$$R_{res}^{E}(r,t) = RP_{res}^{E}(r,t) \times incen^{res} \tag{2.9}$$

here, i, cc, r, are the index of industrial, commercial and residential customers respectively. Demand reduction of different customers have been given by IP_{ind}^{E}, CP_{com}^{E} , RP_{res}^{E}.

$$IP_{ind}^{max}(i,t) \geq IP_{ind}^{s}(i,t,s) - IP_{ind}^{E}(i,t) \quad (2.10)$$

$$CP_{com}^{max}(cc,t) \geq CP_{com}^{s}(cc,t,s) - CP_{com}^{E}(cc,t) \quad (2.11)$$

$$RP_{res}^{max}(r,t) \geq RP_{res}^{s}(r,t,s) - IP_{res}^{E}(r,t) \quad (2.12)$$

Boundary conditions for amount of load reductions are determined by (2.10) to (2.12).

3. Mathematical Formulation

3.1. Objective function

The main objective of this study is to optimize the total operating cost considering variability associated with renewable generations and loads and maintaining the balance between the load and generation with an uninterrupted power supply over a day. A two stage stochastic program is developed for optimization problem and is mathematically formulated by (3.1). First stage variables are called *here-and- now* variable i.e. the optimization variables that are common to all scenarios and indicate the day-ahead energy transaction. The second stage variables or *wait-and-see* variables are the variables those take on different values in each scenario considering the real time operation with wind and solar power variability. One hundred scenarios have been generated by Latin hypercube sampling-Cholesky decomposition (LHS-CD) method and reduced into two scenarios by k-means clustering method [6]. Now the total cost *TC* can be written as

$$TC = \sum_{t=1}^{T}[C^{solar}(t) + C^{wind}(t) + \sum_{m=1}^{M}\{C^{gas}(m,t) + SU^{gas}(m,t)\} + \sum_{i=1}^{I}\{IC_{ind}^{E}(i,t) + \sum_{cc=1}^{CC}\{CC_{com}^{E}(cc,t) + \sum_{r=1}^{R}\{R_{res}^{E}(r,t) \pm C^{grid}(t)] + [\sum_{s=1}^{S} Prob^{s}\{\sum_{t=1}^{T} C_{s}^{solar}(t,s) + C_{s}^{wind}(t,s) + \sum_{m=1}^{M}\{C_{s}^{gas}(m,t,s) + SU_{s}^{gas}(m,t,s)\} + \sum_{n=1}^{N} C_{s}^{gen_{res}}(n,t,s) + \sum_{i=1}^{I} IC_{ind}^{s}(i,t,s) + \sum_{cc=1}^{CC} C_{com}^{s}(cc,t,s) + \sum_{r=1}^{R} C_{s}^{res}(r,t,s) \pm C_{s}^{grid}(t,s)] \quad (3.1)$$

where, C^{solar}, C^{wind}, C^{gas}, C^{grid} are cost of solar, wind, scheduled gas reserve, power generation and selling or buying price of power to or from the grid respectively. Start up cost of the gas generator is SU^{gas}. C_{s}^{solar}, C_{s}^{wind}, C_{s}^{gas}, C_{s}^{grid} are cost of solar, wind, scheduled gas reserve, power generation and selling or buying price of power to or from the grid for each scenario.

3.2. System constraints

Maintaining balance between load and generation is the main constraint of this program. Equations (3.2) and (3.3) give information about load balance in day-ahead condition and in each scenario condition. Therefore, the equation of balance can be expressed as

$$P^{solar}(t) + P^{wind}(t) + \sum_{m=1}^{M} P^{gas}(m,t) \pm P^{excess}(t) = P^{load}(t) - \sum_{i=1}^{I} IP_{ind}^{E}(i,t) - \sum_{cc=1}^{CC} CP_{com}^{E}(cc,t) - \sum_{r=1}^{R} RP_{res}^{E}(r,t) \ b \quad (3.2)$$

$$P_{s}^{solar}(t,s) + P_{s}^{wind}(t,s) + \sum_{m=1}^{M} P_{s}^{gas}(m,t,s) \pm P_{s}^{excess}(t,s) = P^{load}(t) - \sum_{i=1}^{I} IP_{ind}^{s}(i,t,s) - \sum_{cc=1}^{CC} CC_{com}^{s}(cc,t,s) - \sum_{r=1}^{R} RP_{res}^{s}(r,t,s) \quad (3.3)$$

Hourly forecasted power outputs from solar and wind are P^{solar}, P^{wind} and are calculated as in [2]. Scheduled power output is P^{gas} and P_s^{gas} gas power output in scenario. Hourly load demand connected to the microgrid is represented by P^{load}. Excess power to be sold or buy to or from grid is expressed by P^{excess}. Now we can also write

$$F^{gas}(m,t) = [\alpha + \beta \times P^{gas}(m,t) + \gamma \times \{P^{gas}(m,t)\}^2] \times U^{gas}(m,t) \quad (3.4)$$

$$F^{gas}(m,t) \leq F_{max}^{gas}(m) \quad (3.5)$$

$$SU^{gas}(m,t) \geq sc^{gas} \times (U^{gas}(m,t) - U^{gas}(m,t-1)) \quad (3.6)$$

Equation (3.4) represents the relationship between gas fuel and power output of the plant. Amount of fuel required for power generation of m^{th} unit at t^{th} hour is $F^{gas}(m,t)$. The on/off status of the gas unit is U^{gas}: 1 is considered on, 0 is off. Gas unit system constants are α, β, γ. The availability of the fuel over the day is calculated by (3.5). Start-up cost $SU^{gas}(m,t)$ of gas unit is determined by (3.6). Start-up cost of each gas plant unit is sc^{gas}.

4. Results

4.1. *Day-ahead energy scheduling without demand side management*

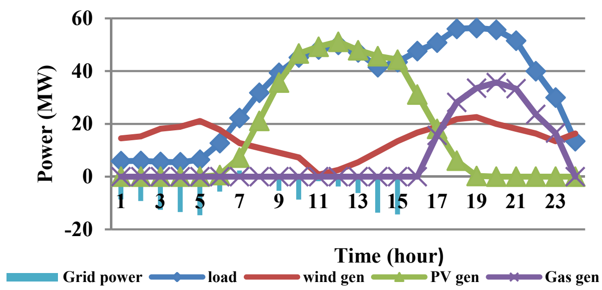

Figure 4.2. Day ahead energy scheduling without DSM

Day-ahead energy scheduling without demand side management program has been shown in Figure 4.1. In day time, e.g. at 10:00 am, as the renewable generation mainly the solar generation is high, excess 8.74 MW generation is sold to grid. In evening time, for example at 8:00 pm, the load is much higher than renewable generation because of zero solar output. Mainly gas reserve takes up the excess load of 35.68 MW and hence increases the fuel cost which in turn increases the total operating cost.

4.2. *Day-ahead energy scheduling with demand side management*

Figure 4.2 shows, the renewable generation is excess from 8:00 am to 4:00 pm and load is excess between 4:00 pm to 9:00 pm. Hence load is shifted from the later period to excess generation period. As for example, load of 9.36 MW is shifted from 7:00 pm and load of 3.43 MW is added to the load at 12:00 pm as the renewable generation is excess. This load shifting is implemented by the developed method explained in section 2.

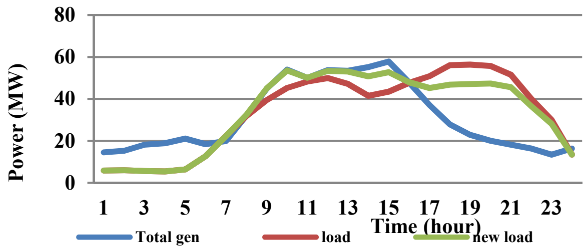

Figure 4.2. Load curve comparison for DSM

The combined effects of load shifting and incentive based demand reduction in day-ahead scheduling are presented in Figure 4.3. As at 12:00 pm some load has been shifted, there is no surplus generation to be sold to grid. At 7:00 pm shifted demand of 9.363 MW and incentive based load reduction of 16.11 MW allow gas unit to generate only 13.55 MW instead of 33.55 MW as in the case of without demand side management.

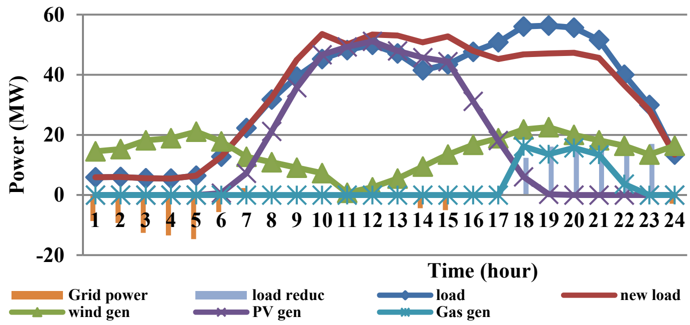

Figure 4.3. Day ahead energy scheduling with DSM

4.3. Cost comparison

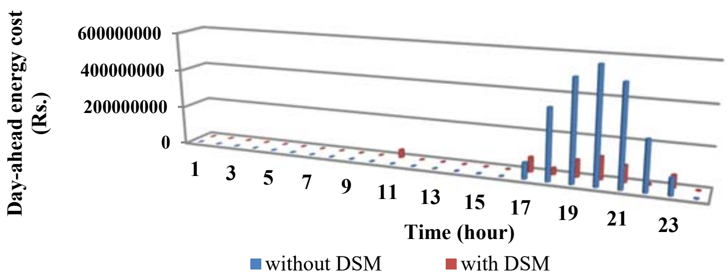

Figure 4.4. Comparison of Hourly energy cost

Figure 4.4 shows hourly cost of energy which clearly shows that reduction in operating cost using DSM occurs during the peak load period. At 8:00 pm the energy cost is Rs. 514996506.3 in case of without DSM whereas with DSM this cost has been reduced to Rs. 86401732.08. It also reveals that, since with DSM loads are shifted to the excess renewable generation period to consume maximum amount of renewable generation it reduces the amount of load in peak load hour. Reserve from load side helps to reduce the amount of demand in peak load with less renewable generation period and hence reduction in operating cost from Rs. 2398829115 to Rs. 505529445.3 is achievable within a day.

5. CONCLUSION

A novel demand side management technique has been developed and implemented in a microgrid. Microgrid considered in this paper utilizes solar and wind as major supply sources and grid and natural gas based generation serve as reserve sources. The energy scheduling of the microgrid is done considering the variability of solar and wind sources. Hourly cost comparison is done to demonstrate the cost reduction period. The total daily cost reduction due to use of DSM and smart scheduling has also been established. For a futuristic approach, demand side management considering appliances with different characteristics can be analyzed.

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Biography

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BATTERIES: CLASSIFICATION AND REVIEW OF ELECTRIC CIRCUIT MODELS FOR ELECTRIC VEHICLE

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Abstract.

Traditional Transportation system is used fossil fuels which created Green House Gas Emission (GHE) and exploited the environmental conditions. Now days the initiative is reflected in many countries of transforming from traditional gasoline based transportation system towards Electric Transportation. There are two types of Electric Transportation system such as Retrofitting based Electric vehicle system and Battery operated Electrical Vehicle (EV) system. Mostly Battery operated Electric Vehicles are attracting to users. Utilisations of EV are day by day increasing and hence there is need to enhance the entire performance of EV by designing the optimistic internal parameters of Battery used in sub systems of EV. The entire performance of battery is depending upon the various factors of battery such as specific energy, specific power, life cycle, safety, charge time, internal resistances, charge and discharge time, temperature, cost, and toxicity. Hence there is need to deals with the above mentioned factors and internal parameters of battery for improvement in performance of Battery. The main objective of proposed research paper is to study and analyse the electric circuit model (ECM) of Battery that used in EV to find the internal parameter by using Algorithm. The various models of ECM such as Simple Model, Enhanced Simple Model, Dynamic Model, Thevenin based model, Modified generic model, Tremblay model are critically reviewed and all are mentioned the elaboration of Internal parameters of Battery. During the study of Thevenin model, it has been highlighted that third order is responsible for creating the huge transient response in ECM and hence to reduce the transient response there is need to design and developed the optimistic R, C parameters of ECM. Detailed studies of comparative analysis of various models are highlighted by considering the uncertainty analysis.

Keywords. Electric, Vehicle, Battery, Modelling, BMS.

1. INTRODUCTION

Due to increasing the cost of oil and gas at International level, the transportation cost is increasing day by day. Fossil fuels based transportation system produces huge Green House Gases (GHE) emission and polluted the entire environment. Electric Vehicle is rapidly acquire conventional automobile market, due to its efficient and easily availability in market[1]. World people's community focus on maximum use of renewable energy for daily use, because of conventional transport system produced huge carbon dioxide, air pollution, impact on ozone layer, climate changes (flood, storm) condition. Today transportation industry work on fuels first and manpower is the second requirement of it. India import crude oil from USA 1.9, 6.2, 10.3, 10.8 million metric ton of spend ₹4138, ₹11398, ₹18915, ₹16614 crore respectively for the year 2017-2018 to 2020-2021. Reducing reliance on foreign oil, a researcher looking for other alternatives sources of energy such as hydrogen storage, a battery, solar PV, Fuel Cell (FC), biofuel and huge injection of various Energy Storage systems (ESs) like batteries, ultra capacitors (UC), etc[2]. Due to limited resources of fuels, huge cost and GHE are the causes for transformation of traditional transportation to sustainable is obtained by using Electric Vehicle (EV) [3]. In EV energy storage system is playing very important role and out of many storage systems are available [4-7], battery is most reliable one. Most suitable, most reliable and more flexible to recharge the battery is nothing but the secondary battery i.e. Rechargeable Battery. The primary battery is a single used battery, the application of this cell is in wrist watch, toy, torch, gas water heater etc.[8] Main focus on internal parameter estimation of battery, the parameter of battery are directly affect on the performances of battery, once we find the perfect value for parameter of battery then it is used in simulation. Various algorithm are developed and explain by researcher for battery parameter [9]. Like an AC system, Battery is not facing the integration issue like reactive power, harmonics, power factor, frequency monitoring and control, synchronisation, etc [10]. Battery charging is hot issue in recent decade, many researcher proposed different charging circuit for differential battery with insight effect on it [11].

