Modified Teaching Learning Algorithm Based Optimal Solution Of Economic Dispatch With Constraint Of Emission Rate

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Abstract - *Economic Load Dispatch (ELD) problem involves the scheduling of generating unit outputs that can satisfy load demand at minimum operating cost. ED aims to schedule the committed units' output power while satisfying practical constraints and load demand. Several approaches have been applied to yield the best solution for the problem. In this paper a new method based on modified teaching learning optimization algorithm is presented and has successfully applied to determine the feasible, robust, fast and globally or near-globally optimal solution within a rapid timeframe for the ED problems. In the proposed algorithm, the methods of teaching phase and learning phase are respectively modified to enhance to disturbance potential of search space, and a new "Self-Learning" method is presented to enhance the innovation ability of the learner and the global exploration performance.*

Key Words: **Economic dispatch, modified teaching learning algorithm, Distributed generation emission rate, valve-point effects.**

1. INTRODUCTION

Economic Dispatch (ED) optimization problem is the most important issue which is to be taken into consideration in power systems.. The problem of ED in power systems is to plan the power output for each devoted generator unit in such a way that the operating cost is minimized and simultaneously, matching load demand, power operating limits and maintaining stability. This problem becomes more complex in large scale power systems, as it is hard to find out optimal solution because it is nonlinear function and it contains number of local optimal. Various techniques are proposed by the researchers for ED. In the past decades, numerous mathematical and heuristic-based optimization techniques are reported in the literatures to handle the ED problems.

The previous work "A new enhanced gradient-based simplified swarm optimization for practical economic dispatch problem" was only suitable for without DG power generation system and not considering power loss and emission rate.

To date, little attention has been paid to establish a powerful solution method in order to find the global or near-global solution to the strictly nonlinear ED problems. In this paper, a new modification phase is proposed and added to the original TLA to improve its performance. The new modified TLA (MTLA) is implemented to solve the nonlinear economic dispatch problem.

The main contributions of this paper can be summarized as follows: 1) the ED problem with Distributed generation system is formulated; 2) a new modified algorithm is proposed to solve the ED problem; and 3) the cost of power loss and emission rate are considered.

1.1 Previous work

In previous work a new solution method of integrating the classical gradient-based optimization technique and a new enhanced simplified swarm optimization algorithm (ESSOA) is used to determine the globally or near-globally optimal solution for the ED problems. This hybrid algorithm called enhanced gradient-based simplified swarm optimization algorithm (EGSSOA) is designed and implemented using MAT LAB. The main objective is to obtain a robust, fast and globally or near-globally optimal solution within a rapid time frame for the ED problems. That means the objective is to minimize the fuel cost while satisfying operational constraints.

In addition, in order to reach global or near-global solution in an acceptable computation time, for each particle of the population, a local optimizer gradient-based method is implemented. This method starts from the ESSOAs generated particle in each iterate of the ESSOA. It works on the principle that the minimum of cost. It is clear that in the iteration and procedure of the EGSSOA, the SSOA updating mechanism probabilistic mutation framework, which constitute the ESSOA, are applied on the population, consecutively. Moreover, in order to increase the local search capability of the proposed ESSOA around the particles, for each particle the gradient search method is used in several steps. In order to determine the performance of the proposed EGSSOA, the ED is implemented.

Test case consisted of 40 generating units are considered to show the effectiveness of the proposed EGSSOA in handling complicated ED problems. The valve-point effects are taken into consideration in the ED problem by superimposing the basic quadratic fuel-cost characteristics with the rectified sinusoid component.

1.2 Proposed Method

In the proposed method **a** new method based on modified teaching learning optimization algorithm is presented and has successfully applied to determine the feasible, robust, fast and globally or near-globally optimal solution within a rapid timeframe for the ED problems. The previous workis only suitable for without DG power generation system and is not considering power loss and emission rate.. To overcome this, an efficient control is used, i.e., modified teaching learning algorithm (MTLA) based optimal solution of economic dispatch with constraint of emission rate. Economic dispatch with DG is strictly nonlinear process. The new modified TLA (MTLA) is implemented to solve the nonlinear economic dispatch problem.

For that first consider the encoding variables such as generator parameters. In the modified TLA (MTLA) the fitness function are of two. They are

I. Fuel cost with emission rate(α)
II. Power loss

$\alpha+\beta \longrightarrow$ Minimum.

For Applying MTLA, initial population is randomly assigned to the encoding variables and then evaluates the fitness function. Then among those minimum values, selection process should be done.

