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Novel Optimization Based on the Genetic Algorithm for Economic Dispatch of 30 Bus IEEE Test Systems

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ABSTRACT

Economic load dispatches (ELD) have been applied to obtain optimal fuel cost of generating units. Genetic Algorithm (GA) is a global search technique based on principles inspired from the genetic and evolution mechanism observed in natural biological systems. This paper presents a novel stochastic Genetic Algorithm approach to solve the Economic Load Dispatch problem considering various generator constraints and also conserves an acceptable system performance in terms of limits on generator real and reactive power outputs bus voltages and power flow of transmission lines. The ELD problem in a power system is to determine the optimal combination of power outputs for all generating units which will minimize the total fuel cost while satisfying all practical constraints. Found some of the available answers by the GA, GA implementation using the Arithmetic crossover operators. Simulation results on the IEEE 30-bus electrical network with the proposed GA are applied to types of ELD problems cost functions. The experimental results show that the proposed GA approach is comparatively capable of obtaining higher quality solution.

Keywords: *Genetic Algorithm (GA), Economic dispatch, Power loss, IEEE tests systems.*

1. INTRODUCTION

Conventionally, economic load dispatch problem allocates loads to plants at minimum cost while meeting the constraints. It is an optimization problem which minimizes the total fuel cost of all committed plants while meeting the demand and losses. The optimal power system operation is achieved when both the objectives of power systems i.e. cost of generation and system transmission losses simultaneously attain their minimum values. Economic load dispatch reflects the optimal electrical output of generation facilities, to fulfill the system load demand, at the lowest possible cost, while providing power in a robust and reliable way. Economic load dispatch problem is one of the fundamental matters in power system operation. In essence, it is an optimization problem and its main objective is to cut-down the total generation cost, without breaching any constraints [1]. Preceding efforts on solving ELD problems have made use of various mathematical programming and optimization techniques [2]. Numerous techniques have been established to help solve the ELD problems, such as Particle Swarm Optimization [3], Artificial Bee Colony Algorithm [4], Genetic Algorithm [5], Pattern Search Algorithm [6], Neural Networks [7], Evolutionary Programming [8], and Harmony Search Algorithm [9]. Each of the employed techniques may have some advantage and disadvantages. For instance, Particle Swarm Optimization (PSO) is well recognized for its capability to permit each particle to maintain a memory of the best solution it has discovered in the particle's neighborhood swarm. Furthermore, PSO is easy to device, and effective [10]. However, the algorithm might experience inequality constraints difficulties. Recently, Ant Colony Optimization (ACO) [11] has turn into a candidate for many optimization applications [12] such as the combinatorial optimization travelling salesman problem (TSP), quadratic assignment problem (QAP), and optimal design and scheduling problem of thermal units [13].

This paper presents a an innovative approach based on Genetic technique in solving Economic Load Dispatch problem for 30 bus IEEE system.[13,14]

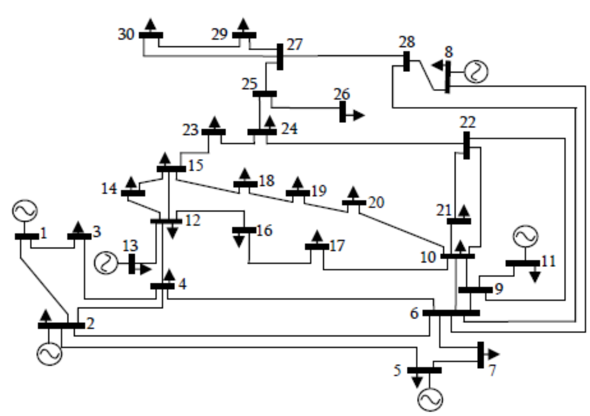

Fig 1: Topology of the IEEE 30-bus

2. ECONOMIC LOAD DISPATCH

The objective of Economic Load Dispatch is to minimize the operating cost of each generating unit in the system. Thus, an optimal generated output can be acquired from the solution. Economic Load Dispatch can be calculated by using the following equations [15-19]

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$$optimum\ cost = \sum_{i}^{Ng} Fi(Pi) \qquad (1)$$

Where *cost* is the operating cost of power system and the objective function is to minimize the cost. *Ng* is the number of units. *Fi (Pi)* is the cost function and *Pi* is the power output of the unit *i*. *Fi(Pi)* is usually approximated by a quadratic function of its power output *Pi* as:

$$Fi(Pi) = a_i + b_i P_i^2 + b_i P_i + c_i \qquad (2)$$

Where *ai*, *bi*, and *ci* are the cost coefficients of unit *i*. The above equation is subjected to both the equality and inequality constraint as follow:

