Economic Load Dispatch Using Moth Flame Optimization

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Abstract— This article suggests the use of the Moth- Flame Optimization (MFO) method in solving the Economic Dispatch (ED) issue, a latest optimization method inspired by nature. In accomplish the lowest cost of power generation, like ramp rate limits, restricted operating zones or engine operating limits, realistic restrictions are included. To illustrate the efficiency of the suggested method Four forms of phases are used spring and winter, autumn, fall weekday, and then MFO output is contrasted to other literature strategies. The findings indicate that MFO is able to achieve lower average costs than other protocols.

Keywords: Economic Dispatch, Economic Load Dispatch, MFO, Chaotic Maps, Optimal Power Flow

I. INTRODUCTION

Economic Dispatch (ED) is one of the complicated issues in the supply of electricity that attracts a great deal of attention from many scientists. ED's mission is to identify the optimum power generation to satisfy the needs at the reasonable expense by meeting all the constraints [1] Moreover, it makes ED a strongly anti control problem, especially for larger structures, by considering organizational and technical restrictions. Any changes in the efficient planning of production will lead substantially to long-term cost reductions.

In the past decades, various bio-inspired architectures are becoming common for solving complex mathematical functions [2]. Natural selection and meta-heuristic approaches are helpful in seeking the best comprehensive solution, since they both create a range of potential solutions in question.

In this paper, the recent established algorithm namely MFO algorithm has been implement to fix practical ED issues . MFO is motivated by moth's navigation at night suggested by [3]. The rest of the paper is organized as follows. Section-II discuss the ED problem formulation followed by the MFO algorithm. Section III presents literature survey regarding ELD. Section IV presents the proposed Methodology and flowchart. Section V presents the results and discussion. Finally, the conclusion is stated in Section VI.

A. Economic Dispatch

Economic Dispatch (ED) is about to found optimal power generation at the smallest price to reliably serve the loads subject to the constraints. In ED, the cost function could be mathematical presented as the quadratic function, as obeys[4]:

$$F_i(P_i) = \alpha_i P_i^2 + \beta_i P_i + \gamma_i \quad (1)$$

$$\text{Min } f = \sum_{i=1}^{n} F_i(P_i) \quad (2)$$

here n is the set of generator units. Eqns. (1) and (2) are subject to the power balanced equation as equality constraint to be satisfied where could be described as obeys

$$\sum_{i=1}^{n} F_i(P_i) = P_{\text{Demand}} + P_{\text{Loss}} \quad (3)$$

here P_{Demand} is the total load demand, P_{Loss} is the average loss of the power device. Since the failures in the interconnected power device cannot be avoided, the B-coefficient method is utilized to measure the losses apart of load flow calculation, as obeys:

$$P_{Loss} = \sum_{i=1}^{n}\sum_{j=1}^{n} P_i B_{ij} P_j + \sum_{i=1}^{n} B_{0i} P_i + B_{00} \quad (4)$$

For the inequality constraint, The electricity production should be regulated within its specific boundaries, as followed:

$$P_{i\,(min)} \leq P_i \leq P_{i\,(max)} \quad i=1,2,\ldots,n \quad (5)$$

Besides that, the functional scope of all generators is constrained by recognizing the practical constraints by their ramp rate limits described as follows,:

$$P_i - P_i^0 \leq UR_i \quad \text{if generation is increased} \quad (6)$$

$$P_i^0, P_i - DR_i \quad \text{if generation is decreased} \quad (7)$$

here P_i^0 is the previous power generation of unit i. UR_i and DR_i are the up-ramp and down-ramp restrictions in MW/h of the i-th generator, respectively. The generator operation constraints with the ramp rate limit now becomes as obeys:

$$\max(P_i^{min}, UR_i - P_i^0) \leq P_i \leq \min(P_i^{max}, P_i^0 - DR_i) \quad (8)$$

