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ECONOMIC LOAD DISPATCH USING GENETIC ALGORITHM

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***Abstract* — This paper present the application of Genetic Algorithm (GA) to Economic Load Dispatch problem of the power system. Economic Load Dispatch is one of the major optimization problems dealing with the modern power systems.ELD determines the electrical power to be generated by the committed generating units in a power system so that the total generation cost of the system is minimized, while satisfactory the load demand. The objective is to minimize the total generation fuel cost and maintain the power flow within safety limits. The introduced algorithm has been demonstrated for the given test systems considering the transmission line losses.**

Keywords— Economic load dispatch (ELD), Genetic Algorithm

I.INTRODUCTION

The sizes of electric power system are increasing rapidly to meet the total demand but the rate of increase of generation is less than the rate of increase of power demand hence it is necessary to operate power system in economic manner. This can be done by ELD techniques. The most common task in power system is to determine and provide an economic condition for generating units without violation of any system constraints, which is known as Economic Load Dispatch (ELD). The parameters must be taken into account for any ELD problem are load demand, transmission power losses and generation cost coefficients. The total operating cost of a power plant depends upon the fuel cost, cost of labour, supplies and maintenance. Generally the costs such as cost of labour, supplies and maintenance being difficult to determine and approximate, are assumed to change as a fixed percentage of the fuel cost. Thus cost function of power plant which is mainly dependent on fuel cost is given as a function of generation. Traditionally the cost function in ELD problem has been approximated as a quadratic function. The generation cost depends upon the system constraint for a particular load demand it means that the generation cost is not fixed for a particular load demand but depends upon the operating constraint of the sources. There are many traditional optimization methods to solve ELD problem. These traditional methods are lambda iteration, gradient method, base point, participation factor method**,** Newton's method, Linear programming, and quadratic programming. ELD is major topic and many research works have been done in this field. In ELD problem has been solved by using GA. In PSO technique has been used to solve ELD problem.

II. Problem formulation

The primary goal 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 at minimum possible cost is done in such a way so as to meet demand constraint and generating constraint. The formulation of ELD problem can be done as follows-

1. Objective function

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

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

Where,
$F(P_{gi})$ =Total fuel cost
$F_i(P_{gi})$ =Fuel cost of i_{th} generator
N_g= Number of generator

The fuel cost of i_{th} generator can be expressed as,

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

Where,
a_i, b_i, c_i = Fuel cost coefficients of i_{th} generator.
From equation (1) and (2),

2. System Constraint

There are two types of 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 all the generating unit must be equal to the total real power demand on the system plus power transmission loss. This constraint is also known as power balance constraint.

$$\sum_{i=0}^{Ng} P_{gi} = P_d + P_L \quad (3)$$

Where,
P_{gi}= Real power generation of i_{th} 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:

$$P_{gi}^{min} < P_{gi} < P_{gi}^{max} \quad (4)$$

Where,
P_{gi}^{min}= minimum limit of power generation of i_{th} generator
P_{gi}^{max}= maximum limit of power generation of i_{th} 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

$$PL = \sum_{i=1}^{NG}\sum_{j=1}^{NG} P_{gi} B_{ij} P_{gj} \text{ MW} \qquad (5)$$

Where,

P_{gi},P_{gj} = Real power generation at the i_{th} and j_{th} buses, respectively

B_{ij} = Loss coefficients

III.GENETIC ALGORITHM

Traditional optimization methods such as those described are by far the most common optimization tool used in the industry. However, these techniques can encounter some difficulties such as getting trapped in local minima, increasing computational complexity and being not applicable to certain objective functions. This calls for developing a new class of solution methods that can overcome these limitations. Heuristic optimization is fast nascent tools that can overcome most of the shortcomings found in derivative based techniques. In 1975 Holland first used the concepts of real world to solve the search and optimization problem and invented GA as a power tool in its “Adaptation in natural and artificial systems”. Main attraction of GA is its simple concept that is both easy to implement and computationally efficient. GA has a flexible and well balanced mechanism to enhance exploration and exploitation abilities. GA can be viewed as a general-purpose search method, an optimization method, or a learning mechanism, based loosely on Darwinian principles of biological evolution, reproduction and ‘‘the survival of the fittest’’. GA maintains a set of candidate solutions called population and repeatedly modifies them. At each step, the GA selects individuals from the current population to be parents and uses them to produce the children for the next generation.GA is adequate of solving the constraint ELD problem, explanatory the exact output power of all the generation units. To model the fuel cost of descent units,a piecewise quadratic function is used and B coefficient method is used to describe the transmission harm. The acceleration coefficients are adjusted intelligently and a novel algorithm is proposed for allocating the initial power values to the generation units.