Real power balance constraint is given by:

$$\sum_{i}^{Ng} Fi(Pi) = P_D + P_L \qquad (3)$$

Real power generation limit is given by:

$$P_{i\min} \le P_i \le P_{i\max} \qquad (4)$$

Where *PD* is the total load demand in MW, *PL* is the total transmission loss of the system in MW; *Pimin* and *Pimax* are the minimum and maximum generation limit of *Pi*. Next, the search of the optimal control vector is performed using into account the real power flow equation which present the system transmission losses (*PL*). These losses can be approximated in terms of *B*-coefficients as [20]:

$$Pf = \left(1 - \frac{\partial P_L}{\partial P_g}\right)^{-1} \qquad (5)$$

These losses are represented as a penalty vector [21-24]given by:

$$P_L = \sum_{i}^{N}\sum_{j}^{N} P_i B_{ij} P_j \qquad (6)$$

The transmission loss of a power System *PL* can be calculated by the *B*-Coefficients method [25] and given by:

$$P_L = \sum_{i}^{N}\sum_{j}^{N} P_i B P_j + \sum_{i}^{N} P_i B_{oi} + B_{oo} \qquad (7)$$

Where *B* is an *ng*×*ng* coefficients matrix, *B0* is an *ng*-dimensional coefficient column vector and *B00* is a coefficient.

3. GENETIC ALGORITHM

3.1 Basic Principle of Genetic Algorithm

Genetic Algorithms (GA) [26,19] are direct, parallel, stochastic methods for global search and optimization, which imitate the evolution of the living beings, described by Charles Darwin. GA is part of the group of Evolutionary Algorithms (EA). The evolutionary algorithms use the three main principles of the natural evolution: reproduction, natural selection and diversity of the species, maintained by the differences of each generation with the previous. Genetic Algorithms works with a set of individuals, representing possible solutions of the task. The selection principle is applied by means of a criterion, giving an evaluation for the individual with respect to the desired solution. The best-suited individuals create the next generation.

3.2 Genetic Algorithm with Arithmetic Crossover

In order to formulate the algorithm for economic ED problem, let the chromosome of the kth individual C_k be defined as follows:

$$C_k = [P_{k1}, P_{k2}, \ldots, P_{kn}] \qquad (8)$$

k is the population size
n is the number of genes

Reproduction involves creation of new offspring from the mating of two selected parents or mating pairs. It is thought that the crossover operator is mainly responsible for the global search property of the GA. An arithmetic crossover operator is used such that it defines a linear combination of two chromosomes. Two chromosomes, selected randomly for crossover, C_i^{gen} and C_j^{gen} may produce two off springs, C_i^{gen+1} and C_j^{gen+1} , which is a linear combination of their parents i.e.:

$$C_i^{gen+1} = a.C_i^{gen} + (1-a)C_j^{gen} \qquad (9)$$

$$C_j^{gen+1} = a.C_j^{gen} + (1-a)C_i^{gen} \qquad (10)$$

Where

C^{gen} is an individual from the old generation,
C^{gen+1} is an individual from new generation,
a is the weight, it is between 0 and 1.

The mutation operator is used to inject new genetic material into the population and it is applied to each new structure individually. A given mutation randomly alters each gene with a small probability.
A random chromosome is selected, and then the mth element is chosen randomly of this chromosome, which is called the random gene. This gene value is altered randomly (any values are possible, even values representing gene devastation.).

4. PROPOSED GA ALGORITHM FOR SOLVING ED PROBLEM

In this study, an innovative approach based on Genetic Algorithm was chosen for solving the load-flow problem, i.e. the two groups of genes are pretended in a parallel mood, in a way that one group moves in the values decreasing direction and the other one move in the values increasing direction. After giving the primary values, the two groups converge to the minimum answer found.

The initialization method that is utilized in the following algorithm is an innovative method. The increasing primary amount is chosen in a way that at first, all the units should take their minimum amount and after that, we act according to the conditions 3 and 4 and the following algorithm:

a. A gene is chosen.
b. According to the probability function of one of the units, one of them is selected. Then the constant value (defined according to the accuracy and cpu time of the program, which can change based on the type of the operation), is added in accordance to the primary value that was defined for it previously. The amount of constant value should be selected in a way that it increases the power value of each unit, because each unit has already got its minimum power value. If this action does not violate condition "4" and that the amount of $\sum_{i}^{N_g} F_i(P_i)$ is less than P_D, then adding the constant value is accepted and proceeding to the level "C" is approved, otherwise the constant value is not acceptable and this level should be repeated.
c. If the condition "3" is not violated, then proceeding to the next level is approved, otherwise going back to the level "B" is mandatory.
d. The primary amounting is done.
e. Chose another gene, i.e. go to level "A". (The number of genes is determined at first.)