Battery has basic source of storage of electricity having different type (Table I) having advantages and disadvantages, Li-ion batteries lead in market for his recent development and performances [12]. DC storage system (Battery) is also facing several issues like life cycle, cost, weight, uncertainty issue, performance, safety, interfacing with electronic component and protection and hence it is indeed to deal with above highlighted issues in EV storage battery system [13-16, 31]. DC storage system (Battery) controlled and operate through power electronics circuitry, the dynamic model of battery as well as charging circuit are discussed [17]. The modelling and simulation give idea about system performances, characteristic, and nature of responses in advanced. Through the simulation we find the behaviour of battery for charging and discharging mode, inserting some critical condition in it. Once we find dynamic responses virtually and it is implement on real time physical system [18-20].

The main objective of this paper is to look upon, the various equivalent electrical circuit's models of lead acid battery, Nickel metal hydride and Lithium Ion battery for enhancing the performance efficiency of battery by using internal parameter identification techniques.

2. BASIC OF BATTERY SIZING.

The battery is a constant source of power, there are three types of Battery packing system are available such as individual battery cell, number of cells are combined in a module and no of modules are combined in a pack [22]. Battery is used in EV and during its normal operation it is discharging in non linear acceleration and variable braking operation. Hence to maintain the stability during the running operation of EV, Energy storage system is ensure the tolerable values of performance parameters by maintaining the stability, reliability and optimum operation of EV.

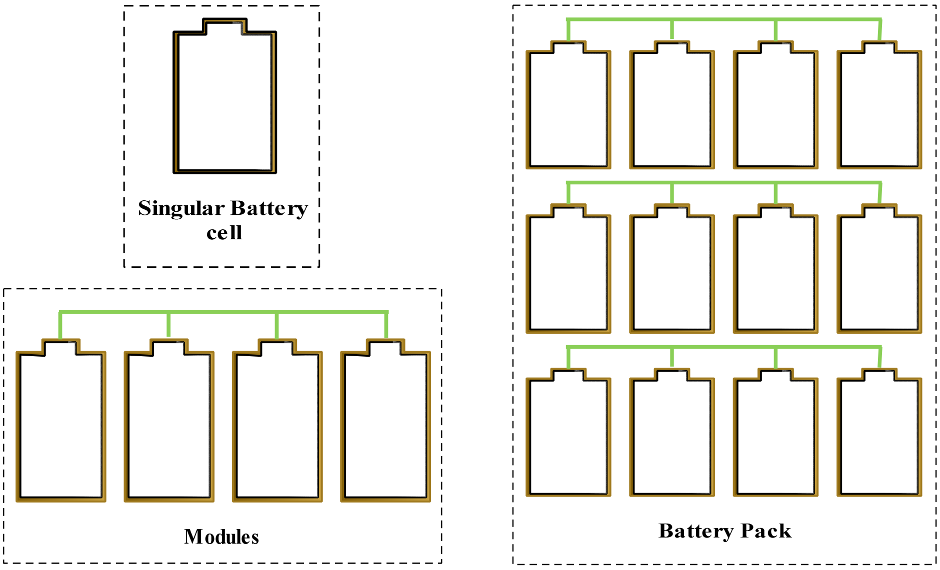

Figure 1: Level of battery pack.

Hence by proper planning and selection of battery above mentioned parameters can be enhanced [5]. Electro mobility needs lightweight batteries which are having enough capacity to fulfil the need under fast charging and discharging mode of operation. Fig. 1 shows the proper battery pack system in singular cell, modules and level of battery packing system.

2.1 Selection criteria of Battery

The selection of battery is deciding upon the efficiency, safety, charging and discharging time, cost, life cycle, etc and following factors are consider in systematic selection approach.

1) Proper selection of battery according to load. (Few KW to 100 KW): According the size of chassis, weight and load to be carrying, the motor rating is selecting. According to motor rating the battery rating to be decided[30, 31].
2) Shape of Battery. There are three types of shapes of battery are available such as Cylindrical, Pouch, Prismatic. According to size of vehicle, it is decided the particular shape.
3) Topology for charging and discharging: There are different types of charging and discharging topologies are available (seen section 5) such as stable current, stable voltage, combine stable current and voltage, etc.

4) Battery Management System: During the continuous operation of battery, the sudden charging and sudden discharging of battery affected the voltage profile of cells and unequal voltage available in different cell and in battery. Hence the entire performance of battery is affected. Hence it is needful to maintain balance voltage throughout the different cell. Hence BMS is used in battery to maintain stable constant voltage in entire battery[31].

2.2 Development of Battery

Battery has long history Figure 2 give idea about evolution in it. The progress has happen in electrode, electrolyte solution, life of cell, charging and discharging rate, safety and its application in various industrial, commercial and domestic use. In early era of battery used for limited application but recently development in technology and limited sources of conventional energy sources and its impact on environment is key point to use it. Battery can be charged through renewable energy source (i.e. sunlight), from solar panel we got DC power to store this power into battery [4, 13, 17].

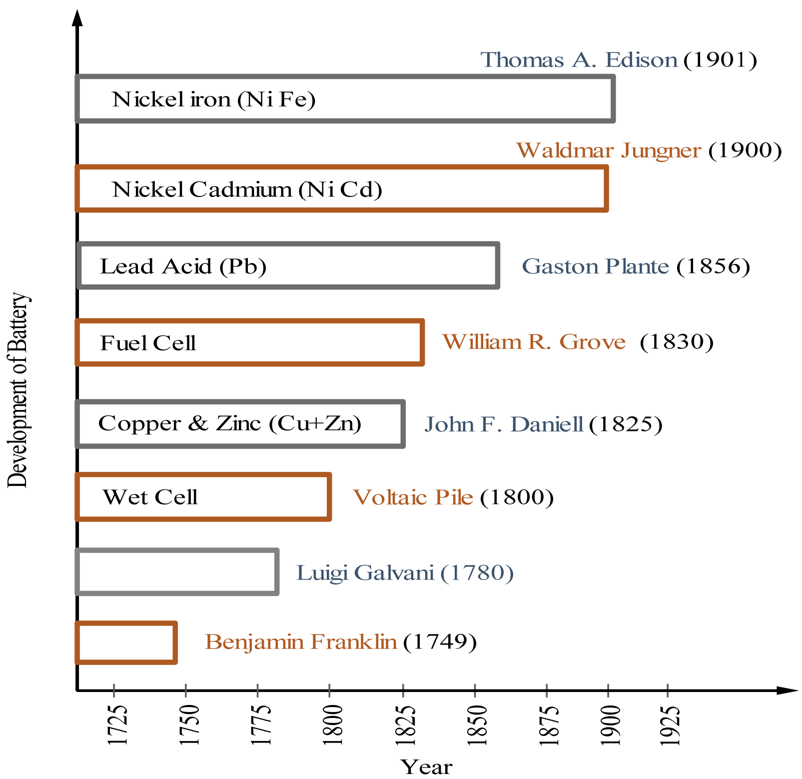

Figure 2: Development of battery.

- Benjamin Franklin an American researcher was introduced the concept of storage energy using battery in 1749.
- Luigi Galvani was suggested some modification in battery in 1780.
- Voltaic Pile [28] was introduced the concept of wet cell in 18th century.

- John F Daniell [28] continue the work of V. pile and remove the error in previous research of battery. He introduced the combine copper and zinc electrodes in battery during 1825.
- William R. Grove was described the concept of fuel cell in 1830-39.
- Gastone Plante [28,29] was lunched the concept of Lead acid battery in 1856.
- Waldmar Jougener [29] was developed the concept of Nickel Cadmium during 19th century.
- In 1901, [29] Nickel Iron battery was introduced by Thomas Edition.

Battery is performed well during static load operation but during the dynamic load of operation it's discharging mode of operation affects the overall performance of battery. During the charging and discharging mode of battery operation, the overall temperature of battery increases and it is indeed to control the temperature within the tolerable predefined values. Aging and de-rating effect of battery needs to consider during performance analysis of battery under charging and discharging mode of operation.

Table I: Comparative Study Of Various Batteries Parameter (24).

Specification	Lead Acid (PbO_2)	Nickel Cadmium (NiCd)	Nickel Metal Hydride (NiMH)	Lithium Ion		
				Cobalt (Co)	Manganese (Mg)	Phosphate (PO_4)
Specific electric Energy(Wh/kg)	35-55	40-85	55-125	155-255	110-155	95-125
Charge Time (Hr)	6-10	1-2	2-3	2-4	1-2	1-2
Internal Resistances	Very low	Very low	Low	Moderate	Low	Very low
Life Cycle	200-300	1000	300-500	500-1000	500-1000	1000-2000
Self Discharge / month (%)	5	20	30	Less than 5		
Battery Cell Voltage (V)	2.1	1.30	1.30	3.5	3.6	3.1-3.4
Charge Cut off voltage (V/cell)	2.40	1.5	1.5	4.2	4.2	3.6
Discharge Cut off voltage (V/cell)	1.75	1	1	2.50-3	2.50-3	2.50

Specification	Lead Acid (PbO_2)	Nickel Cadmium (NiCd)	Nickel Metal Hydride (NiMH)	Lithium Ion		
				Cobalt (Co)	Manganese (Mg)	Phosphate (PO_4)
Charge Temperature (°C)	-20 to 50	0 to 45	0 to 45	0 to 45		
Discharge Temperature (°C)	-20 to 50	-20 to 65	-20 to 65	-20 to 65		
Maintenances Required	4-5.5 months	2-4.5 months	2.5-3.5 months	Free		
Safety	Temp is controlled and it is stable	Temp is controlled and it is stable using fuse protection system		BMS protection is required		
Cost	Low	Moderate		High		
Toxicity	Very High	Very High	Low	Low		

3. Model of Battery

To understand the nature and operation of battery, modelling of battery is indeed. Battery consist of Anode, cathode and electrolytic solution which is shown in Figure 3. Operation of battery is established by electrochemical process, Lithium ions are travel from Anode to cathode under charging process and electrons are travelled through wire to form a electric circuit. During discharging process, Lithium ions are moved out in extraction mode to form electric circuit. Ions are travel form anode to cathode under intercalation mode and neutralize the charges. In battery operation movement of Li ion is important process, In discharge mode the electrolyte solution in neutralised mode therefore ion not travelled from it, in the chemical action water is form as by-product and its reduces specific gravity of electrolyte. For fully charged battery specific gravity of acid is 1.26 and for fully discharge battery is 1.17, it is measured by hydrometer. In Charging mode in the battery electrolyte for a chemical reaction in it and ion travelled from it and we get power from battery [6, 8].

The viscosity of electrolytes is an important parameter for SoC calculation. Lithium technology is heavily used among the batteries option because of its upper electric energy density and decreases the electric discharge rate.

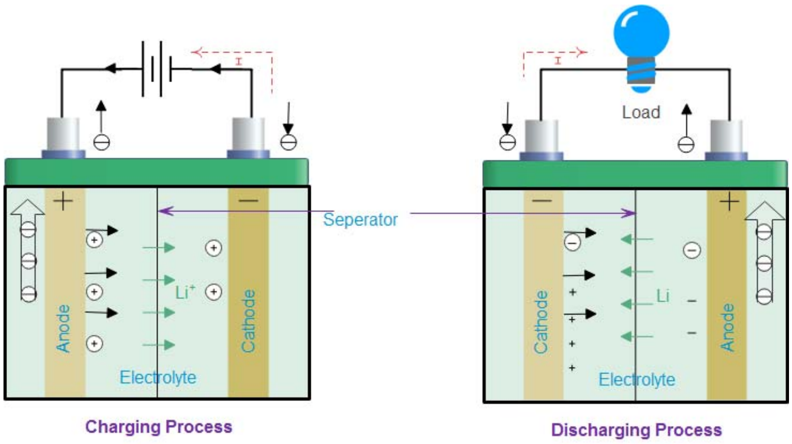

Figure 3: Charging and discharging process[32].

Battery performances carried out by parameter are Specific Power, Safety, Performance, Life Span, Cost, Specific Energy, etc. (Figure 4). The average life of a battery is 7 to 10 years depending on the power consumption profile of the battery at the time of acceleration and braking mode [4].

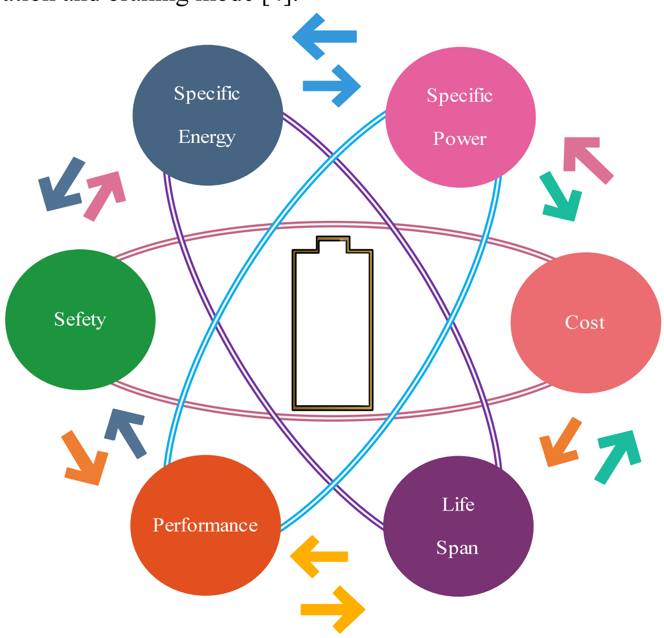

Figure 4: Battery performances major parameter[31].

Electrical circuit models are frequently transform into an equivalent circuit for the scientific model to produce the effect of the batteries under charging and discharging mode of operation. Electrical model, we know the mathematical model of battery, if ones we got dynamic model use different analysis tools such as Machine learning, Neural network, fuzzy logic, artificial intelligence to predict the batteries performance [15,32].