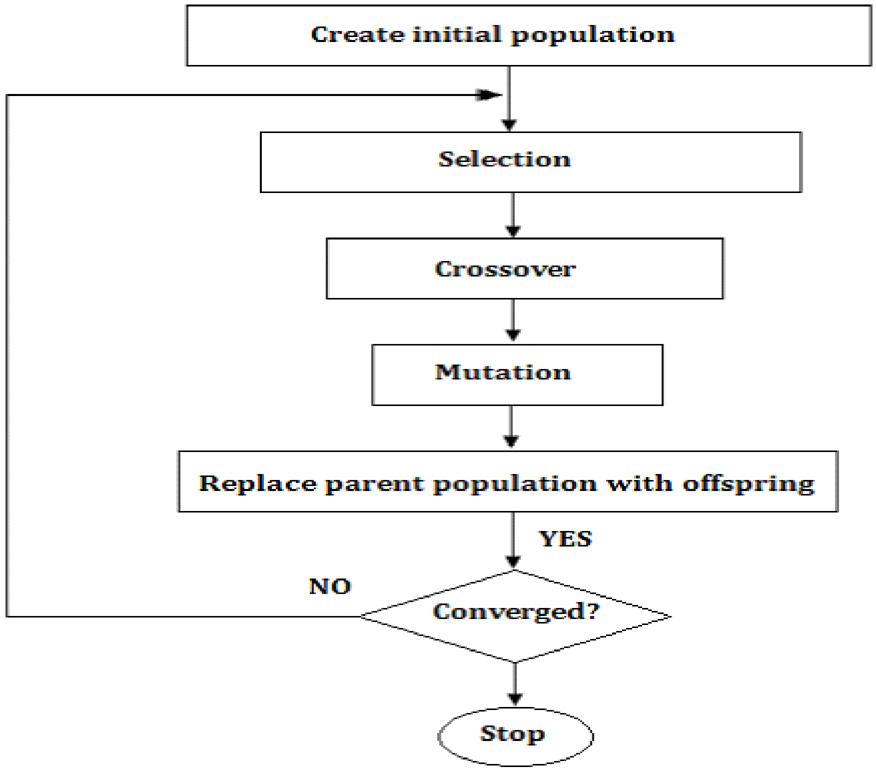

Fig 1:-Flow Chart of Genetic Algorithm

A. ECONOMIC LOAD DISPATCH USING GA

Step 1. Initialization
Initialize population size, maximum generation, stall time limit and read the cost coefficients and B coefficients.

Step 2. Formation of population
The initial power search for each generator can be obtained by
$P_{ij} = P_{imin} + \{(P_{imax} – P_{imin}) / (2_l-1)\}*b_{ij}$

Where,
i = number of generator
j = number of generation
Step 3. Evaluate the fitness function
The incremental transmission losses denoted as 'B' is calculated as per formula the given below and determines the best fitness and mean fitness values.
Step 4. Apply genetic operators
Parent individuals are selected using 'Roulette Wheel' selection procedure and single point crossover is used and finally mutation operator is used for regaining the lost characteristics during the process.
Step 5. Repeat the step 3 and step 4 until the process has been converged or it satisfies the stopping criteria.

