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A Novel Technique for Economic Load Dispatch and Test on 13 Generating Units

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Abstract
Inadequate amount ofenergy resources, increasing power demand and growing electricity generation makes economic load dispatch (ELD) a very important part of power system. The main objective of economic load dispatch is to identify the generation of the various plants such that total generation meets the demand and losses by keeping total fuel cost of generation as minimum. Swarm optimization technique with dynamic acceleration coefficients is introduced in this paper to solve ELD problem. This paper gives the information regarding simulation of ELD problem for 13 generating units using MATLAB software.
Keywords: Economic Load Dispatch (ELD), MATLAB, Generator constraints.

1. Introduction

Now-a-days the electrical power system is expanding vastly to meet the demand, however the amount of generation is not enough to meet the amount of demand hence it is necessary to operate the system in economic manner. This economic operation of power system is achieved through the economic load dispatch techniques. The important condition in power system to find and provide the operating point such that all the generating units operate at minimal fuel cost to meet the demand and losses without violating the generator constraints, which is called as Economic Load Dispatch (ELD). Any ELD problem considers load demand, transmission power losses and generation cost coefficients as its necessary parameters. However, the total operating cost of the plants depends upon the fuel cost, labour expenditure plant maintenance. Taking labour expenditure and plant maintenance into account is difficult hence the total operating cost is assumed to be only due to fuel cost. Hence, the cost function which is mainly dependent on fuel cost is given as a function of generation. The generation cost of the unit not only depends on the fixed load demand but also it depends on the operating constraints of the system.

The main objective of this study is to develop a method which minimizes the fuel cost by taking equality and inequality constraints into account. To test the model a generating station is considered which has 13 generating units with minimum and maximum active power limits as inequality constraints.

2 Problem Formulation

In any economic dispatch problem the main concern is to minimize the objective function. The total fuel cost of the generating station that meets the total demand, losses and inequality constraints is taken as the objective function.

1. Objective function

The total fuel cost of the station can be represented by a single quadratic function as follows:

$$C_{Total}(P_j) = \sum_{j=1}^{n} C_j(P_j) \quad (1)$$

Where,

$C_{total}(P_j)$ = fuel cost of total generation (Rs/hr)

$C_j(P_j) = a_j P_j^2 + b_j P_j + c_j$ = fuel cost of j^{th} unit (Rs/hr)

a_j, b_j, c_j = fuel cost coefficients of j^{th} unit

n= number of generating units.

Here the valve point loading of the generators is also considered. Which is given by the following equation:

$$C_j(P_j) = a_j P_j^2 + b_j P_j + c_j + \left| e_j \sin(f_j (P_{j\,min} - P_j)) \right| \quad (2)$$

2.*Generator Constraints*

There are two types of constraints in the system, they are:

2.1 *Equality Constraints*

The equality constraint is given by the summation of active power of all the generating units which is equal to the sum of total active power demand and transmission losses. This is usually called as power balance constraints.

$$\sum_{j=1}^{n} P_j = P_{demand} + P_{Loss} \qquad (2)$$

Where,

P_{demand} = total active power demand

P_{loss} = transmission line power loss

P_j = power generation of j^{th} unit

In this paper effect of loss is taken as zero.

2.2 *Inequality Constraints*

These constraints are related to the minimum and maximum generating limits of a unit, they are represented as follows:

$$P_j^{min} \le P_j \le P_j^{max} \qquad (3)$$

Where,

P_j^{min} = minimum active power limit of j^{th} unit

P_j^{max} = maximum active power limit of j^{th} unit

3 Problem FORMULATION FOR MINIMIZING a quadratic function

It is a basic stochastic search algorithm formulated using a position and velocity vector.The position and velocity vector of the i^{th} particle at iteration "*iter*" is given by the following vectors.

Position vector= $$x_i^{iter} = \begin{bmatrix} x_{i1}^{iter} \\ x_{i2}^{iter} \\ . \\ . \\ . \\ . \\ x_{ij}^{iter} \end{bmatrix}$$

Velocity Vector= $$v_i^{iter} = \begin{bmatrix} v_{i1}^{iter} \\ v_{i2}^{iter} \\ . \\ . \\ . \\ . \\ v_{ij}^{iter} \end{bmatrix}$$

The best known position of the i^{th} particle till iteration "*iter*" is given as follows:

$$\textbf{Personal Best generation=}\ P_{besti}^{iter} = \begin{bmatrix} P_{besti\,1}^{iter} \\ P_{besti\,2}^{iter} \\ . \\ . \\ . \\ . \\ P_{bestij}^{iter} \end{bmatrix}$$

The global best is selected from the entire population gbest.