3.1 Classification of Battery Models.

Modeling of battery circuit, drive an important role in the research and blooming of any real-time problem. Modeling will help to change the thinking on subject in many ways for the same problem. Real systems can be transformed into physical models or a mathematical model which allows knowing the dynamics behavior of the system through simulation. Modeling helps to predict the responses of any real system, in advance before implementing it on the object. It is done by system theory and deep knowledge of particular object. Modeling is based on computer-based software and it gives optimum result and accuracy for the system.

As per the various internal factor, battery circuit are classify in many model are listed below

i. Electrochemistry models,
ii. Electrical models,
iii. Thermal (Heated) models,
iv. Mechanized models,
v. Atomic (Molecular) models,
vi. Interdisciplinary models (Electric-thermal-chemical, etc.)[18],

Distinct techniques or approaches of modelling:

i. Physical based models (Electrochemistry),
ii. Experiential models,
iii. Analytical based or mathematical model,
iv. Electrical circuit models,
v. Stochastic models,
vi. Compound models, [7, 19].

4. EQUIVALENT BATTERY CIRCUIT MODEL

Many researcher explain various battery model for different factor are present in the literature that is used in modeling of battery for a simple differential model to third order or 'n' number of order differential model. For the estimation of battery performance, various mathematical models play a significant role [20].

4.1. Simple Models

The first mathematical modeling is presented by M. A. Casacca [7] in 1992 for lead-acid batteries. Battery specifications of an ideal battery are given in capacity Ampere hour (Ah) and voltage (V). The present power of the battery calculate by the product of Current capacity and Voltage i.e Wh, Figure 5 shows a simple linear model it consists of internal resistances (R_{int}), Open circuit voltage (Voc), and battery terminal voltage (U_T). This model shows linear characteristics not contain any nonlinear element in this model. This model gives the steady-state response.

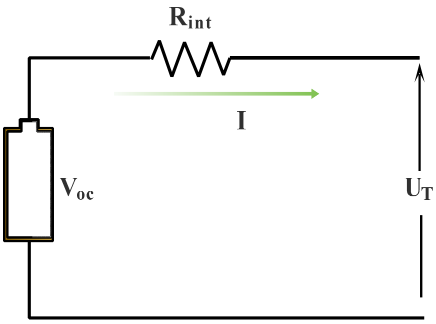

Figure 5: Simple linear model.

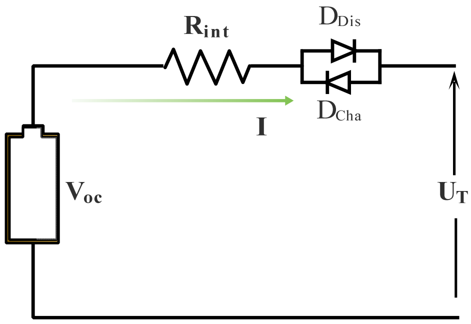

Figure 6: Charging and discharging circuit.

The R_{int} decides the heat generate in a battery. Basically battery temperature is majorly depends on internal resistances, so every researcher has air to nullify the resistances of internal parameter of battery. Whenever a load is connected the terminal voltage is:

$$U_T = V_{oc} - R_{int} * I \tag{1}$$

In the Simple linear model is neither U_T nor V_{oc} vary with state of charge (SoC). Internal resistance of this simple model does not consider into account because the state of charge, electrolyte concentration, and electrolyte formation not dependent on it i.e Rint.

Resistances for figure 6 shows different for charging and discharging condition, For charging condition $U_T > V_{oc}$, the charging Diode is in forwarding bias and discharge Diode in reverse bias and vice versa in discharged condition.

For Charging, Terminal Voltage,

$$U_T = V_{oc} + R_{int} * I \tag{1a}$$

For Discharging, Terminal Voltage,

$$U_T = V_{oc} - R_{int} * I \tag{1b}$$

4.2. Enhanced/Amplify Simple Battery Model

In the amplify battery model, the voltage source is replaced by the state of charge (SoC) controlled voltage. The effect of open circuit voltage (Voc) is dependent to SoC.

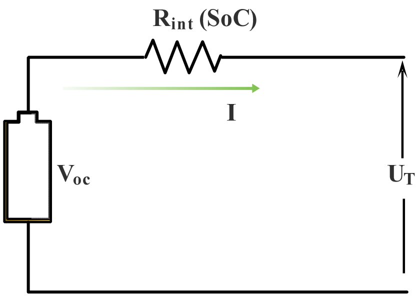

Figure 7: SoC simple battery model.

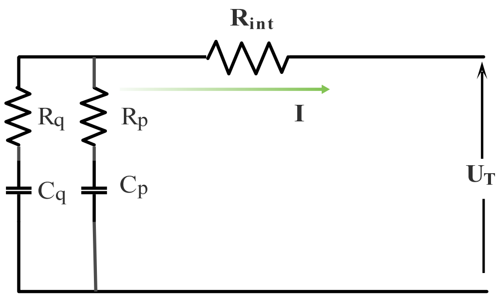

Figure 8: Dynamic model with RC.

In figure 7 shows the amplify circuit model for battery, from this model the new terminal Voltage (U_T), is,

$$U_T = V_{oc} - R_{int}(SoC) * I \quad (2)$$

Where internal resistances can be calculated as,

$$R_{int}(SoC) = R_0/S^k \quad (3)$$

Where SoC, R_0, and k are present charge status of the battery, initial internal resistance and a capacity factor respectively.

$$SoC = 1 - \frac{\sum Ah}{C_{10}} \quad (4)$$

Where A indicate value for current, h is time and C_{10} is battery capacity for 10 hours.[8]

4.3. Dynamic Model

The RC or dynamic model is consist of polarisation (p) and capacity of battery (q) parameter shown in Figure 8. It was first invented in 2000 by the SAFT Battery Company for the NREL.
Figure 8 it having two resistances and two capacitances (R_p, R_q, C_p, and C_q). where 'p' is polarization and 'q' is the capacity of the battery respectively, C_q is indicating SoC capacity of the battery, and the value of C_q is very high. R_q indicates limiting resistances.

The equation are as:

$$V_T = V_{oc} - I_q * R_q * R_{int} * I \quad (5)$$

$$V_T = V_{CP} - I_P * R_P - R_{int} * I \quad (6)$$

4.4. Thevenin-Based Battery Models

Thevenin model is considered for finding nonlinear responses of the system. This model gives a valid solution for the transient state. To simulate transients result in computer based software, some phenomena as polarization must be considered.
Thevenin model are categories between

i. First (I^{st}) order Thevenin model
ii. Second (II^{nd}) order Thevenin model
iii. Third (III^{rd}) order Thevenin model
iv. N^{th} order Thevenin model

According to the cell connected in series and Parallel for constant output Voltage.

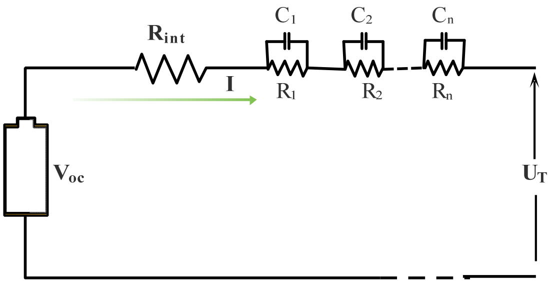

Figure 9: N[th] order thevenin model

In figure 9 consist the battery model with n number of pairs of parallel resistors and capacitors, (R1, C1), (R2, C2), . . . , (Rn, Cn), The Equivalent Output Voltage of thevenin model is,

$$U_T = V_{oc} - R_{int} * I - \sum_{K=1}^{n} R_k I (1 - e^{-\frac{t}{R_k C_k}}) \tag{7}$$

For n[th] order battery model, we calculate the value of Resistances and capacitances for SoC and SoD. The Value of n pairs of parallel resistor and capacitor can be calculated by [10, 11].

4.5. Modified generic battery model (Shepherd Model)

C. M. Shepherd elaborate a battery model in 1965. His research he find a mathematical equation that explain the discharging processes of different cells by calculating the cell voltage during discharge [3]. Shepherd's find that the relation between battery terminal voltage and current, Shepherd's model derive the interaction between the terminal voltage of the battery and the discharging current. These experimental models give the best result for stable characteristics performances of the battery on a certain discharging current (exponential current). Figure 10 give the idea to build-up nature in simulation [11].

$$U_{dis} = E_0 - K\left(\frac{Q}{Q-it}\right)i - R_0 i + A\exp(-BQ^{-1}\, i\, t) \tag{8}$$

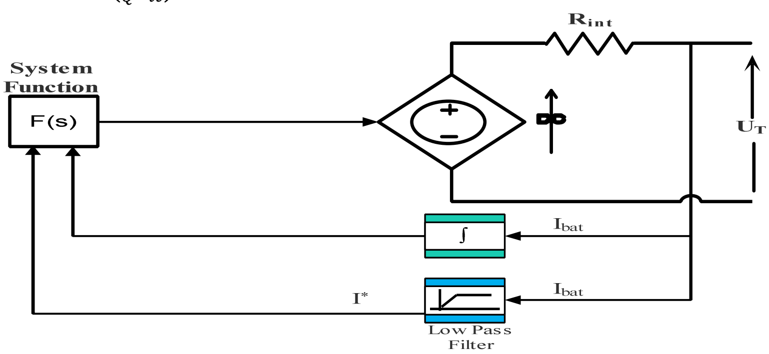

Figure 10: Modified generic battery model.

4.6. Tremblay Model

Olivier Tremblay presented an easy-to-use battery model using dynamic simulation software. To avoid the problem of forming an algebraic loop, this model only used the SOC of the battery as a state variable [2]. The controlled terminal voltage (U_T) is depended on current consumed by battery, for proposed battery model it assume R_{int} and thermal characteristic are kept constant.

$$U_T = E_0 - K\left(\frac{Q}{Q-i*t}\right) + A\exp(-B*\ i*t) \quad (9)$$

Tremblay model have two constraints
First, the minimum no-load battery voltage was zero V, whereas the most battery voltage wasn't restricted. Second, the minimum capability of the battery was zero Ah, whereas the most capability wasn't restricted. Therefore, the most SOC is larger than 100 percent if the battery is overcharged. Once the parameters were well determined from the discharge curve provided by the makers. The Tremblay model might accurately represent the behavior of the many kinds of batteries. The electric circuit models square measure enforced in dynamic simulation studies like wind energy conversion systems, electrical phenomenon systems, and electric/hybrid vehicle systems [10, 11].

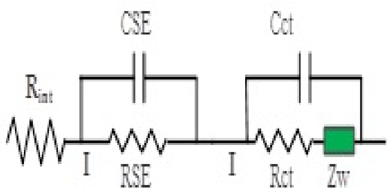

Figure 11. Impedance based battery model.

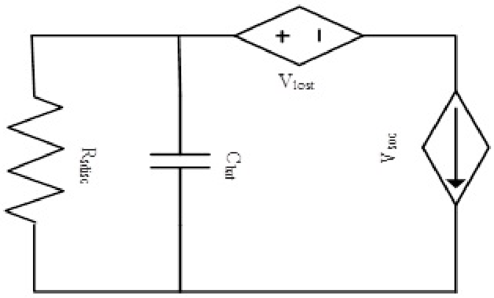

Figure 12. Run time based battery model

4.7. Impedance based battery model

Figure 11 show circuit for electrochemical impedance spectroscopy (EIS), for calculating battery parameter this technique are commonly used. Impedance are depends on applied voltage and its result take on nyquiest plot[6].

4.8. Run time based battery model

Figure 12 Simple run time model for estimate the parameter. In circuit R_{sdisc} is self discharge resistances, C_{bat} is the capacity of battery, V_{bat} is battery voltage is depends on SoC .

4.9. Combine or Hybrid Model

In this model combine two different model to check the parameter of battery using high computation method. Combination of two model open number of algorithm for nding real time State of Charge SoC , State of Health SoH , Depth of Discharge DoD for further information of battery. Figure 13 give simple view of hybrid model.

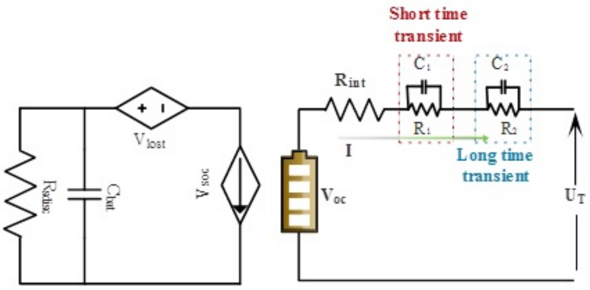

Figure 13. Combine or Hybrid Model.

5. CHARGING TOPOLOGY

Battery charging is important task in EV. Charger having two type according to power flow in battery unidirectional and bidirectional charger. In unidirectional mode only grid supply power to the battery through charger and in bidirectional charging mode grid supply power to the battery at rated current according to the charger design and in steady mode of devices flow power from battery to grid in peak load condition. A charging device has the subsequent 3 functions: 1) Delivering safe charge to the battery; 2) Optimizing and control the charge rate, and 3) Terminating the charge. In literature battery having different type according to his material used in it, chemical action, electrolyte, etc. Nickel batteries require solely constant current (CC), whereas Li-ion batteries need a continuing current/constant voltage (CC/CV). Pulse charging, which uses a pulse current for up to one second, followed by a rest period and a discharge pulse for milliseconds, is claimed to be best as a result of improves the charging speed and efficiency[11]. Design an economical charger are simple and reliable for charging of the battery, the literature compare and evaluate some charging algorithms because every battery having a limitation for nickel and lithium batteries (lead-acid batteries are escaped due to the nature of their applications, which is different from nickel and lithium batteries) [12, 13, 26].