2. PROBLEM FORMULATION

The aim of this section is to define the fuel cost minimization and power loss minimization while satisfying operational constraints.

i) Minimize fuel cost -The fuel cost of each unit is characterized in the form of a quadratic function plus the absolute value of a sinusoidal term corresponding to the valve point effects. The problem is formulated as follows:

$$F(P_G) = \sum_{i=1}^{NG} F_i(P_i(t))$$
$$= \sum_{i=1}^{NG} (a_i + b_i P_i(t) + c_i P_i^2(t) + \left| d_i \sin(e_i(P_{i,\min} - P_i(t))) \right|)$$

Where

$P_G=[P_1, P_2 \ldots P_{NT}]$

$-P_t=[P_{1,t} \;\; P_{2,t} \ldots P_{NU,t}]^T$

Limits associated with ED are as follows:

a) *Power balance*

$$\sum_{i=1}^{NG} P_i(t) = P_D(t) + P_{Loss}(t)$$

Where the power losses is in the following form

$$P_{LOSS}(t) = \sum_{i=1}^{NG}\sum_{j=1}^{NG} P_i(t) B_{ij}(t) P_j(t) + \sum_{i=1}^{NG} B_{0,i}(t) P_i(t) + B_{00}(t)$$

t=1,..........,NT

b) *Up/down ramp rate limits*

The power generated at the output of the th thermal unit at time may affect its output power in the next time step. This limitation can be expressed as follows:

$$P_i(t) - P_i(t-1) \le UR_i$$
i=1,....,NU, t=1,….,NT

$$P_i(t-1) - P_i(t) \le DR_i$$
i=1,....,NU, t=1,….,NT

c) *Generation limits*

According to the ramp rate, the generation limits will be

$$\underline{P_i(t)} \le P_i(t) \le \overline{P_i(t)}$$
i=1,....,NU, t=1,….,NT

$$\overline{P_i(t)} = \min(P_{i,\max}, P_i(t-1) - UR_i)$$
i=1,....,NU, t=1,….,NT

$$\underline{P_i(t)} = \max(P_{i,\min}, P_i(t-1) - DR_i)$$
i=1,....,NU, t=1,….,NT

d) Emission limits

$E_s \le L_{Sox}, E_n \le L_{NOx}, E_c \le L_{CO2}$

where Es, En, Ec are the SOx, NOx, CO2 gases emission due to the combustion of fuel in thermal plants and LSOx, LNOx, LCO2 are the maximum limits for emission of different gases.

ii)) Minimize Power loss-Total power loss in all the units, can be determined by summing up the losses in all the sections of network, which is written as

Min $P'_{T,Loss}$=

$$P'_{T,Loss} = \sum_{k=1}^{n} P'_{Loss}(k, k+1)$$

Where $P'_{Loss}(k, k+1)$ is the power loss of a section after reconfiguration of network and can be computed as

$$P'_{Loss}(k, k+1) = R_k . \frac{P_k'^2 + Q_k'^2}{| V_k' |^2}$$

` Description

In the basic TLBO algorithm, the result of the learners is improved either by a single teacher (through classroom teaching) or by interacting with other learners. However, in the traditional teaching-learning environment, the students also learn during tutorial hours by discussing with their fellow classmates or even by discussion with the teacher himself/herself. During the course of optimization, this situation results in a slower convergence rate of the optimization problem. Considering this fact, to enhance the exploration and exploitation capacities, some improvements have been introduced to the basic TLBO algorithm. In the present work, the previous modifications are further enhanced and a new modification is introduced to improve the performance of the algorithm.

Moreover, if the class contains a higher number of below average students, then, the teacher has to put more effort into improving their results; even with this effort, there may not be any apparent improvement in the results. In the optimization algorithm, this fact results in a higher number of function evaluations to reach optimum solution and yields a poor convergence rate. In order to overcome this issue, the basic TLBO algorithm is improved by introducing more than one teacher for the learners. By means of this modification, the entire class is split into different groups of learners as per their level (i.e. results), and an individual teacher is assigned to an individual group of learners. This modification is explained in the implementation steps of the algorithm. The concept of number of teachers is to carry out the population sorting during the course of optimization and, thereby, to avoid the premature convergence of the algorithm.

Thus, the self-learning aspect to improvise the knowledge is considered in the MTLA.

Step 1: Define the optimization problem as Minimize or Maximize f (X)

where f (X) is the objective function value and X is a vector for design variables.