IV.NUMERICAL RESULTS

The result of ELD after the implementation of proposed method Genetic Algorithm method is discussed. The programs are implemented in MATLAB 7.6.0. The performance is evaluated with considering losses using 3 generator and 6 generator test system. The coefficients of fuel cost and maximum and minimum power limits are given below:-

Table1:- Fuel cost coefficient for 3 generator test system:

a_i	b_i	c_i	P_g^{min}	P_g^{max}
0.008	7	200	10	85
0.009	6.3	180	10	80
0.007	6.8	140	10	70

Table2:-Loss coefficients for 3 generator test system

0.000218	0.000093	0.000028
0.000093	0.000228	0.000017
0.000028	0.000017	0.000179

Table3:-Fuel cost coefficient for 6 generator test system:

a_i	b_i	c_i	P_g^{min}	P_g^{max}
• 0.005	• 2	• 100	• 10	• 85
• 0.010	• 2	• 200	• 10	• 80
• 0.020	• 2	• 300	• 10	• 70
• 0.003	• 1.95	• 80	• 50	• 250
• 0.015	• 1.45	• 100	• 5	• 150
• 0.010	• 0.95	• 120	• 15	• 100

Table4:-Loss coefficient for 6 generator test system(*10^{-4}):

0.14	0.17	0.15	0.19	0.26	0.22
0.17	0.6	0.13	0.16	0.15	0.2
0.15	0.13	0.65	0.17	0.24	0.19
0.19	0.16	0.17	0.71	0.3	0.25
0.26	0.15	0.24	0.3	0.69	0.32
0.22	0.2	0.19	0.25	0.32	0.85

Table5:-Optimal result for 3 generator test system using GA in MW (P_d=150)

P_{g1}	34.489
P_{g2}	64.029
P_{g3}	54.153
Total Generation (MW)	153.671
Total cost(Rs/Hr)	95999.091

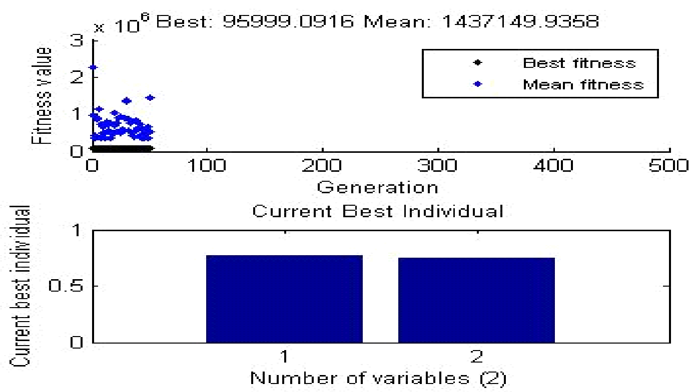

Fig 2:- Fuel cost for 3 generator system

Table5:-Optimal result for 6 generator test system using GA in MW (P_d=450)

P_{g1}	84.23
P_{g2}	41.12
P_{g3}	23.76
P_{g4}	153.96
P_{g5}	53.49
P_{g6}	100
Total generation(MW)	456.56
Total cost(Rs/hr)	117099.60

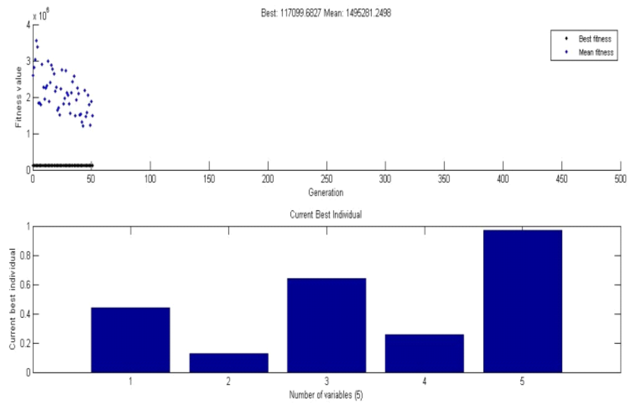

Fig 3:- Fuel cost for 6 generator system

VI.CONCLUSION

In this paper, an approach based on a genetic algorithm has been successfully presented and applied to the generation cost in electrical power network to obtain the optimum solution of ELD. Test results shown GA can provide highly optimal solutions ne reduces the computational time. Another advantage of GA approach is the ease with which it can handle arbitrary kinds of constraints and objectives.

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