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An Enhanced Artificial Hummingbird Algorithm Outperforms Established Metaheuristics in DMFC Parameter Optimization

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Abstract

Identification of the parameters is important to creation of precise performance models of direct methanol fuel cells (DMFCs) because some of the core internal parameters are not always covered in datasheets of manufacturers. This investigation introduces Enhanced Artificial Hummingbird Algorithm (EAHA) as an algorithm that is used to estimate the parameters that are not known, by minimization of the squared error (SSE) of the predicted and observed voltages. The efficiency of EAHA is strictly examined by means of comparative analysis with five known metaheuristic algorithms, namely: Particle Swarm Optimization (PSO), Dragonfly Algorithm (DA), Harris Hawks Optimization (HHO), Reptile Search Algorithm (RSA) and the original Artificial Hummingbird Algorithm (AHA). These findings demonstrate that EAHA has much reduced SSE (1.01E-10) and reduced computation time (0.127 seconds) compared to normal operating conditions and the reason behind its high accuracy and efficiency.

Keywords. Direct Methanol Fuel Cell (DMFC); Parameter Identification; Enhanced Artificial Hummingbird Algorithm (EAHA);

1. INTRODUCTION

The direct methanol fuel cells (DMFCs) technologies are gaining relevance due to the demand for clean energy around the globe. The principal advantage of DMFCs is their application in mobile power and combined heat and power systems, primarily due to their high energy efficacy, portability, safe refuelling, and low operating temperature characteristics, which are the main benefits. Nonetheless, they are constrained by critical issues, especially slow reactions, inactivation of catalysts, and acute mass transport issues [1-2]. The main guilty party to these transport issues is based on poor design of flow channels that deliver the fuel. Specifically, poor design of flow channels results in a lack of distribution of fuel and concentration of bubbles of waste gas (primarily CO2) in the gas diffusion layer (GDL) of the cell. This is called gas blockage that starves the catalytic layer of methanol fuel, seriously impairs the performance of the cell, and leads to tremendous loss of power [3-5].

2. FUEL CELL MOLDING

Fuel Cells Fuel cells are the devices that carry out the electrochemical reaction that produces electrical energy from the chemical energy, with the continuous supply of fuel and oxidizing agent to the system. Most importantly, they produce power and do not store power, like batteries; The main products of them are water and electricity.

3. BEING PROPOSED: ENHANCED ARTIFICIAL HUMMINGBIRD ALGORITHM (EAHA)

Artificial hummingbird algorithm (AHA) is a metaheuristic optimization algorithm that is centred on the remarkable memory and foraging behaviour of the hummingbirds. Hummingbirds are able to recall the position of food resources as well as the rate and duration of time needed to forage between the two sources of nectar, leading to very efficient foraging.

4. RESULT AND DISCUSSION

In order to determine the strength of the suggested Enhanced Artificial Hummingbird Algorithm (EAHA), the authors conducted an elaborate comparison of the main benchmark optimizers: Particle Swarm Optimization (PSO), Dragonfly Algorithm (DA), Harris Hawks Optimization (HHO), Reptile Search Algorithm (RSA) and the original Artificial Hummingbird Algorithm (AHA). This assessment was made on basis of DMFC technical specifications in Table .1 and the optimization constraints which were in Table 1 and Figure 1. To statistically verify, each of the algorithms was applied 40 times in MATLAB 2020a.

Table 1 Parameter Estimation of the Double Line-Fed, Direct Driven Induction Machine.

Parameters /Algorithms	α	C_1	β	R	j_{eid}	e_o **(V)**	**SSE**	r_{eq}	**Computation Time (Sec)**

Proposed Algorithm	0.7859	-0.4528	1.3024	1.0521	0.2541	0.745	**1.01E-10**	27.301	**0.127**
DA	0.5521	-0.2509	0.5481	2.0541	0.1428	0.7215	**1.21E-04**	24.524	**1.198**
PSO	0.4527	-0.7831	0.2145	1.8452	0.2015	0.7594	**1.00E-03**	15.624	**2.014**
RSA	0.3651	-0.2534	1.0547	1.3514	0.2017	1.0218	**1.31E-06**	17.964	**1.247**
AHA	0.2571	-0.8154	0.9654	1.8421	0.187	0.7524	**1.55E-08**	25.324	**1.001**
HHO	0.489	-0.7421	0.6524	2.6527	0.1534	1.6357	**1.15E-05**	19.051	**1.547**

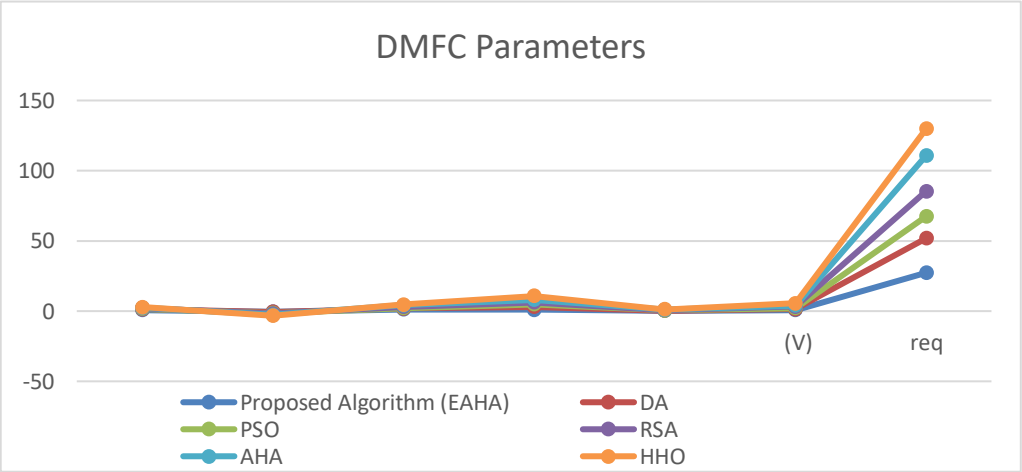

Figure 4.1. Estimation of DMFC Parameters Using Various Algorithms.

5. CONCLUSION

In this investigation, an EAHA was developed and tested in order to discover the key factors in DMFCs in an accurate manner. The EAHA functioning was strictly checked and achieved high results in comparison with a lot of popular metaheuristic algorithms, particularly, PSO, HHO, DA, RSA, and the original standard AHA. According to the results, EAHA demonstrates an overwhelming advantage in accuracy and computation efficiency. Under typical conditions it gave a very small value of squared error (SSE) of 1.01E-10 and was found to converge with solutions with much greater accuracy than any other algorithm across a variety of operating temperatures. This performance supports the fact that it can produce highly accurate DMFC models that highly replicate experimental behaviour.

6. REFERENCES

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