Step 2: Initialize the population (i.e. learners, k=1,2,…,n) and design variables of the optimization problem(i.e., number of subjects offered to the learners, j =1,2,…,m) and evaluate them.

Step 3: Select the best solution (i.e. $f(X)_{best}$) who acts as chief teacher for that cycle. Assign him/her to first rank.

$(X_{teacher})_1 = f(X)_1$ where $f(X)_1 = f(X)_{best}$

Step 4: Select the other teachers (T) based on the chief teacher

and rank them,

$f(X)_s = f(X)_1 - rand^* f(X)_1 s = 2, 3, \ldots, T$.

(If the equality is not met, select the f (X)s closest to the value calculated above)

$(X_{teacher})_s = f(X)_s$, where s = 2, 3, . . . , T .

Step 5: Assign the learners to the teachers according to theirfitness value as:

For k = 1 :(n − s)

If $f(X)_1 \geq f(X)_k > f(X)_2$,

assign the learner $f(X)_k$ to teacher 1

(i.e $f(X)_1$).

Else, if $f(X)_2 \geq f(X)_k > f(X)_3$,

assign the learner $f(X)_k$ to teacher 2 (i.e $f(X)_2$).

Else, if $f(X)_{T-1} \geq f(X)_k > f(X)_T$,

assign the learner $f(X)_k$ to teacher 'T −1' (i.e $f(X)_{T-1}$).

Else,

assign the learner $f(X)_k$ to teacher 'T '

End

(The above procedure is for a maximization problem; the procedure is reversed for a minimization problem.)

Step 6: Keep the elite solutions of each group.

Step 7: Calculate the mean result of each group of learners in

each subject (i.e. (M_j)s).

Step 8: For each group, evaluate the difference between the current mean and the corresponding result of the teacher of that group for each subject.

Step 9: For each group, update the learners' knowledge with the help of the teacher's knowledge, along with the knowledge acquired by the learners during the tutorial hours.

Step 10: For each group, update the learners' knowledge by utilizing the knowledge of some other learners, as well as by self-learning,

Step 11: Replace the worst solution of each group with an elite solution.

Step 12: Eliminate the duplicate solutions randomly.

Step 13: Combine all the groups.

Step 14: Repeat the procedure from step 3 to 13 until the termination criterion is met.

3. SIMULATION RESULTS

In order to determine the performance of the proposed modified TLA (MTLA), the ED with DG is implemented. Test case consisted of 40 generating units are considered to show the effectiveness of the proposed MTLA in handling complicated nonlinear ED problems. Thus the MTLA performs better on more complex problem when the other methods miss the global optimum basin.

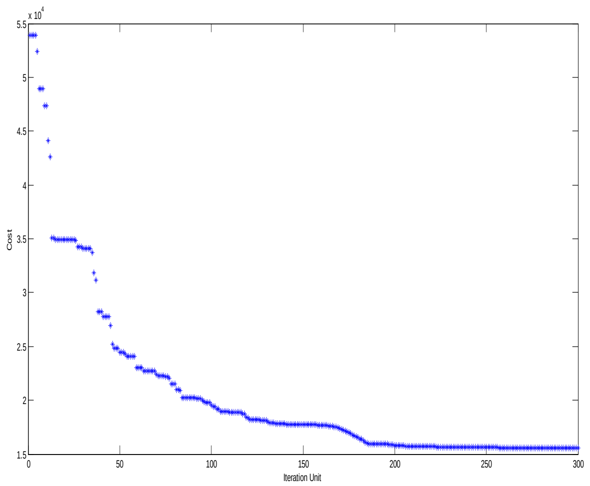

Fig -1: Output of MTLA

This figure demonstrates the MTLA method which is used to find a global optimal fuel cost, i.e. the minimum cost of fuel and minimum cost of power loss which is global. Here there are 300 iteration units. At the zeroth iteration unit, the cost is maximum which is Rs 53,000/- and decreases gradually. Finally the cost at the 300th iteration unit is the global optimum cost value which is Rs 16,000/-.

4. CONCLUSIONS

This project proposed a generalized and versatile MTLA approach on has successfully applied to determine the feasible, robust, fast and globally or near-globally optimal solution within a rapid timeframe for the ED with DG. These attempts are made to minimize the fuel cost with emission rate and power loss of the constrained ED problems with non-linear characteristics. The performance of proposed algorithm is tested for40 generating units. This project is under way in order to apply the proposed method in other power system combinational optimization problems, like unit commitment, like unit commitment, optimal power flow, reactive power and voltage control in the search of better quality results.

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