Economic Load Dispatch & Unit Commitment Solution using Advanced Optimization Approach

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Abstract— This study introduces a new hybrid approach by using Grey Wolf Optimization and State Transition optimization algorithm for resolving the issue of economic load dispatch and unit commitment in electric power generation system. The simulation of GWOST is investigated by using the 40 various power units. The results prove that the GWOST outperforms the TLBO (teaching learning based optimization), QOTLBO (Quasi-Oppositional teaching learning based optimization), KHA (Krill Herd Algorithm), GWO (Grey Wolf Optimization) and SDE (Shuffled Differential Evolution) mechanism of economic load dispatch. The performance is compared in the terms of total cost incurred and level of power generation.

Key words: Economic Load Dispatch, Unit Commitment, Power Generation, Grey Wolf Optimization, State Transition

I. Introduction

The optimum load dispatch problem has been used to solve two different problems whereas the first of them is unit commitment or pre dispatch problem and another one is economic dispatch or online economic dispatch. In the first problem it is required to select an optimal source out of available generating sources so that expected load can be meet according to specified margin and period time whereas in the second problem load should be distribute among the generating units paralleled in order to reduce the total cost of the operation[1].

ELD stands for Economic Load Dispatch. The main focus of ELD is to allocate the power to various units in order to fulfill the load demand of the units. The power allocation is done along with the minimum cost incurred on transmission and fuel. By studying the economic dispatch, it is observed that the online power generators are available to generate the power to small connected units. The online generator relates the production cost with their power outputs [2]. Quadratic cost function is used for designing such a generator which simplifies the arithmetical formulation and traditional optimization techniques should be applicable to them. Such approaches defines that the curve of fuel cost either increase constantly or decrease constantly in order to get optimal solution. The techniques like dynamic programming may or may not suits in case of large scale systems because they requires large number of computations in order to provide more accurate and reliable results. But with the introduction to the optimization algorithms such as PSO, evolutionary optimization algorithm which uses the simplification model this type of problems can be solved easily and also generates accurate and fast results [3].

Unit commitment problem is considered as a problem of dealing with optimum amount of time an individual generating unit takes at a per hour basis to fulfill the load requirements of the user effectively. Least possible losses with minimum fuel consumption can be optimized while supplying power to maximize the profit [4]. A generation schedule requires being satisfied number of operating constraints besides achieving minimum total production cost. This particular constraint reduced the choice of starting up as well as shutting down of generating units. The numbers of constraints which need to be satisfied are: capacity limits, minimum up time, status restriction of individual generating units, minimum down time, generation limit for 1st and last hour, power balance constraint, limited ramp rate, spinning reserve constraint, group constraint etc.

In the Unit commitment, the decision is to schedule when and which generating unit at each power need to ON or OFF. On the counterpart, Economic dispatch decides the power output of the scheduled generating unit at each time-point. Among these problems, unit commitment is the most challenging optimization problem. The demands of electricity in view of off-peak and on-peak may vary for different purposes. If the consumed units can be monitored effectively, in that case more units can be saved while demand is less such as at night time in comparison with day time. Thus, the primary objective is to plan the operating time of different generating units while satisfying the constraints. The UC problem has been applied to both deterministic as well as stochastic loads. The results acquired from deterministic approach are definite as well as unique whereas from stochastic loads they are not exact. The deterministic loads data envelopment analysis is a nonparametric method where initially input variables and then output variables are defined [6]. For DEA, principal component analysis method is employed. Using this approach, number of variables can be reduced to the minimum. The constraints in stochastic models are changed to the determinate constraints and any algorithms can be used to solve the formulation.

II. Problem Formulation

Electrical power industry restructuring has created highly vibrant and competitive market that altered many aspects of the power industry. Economic Load Dispatch (ELD) is one of the important optimization problems in power systems that have the objective of dividing the power demand among the online generators economically while satisfying various constraints. Economic load dispatch problem is the sub problem of optimal power flow (OPF). The economic load dispatch is defined as the process of allocating generation levels to the generating units, so that the system load is supplied entirely and most economically. For the connection between the two systems it is important that the expenses should be minimized. To describe the production level, each unit in the system is defined, so that the total cost of the system is calculated. The expenses should be less. Economic load dispatch problem is the sub problem of optimal power flow (OPF). The main objective of ELD is to minimize the fuel cost while satisfying the load demand with transmission constraints. So, main aim of ELD is to minimize the expense of the system.