A unit's possible operating areas could be calculated as follows[5]:

$$\begin{cases} P_i^{min} \leq P_i \leq P_{i,1}^{lower} \\ P_{i,j-1}^{upper} \leq P_i \leq P_{i,1}^{lower}, \quad j=2,3,\ldots,PZ_i \\ P_{i,PZi}^{upper} \leq P_i \leq P_{i,}^{max} \end{cases} \quad (9)$$

B. MFO for ED Problem

In fixing the ED issue, MFO is implemented by finding the optimum energy production values while rewarding all the constraints listed in section II. The amount of moths, or selection agents, and the extends are originally set. As represented in eq, the populace (candidate for remedy) is formed in matrix form. (10) in which the amount of moths is represented in the row and the column is the amount of dependent parameters to be optimized (power generation)[6].

$$M = \begin{bmatrix} m_{1,1} & m_{1,2} & \cdots & m_{1,d} \\ \vdots & \vdots & \cdots & \vdots \\ \vdots & \vdots & \cdots & \vdots \\ m_{n,1} & m_{n,2} & \cdots & m_{n,d} \end{bmatrix} \quad (10)$$

$$F = \begin{bmatrix} F_{1,1} & F_{1,2} & \cdots & F_{1,d} \\ \vdots & \vdots & \cdots & \vdots \\ \vdots & \vdots & \ddots & \vdots \\ F_{n,1} & F_{n,2} & \cdots & F_{n,d} \end{bmatrix} \quad (11)$$

$$OM = \begin{bmatrix} OM_1 \\ \vdots \\ \vdots \\ OM_n \end{bmatrix} \quad (12)$$

$$OF = \begin{bmatrix} OF_1 \\ \vdots \\ \vdots \\ OF_n \end{bmatrix} \quad (13)$$

In order to acquire the OF, every position of Moth is measured to give the final cost using the (2). Once the total cost for the admired moth has been acquired (upon redesigning with the flames as eqn. (11-14)), the vector is resolved where the ideal option is at the edge so far, because the worst outcome is at the lower part of the demographic matrix If the latest parameters are outside the restrictions, the high or low borders are projected so that the data generated is accurate. The penalty method was used to cope with the usable that in (3). The penalty is displayed in the imbalance of the power balance and incorporated into the CF (2) as follows:

$$F= (F)+ PF^{*}abs\ [(\textstyle\sum_{i=1}^{n} P_1) - P_{Demand} - P_{Loss} \quad (15)$$

II. Literature Survey

Trivedi et al.,(2016) Levy Flights-based MFOs are capable of solving ELD problems with highly complicated constraints. The findings of MFOL correspond to the system's ability to solve the restricted ELD issues and the correlation clearly indicates that MFOL is outperforming the regular MFO, PSO and GA in the 6 and 15 generating unit framework. , the 13-unit device exceeds as compared with CEP, FEP, MFEP, and IFEP. Enhanced MFO-based Levy flights demonstrate quick convergence capacity; optimize resource quest productivity in unpredictable environments [7].

Zhao et al.,(2020) presented the DE into QPSO and utilized the suggested QPSO to take care of issue. Through Friedman test, the exhibition is analyzed. The outcomes show that: First, sustainable power source ought to be favored for age, smaller scale GT take need to match warm current, energy component, capacity battery are utilized for PS as well as force exchange. This arrangement could improve the parts yield and decrease the emanation of contamination gas on the reason of fulfilling the normal activity of the MG. Second, in the end phase of suggested QPSO, the capacity to leap out of nearby ideal arrangement is more grounded. At that point, the suggested QPSO could get excellent outcomes. Thusly, the suggested QPSO has best execution, and it is most appropriate for tackling MG EED issues as compared to QPSO , CLQPSO[8].

