
A Design and Implementation of Jet shrouded Wind Turbine System

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Abstract.

Scalable and sustainable energy sources are required for the entire world. When wind energy conditions are not predictable, the conventional wind turbine frequently faces difficulties. In order to investigate pressure distribution, velocity, and efficiency, this paper uses LABVIEW simulations to analyze the design and performance of jet turbine systems. The study examines how the system performance configuration greatly improves turbine efficiency when compared to traditional designs by modelling the shroud design of a jet turbine. This makes it a promising method for small, decentralized wind energy applications. The hardware-in-the-loop testing of the jet wind turbine system is based on this work. LabVIEW simulations were used for performance analysis to assess torque generation, power output, velocity enhancement, and pressure distribution.

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Keywords: Jet Wind Turbine; Wind Energy; LabVIEW Simulation; Renewable Energy; Energy Efficiency.

1. INTRODUCTION

The growing demand for clean energy has increased interest in wind power. Conventional wind turbines have limited efficiency under low and variable wind speeds due to turbulence, yaw misalignment, and insufficient airflow. This study proposes a compact jet wind turbine that accelerates airflow to improve energy extraction while requiring less installation space. Since wind power increases with the cube of wind speed, enhancing airflow velocity can significantly improve turbine output.

2. LITERATURE SURVEY

Previous studies have explored shrouded and vertical-axis wind turbines to improve wind energy extraction [1–2]. Research has also examined yaw control, turbulence effects, blade shapes, and generator parameters for improved efficiency [3–5]. 3D modelling and printing techniques have been used for optimized turbine designs [6], while helical-blade turbines have shown potential for efficient electricity generation in rural and emergency applications [7].

3. JET WIND TURBINE SYSTEM

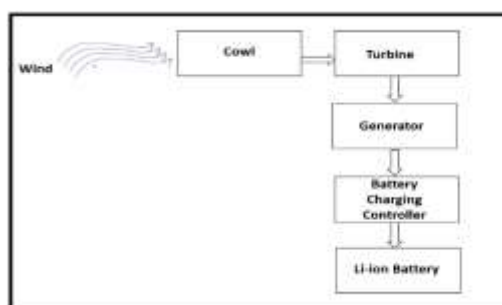


Figure 3.1. Block diagram of Jet Wind Turbine System

In this proposed system wind is blow with 20m/s and directed towards the cowl shape wind turbine. The cowl shape structure utilizes the more wind energy which is input to the jet

wind turbine. The generator generates the power which is controlled by TP4056 battery charging controller. The output is tested by connecting the two series Li-Ion rechargeable batteries with successfully charged up to 5.6V.

Work	Flow Acceleration	Compact Design	Simulation Validation
Variable Speed [1]	NO	NO	YES
Wind Lens Turbine [2]	YES	NO	YES
Blade Optimization [5]	NO	NO	YES
Cowl shape jet turbine	YES	YES	YES

Table 3.1.1. Comparative Analysis of Jet wind Turbine

3.1. Calculations

The system consists of,

- i. Converging duct (cowl)
- ii. Cambered rotor blades
- iii. Shaft coupling
- iv. Generator
- v. Li-ion battery
- vi. Battery Charge Controller

Power equation used:

$$P = \frac{1}{2} \rho A v^3 C_p$$

Where,

ρ = Air Density

A = Swept Area

v = Wind Velocity

C_p = Power Coefficient

3.2 Theoretical Calculation:

In conventional Wind Turbine,

$v = 20 \text{ m/s}$

Diameter = 0.27 m

$\rho = 1.2 \text{ kg/m}^3$

Calculated Power $\approx 274 \text{ W}$

3.3 Efficiency improvement:

Jet turbine aerodynamic efficiency: 0.45

Jet turbine mechanical/electrical efficiency: 0.9

Conventional turbine aerodynamic efficiency: 0.35

Conventional mechanical/electrical efficiency: 0.8

$$\text{Efficiency improvement} = \frac{0.45 \times 0.9}{0.35 \times 0.8} = 1.45$$

For Conventional wind turbine Power

$$\text{output} = 274 \times 0.28 = 76.7 \text{ Watt}$$

$$\text{For Jet Wind Turbine Power output} = 274 \times 0.405 = 111 \text{ Watt}$$

4. RESULT AND DISCUSSION

4.1 Simulation Results:

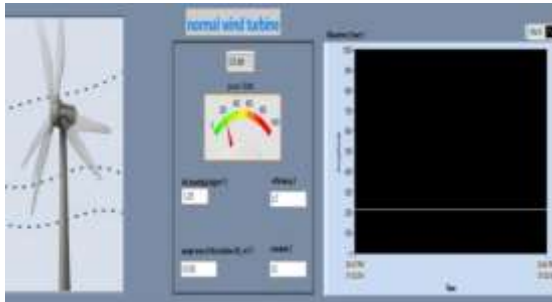


Figure 4.1. Conventional Wind Turbine Simulation in LABVIEW

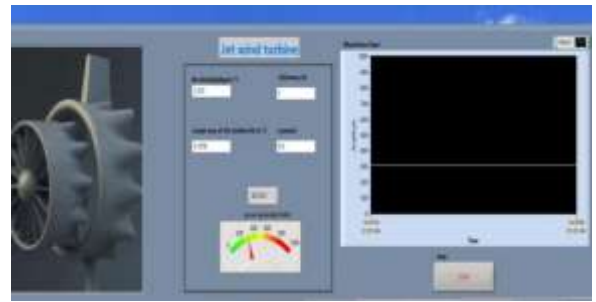


Figure 4.2. Jet wind turbine Simulation in LABVIEW

4.2 Hardware Results:

The shrouded configuration lowers turbulence losses and greatly increases airflow concentration. Figure 4 shows the prototype model of jet wind turbine.

Overall efficiency by about 1.45 times when compared to conventional turbines under the same environmental conditions. In this model, two 3.7 V rechargeable batteries are connected in series to show the working of the jet wind turbine and to store power in a stable way.



Figure 4.3. Prototype of Jet Wind Turbine



Figure 4.4. Discharge Battery



Figure 4.5. Charged Battery

The system shows higher torque, lower turbulence losses, and better stability. Rooftop installations, telecom towers, urban renewable energy systems, and hybrid solar-wind energy systems are examples of applications. Because wind speed and power have a relationship, the results verify that airflow acceleration significantly boosts power output. The jet configuration stabilizes output performance and enhances torque generation.

Deployment in rooftop and urban installations is made possible by the structure's compact size. Never the less, additional experimental validation and analysis are needed.

5. CONCLUSION

Conventional wind turbines are less effective in low-wind-speed regions. This study proposes a jet wind turbine that accelerates airflow to improve energy capture. LabVIEW-based monitoring showed approximately $1.45\times$ higher efficiency than a conventional turbine, with successful battery charging, demonstrating its potential for low-wind applications.

6. REFERENCES

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Biographies



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