An alternate approach to economic generation for solving economic load dispatch problem for a multi machine system

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Abstract: The paper represents an approach for determining the condition of economic generation in a multi machine system. The economic load dispatch (ELD) problem is generally based on the economic generation of the system. Economic generation problem can be solved in best case by equating the ratio of overall cost to generated power i.e. lambda optimization for all generators in the particular system. In this paper, a new technique is incorporated to minimize the iteration of choice of the economic lambda. The primary purpose of the classic optimal generation dispatch problem has always been to minimize the generation cost of the power system, which includes fuel and operational cost. A heuristic algorithm is also introduced here to establish the method more valuable and effective. The described method is also applied on different test systems to explain the application of the algorithm.

Keywords: GA=Genetic Algorithm, ELD= Economic Load Dispatch, Optimization, MATLAB, Lambda operator, Economic generation, Iteration

1 INTRODUCTION

THE complexity in modern electric power system is due to presence of multiple generators in that particular system which should satisfy the total demand. However, the rate of increase of generation is less than the rate of increase of power demand hence it is necessary to operate generators in economic way [1]. This kind of problem can be expressed in some classical mathematical way where the relationship between cost and power are established [1] [2]. There are many traditional optimization methods to solve ELD problem. These traditional methods are lambda iteration [1][2],gradient method, base point, participation factor method, Newton's method, Linear programming, and quadratic programming [3]. The ELD problem can be solved by using some soft computing numerical techniques like pattern search [4], evolutionary computation [5], genetic algorithm [6][7][8], particle swarm optimization [9], and etc. MATLAB [10] is the computer software, which can be very helpful to develop the programming techniques. Here in this paper a modern technique is incorporated which is developed with help of GA and lambda iteration.

2 Formulation of ELD Problem

The major part of ELD problem is to minimize the total fuel cost while fulfilling the operational constraints of the power system. In ELD problem allocation of optimal power generation among the different generating units with minimum possible cost i.e. optimal cost is done in such a way so as to meet demand and generating constraint. The mathematical modeling of ELD problem can be expressed as follows-

1. Objective function

The ELD problem can be formulated by single quadratic function that is given by following equation:-

$$F(P_{gi}) = \sum_{i=0}^{N_g} F_i(P_{gi}) \qquad (1)$$

Where,

$F(P_{gi})$ =Total fuel cost ($/h)

$F_i(P_{gi})$ = Fuel cost of ith generator ($/h)

N_g = Number of generator

The fuel cost of ith generator can be expressed as,

$$F_i(P_{gi}) = a_i P_{gi}^2 + b_i P_{gi} + c_i \qquad (2)$$

Where,

a_i,b_i , and c_i = Fuel cost coefficients of ith generator.

From equation (1) and (2),

$$F_i(P_{gi}) = \sum_{i=0}^{N_g} (a_i P_{gi}^2 + b_i P_{gi} + c_i) \text{.........}(3)$$

2. System Constraint

The constraints in ELD problem:

2.1 Equality Constraint (Power balance constraint)

The cost function is not affected by reactive power but it is affected by real power. According to this constraint, summation of real power of the entire generating unit must be equal to the total real power demand on the system and power transmission loss. This may be expressed as follows:

$$\sum_{i=0}^{N_g} P_{gi} = P_d + P_l \text{..........................}(4)$$

Where,

P_{gi} = Real power generation of ith generator

P_d = Total real power demand

P_l = Power transmission loss

2.2 Inequality Constraint

Inequality constraints for the generating unit can be given as follows:

$$P_{gi}^{\min} \le P_{gi} \le P_{gi}^{\max} \text{..................................}(5)$$

Where,

$P_{gi}^{\min}$ = minimum limit of power generation of ith generator

$P_{gi}^{\max}$ = maximum limit of power generation of ith generator

Transmission loss can be expressed as a function of generator power through B-coefficients. The simplest form of loss equation using B-coefficients is given by

$$P_l = \sum_{i=0}^{N_g} \sum_{j=0}^{N_g} P_{gi} B_{ij} P_{gj} \ \text{MW.......................}(6)$$

Where,

P_{gi}, P_{gj} = Real power generation at the ith and jth buses, respectively

B_{ij} = B_{ji} = Loss coefficients

For this constraint based optimization problem we use Lagrangian multiplier. So the augmented cost function is given by

$$L(P_{gi}, \lambda) = F(P_{gi}) + \lambda[P_D + P_L - \sum_{i=0}^{N_g} (P_{gi})\ ] .(7)$$

Where λ is the Lagrangian multiplier.

The necessary condition for optimization problem is given by equation (8)

$$\frac{\delta L(P_{gi}, \lambda)}{\delta P_{gi}} = 0, (i = 1, 2\text{........}N_g)\text{..............}(8)$$

$$\frac{\delta F(P_{gi})}{\delta P_{gi}} + \lambda\left(\frac{\delta P_L}{\delta P_{gi}} - 1\right) = 0\text{.......................}(9)$$

$$\frac{\delta F(P_{gi})}{\delta P_{gi}} = \lambda\left(1 - \frac{\delta P_L}{\delta P_{gi}}\right), (i = 1, 2\text{........}N_g)\text{............}(10)$$

Where, $\frac{\delta F(P_{gi})}{\delta P_{gi}}$ = Incremental cost of the ith generator (\$/MWh)

$\frac{\delta P_L}{\delta P_{gi}}$ = Incremental transmission loss (ITL) of ith generator.

The above equation is called as coordination equation.