J.N. Bharothu et al.,(2018) proposes a way to deal with assemble the nonlinear AC-DC OPF issue as a proportional conventional AC OPF issue. A changed versatile differential development calculation is proposed to fathom the non-arched AC OPF issue, Finding contemplates are conducted on an IEEE 30-transport and IEEE 39-transport test framework associated with 6-transport and 9-transport DC MG under both ordinary activity or system possibility conditions. The outcomes acquired on the test frameworks by the suggested technique affirm the legitimacy of the created algorithm [9].

Ali et al.,(2017) MFO deployment to fix issues of multi-area economic dispatch is introduced. In this analysis, the realistic nonlinear generator restricted as VPL and POZ together with tie-lines power flow restrictions are also taken into account. In order to verify and display high results for the analysis of MAED issues with multiple dimensions and complexity levels, the data gathered by MFO are contrasted with previously reported outcomes. The Technique to make was found to offer a great solution with a lower set of control variables in terms of convergence speed and optimum price. The MFO is found to be a promising technique for real-world issues [10].

Sun et al.,(2020) By implementing the broad M process, the proposed system generation grid-load economic dispatch athematical design is translated into a mixed integer programming system. The study of realistic instances shows that regarding demand response, the developed integrated generation-grid-load economic dispatch will minimize wind power reduction and increase the operation of the power device economy[11].

III. Proposed Methodology

A. *Objectives*

- To study the economic Load dispatch and various meta-heuristic approaches.
- To implement Moth flame optimization to reducing a Economic load dispatch .
- To compare the proposed work with existing work for check the effectiveness.

B. *Methodology Steps*

- To study literature of economic load dispatch problem.
- Gather the specifications to be used in the proposed work.
- Define the specifications and generate input on which the processing will be performed.
- Process the data and perform Moth Flame Algorithm to minimize the System cost.
- Perform hybrid optimization using Moth Flame Algorithm with Chaotic maps to Improved the overall performance of the existing system by making it cost and nature friendly.
- After optimization, the performance of the proposed work will be evaluated and compare it with the base approach.

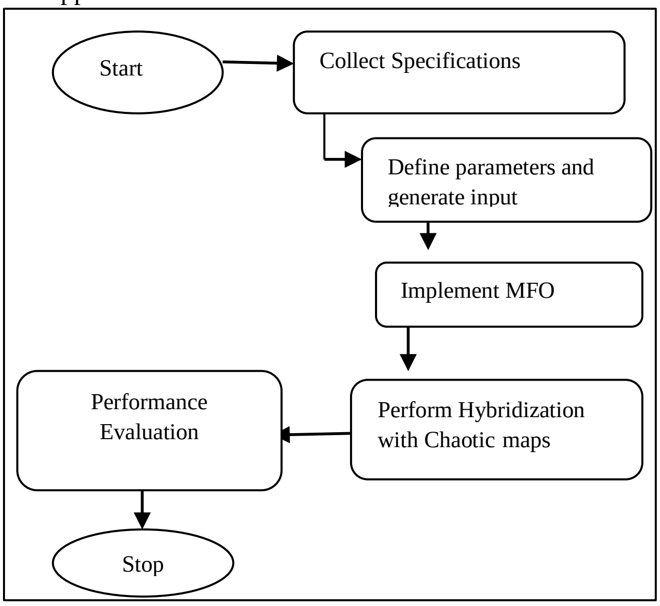

Fig. 1: Flowchart of Proposed Methodology

IV. RESULTS

For this research work, MFO is a stochastic search technique minimized by random search, which purifies local searches in the proximity of local minima. MFO doesn't even need a reference point, but has low global optimum search capability. So, the expected outcomes of both methodologies are used here to get the peak point. Chaos is a stochastic, natural occurrence discovered in a NL distributed device that is NP, NC, constrained. The results obtained by the Hybrid moth flame and chaotic maps approach are more efficient and reduce the overall transmission losses and make the overall power system more reliable and economical.