III. PROPOSED WORK

The objective of the Economic Dispatch Problems (EDPs) of electric power generation is to schedule the committed generating units outputs so as to meet the required load demand at minimum operating cost while satisfying all units and system equality and inequality constraints. The Economic Dispatch Problem is solved by specialized computer software which should honor the operational and system constraints of the available resources and corresponding transmission capabilities. Recently, global optimization approaches inspired by swarm intelligence and evolutionary computation approaches have proven to be a potential alternative for the optimization of difficult EDPs.

Therefore in the proposed work the solution of economic load dispatch is done by using the hybridization of GWO optimization technique with state transition algorithm as mostly the work is done on basis of GA, ACO. PSO,

The proposed technique uses the GWOST in order to minimize the cost incurred on power generating and transmission. The methodology of proposed technique is implemented in following steps:

1) STEP 1: First step is to set power generator parameters. Every generator have its own parameters such amount of generated power, amount of total lost transmission etc. The parameters are generated on the basis of some equations.
2) STEP 2: After setting the power generator parameters the next step is to evaluate the cost function.
3) STEP 3: Apply the GWO algorithm to update the initially generated population.
4) STEP 4: Now calculate the new cost function. And compare the Initial cost function to New cost function. If initial cost function is greater than update the initial cost function else update the population by using ST algorithm.
5) STEP 5: After applying the St the next step is to evaluate the cost function again and to compare it with the existing cost function. If existing cost function is greater than the new cost function than the value of initial cost function is updated and otherwise the control moves to the step no 3.
6) STEP 6: Number of iterations will execute in order to find the best cost function.

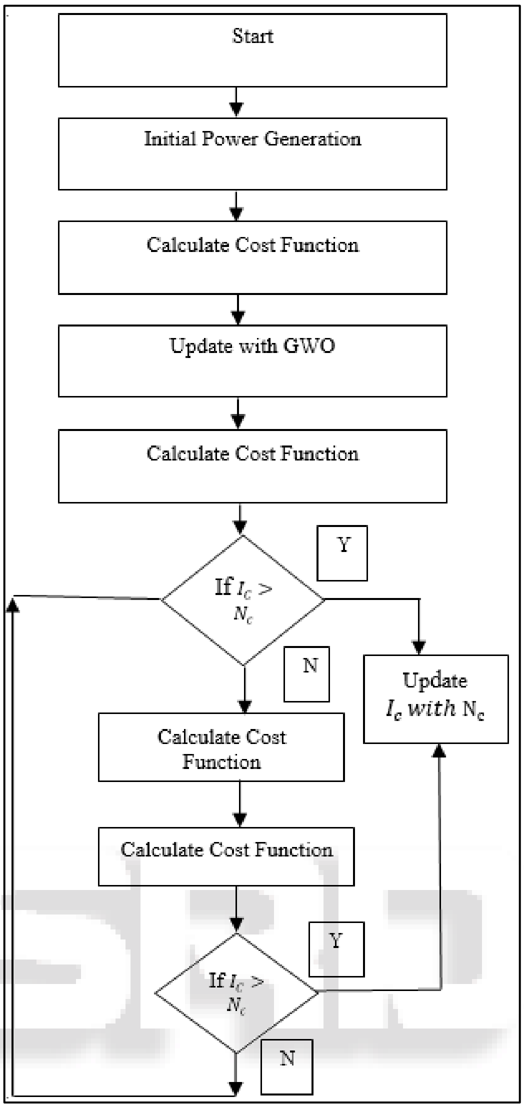

Fig. 1: Block Diagram of Proposed Work

IV. RESULTS

This section discusses the various results which are obtained after applying the proposed work or method on the various power unit generation plants. In this study 400 unit generation power plants is considered for simulation.

The proposed work is implemented on 40 different power generation units. The graph for power generated by the proposed work in different power units is shown in figure 2. The x axis in the graph represents the different power unit's i.e. total 40 power units and y axis depicts the amount of generated power and it ranges between 0 and 500. As can be seen from the graph, the power generated by the proposed technique is quite efficient and reliable.