6. PARAMETERS CALCULATION FOR OPTIMIZATION

First-order (RC) model, the parameters can be easily evaluated from the experiment. The models with two or more pairs of parallel RCs element, having different rating give the stable responses but increasing the RC pairs the order of model will increase and it directly affect on system responses. Therefore to find all values for RC is mandatory to minimize the error in physical model. According the research of the Tingshu Hu et al., give primary idea about to estimate internal parameter (R, C) of the Thevenin model. This battery model deal with nonlinear characteristics, because the voltage and current are depends on state of charge. The SOC will vary the battery performances characteristics. Figure 14 Flowchart give the accurate value for battery internal parameter for fast and most efficient SOC, to find battery model.

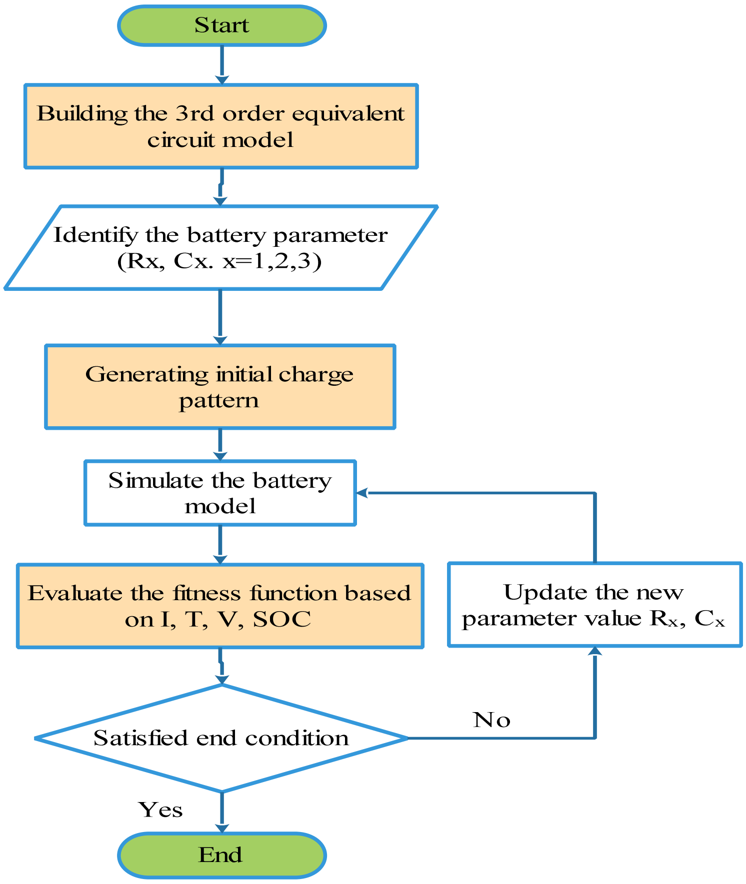

Figure 14: Flowchart for Parameter estimation[10],[25].

7. RESULT

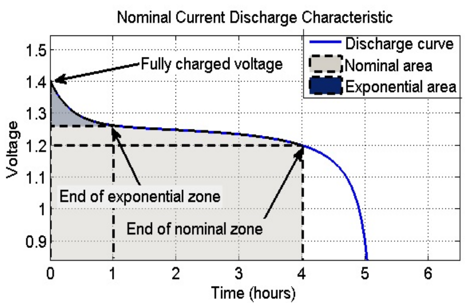

Figure 15. Typical discharge curve [3]

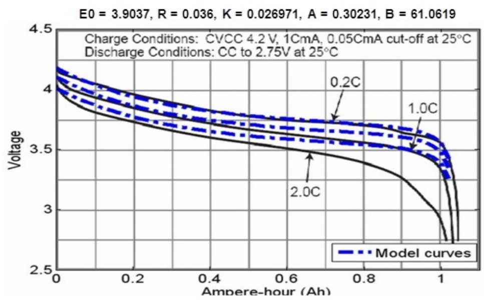

Figure 16. Li-Ion battery 3.6V, 1 Ah [3]

Figure 15 shows a typical discharge characteristic (TDC) which is referred from specific battery data sheet.TDC is supporting to calculate the various technical parameters such as Nominal Voltage (V) , maximum capacity (AH) , Rated capacity (Ah) , Fully charged voltage (V) , the internal resistance (R) , Nominal discharge current and end of exponential & nominal zone from manufacturer data sheet. Data sheet of battery contains ideal discharge characteristics which is consider as a reference and various technical parameters are refereed from data sheet and utilised in MATLAB simulation model. MATLAB simulation model results are validated with ideal reference discharge characteristics. It has been observed that the results are exactly matches with ideal reference discharge current. Figure 16 shows that Lithium Ion Battery having capacity of 3.6 V and 1Ah. Fig indicates that E_0 is important term and it is calculated by referring the various technical parametersfrom data sheet. E_0 is calculated for different batteries and it is varied according to TDC. Results obtained from simulation models are validated by considering Charge rate of 0.2, 1 and 2. Figure 17 (a) shows the relationship between Soc and time, Experimental and simulation result are compared and validated. In this plot, battery initially has fully charged i.e SoC is 1 and according to utilization of power present in battery, SoC is decrease. According SoC graph curve, It has been concluded that, Soc is predicted the approximate range in kilometer. Soc is decrease during discharging process and SoC increase during charging time. It has been observed that both curves are in same nature and 5% tolerance are expected due to certain constraints. Figure 17 (b) shows curve of voltage verses time. In this case both the simulation and experimental analysis shows satisfactory result. Figure 17 (c) shows relationship of current verses time. The nature of battery current is same during both the simulation and experiment result with maximum 5% tolerances are provided herewith. Current is varied according to SoC of battery. Plot C shows that initially more current is draw due to accelerating mode of electric vehicle and constant for rest period for 20-80% of SoC state.

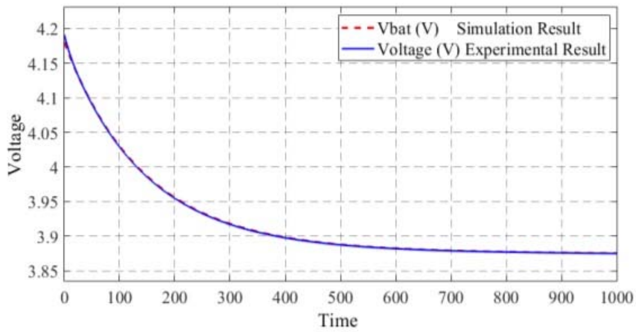

Figure: 17(a)

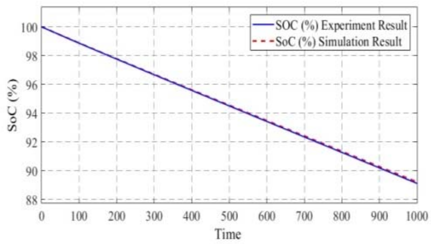

Figure: 17(b)

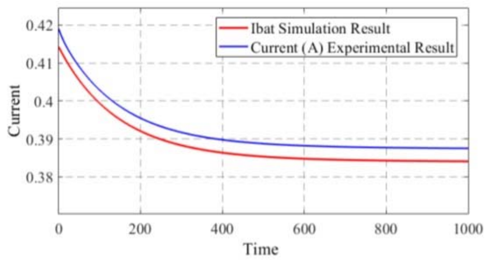

Figure: 17(c)

Figure 17. Experimental and Simulation Results.

8. CHALLENGES OF ELECTRIC VEHICLE

- EV is best alternative for IC engine, To Drive EV, need of Battery, Supervisory Controller, Sensor, Decision controller, Alarm System.
- EVs are the least expensive compare to any other vehicle combination.
- Modern Electric Vehicle will be essential that develop supervisory control strategy and to study the performance of the vehicle under different driving conditions.
- Economical and safety issue, simulation of the vehicle control strategy is needed prior.
- Overcome of limited range problem of vehicle test different Configurations/architectures can be considered for converting the existing electric vehicle.
- The variety of battery chemistries available,[1,32]

9. CONCLUSION

In the development of electric vehicles the battery is the soul of the whole system, find the best battery for the system is a very important task. The battery performances, we know the internal parameter of the battery that directly affect the battery performances (SOC, SOH, SOP, Temp., Voltage, Current) In this perspective article we discuss different equivalent electric circuit model (ECM) for the simulation process having different pros and cons, Among them Thevenin third-order model has the good dynamic result for parameter estimation of the battery. Modified generic battery model has been developed in simulink and compare with experimental result. This model show very good result to apply for BMS algorithm. All this equivalent circuit model reduces the charging time of EVs, a safe and efficient electric model of the battery. Also, discuss charging topology for battery performances.

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Energy Efficient Heat Treatment Process to Remove the Failure of Tool Steel in Industrial Component

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Abstract

The major components in forming process of operations are dies and punches. The combination of die and punch together make a one unit which is called as die set. As per the requirement basic material to manufacture die and punch is cold work tool steel. To perform maximum work then wear resistance as well as strength of die is required. Generally working surface of die is made with stellite or cemented carbide material. For the present work, the investigators have visited to automobile industry where industry is presently facing the problem of failures in inner lower control arm which is a part of suspension system. The surface of component can display typical ductile fracture on inner and outer surface of inner lower control arm. The experimental work had been carried out with energy efficient heat treatment process for tool steel such as OHNS, D-2, D-3, and EN-31 as per industrial requirement on the basis of tensile test and chemical Compositions.

Keywords. Cold work tool steel, Failure Mode Effect Analysis (FMEA), Rework priority number (RPN), Draw bed restraining Forces, Percentage indices process capable.

1. INTRODUCTION

In automobile industry sheet metal parts perform an important role also it will increase competition in global markets. Different parts of four wheeler system, body parts of vehicle, and door parts are manufactured in sheet metal industry. In manufacturing industry we can observed that for each and every process there are some defects [1]. In manufacturing engineering process design for sheet metal forming is also important aspect, which can calculate cost and evaluate quality of product. On the basis of trial and error method conventional process design is efficiently implemented [2]. So to reduce cost, remove defects, improve product quality and productivity decide whether the industry can maintain their leading edge and competitiveness in all over market places [3].

Recently, the industry has to set group for the forming simulation which are as follows [4].

I. Reduce the time:
   a. Early checking of work pieces
   b. Reduce the time for development
   c. Reduce the trial times
   d. Check modification wishes with minimum time

II. Reduce the Cost:
   a. Manufactured product with minimum cost
   b. Reduce the cost of die

c. Press down sizing
d. Reliability of part increases

III. Improve the product quality:

a. Selection of quality work piece material
b. Complicated parts with Quality
c. Accumulation for new materials
d. Process repeatability

1.1. Origin of the Research Problem

This project focused on industrial component which are used in automobile suspension system which is attached to chassis. Now demand of industry is to avoid component failure as well as no fracture or no rework. The tools are loaded in complex manner, understanding these loading conditions are important for efficient jigs and fixture design. The components must be durable enough to tolerate significant loads and harsh environmental effects. From design point of view, data for defective components is shown below.

1.2. Failure of tool steel as well as burr on edge of component

Figure 1.1 Failure of Punches as well as burr on edges of component

Inside this industrial requirement base and graphical as well as experimental failure analysis it is observed that, material selection is more important for tool steels with appropriate grades also. In this project work select tool steels are D-2, D-3, OHNS and EN-31material grade. The main purpose for the selection of above tool steel are availability and cost of tool steel material as well as demand if industry. During the punching and piercing operation failure of tool steel as well as burr on edge seen on component to which rejection of part take place.

1.3. Justification for Problem Selection

During manufacturing and forming process defects are burr, wrinkles, spring back, punch failure, taper cutting and cracking etc. seen on the components. All the defects are study under product and process failure mode effect analysis (FMEA) and check their severity, occurrences and detections calculate rework priority number (RPN) for each and every defect. From this defects punch failure and Fracture on edges of component is a major problem with maximum RPN number, on the nose of punch cracks are visible. Now the present work has to focus on above define defects are to be visible on inner lower control arm component.

Table 1.1 List of operations with defects and actions

Stages of Operations	Type of Defect	Type of Issue	Remarks /Action required
Shearing	Burr on edges	No Effect	Grinding
Blanking	Burr on edges	No Effect	Rework / Grinding
Drawing	Wrinkles	Quality	Rework for quality
Forming	Spring back	Die design	Rework on die design
	Fracture on Edges	Production Loss	Part rejected
Pocket on left side	Burr on edges	Quality	Grinding
		Rework	
Pocket on Right side	Burr on edges	Quality Issue	Grinding
		Rework	
First Notching	Taper Cutting	Loss of production	Part rejected
Second Notching	Taper Cutting	Loss of production	Part rejected
Punching of Four Holes	Failure of Punch	Maintenance Issue	Change Punch
		Repairing	

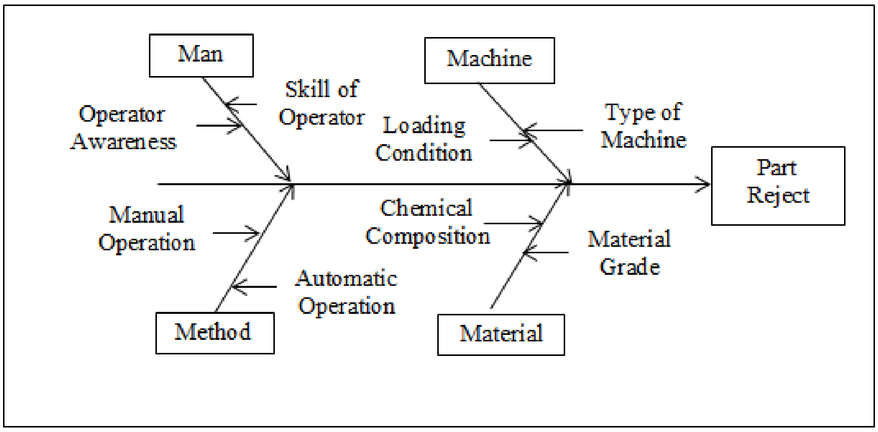

Figure 1.2 Causes and Effect Diagram

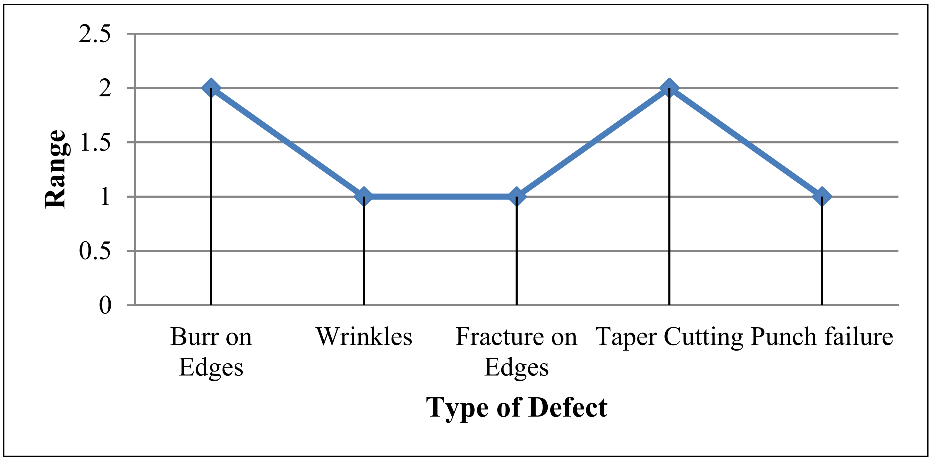

Figure 1.3 Graphical representations of Range and Type of defect

Graphical representation shows that, the failure range of each defect with respected to type of defect in Shearing, Blanking, Drawing, Forming, Punching and Notching process of operation. To identify different defects of components select 2000 samples. The maximum failure rate of punch failure is very high on the basis of maintenance time and cost of component. From this chart we focus on Burr on edges of components as well as failure of punch. For this identification and selection of problem referred product FMEA and Process FMEA with reference to Rework priority number also.