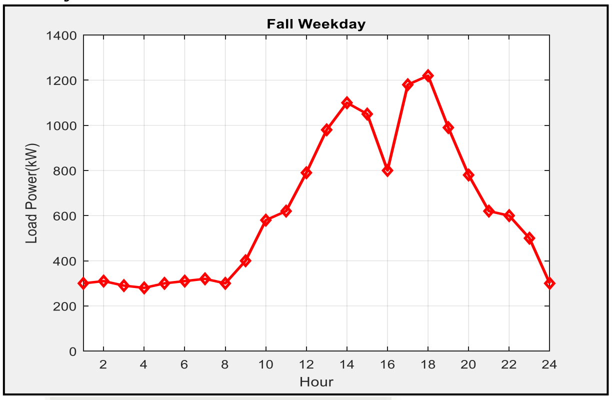

Fig. 2: Load power(KW) versus hour for fall weekday

Figure 2 show the real electricity demand with one-hour resolution.

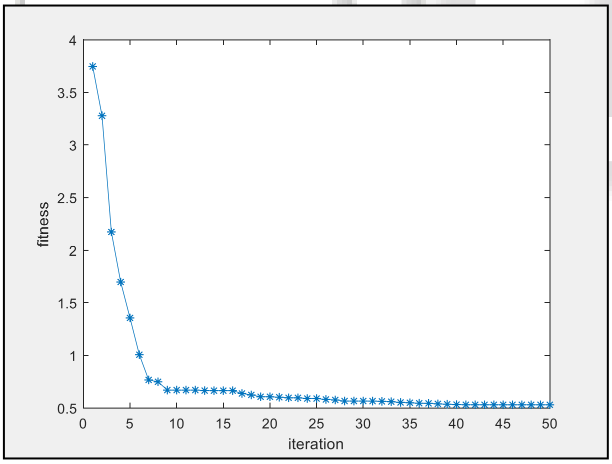

Fig. 3: Fitness Function Versus Iteration

In figure 3 shows fitness value of proposed method in fitness function have used RMSE value it is decreased when iteration increases.

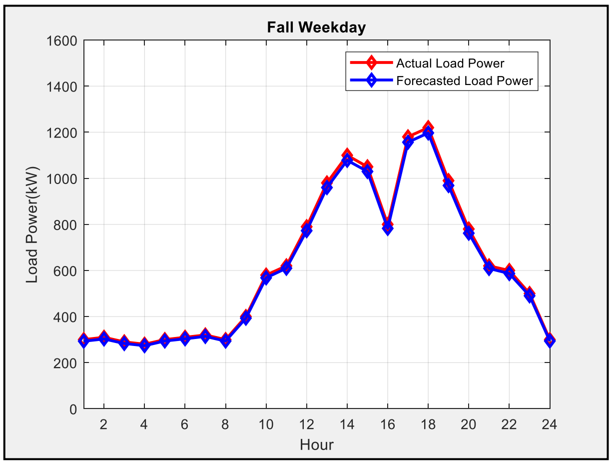

Fig. 4: Graphical representation of Actual Load Power and Forecast Load Power in terms of Hour

The results obtained are viewed with a one-hour resolution for the research days. Figures for fall weekends and holidays are shown in the electricity production projections by the suggested integrated AI system. Figure 4 shows the current generation capacity against the projected demand by the developed approach.