We should do the same guess algorithm in a decreasing way, in which we give the maximum amount of units to them and we do the same steps in the decreasing route.

In order to get to the optimum result in accordance to the guess algorithm, in the part that we are getting the best results, the more the number of these results (genes), the more the accuracy and the less the speed of running the code(CPU time), so the existing results give the prices of each unit.

Actually a large amount of data is obtained at the end of the process. We have to get to the most optimum level within the data, by means of GA algorithm based on arithmetic crossover and standard mutation separately.

The method was used in IEEE 30 Bus system with six generating (assuming the losses not to be zero). It should be mentioned that in this case, limitations such as speed and the forbidden work zones of each generator is considered.

5. SIMULATION RESULTS

To asse the feasibility of the Proposed GA approach, compare studies of ELD with All optimization methods (GA, TS, PSO, and ACO) and conventional method same as N-R were implemented in MATLAB_(7.6.0.6324(2008a) version). These programs in each case study, 100 independent runs are carried out for each optimization method. In addition, 100 different initial trial solutions are used for each method.

The Proposed GA is applied to ELD problems for IEEE 30 Bus system with six generating. The input data for 6 generating units system are given in [14],[Table A.1] with 283.4 MW load demand. The global solutions for these systems are not discovered yet. After performing 100 trials, The best results for "P_i"s for IEEE 30 Bus system with six generating , in order for the best answer to be found, is shown in the Tables 1.

In the Tables 2, there is a brief comparison between our suggested method and some other innovating methods proposed by other researchers and some standard methods based on the smart algorithms (that Described above) and conventional method which are the results of other researchers.

The transmission loss coefficient denoted as *Bij* is given according to Eq. (13) that calculated with *N-R* conventional method [14].

$$B_{ij} = \begin{bmatrix} 0.218 & 0.103 & 0.009 & -.010 & 0.002 & 0.027 \\ 0.103 & 0.181 & 0.004 & -.015 & 0.002 & 0.030 \\ 0.009 & 0.004 & 0.417 & -.131 & -.153 & -.107 \\ -.140 & -.015 & -.131 & 0.221 & 0.094 & 0.050 \\ 0.002 & 0.002 & -.153 & 0.094 & 0.243 & 0.000 \\ 0.027 & 0.030 & -.050 & 0.50 & 0.000 & 0.358 \end{bmatrix} \times 10^{-3} \quad (13)$$

6. CONCLUSIONS

Research in the area of metaheuristics has made possible the development of optimization methods that have the goal of providing high-quality solutions to complex systems. The simulation results and the comparison between other researches results, and the significant difference between them, The IEEE 30-bus test systems were used to investigate the effectiveness of the proposed technique. The Proposed GA is compared with other, such as DE-OBL, ABC, DE, ACO-OPF and GA. it is obvious that , the proposed technique can be a proper method for medium-scale system an ant colony optimization method can give a best result.

Table 1: Fuel cost coefficients for IEEE 30 Bus system with six generating.

Generator	P_{min}(MW)	P_{max}(MW)	P(MW)
P_{G1}	50	200	165.5
P_{G2}	20	80	49.7
P_{G3}	15	50	24.9
P_{G4}	10	35	16.6
P_{G5}	10	30	10
P_{G6}	12	40	21.9
P*loss*			4.8395
PD			283.7605
Total generation cost			794.0041

Table 2: Convergence results for IEEE 30 Bus system with six generating

Method	Best Cost
Load demand	283.4 MW
Proposed GA	794.0041
DE-OBL [14]	794.9129
ABC	801.881
DE	802.23
ACO-OPF[27]	803.123
GA	803.699

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APPENDICES

Table A. 1: Fuel cost coefficients for the 13 thermal units. [19]

Generator	$P_{\min}$ (MW)	$P_{\max}$ (MW)	a_i (\$/(MW)^2)	b_i (\$/MW)	c_i (\$)
P_{G1}	50	200	0.00375	2	0
P_{G2}	20	80	0.01750	1.75	0
P_{G3}	15	50	0.06250	1	0
P_{G4}	10	35	0.00834	3.25	0
P_{G5}	10	30	0.02500	3	0
P_{G6}	12	40	0.02500	3	0