2. Experimental Method & Material Selection

Figure 2.1 Unfinished test samples before experimental work

In sheet metal production different operation are carried out to manufacture product are blanking, forming, bending, notching, piercing, punching as per requirements of components and their materials, from which they are manufactured. In punching operation elasticity, fatigue and stress-strain are never found to maintain burr free operations of without punch failure will never avoid. In above operations major problems are seen on punch failure and it is observed that it will create other issues on industrial components.

Step 1: Industrial survey for preparation of objective function and selection of tool steels.

Generally many number of tool steels are used in sheet metal processing industry as per their need, from the available material with best suitable heat treatment process selection of tool steel again very important. To maintain object function of project work it is important to perform overall analysis.

Step 2: Specimen preparation with turning operations

Figure No.2.2 Specimen preparation with turning operations

In experimental work always require sample with their specimen preparation. For this testing purpose select four sample materials as per the requirement of industrial expert, availability of sample material and cost of material. Prepare a two sample for each material for two heat treatment process like annealing, hardening and tempering. For the sample preparation material cutting is the initial step which is carried out using Hydraulic or Power Hack saw machine. Sample sizes are 16 mm diameters with 250mm to 100mm length are prepared using required lathe operations on turret lathe.

Step 3 : Testing of tool steel materials before heat treatment for EN-31, D-3, D-2 AND OHNS

To check the performance of tool steel it is important to check their chemical composition. In chemical composition it easily checks the alloy elements and their impact on performance of tool steels just like shearing. If we consider the physical properties and mechanical properties of tool steel like stiffness, corrosion resistance, strength, ductility, plasticity, elasticity then it is important to check their alloying elements. Each and every alloying elements like chromium, molybdenum, tungsten, vanadium having a specific role to determine above properties. Test for each sample is done 2-4 times from smooth surface of sample on different point. So this overall procedure is performed for OHNS, D-3, D-2 and EN-31tool steel samples.

3. RESULTS AND DISCUSSION

Table 3.1 Tool steel material Chemical Composition

Material	EN- 31	D-3	D-2	OHNS
Si%	0.29	0.43	0.58	0.58

Material	EN- 31	D-3	D-2	OHNS
C%	0.92	2.34	1.58	1.28
Mn%	0.34	0.28	0.3	1
Ni%	--	--	--	0.17
W%	-	0.02	--	1.5
Mo%	--	--	1.04	--
V%	-	0.10	1.02	--
S%	0.007	0.005	0.005	0.02
P%	0.02	0.026	0.02	0.027
Cr%	1.42	12.2	11.01	0.44

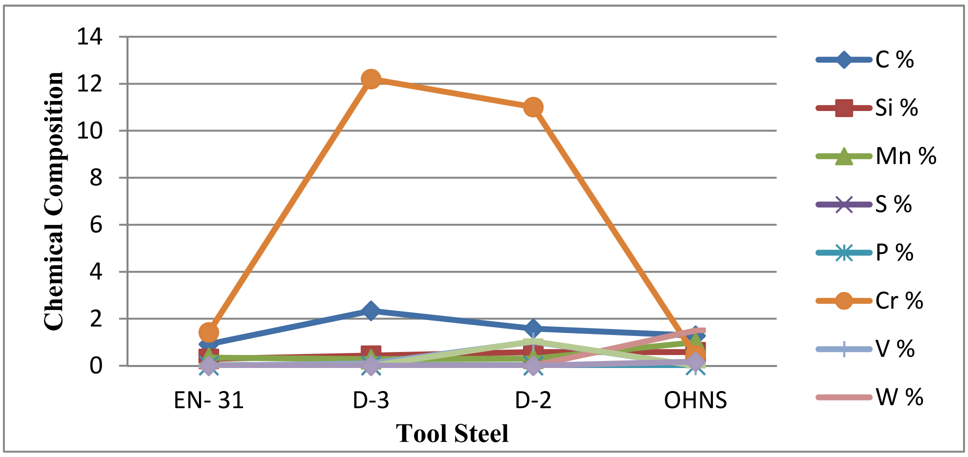

Figure 3.1 Tool steel material Chemical Composition

From the above graphical study it is observed that for D-3 and D-2 materials chromium content is maximum for these two materials. Chromium is a steely-grey, lustrous, hard, and brittle transition metal. Chromium is the main additive D-3 and D-2 materials, to which it adds anti-corrosive properties. If higher is the Melting point (1907 °C) of chromium will increase the melting point of D-3 and D-2 tool steels.

Table 3.1 Physical Properties of Sample Materials

Materials	Dia. (mm)	Area (mm^2)	Gauge Length (mm)	Final GL (mm)	Yield load (KN)	Ultimate Load (KN)	Yield Stress (MPa)	UTS (MPa)	% E
OHNS	15.25	182.65	80	96.1	85.9	157.98	441.85	816.6	20.1

Materials	Dia. (mm)	Area (mm^2)	Gauge Length (mm)	Final GL (mm)	Yield load (KN)	Ultimate Load (KN)	Yield Stress (MPa)	UTS (MPa)	% E
EN-31	15.1	179.08	82	100.1	111.02	158.9	491.23	703.1	22.1
D-2	15.05	177.89	85.1	95.05	87.12	153.05	413.77	724.1	11.7
D-3	15.12	179.55	84.9	86.65	97.2	204.56	451.11	949.4	2.06

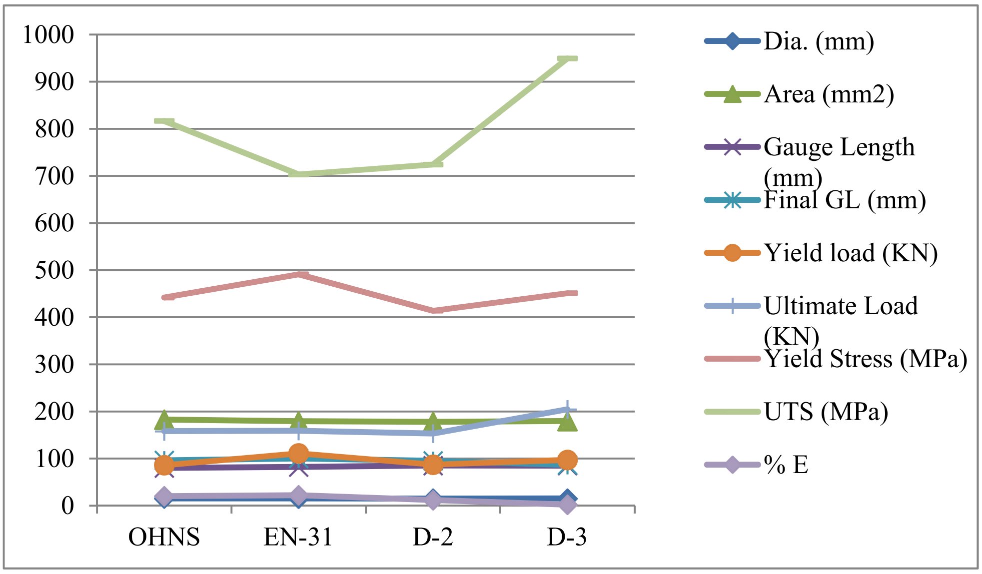

Figure 3.2 Graphical representation of Physical properties of Tool steels

Samples are to be selected for present work should be maintaining all the basic parameters to which entire experimentation done with same sequence of order. To check amount of plastic or elastic deformation of material will measured percentage of elongation. From the above measurement technique quantifies the ductility of materials. Also comparison between final length and original length determine ductility of material and percentage of elongation. From the above graphical study it is observed that percentage of elongation for D-3 and D-2 is more compared to EN-31 and OHNS.

3.1. Hardness and Heat treatment Process

Hardness is not a fundamental physical property of material it's a characteristic of a material. It is determined by measuring the permanent depth of the indentation and is defined as the resistance to indentation. By using 12 different test methods and area of indentation, indentation hardness value will be obtained easily. To check the hardness of four sample materials D-2,D-3 OHNS and EN-31used Vickers hardness tester, Brinell hardness tester and Rockwell hardness tester. From this testing methods calculate Rockwell hardness, Brinell Hardness and Vickers Hardness etc.

Testing of hardness for two general characterization

I. Material Characteristic

- Material Checking test
- Hardenability test
- Processes confirmation test
- Testing of tensile strength

II. Functionality

- Test to check function **as** per designed
- Wear resistance test
- Toughness of material
- Resistance to impact

Table 3.2 Heat Treatment of Tool steel

Test Material	**OHNS**		**EN-31**		**D-2**		**D-3**	
Heat Treatment	Annealing	Hardening & Tempering	Annealing	Hardening & Tempering	Annealing	Hardening & Tempering	Annealing	Hardening & Tempering
Rockwell C- HRC	25	65	20	55	20	75	30	60
Rockwell B- HRB	105	125	105	125	102	65	110	50
Brinell Hardness (HB)	195	470	230	470	195	590	285	560
Vickers (HV)	190	495	225	495	190	225	270	680

After Annealing Heat treatment :- From the above table and graphical representation it is observed that, Brinell hardness in annealing heat treatment process for OHNS, EN-31, D-2 and D-3 tool steel is 198HB, 230HB,195HB and 285HB. It means that, if we consider only Annealing Heat treatment process than it is observed that D-3 material is having higher hardness than OHNS, EN-31 and D-2 tool steel. Generally many times it is observed that, Hardness of tool steel material after hardening and tempering always increased or decreased. Parallel study again represents that, in Vickers hardness test D-3 tool steel having maximum (270HV) as compared to EN-31, OHNS and D-2 materials.

After Hardening and Tempering Heat treatment: - From the above table and graphical representation it is observed that, after hardening and tempering Brinell hardness of tool steels like OHNS and EN-31 is 470 HB and 470HB less than D-2 and D-3 tool steel. If we check Vickers hardness then it is observed that, Vickers hardness for OHNS is 495 HV, EN-31 is 495 HV, D-2 is 225 HV and D-3 is 680 HV etc.

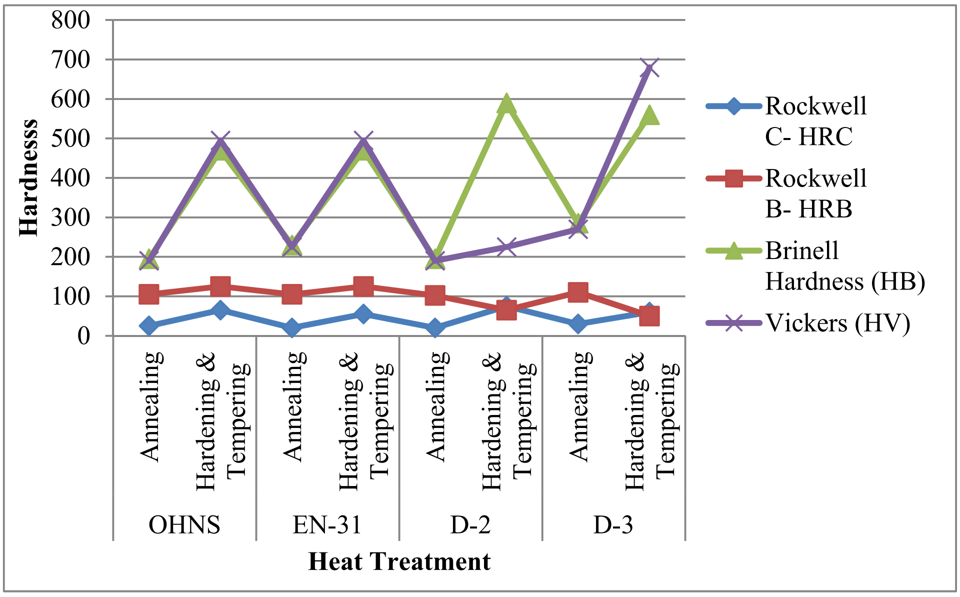

Figure.3.3 Graphical representation of Hardness and Heat Treatment Process

Comparison of Annealing and Hardening & Tempering After annealing heat treatment it is observed that, components will increase their hardness. In microstructure shows lack of grain boundaries and grain formation is not uniform. To improve this causes and effect of annealing heat treatment need to used hardening and tempering heat treatment process for good corrosion resistance, tensile strength and hardness of tool steel.