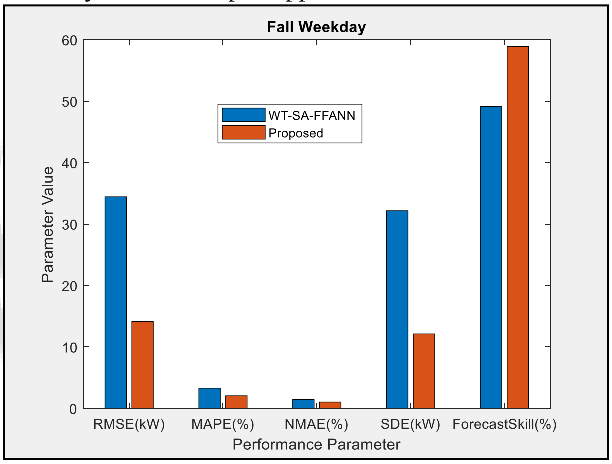

Fig. 5: Comparsion of Parameter Value and Performance Parameter

Parameter	WT_SA_FFANN	Proposed
‘RMSE(KW)’	34.44	14.149
‘MAPE(%)’	3.3	2.0542
‘NMAE(%)’	1.43	1.0368
‘SDE(kW)’	32.17	12.122
‘ForecastSkill(%)’	49.15	58.918

Table 1: Comparsion table of various parameters

The calculated values used to calculate the forecast error of the suggested integrated AI-based method for day-ahead energy consumption prediction in MG are presented in Figure 5 and Table 1 above.

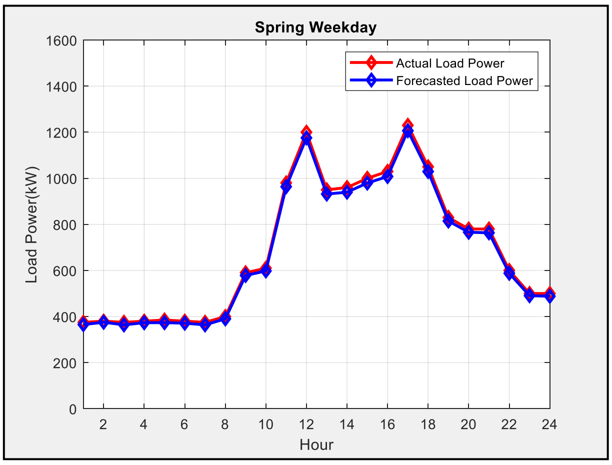

Fig. 6: Graphical representation of Actual Load Power and Forecast Load Power in terms of Hour

The following calculations are viewed with a one-hour resolve for the research days. Figure 6 for spring portrays the energy consumption projections by the suggested integrated AI system.

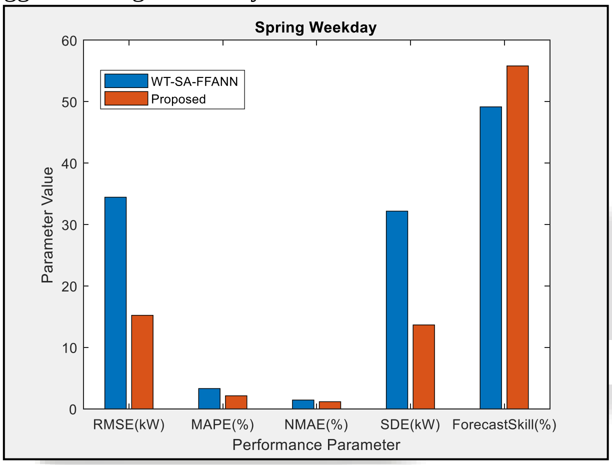

Fig. 7: Comparsion of Parameter Value and Performance Parameter

Parameter	WT_SA_FFANN	Proposed
'RMSE(KW)'	34.44	15.218
'MAPE(%)'	3.3	2.1236
'NMAE(%)'	1.43	1.1583
'SDE(kW)'	32.17	13.654
'ForecastSkill(%)'	49.15	55.812

Table 2 Comparsion table of various parameters

The predicted values used to calculate the forecast error of the suggested integrated AI-based method for day-ahead energy consumption forecasts in microgrid are presented in Figure 7 and Table 2 above.