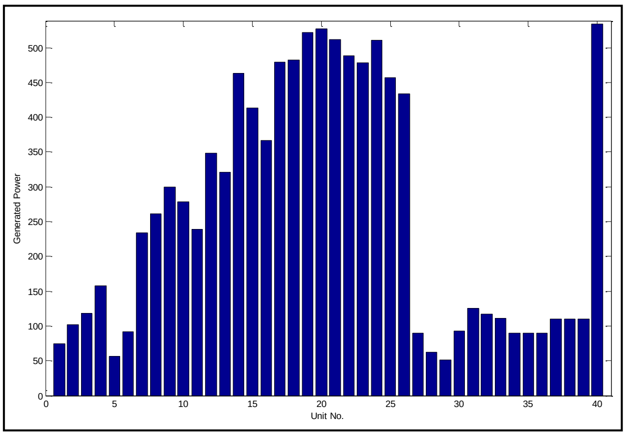

Fig. 2: Power Generation with Respect to Number of Units of Proposed Work

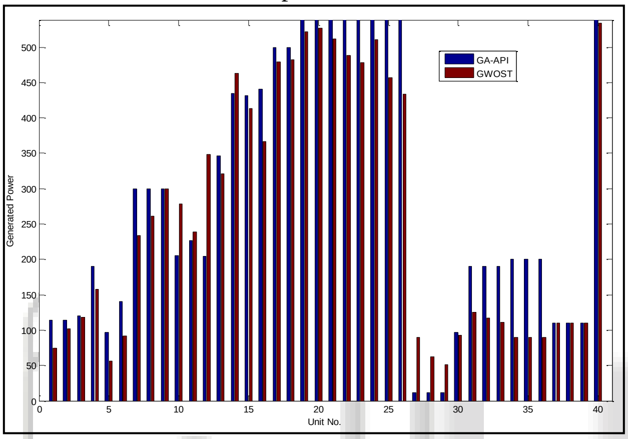

Fig. 3: Power Generation of GA-API & GWOST

The graph in figure 3 shows the comparison of proposed work i.e. GWOST and GA-API with respect to the generated power corresponding to the 40 power generation units. The bar in blue color shows the level of power generation by the GA-API mechanism and bar in magenta color depicts the level of power generation by the GWOST mechanism. From the graph it can be seen that the power generation level of GA-API is quite higher in comparison to the GWOST. Hence it is proved that the proposed system is better than GA-API as it generates only that amount of power which is required by the power unit without generating extra amount of power.

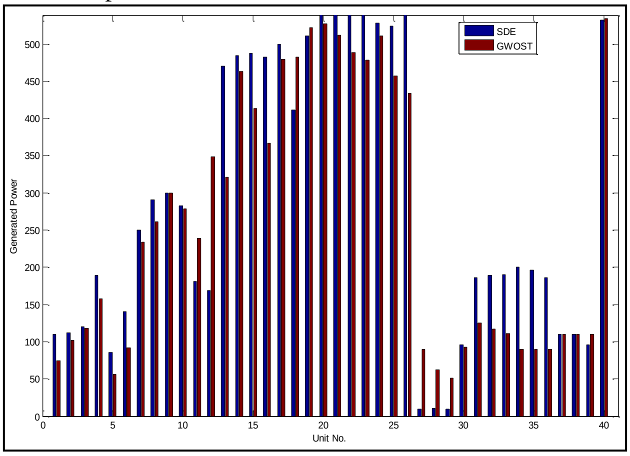

Fig. 4: Power generation of SDE and GWOST

The graph in figure 4 delineates the comparison of SDE and GWOST with respect to the level of the power generation. The y axis in the graph is shows the level of power generation. The graph makes it sure that the power generation efficiency of the GWOST is much better than the SDE technique.

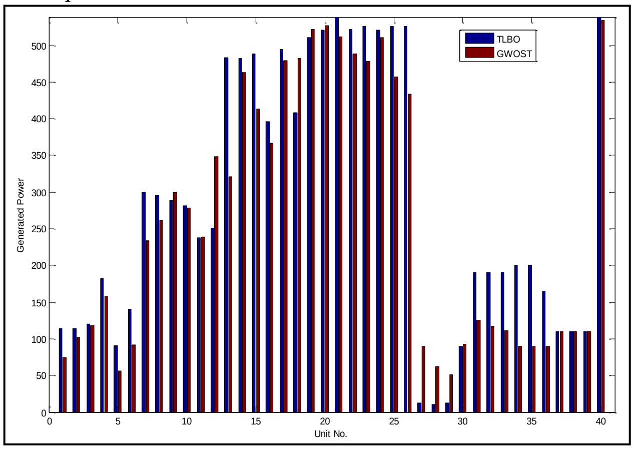

Fig. 5: Power Generation of TLBO & GWOST

The graph in figure 5 and 6 represents the comparison of proposed work with TLBO and QOTLBO mechanism respectively. In both cases it is observed that the proposed work outperform rest of the techniques in terms of power generation.