Figure 3.4 Trail on Pneumatic press machine

In industry all sheet metal processes are carried out on pneumatic press with different capacity of press are 250,400,600 tons to perform different operation like bending, drawing, blanking, piercing, Trimming, Notching etc.

4. CONCLUSION

This experimental study is very useful to avoid defects in industrial sheet metal components as well as improved energy efficiency of industries. In this paper used four samples are D-2, D-3, OHNS and EN-31 to performed energy efficient heat treatment process like Annealing, Hardening and tempering to calculate Rockwell hardness, Brinell Hardness and Vickers hardness etc. From the entire experimental study it is concluded that, D-3 tool steel give higher Vickers hardness (HV) 680 as compared to D-2, OHNS and EN-31. After experimental procedure, actual trial conducted on industrial pneumatic press machine to check the overall defects on industrial components and it is observed that defects are minimized up to 22% and it is calculated with total number of components rejected and accepted out of 2000 components. In this experimental study mostly focus on effect of heat treatment process like annealing and hardening & tempering for tool steels like OHNS, D-3, D-2 and EN-31.

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Modern way of living: Smart City Management

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Abstract.

Homes being smart is referred to gadgets that provide binary connections, automation or intensified assistance to occupants of buildings. Recently technology is being so forwarded that smart home management has become a burning topic everywhere with different policies of energy efficiency management, sustainability of the building and even climate change. The smart home is playing a central role in building a smart city. Is the planning of a smart home actually encouraging goals of sustainability? What are the risks, benefits and agendas to follow up for the smart city development? A study of recent research paper on smart city development and smart home management revealed implement of smart material manufacturing technology into a smart building, finally developing a smart city. It is found that a high-speed internet connection plays a crucial role in managing a smart city system, smart homes being its smallest management unit. Some technologies have been adopted from the European Culture of smart home cities. Moreover, things can be made smarter by pairing smart home voice assistant to our broadband provider (Wi-Fi) e.g., Amazon Alexa, Google Echo.

Keywords. Binary, automation, sustainability, smart city, internet.

1. INTRODUCTION

Digitalization is the key to unlocking solutions and opportunities to everything. According to projections, "nearly 65-70% of the world's population will live in urban areas by 2050, while many megacities are struggling to handle the alarming increase of inflow of people" [1]. It is essential to idealize metropolises and megacities and primarily "to create smart cities in order to make urban areas more livable and truly sustainable [2]. An eco-city or sustainable city, the smart cities aim to improve the quality of urban services or reduce its costs". Cities can also be made more sustainable by turning their homes into batteries [3].

1.1 Smart manufacturing

Intelligent manufacturing refers to the process of monitoring the production process by machinery connected to the internet. Smart manufacturing of each building block and other units for different kinds of utilities contributes to the conception of a Smart city [4].

1.2 Smart building materials

Each building materials type such as bricks, cement, sand and their types, is to be manufactured using internet-connected machines [5].

1.3 Smart Construction

The use of machines from small scale to large scale controlled via the internet should be encouraged for construction purposes. This would reduce the need for a large number of labours at the construction sites, as well as accelerate the building process [6].

1.4 Smart Home

The use of smart devices such as Alexa and Google Home in private homes would improve the way of living using smart voice assistants. When these devices are connected throughout the building and all its appliances are running, a lot of electricity and energy can be consumed [7].

1.5 Smart building

Smart voice assistants and sensor assistant devices should be applied to public buildings as well as corporate buildings to save energy and resources [8].

1.6 Smart Security

The security system plays a crucial role in preserving the health of society, as well as preserving the resources including wealth, power and energy. It is necessary to maintain security from the home level to the level of defence. CCTV (Closed Circuit Television) systems, smart door locks, and mini vaults should be installed in each home. Using a smart GPS (Global Positioning System) along with a higher bandwidth of internet connection, local security should be able to view my movements and act within seconds. Defence should have smart weapons and defence systems suitable to their needs [9].

1.7 Smart Transport

Vehicles should be powered by low emission fuels (LEF) or, better yet, zero-emission fuels (ZEF) to reduce pollution in the area. Every vehicle, private as well as public, should have a GPS tracking system to ensure passenger safety and health, as well as provide records and safety measurements in case of an accident. Internet and technology can be used to control traffic systems from a master computer in a control room, therefore reducing the need for human traffic control [9]. The control room can even be used to monitor illegal activities. Human traffic patrols should be encouraged nonetheless. Construction of adequate roads, railways, and bridges should be a priority, ensuring their proper use when and where necessary. A better, faster, and more secure way of transportation should be developed for air travel and its stations [10].

1.8 Smart Energy:

The production of energy plays an important role in reducing pollution. Using more green energy, such as wind, water, or solar, can reduce pollution to a minimum. Thus, using any kind of fossil fuel energy should be discouraged [11].

1.9 Smart Waste Management

Using modern equipment, nothing should go to waste. Any kind of waste can be utilized as required. Mostly biodegradable wastes, that are organic, are usually left out for decomposition in nature. But with proper care, they should be recycled and reused. Artificial polymer fibres like plastic should not be dumped in nature, rather they can be recycled into other forms to be reused as required [12].

1.10 Smart Resources:

The economy and resources should be preserved securely for enhancing the livelihood of each and everyone living in the city. Installation and maintenance of smart devices and machinery cost a huge number of resources. Availability of daily requirements including foods and hardware equipment should be sustained within the city. A government should be formed by the people themselves for the proper running of the city and its developments. Schools/colleges have to be set up to provide proper education and preach a better way of living to the upcoming generations. Children should have abundant time and place to play and to be nourished in the greens. Hospitals and other health care organizations should be set up with proper technologies and equipment to keep the city safe from diseases [13]. The government should look after newer and better ways for sustaining the way of living, forming a proper set of regulations and rules.

1.11 *Smart Atmosphere*

A vision of a proper pollution-free environment is to be obtained within the city. This enhances the wellness of living beings. Any kind of emissions from factories, wastes should be controlled using the required techniques which would keep the pollution of the environment in check. Water bodies and biosphere should be well reserved to secure the sustaining conditions for every bio-organisms. Bio labs are to be set up within the city to preserve the atmosphere [14].

1.12 *Smart City:*

All the small elements from their manufacture to utilization should be performed using green energy ensuring proper use of technologies and safety protocols. When all these are present in a particular area or city then that city can be called a smart city [3].

1.13 *Turning Home into Battery:*

A rechargeable cement battery has been becoming a realistic possibility changing the way to store energy by turning the walls of your house into a giant battery. "Researchers at the Chalmers University of Technology in Sweden developed cement batteries that can store around 10 times more energy than previously developed structures, even though at the moment they are still hundreds of times less energy-dense than a lithium-ion battery. It can help transmit and distribute electricity and store energy from renewable sources like solar and wind power. Batteries can help compensate for times when the sun is not shining or the wind is not blowing". Here the technology works as, the concrete layer is sandwiched between iron-coated carbon fibre mesh (anode layer) and nickel-coated carbon-fibre mesh (cathode layer) attached with a solar panel, which will store energy and can be used when needed [16].

2. IMPACT ON SOCIETY AND FUTURE DEVELOPMENTS

With the increase in population, pollution and crime the requirement for smart city civilization has been increasing each day. A smart city ensures the proper way of living keeping pollution, crime and biosphere in check such that people and other living beings find it sustainable and economic. In recent developments, the concept of electric vehicles has been an uprising and been produced in ample quantities showing very less pollution along with green energy. However, the installation cost is heavy for most people and availability and production of smart equipment in abundant quantity is not yet possible, which makes up another reason for every city not developing to be a smart city. Whereas there has been a huge scope of its development in future when the products would be manufactured and be available enough and the people should have proper idea about its benefits to encourage building up more and more smart cities in future [15].

3. RECENT IMPLEMENTS

The United Nations has predicted that “70% of the world’s population will be living in cities and urban areas by 2050, lesser emissions and green energy usage will continue to rise with every passing year. The need for smarter urban transport networks, environmentally-friendly water disposal facilities and buildings with high energy efficiency are critical than ever. The annual report, conducted by the Institute for Management Development with Singapore University for Technology and Design (SUTD), ranks cities based on economic and technological data, along with their citizens’ perceptions of how *smart* their cities are”. “Singapore, Helsinki and Zurich have topped the list as the world’s smartest cities in the 2020 Smart City Index”. As more countries and cities continue to take up the smart city movement, smarter ways of living could be adopted with each passing year [1].

4. DRAWBACKS

However smart a city may be, utilizing all forms of renewable sources and waste products to develop a healthy and smart lifestyle, but setting up a smart city costs a huge amount in the first place. The equipment is not at all affordable for everyone. Even the maintenance cost is huge. Security management is a huge sector in smart city management. Setting up smart security in industries and every household is a challenge for the government of every country. Thus, worldwide acceptance of smart cities is practically impossible.

5. CONCLUSION

A smart home is highly beneficial to their users. Communicating, exchanging data and triggering action is much easier now with the use of smart home devices. Processes can be automated and schedules can be created engaging multiple devices. In terms of smart city, the innovative security system, transport and green energy play a hugely beneficial role in the everyday life of the people living in a smart environment. Regardless of all the benefits, the investment and maintenance costs have been the hardest hurdle to cross. Proper preaching about the benefits and putting an impact of the idea of a smart city in public may help a way out to have more smart cities in future days.

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A detailed study of Automation Techniques at Home that contribute to Energy Efficiency

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Abstract.

Witnessed with the increase in energy consumption and population, there is great concern to conserve energy in every possible way. Lack of access to and management of electrical equipment from remote areas is one of the main causes of power loss. Therefore, the concept of smart house is gaining attention a few years ago. The current 'system' is also ready to solve one or two of those problems. However, a smart home automation 'system' is not only secure, but, nevertheless, even the most intelligent understanding process and analytical talents have. This method will create the use of 'Wi-Fi', 'GSM', 'Bluetooth', 'ZigBee' completely different governing devices are available in existing 'system's. The Internet or associate degree application automaton is used by users to provide directions to those 'system'. These applications are already available in a few places for a large variety of applications. Also, an automatic home reduces excess energy loss and helps save energy. This paper presents a survey of all these 'system's associated with energy efficiency.

Keywords. Energy saving, Electrical and Electronics, Devices, Home Automation and System

1. INTRODUCTION

The electrical along with its applied entities in relation to the given concept in any area that includes electrical equipment such as air conditioner, fan, T.V, motor, heater, lighting 'system's, etc. and is controlled using software as a virtual connector, which integrates the Android 'system' and the web 'system'. Such remote access 'system's already exist in the market, but they also have many drawbacks. This paper aims to research all such existing programs and compare the available features.

2. STRATEGIES

2.1. Home automation through GSM

This type of 'system' provides three home management methods: Internet, GSM network and voice [1]. Real-time monitoring is a smart utility application 'system' that can be used in changing home 'system's. In the event of a change in device status, the user may be notified in real time. User instructions are transmitted to a server usually generated by the PC [2]. The server runs operations on user commands and pushes them to the appropriate units. It helps control and operate electrical items.

This method establishes a connection in areas where lack of proper internet connection is there. The server processes 'AT commands' to connect to the 'GSM modem' [3]. The server has four active engines - a web server, a website, a central control 'system' and a speech recognition 'system'. SMS technology is equipped to control the commands in this 'system', like verification messages. Speech processing works on a flexible folding algorithm [4]. Testing this 'system' with voice processing, it was found to be less effective. Alternatively, voice input can be activated with the wireless unit present. Every node of the application has four components - transmitter, receiver, Input / Output device and 'microcontroller' [5]. The main server controls 'system' that captures data like status information on the device in real time.

The next advancement was the introduction of GPRS or General Packet Radio Service [6]. This application prefers to run on SMS and 'Attention commands'. There is a PC which acts as a command center. GSM dialing and communication 'system' are embedded in PC. The PC receives the messages and executes the required commands. For any application, this 'system' can be tailored. Any mechanical devices can be operated via the sensors that transform electrical signals into 'mechanical signals' from this 'system' [7]. But it can't be used as a 'real-time control 'system'' as it does not give feedback.

The head (main) server is built on an "SMS / GPRS mobile module" with a small controller, like "Java-enabled" phone. This paper also introduces the design and implementation of an "AT modem" driver [8]. It is a text-based command processing software which operates through a 'microcontroller'. Mobile phones provide an easy-to-use interface which work by sending commands and receiving feedback from the 'system'. Password-based verification 'system' must be used to ensure security. But this 'system' is not so reliable as SMS charges are high, slow and prone to attackers.

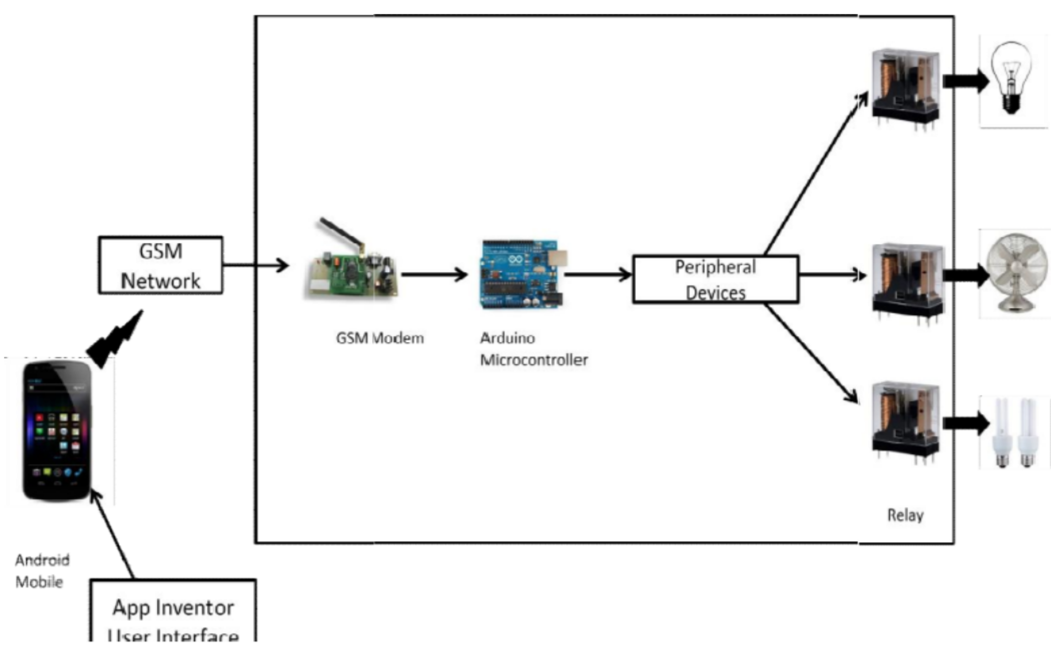

Figure 1 - GSM based HAS

2.2. Home automation with 'Bluetooth technology'

The 'Bluetooth technology' is secure along with low cost feature [9]. It uses Arduino and Bluetooth module. An active python application is used on mobile phones to provide a user interface. Bluetooth board Input / Output ports and slides used to communicate with devices with user instructions. Password protection feature of 'bluetooth' makes it a safe technology. Hence, it ensures that "the 'system' is secure and not misused by any attacker". Bluetooth has a short-range operation of 10 to 100 meters It has 2.4 GHz bandwidth and 3 Mbps data transmission speed [10]. It is fast and efficient. It can detect problems in the 'system' and send feedback accordingly. The con about 'Bluetooth' is that it is time-taking to find active devices near it.