Furthermore,

$$\frac{\delta L(P_{gi}, \lambda)}{\delta \lambda} = P_D + P_L - \sum_{i=0}^{N_g} (P_{gi}) = 0\text{........................}(11)$$

By differentiating equation (6) with respect to P_{gi}

$$\frac{\delta P_L}{\delta P_{gi}} = \sum_{j=0}^{N_g} (2B_{ij} P_{gj})\text{..}(12)$$

The incremental cost of ith generator can be obtained by differentiating equation (3) with respect to P_{gi}

$$\frac{\partial F(P_{gi})}{\partial P_{gi}} = 2a_i P_{gi} + b_i \text{.....................}(13)$$

With the help of equation (12) & (13), equation (10) can be written as

$$2a_i P_{gi} + b_i = \lambda[1 - \sum_{j=0}^{N_g} (2B_{ij} P_{gj})]\text{...................................}(14)$$

By arranging equation (14)

$$2(a_i + \lambda B_{ij}) P_{gi} = \lambda(1 - \sum_{j=0, j\ne i}^{N_g} (2B_{ij} P_{gj})) - b_i \text{..................}(15)$$

The value of P_{gi} can be formulated as

$$P_{gi} = \frac{\lambda(1 - \sum_{j=0, j\ne i}^{N_g} (2B_{ij} P_{gj})) - b_i}{2(a_i + \lambda B_{ij})}, (i = 1, 2\text{..................}N_g)\text{.....}(16)$$

If λ is known then generator real power can be obtained by equation (16).

III. The algorithm to solve the problem:

The concept of the problem structure has already been discussed earlier. The steps of the algorithm to solve the problem may be described as follows:--

a) Read the all existing generator data as Active and reactive power limits, generating cost coefficients, etc.

b) Calculate the lambda operator for all generators.

c) Check the magnitudes of lambda for all maximum limits of power for all generators are equal or not. If equal then the system is already optimised and display the results as the existing power. If not then follow the steps (d) to (f).

d) Taking the maximum lambda magnitude check whether the power generations for all the generators are within the individual limit or not. If yes then take the magnitudes of the generator power for that optimised lambda. If not then go for the steps (e) to (e). Update the maximum lambda by reducing it with some small tolerance and find out the magnitude of power for the specific new lambda. (This step may be considered as mutation in Genetic Algorithm).

f) Find the power of all generators for the new lambda. Go to step (c).

The results will be some power magnitudes for the all connected generators. This is the optimized result for the specified case.

The overall GA based algorithm is developed in program form in MATLAB coding and observed the result. The updation of the magnitude of lambda is taken randomly.

IV. Results:

In this paper, only one case study [1] is done. The results are taken as the output of the MATLAB program.

a) Case Study -I:-- The data for the three machine system;

Unit	Pgi	Pgi	ai	bi	ci
1	10	85	0.0	7	2
2	10	80	0.0	6	1
3	10	70	0.0	7	1

The result of the economic generation for lambda=**7.731456** will be as follows P_{g1} = 45.716, P_{g2} = 79.525, P_{g3} = 66.533. Total generated power in Bus= (66.533+79.525+45.716) = 191.774. It is observed in 21st iteration.

V. Discussion and future scope:

The method is helpful to identify the economic generation condition and the status of health of generation in a multi machine system. After observing this anyone can farther take a study on the change of the cost constants in the existing generators. But in this paper a modified Genetic Algorithm is used to change or update the lambda operator. But the other changes may observed by taking modification of the cost coefficients.

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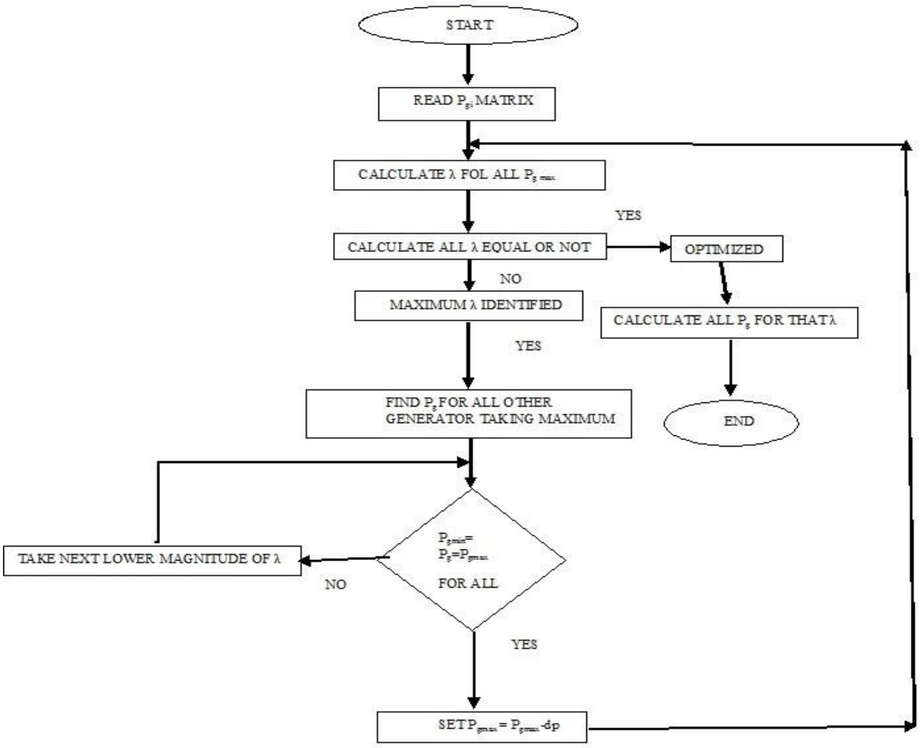

Flow Chart of the mentioned algorithm

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