

Teaching Learning Algorithm based Non Smooth Economic Dispatch Problem

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E-mail - elanchezhian.eb@gmail.com**Abstract**

This paper presents a novel nature inspired Teaching Learning Algorithm (TLA) methodology in order to determine the feasible optimal solution of the Economic Dispatch (ED) problem considering non-smooth Cubic Cost Functions (EDCCF). In this paper, proposed TLA is applied on Wollenberg's 3 unit test system and compared with most of the recent methodologies. The results show the effectiveness of the proposed method and prove that TLA can be applicable for solving the power system economic dispatch problem involving higher order cost functions.

Keywords: Economic power dispatch, non-smooth, cubic cost functions, teaching learning algorithm

1. Introduction

The operating cost of a power plant mainly depends on the fuel cost of generators and is minimized via Economic Load Dispatch (ED). ED can be defined as determining the least cost power generation schedule from a set of on line generating units to meet the total power demand at a given point of time. The main objective of ED problem is to decrease fuel cost of generators, while satisfying equality and inequality constraints. In this problem, fuel cost of generation is represented as cost curves and overall calculation minimizes the operating cost by finding a point where total output of generators equals total power that must be delivered. In conventional economic load dispatch, cost function for each generator has been approximately represented by a single quadratic function and is solved by various optimization techniques such as Genetic Algorithm (GA) [1], Particle Swarm Optimization with Bacterial Foraging (PSO-BF) [2], Quantum-inspired Particle Swarm Optimization (QPSO) [3], Real Coded Genetic Algorithm (RCGA) [4] and Improved Harmony Search (IHS) [5]. The conventional ED solution accuracy can be improved by introducing cubic cost functions which has the great influence on the cost minimization process. Due to the importance of ED problem involving cubic functions few authors have been interested in investigating, solving and publishing the outcome of research done in the area of as ED with Cubic Cost Functions (EDCCF) by applying various optimization methods such as Evolutionary Programming (EP) [6], Partition Approach Algorithm (PPA) [7], Pattern Search Algorithm (PSA) [8], Bacterial Foraging-Nelder-Mead (BF-NM) Algorithm [9] and Simulated Annealing (SA) [10].

In this paper, a recent heuristic algorithm introduced by Rao et al. [11] named Teaching Learning Algorithm (TLA) [12], based on the effect of the influence of a teacher on the output of learners in a class, is utilized for the solution of EDCCF problem.

2. Problem Formulation

The objective function corresponding to the fuel cost can be approximated as a non smooth cubic function of the active power outputs from the generating units can be metaphorically represented as

$$F_i(P_i) = \sum_{i=1}^N a_i + b_i P_i + c_i P_i^2 + d_i P_i^3 \left(\frac{\$}{h} \right) \quad (1)$$

where $F_i(P_i)$ is the expression for the cost function corresponding to the i^{th} generating unit and a_i , b_i , c_i and d_i are its cost coefficients. The EDCCF problem is subjected to following constraints.

Power balance constraints: The generated power of all thermal generating units must gratify the load demand (2), which is defined as

$$\sum_{i=1}^N P_i = P_d \quad (MW) \quad (2)$$

Power generation limits: The generating unit power output must falls within its minimum ($P_{i, \min}$) and maximum limits ($P_{i, \max}$), which can be formulated as:

$$P_{i, \min} \leq P_i \leq P_{i, \max} \quad (3)$$

3. TLA - nature inspired algorithm

The TLA algorithm is a new efficient population based algorithm inspired by the influence of a teacher on learners. It is based on the cause of influence of a teacher on the output of learners in a class. Also it requires only the tuning of common control parameters and not the algorithm-specific parameters. The burden of tuning of control parameters is comparatively less in TLA, which makes it superior than other optimization algorithms. In order to find the solution for ED, a TLA technique is proposed to solve the non-smooth objective function. TLA is like other evolutionary algorithms, each searching generation includes initializing of class, Teacher phase, Learner phase and Termination.