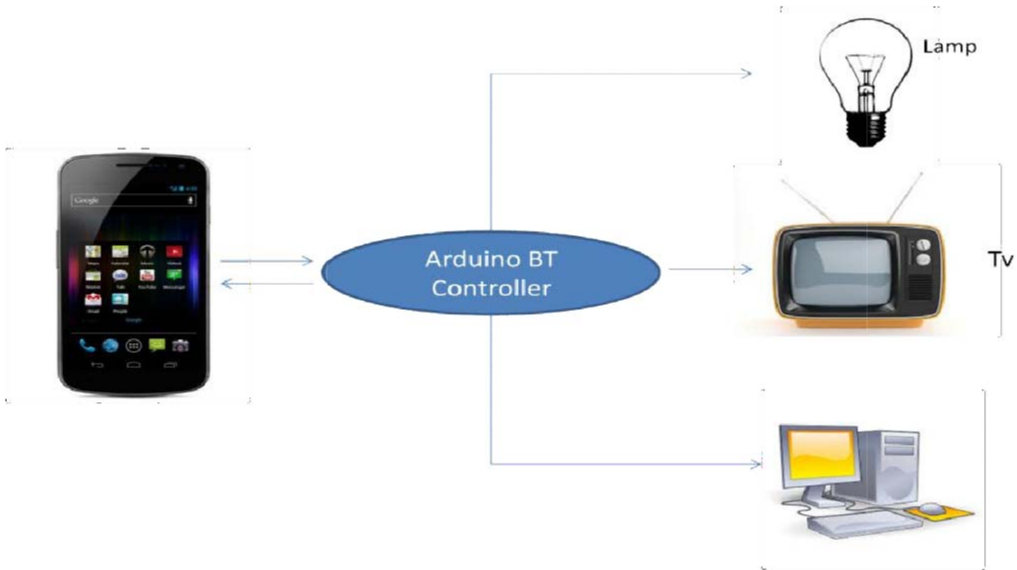

Figure 2 - Bluetooth based home automation

2.3. Phone based short range home automation

Permissive 'system' is a 'system' that exercises special abilities to provide a standard technical brochure for 'home automation' [11]. It offers an automated home 'system' which facilitates utilities such as a "controller", 'wide house wires' and "a common interface". This will allow you to use the existing 'system' for home automation. Remote control based on hardware control panel is defined [12]. The remote control functions the power provided to remote devices. The 'system' uses the phone line to transfer instructions. The controller eliminates the costs used as of microcontrollers. It uses a ' DTMF' transceiver connected to a "solid state relay". This controls power supply. It can also be used for testing of infra red signals and the company's AC power network technology. The home automation 'system' uses 'dual tone multi frequency' or 'DTMF' which exists in telephone lines [13]. This 'system' has three divisions. First, the 'DTMF receiver' and 'the ring detector'; after that is the IO interface unit; and the final component is a PC that performs online functions. The PC in this 'system' searches for the line ring and confirms the user.

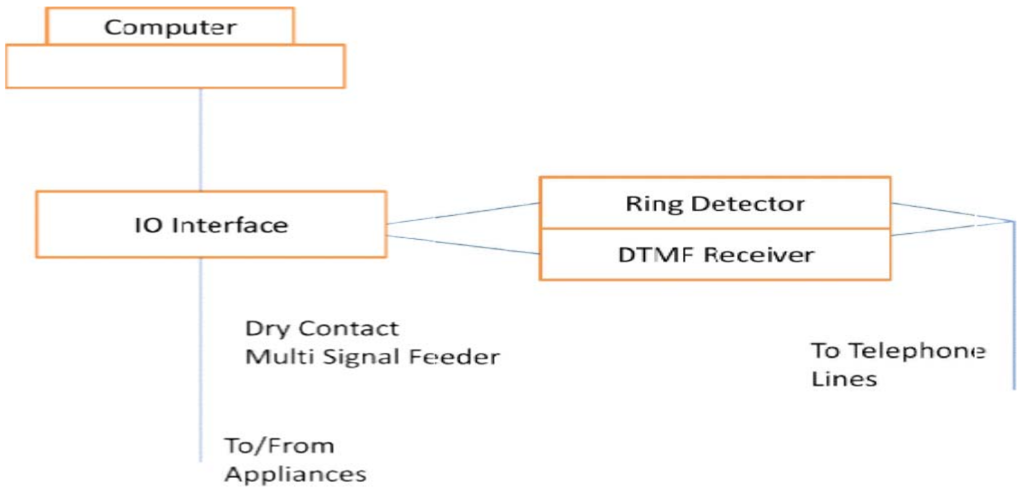

Figure 3 - Smart Control ‘system’ for remote control of telephones

2.4. Home automation with the help of ‘Zig-Bee’

‘ZigBee’ can be implemented to enable automation at home [14]. It is a wireless communication technology. It uses a small PIC controller and voice-recognition for its functioning. Voice-recognition technology compares the voice command in a block and processes further. Then the command is transmitted to the receiver element by the PIC controller via ‘ZigBee’. The receiver also has a PIC controller that can process the incoming commands. Relays are used to operate the appropriate equipment. “ZigBee” is a “low-level communication system”, so “remote access” is limited to remote locations. Also, “the voice module” may be uncontrollable. This ‘system’ is very useful and has various applications like, if any smoke is detected in home, it alerts the user via the ‘built-in cell’ phone number of the user.

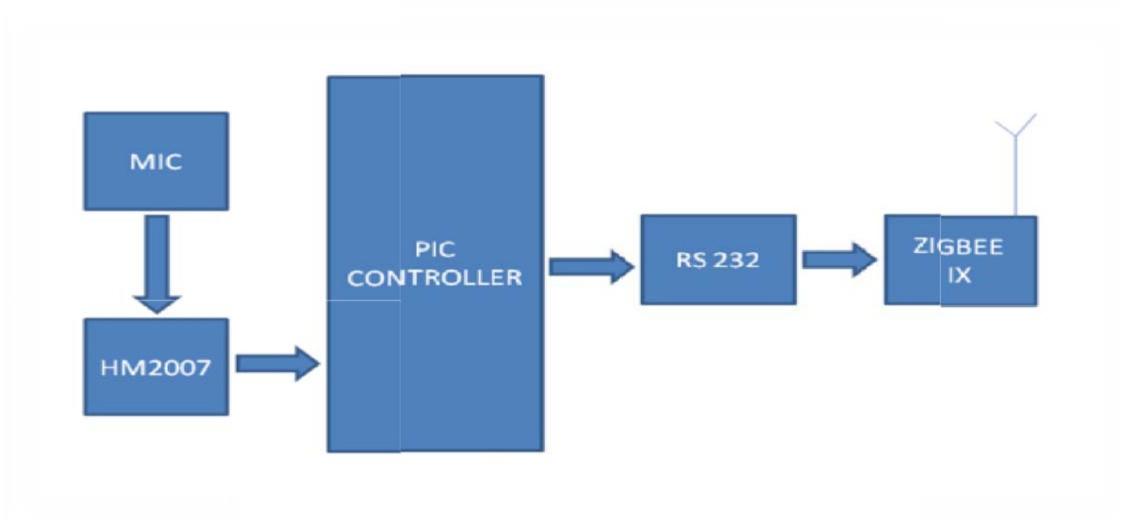

Figure 4 - Transmission Unit flowchart and elements

2.5. Home automation via Wi-fi

'System's that use wireless connections can be made by connecting independent electrical appliances located in the home or office and integrated into a co-operative network. 'Wi-Fi' and 'Bluetooth' can be used together for integrating a 'system'. A transparency is entitled in the network with the global power of "Plug and play" technology. The 'system' uses "Open Service Gateway Interface (OSGi)" [15]. The machines are connected by many inter-connected network technologies. User application layer uses web browsers, pocket PC can also be used to control electronic items. Linux environment provides the processing medium for the functioning of this integrated 'system'. A device can be identified in the network by this 'system'. It is best to work with "pattern-recognition", sensors and "intelligent control modules". The program features "the ability to add intelligent control modules". The "control module" poses the capacity to extract information and perform 'pattern recognition'. The universal "plug and play system" uses various unique protocols to work together. The makeable utilization of the "system" is its "interoperability" [16].

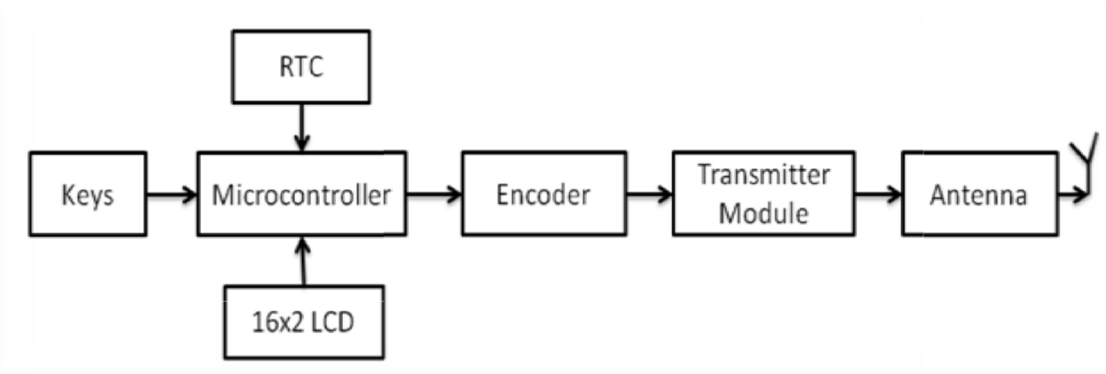

Figure 5 – Transmitter Section flowchart and elements

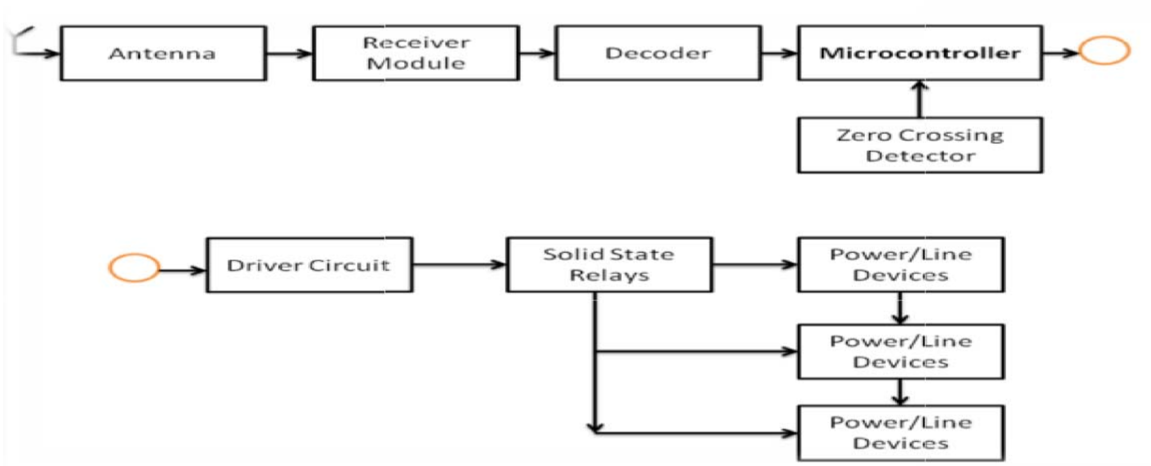

Figure 6 – Receiver Section flowchart and elements

2.6. Home automation using Mixed Type

Home automation cab ne done via any of ‘GSM’, ‘Bluetooth’, ‘ZigBee’, ‘Wi-fi’ or a combination of these. Communication can be done through an app on Android platform. The app takes a user input, may be in voice or any form of data and transmits text instructions. These instructions are sent via SMS to a phone at home. This ‘system’ is known as a “remote control unit” [17]. This remote control unit sends commands to the ‘ZigBee Transceiver’ which in return processes these commands via ‘ZigBee’ and transfers to the chief controller. “The main controller translates the commands and performs the required function which also sends status feedback via ZigBee”. This ‘system’ is very practical and readily usable. But, the whole ‘system’ installation and implementation incurs little more cost than usual. This is because it uses technologies.

Many unusual home automation ‘system’s are available in combination with the GSM and “FPGA (Field Programmable Gate Array) system” [18]. The “FPGA” provides flexibility to be customized by the required application by the user. In comparison to a microcontroller, it stands cost efficient. Hence, overall ‘system’ is deployed at a lower cost. “FPGA” is connected to the “GSM modem”. The “GSM modem” interacts among the devices. “FPGA” decides functioning about the equipments. “UART” implementation enables connection in-between “GSM modem” and “FPGA”. Real-time programs use this automation widely.