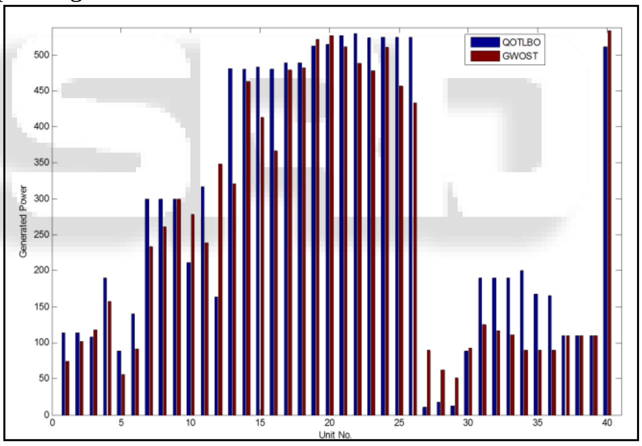

Fig. 6: Power Generation of QO & GWOST

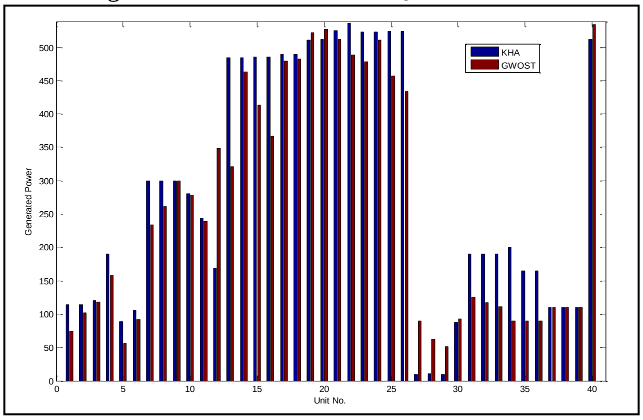

Fig. 7: Power Generation of KHA & GWOST

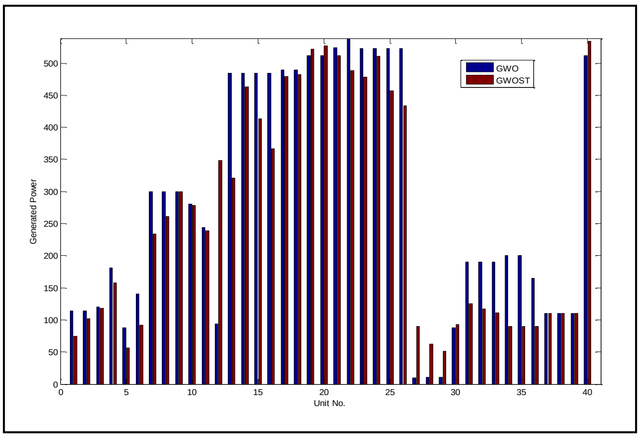

Fig. 8: Power Generation of GWO & GWOST

The comparison of GWOST is also done with KHA and GWO mechanism on the basis of the power generation capacity. The graph in figure 7 shows the comparison of GWOST with KHA and figure 8 portrays the comparison graph of GWOST and GWO. In both cases the GWOST is proven to be more efficient then defined ones.

S. No.	Techniques	Value
1	GA-API [33]	139864.96
2	SDE[32]	138157.46
3	TLBO[34]	137814.17
4	QOTLBO[34]	137329.86
5	KHA[35]	136670.37
6	GWO[36]	136446.85
7	GWO-ST	111798.38

Table 1: Total Cost of Power Generation Unit by using Different Techniques

The table 1 comprised of facts or data related to the total cost of the power generation units by using different techniques i.e. GA-API, SDE, TLBO, QOTLBO, KHA, GWO and GWOST. On the basis of the figures that are given in table 1 it is concluded that the power generation sot of GWOST is lower in comparison to the rest of the techniques whereas the power generation cost of GA-API is the highest one.

For the purpose of unit commitment in proposed work, total 4 power generation units has been considered with the total 44 Mw power. Then after evaluating the unit commitment it is obtained that total 11 Mw is need to be committed by each unit individually.

Generator Units	Unit Commitment(Mw)
G1	11
G2	11
G3	11
G4	11

Table 2: Power Unit Commitment in Four Generators

V. Conclusion & Future Scope

Economic Load Dispatch is the process known for distributing load in such a way so that economic cost of the power system should be used less and requirement of the consumer fulfilled. Thus in this thesis different optimization algorithms have been studied which can be used to evaluate proper distribution of load over the power systems along with the unit commitment. Evaluation has been done between SDE, GA-API, TLBO, QOTLBO, KHA, GWO and GWOST. The comparison ensures that GWOST outperforms among them. The investigation of GWOST is done on the basis of total power generated and total cost incurred for power generation by the units and also evaluates unit commitment along with the above defined parameters.

As various optimization algorithms have been elaborated in this thesis where GWO-ST is declares as an efficient technique. In future more amendments can be done in ELD along unit commitment by using some advanced artificial technology based techniques. This will lead to the more accuracy and efficiency in the system.

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