The steps involved in the search procedure of the TLA algorithm for the proposed EDCCF problem is summarized as follows.

Initialization of ED Problem

Step 1: Define the EDCCF optimization problem as minimization problem.

Step 2: Population size (P_s), number of design variables (N_d) which represents number of generating units, maximum and minimum generation limits (limits of design variables) and stopping criteria (maximum number of iterations) are defined in this step.

Teacher Phase

Step 3: Evaluate the difference between existing mean result and best mean result by utilizing Tf .

Learner Phase

Step 4: Update the learner's generation value with the help of teacher generation.

Step 5: Update the learner's generating value by utilizing the generating value of some other learner.

Termination Criteria

Step 6: Repeat the procedure from step 2 to 5 till the maximum number of iterations is met.

4. Case Study and Discussion - Wollenberg Network Power System

A Wollenberg network power system with three generators is used to demonstrate how good the proposed approach works for this type of system having cost functions expressed in non smooth cubic form. The unit characteristics like cost coefficients, operating limits of generators are given in [10]. The load demand is 2500 MW.

Table 1. Comparison of computational results of 3 unit system.

	TLA	Wollenberg[10]	PRPGA[10]	SA[10]
P ₁ (MW)	724.98	726.9000	724.991408	725.01284
P ₂ (MW)	910.17	912.8000	910.153159	910.18417
P ₃ (MW)	864.85	860.4000	864.855433	864.80299
P _d (MW)	2500	2500	2500	2500
F (\$/h)	22729.30	2730.2167	22729.324579	22729.32458

EDCCF results obtained by proposed TLA are shown in Table 1 and are compared here with Wollenberg [10], Parallel Repaired Population Genetic Algorithm (PRPGA) [10] and Simulated Annealing (SA) [10]. The cost obtained by proposed TLA is 22729.30 \$/h, which is less than the cost fetched by other rival optimization algorithms. The fetched optimal results prove the superiority of the TLA over other renowned optimization algorithms. A convergence characteristic of TLA algorithm for the 3-generator system is shown in Fig. 1.

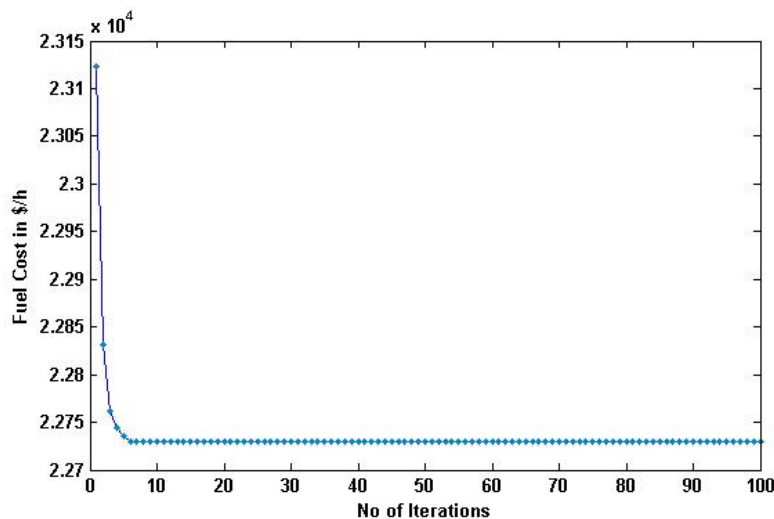


Figure 1: Convergence characteristics of TLA for 3 unit test system

5. Conclusion

The TLA method has been successfully implemented to solve EDCCF problems. It has been observed that the TLA has the ability to converge to quality of solutions and possesses better convergence characteristics. It is also clear from the results of different trials that the implementation of TLA approach can eliminate the shortcoming of premature convergence, exhibited by other optimization techniques. Also, when more complex non smooth fuel cost characteristic is considered (cubic cost functions), it is observed that solution quality, computational efficiency of TLA are significantly

better than those of other methods. Due to these features, the TLA method seems to become an important tool for solving more complex optimization problems.

6. References

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