3. CONCLUSION

On the whole, the paper tries to collate the programs available in the script so far. The ‘system’s tested have some similar features. All of these programs use basic communication techniques. Now, there exists some advantages and disadvantages of the “system” are found in this basic technology. Each one of the above ‘system’ includes a control circuit which function the electrical equipment. A standard command ‘system’ is used to execute instructions in the control circuits. “The user interface determines how the user will interact with the system” and therefore, design the level of control needed in the ‘system’ [19]. This is necessary as it affects the performance of the ‘system’. “Many ‘system’s also have security features to ensure authorized access only.”

GSM ‘system’ heavily depend on use of SMS messages to transmit user-issued commands to the central home ‘system’. This ‘system’ provides the facility to function electrical items from anywhere in the world. However, the costs incurred may be significant depending upon the location. On the other side, there are certain drawbacks too. Delivery of a message is unreliable and uncertain. Real-time ‘system’, thus, do not use GSM technology.

The ‘Bluetooth’ ‘system’ relies on a smart-phone or a PC acting as the receiver element. At home, the Bluetooth function can provide complete control of household entities as long as the user is in the specified range. It can serve as a ‘real-time’ program. There is security feature in Bluetooth technology as well as transmission speed. But, it cannot provide control outside its range. Bluetooth distance range is 10 meters which marks a drawback of this ‘system’.

“ZigBee” is another technology parallel to “Bluetooth”, which has identical pros and cons as of ‘Bluetooth based system’, but slightly better because it does not have a range factor.

‘Wi-Fi systems’ can use a number of communication technologies and devices. It can be implemented in ‘real-time systems’. Spectrum availability is the only factor pulling it back; otherwise, the signals are very wide and offer great options for remote access.

Many existing ‘system’ uses a combination of methods to compensate for their individual obstacles. Such integrated implementation may give rise to sound ‘system’. The lone factor is that, it can affect such programs is the cost of programs and the possibility of duplication.

The “User-Interface (UI)” is another feature where ‘system’ is very different. Previous ‘system’s used with little or absolutely no user interface feature allowed the user to enter commands in the controls. But now-a-days, in smart automated ‘system’s, they have an intuitive UI and much attention is paid to its design and fabrication. The most abundant choice for this ‘system’ is a smart phone. Smart phones are often a useful tool for controlling changing ‘system’s at home. Another option for using web applications is that it may work in browsers.

A quick walk-through of the various technologies for home automation is given below [18].

System	**Primary Communication**	**Remote Access**	**Count of Devices**	**Cost**	**Speed**	**Real Time**
GSM	SMS messages	Anywhere	Unlimited	High	Slow	No
Bluetooth	Bluetooth and AT commands	Within 10 metres	Unlimited	Low	Fast	Yes
Phone Based	Phone lines	Anywhere with a phone line	12, due to 12 frequencies of DTMF	Average	Fast	No
Zigbee	Zigbee and AT commands	Around 10 metres	Unlimited	High	Fast	Yes
Wireless	Radio/infrared Or other waves	Depends on Range and Spectrum of Wave used	Unlimited	High	Slow	Yes

Table 1: Microscopic Comparison Report of all ‘systems’

Summarizing all the tested programs and their advantages and disadvantages, this paper introduces features that should have a good 'home automation' 'system' with 'remote access'. Availability of the most feasible and efficient program worldwide will be showcased in the upcoming time to the user and in real time. One guarantee that access can always be made available through the internet. This will create a general access point for household entities exercising the "Internet Protocol (IP)". The displayed information must be a "web application" with an inter-linked "mobile application" that the user will interact. Only then w e can automate homes, ready to be able to trade. Homes can be connected to various sensors like, 'light sensors', 'smoke sensors' and 'temperature sensors' and provide automatic device-based switching. Additional power can be saved by marking the seal that the home stays afloat before turning on the devices and regular inspection of the lights and turning off the lights when not necessary. The further span would be to stretch the program to a larger scale, such as warehouses, corporate offices, factories and other workplaces.

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Use of Autoclaved Aerated Concrete Blocks as Energy Efficient Building Construction Materials

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Abstract.

In the history of building construction, brick is one of the oldest of all materials used. Bricks are very widely used building material due to very low manufacturing cost and simple manufacturing procedure. Generally, bricks are used in partition wall and main wall of building. Brick masonry takes time in construction of wall and other components of building. So, a new masonry technique for building construction is required [1,5]. Autoclaved Aerated Concrete (ACC) block is a light weight concrete block and its weight is 1/5 of than that of concrete block to reduce dead load of wall and other components. AAC block have more air bags due to which weight of AAC block is very less as compared to ordinary concrete block [12]. The manufacturing of ACC blocks requires cement, sand, fly ash, gypsum, lime, aluminium powder and expansion agent. AAC blocks are very excellent material for construction site due to its energy efficient and it is ecologically friendly concrete. This paper presents the properties of ACC blocks and its advantages compared to other construction materials.

Keywords. Autoclaved Aerated Concrete, Energy Efficient, Aluminium, Fly ash, Cellular concrete, Lightweight concrete.

1. INTRODUCTION

Autoclaved aerated concrete (AAC) is a technology in masonry construction where special type of concrete is used for manufacturing of blocks. These blocks have special characteristics, so these blocks have good demand in construction industry. These blocks are porous and light in weight to decrease dead load of structure. AAC blocks have thermal resistance and sound resistance. Due to its low density, unique thermal and breathing properties, and high fire resistance, AAC is one of the most commonly used light-weight construction materials for contemporary buildings [2]. ACC structures also have earthquake resistant in nature. If AAC blocks are used in building construction then cost is comparatively less as compared to other traditional buildings and also time of construction of building is less compared to traditional building. ACC completely replaces the other construction materials like brick, stone, wood because of good fire resistance, sound resistance, less in cost, less time consumption in construction of structures as compared to other building material. In addition, AAC blocks are very excellent material for construction site due to its energy efficient and environmentally friendly concrete [5,6].

Figure 1.1 Autoclaved aerated concrete block [14]

2. RAW MATERIALS OF ACC BLOCKS

Cement: Cement is a binding material which is use in construction of building and other structure. In Autoclaved Aerated Concrete we use OPC 53 grade of cement and density of cement is 1440kg/m^3.

Fly Ash: Fly ash is a by-product of the construction industry that is used to save money. Fly ash density varies between 400 and 1800 kg/m^3 [6,7]. It provides sound absorption, heat insulation, and fire resistance. Class C fly ash was employed, which includes 20% lime (CaO) and has a loss of ignition of less than 6%.

Sand: Sand is a crushed material of rock which is use in concrete as fine aggregate. We use fine sand as per codal provision IS383:1970.

Lime Stone: Limestone is made up of calcite aragonite. Limestone is obtained by crushing it to a fine powder at an AAC factory or by acquiring it in powder form straight from a merchant.

Aluminium Powder: Aluminium Powder mix in concrete and this powder works as an expansion agent. When the raw material reacts with aluminium powder, air bubbles are formed as a result of the reaction of calcium hydroxide, aluminium, and water, and hydrogen gas is generated. [9].

$$2Al+3Ca\,(OH)2 +6H2O \longrightarrow 3CaO.Al2O3.6H2O +3H2 \qquad \text{eq. (1)}$$

Gypsum: Gypsum is a common building material that comes in powder form.

3. PHYSICAL PROPERTIES OF AUTOCLAVED AERATED CONCRETE

The density of autoclaved aerated concrete affects several of its physical qualities. The density of autoclaved aerated concrete classify in European Norms are show in table below:

Table 1. Density Classes of Autoclaved Aerated Concrete

Sl. No.	Density class	Dry density (kg/m3)
1	300	250 - 350
2	400	350 - 400
3	500	450 - 500
4	600	550 - 600
5	700	650 - 700
6	800	750 - 800
7	900	850 - 900
8	1000	950 - 1000

AAC have wide range of density and no other industrial product that covers such a range in apparent density. In AAC we use 350 kg/m3 or more Density use for load bearing purpose and less than 350 kg/m3 density use for thermal insulation purposes [12]. Density is related to water/cement material ratio of the mixture since it is related to the amount of aeration obtained. For a given density, water/cement ratio increases with proportion of sand.

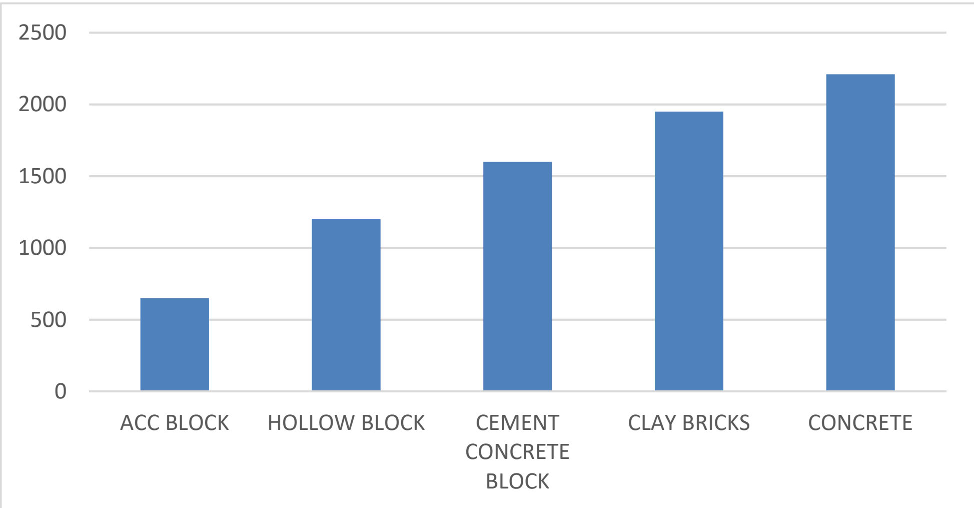

Figure 3.1. Density comparison Autoclaved aerated concrete block

3.1. Size of Autoclaved Aerated Concrete

Generally used autoclaved aerated concrete size is 600mm X 200mm X (75mm to 300mm). Autoclaved aerated concrete block height is varying according to requirement of construction. Size of autoclaved aerated concrete is more than clay brick (230mm X 115mm X 75mm) so they are placed easily at location and cover more area as compared to clay brick. when we construct two walls of same size by autoclaved aerated concrete blocks and clay brick than we find that time consumption in both walls is different and difference is surprisingly affecting our work tradition because autoclaved aerated concrete blocks wall takes just half time of clay brick wall [10]. Working with autoclaved aerated concrete blocks is very simple and easy to understand.

3.2. Compressive Strength of Autoclaved Aerated Concrete

Compressive strength of autoclaved aerated concrete is more than general clay brick. Generally, we use clay bricks in building construction and these bricks compressive strength (2.3 N/m2 to 3.5 N/m^2) is less than AAC blocks compressive strength (3 N/m^2 to 4.5 N/m^2).

3.3. Normal Dry Density of Autoclaved Aerated Concrete

Normal dry density of autoclaved aerated concrete is much less than general clay brick. Dry density of any material is directly affecting the water absorption capacity of material [10]. Autoclaved aerated concrete blocks required less curing as compare to clay brick.

Table 2. Dry Density of Autoclaved Aerated Concrete

Property	Autoclaved Aerated Concrete	Clay Brick
Dry density(kg/m3)	550-650	1800

3.4. Other physical properties of Autoclaved Aerated Concrete

Many physical properties of Autoclaved Aerated Concrete are use in engineering works. Different engineering properties are use in different works. Some Physical properties of Autoclaved Aerated Concrete are given bellow:

Table 3. Physical Properties Autoclaved Aerated Concrete

Sl. No.	Property	Autoclaved Aerated Concrete	Clay Bricks
1	Sound Reduction Index (Db)	45 for 200 mm thick wall	50 for 230 mm thick wall
2	Fire Resistance (hr)	2-6 (depending on thickness)	2

3	Thermal Conductivity,K (W/m-K)	0.16-0.18	0.81
4	Drying Shrinkage (%)	0.04	-

4. ECONOMIC CONSIDERATION

When we make a simple building than first factor which affect directly to owner is economic condition. Now days a building construction is a very difficult for medium economic condition family because cost of a simple building is very high and medium economic family cannot bear cost of a building. If we use AAC block than cost of building decrease and strength also increase [11,13]. Some Parameter is given below which show that how cost of building affected by AAC block.

Structural Cost: Every concrete structure requires steel for bearing tensile load of structure. If we use Autoclaved Aerated Concrete in structure than we save up to 15% of steel.

Cement Mortar for plaster & masonry: Quantity of cement mortar is less required in Autoclaved Aerated Concrete Blocks because they have regular shape and less no. of joints as compare to clay brick.

Breakage: AAC blocks have good strength and light in weight so they do not break easily. AAC Blocks generally break less than 5% and clay brick break average 10 to 12%.

Construction Speed: Speed in construction of Autoclaved Aerated Concrete block is very fast as compare to clay brick [3,7]. Autoclaved Aerated Concrete block have large size so speed of construction is obviously increase.

Quality: Autoclaved Aerated Concrete quality is very good because they are manufacture in industries and clay brick have average quality.

Carpet Area: Carpet area of Autoclaved Aerated Concrete is more because less thickness of walling material as compared to clay brick.

Availability: Autoclaved Aerated Concrete blocks available every time and clay bricks generally not available in monsoon.

Energy Saving: Autoclaved Aerated Concrete reduce air-conditioned load approx. 30%.

Chemical composition: Sand, fly ash used around 60-70% which reacts with lime & cement to form Autoclaved Aerated Concrete and in clay brick soil is used which contains many inorganic impurities like sulphates etc. resulting in efflorescence.

5. CONCLUSIONS

- AAC blocks have a higher compressive strength than ordinary clay bricks.
- AAC blocks have a density that is 1/3 that of ordinary clay bricks, and there is no change in wet conditions.
- Structures with autoclaved aerated concrete have less dead weight.
- Cost of construction reduces up to 30%.
- The energy used throughout the manufacturing process produces no pollutants, by-products, or harmful waste products.
- The workability of AAC helps to eliminate waste on the job site.

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