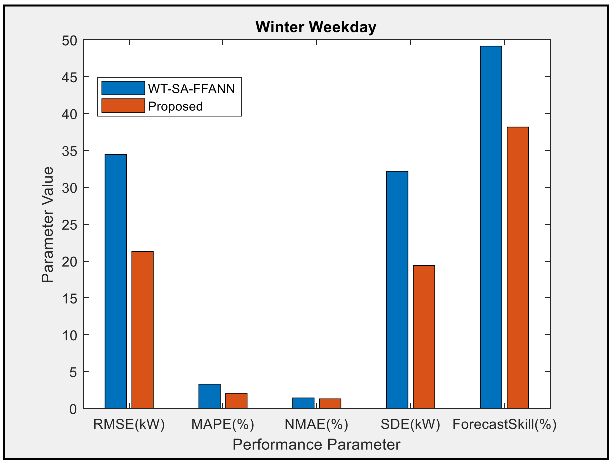

Fig. 8: Comparsion of Parameter Value and Performance Parameter

Parameter	WT_SA_FFANN	Proposed
'RMSE(KW)'	34.44	21.294
'MAPE(%)'	3.3	2.063
'NMAE(%)'	1.43	1.3059
'SDE(kW)'	32.17	19.398
'ForecastSkill(%)'	49.15	38.171

Table 3: Comparsion table of various parameters

The predicted values used to calculate the prediction error of the suggested integrated AI-based method for day-ahead energy consumption prediction in MG are set out in Figure 8 and Table 3 above.

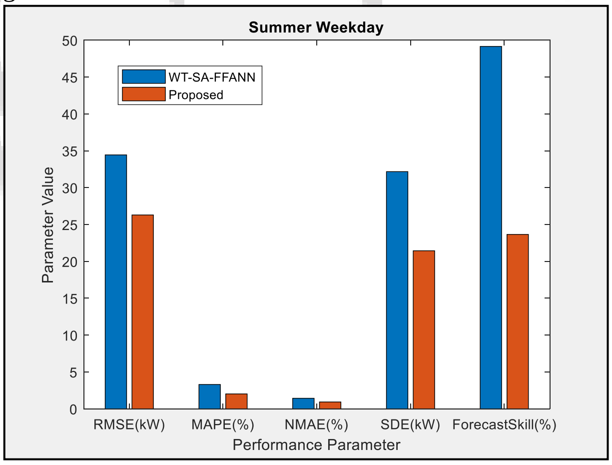

Fig. 9: Comparsion of Parameter Value and Performance Parameter

Parameter	WT_SA_FFANN	Proposed
'RMSE(KW)'	34.44	26.294
'MAPE(%)'	3.3	2.0232
'NMAE(%)'	1.43	0.92925
'SDE(kW)'	32.17	21.438
'ForecastSkill(%)'	49.15	23.652

Table 4 Comparsion table of various parameters

The calculated values used to measure the prediction error of the suggested integrated AI-based method for the day-to-day prediction of generation capacity in the microgrid are given in Figure 9 and Table 4 above.

The results obtained in the advance MATLAB software, shows the seasonal changes in the ELD and the also discuss the various performance parameters based on actual and forecasted load demands. The Presented Outcomes of proposed work provide better results as compared to existing work.

V. CONCLUSION

A new nature-inspired computing method, the Moth-Flame Optimization technique, has been suggested in this study to solve the issue of economic dispatch. Computation findings demonstrate that in process of selecting the lowest generation cost centered on real and predicted load demands, MFO is superior as contrasted to other algorithms. The Future scope of proposed work are Variance Evolution with Neighborhood Search Operation method could be used to rectify certain electrical power system optimization issues like Unit Commitment and Optimal Power Flow, the ED issue fix by using Differential Evolution with Neighborhood Mutation may be subject to additional restrictions or optimization problem. The current technology could be implemented with renewable energy sources in minimizing the overall manufacturing costs and Economic Dispatch issue considered in this research could be enlarged to address the issue of constrained emission optimization. It could be developed as a multi-objective optimization issue by numerous gas emissions like NOx, Cox and SOx in the research framework.

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