A particle attains a better solution with randomly weighed,fixed accelerationfactors using its present velocity and past experience of its own and other particles.The velocity and position of every particle will be updated using following equations:

$$v_i^{iter+1} = w \times v_i^{iter} + c1 \times r1 \times \left(P_{bestij}^{iter} - x_{ij}^{iter}\right) + c2 \times r2 \times (g_{best}^{iter} - x_{ij}^{iter}) \tag{3}$$

$$x_i^{iter+1} = x_i^{iter} + v_i^{iter+1} \tag{4}$$

Where,

C_1,C_2 are positive acceleration coefficients fixed at [2 2]

r_1,r2 are random valves with a range of [0 1]

w is the inertia weight which is given by equation (5)

$$w_i = w_{max} - \left(\frac{w_{max} - w_{min}}{max\_iter}\right) \times i \tag{5}$$

Modification to the Previous PSO :

The convergence and quality of the solution depends on the proper selection of acceleration constants. In normal PSO algorithm these constants are kept constant and are equal to 2.When social component value is relatively high when compared to cognitive component the problem is forced to search for the best solution locally.The higher valves of the cognitive component makes the particle to search for the solution around the search space.Hence, to improve the solution quality and convergence the coefficients are updated as the iteration progresses in such a way that the cognitive component is reduced and social component is increased.

These coefficients are updated by the following equations:

$$c1 = c1ini + \left(\frac{c1fin - c1ini}{iter\ max}\right) \times iter$$
$$c2 = c2ini + \left(\frac{c2fin - c2ini}{iter\ max}\right) \times iter \tag{6}$$

The ELD is solved by the following steps:

1. Feed the fuel cost function coefficients, active power limits and total active power demand as input data.
2. Initialize the algorithm parameters population size, C_{1ini}, C2ini, C1fin, C2fin, Wmax,Wmin, max-iteration.
3. Start the solving of problem by assigning the generations of each generators with a random value satisfying the active power limits of all generators.
4. Initialize the objective function i.e, Total cost function from the individual cost function of the various generators.
5. For each vector of the active power calculate the objective function. In each iteration the results obtained are compared to obtain the personal best (P_{best}). At the end of each iteration all the valves of the whole population are compared to obtain the global best (g_{best}).
6. At each step these values are updated.
7. For every iteration the global best (cost) is plotted this is called as convergence curve.
8. This final value of the g_{best} is the minimum cost and the generating valves of each unit represent the economic load dispatch solution.

4 Results and Discussion

The developed model is tested to simulate ELD problem for 13 generating units in MATLAB software.

4.1 *Data of the Generating Units Considered for Solving ELD Problem*

The fuel cost coefficients, limiting constraints of generation of 20 plants used for solving the economic load dispatch problem are given in appendix.

4.2 *Generation of Every Plant after Solving the ELD Problem*

Simulation is done for demands of 1800MW, 2100MW and 2400MW.The respective generations of eachplants are given in following Table I .

TABLE I
Generation of the units for different demands

Units	Pd=1800MW	Pd=2100MW	Pd=2400MW
1	629.0918	630.55	627.1905
2	221.119	288.81	357.3686
3	300.7918	360	296.750
4	60	150	165.6828
5	60	60	105.2124
6	60	60	167.6601
7	112.3813	156.6234	106.6171
8	67.3022	144	158.9253
9	60	60	160.9026
10	40	40	40
11	76.8458	40	40
12	55	55	84.1234
13	57.4682	55	89.5681

4.3 *The total fuel cost of the plant for 15 test runs and its convergence curve*

Using the data given in appendix ELD problem is tried to solve by the model developed considering the generation power limits. For a demand of 1800MW 15 test runs were made and the minimum cost obtained is 18021$, whereas, the maximum cost is 18180$ and the mean cost obtained is 18120$. The convergence curve is given by the following figure.

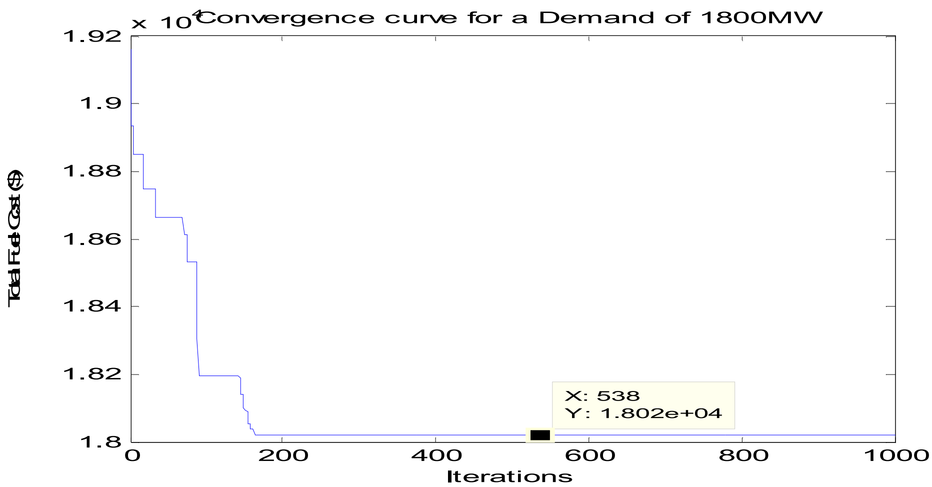

Fig.1. convergence curve of the solution.

5 Conclusion

The developed model found to be minimizing the cost effectively compared to traditional PSO.Convergence of the solution is found to be faster than the traditional PSO.

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