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Economic Load Dispatch for Number of Thermal Plants Using Genetic Algorithm and Refined Genetic Algorithm

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Abstract- Economic load dispatch (ELD) is a sub problem of the optimal power flow (OPF) having the objective of fuel cost minimization. The classical solutions for ELD problems have used equal incremental cost criterion for the loss-less system and use of penalty factors for considering a system losses. The main focus of this paper is on the application of Genetic Algorithm (GA) to search for an optimal solution to a realistically formulated economic dispatch (ED) problem. GA is a global search technique based on principles inspired from the genetic and evolution mechanism observed in natural biological systems. A major drawback of the conventional GA approach is that it can be time consuming. The effectiveness of CG at 6-bus test system can be found easily. Simulation results obtained on this network using CGA validate their effectiveness when compared with the published results obtained via the classical network approaches. Finally, both GA approaches have been successfully applied to the 8-bus system fed by four thermal plant system than the result of these are compared with other methods that are adopted for ELD. In this paper it is found refined GA is less time consuming more accuracy.

Keywords- *Economic dispatch; genetic algorithm; refined genetic algorithm*

I. INTRODUCTION

In order to maintain a high degree of economy and reliability of the power system, Economic dispatch allocates the total power demand among the online Generating units in order to minimize the cost of generation while satisfying system constraints. The important factors that influence economic operation of the system are operating efficiency of generating units, fuel and operating cost, and transmission losses.

Economic load dispatch (ELD) problem is a constrained optimization problem in power systems that have the objective of dividing the total power demand among the online participating generators economically while satisfying the various Constraints. Over the years, many efforts have been made to solve the problem incorporating different kinds of constraints or multiple objectives, through

Various techniques such as LaGrange based methods the conventional methods include Lambda iteration method [3,4], base point and participation factors method [3,4], gradient method [3,5], etc. Among these methods, lambda iteration is most common one and, owing to its ease of implementation, has been applied through various software packages to solve ELD problems. But for effective implementation of this method, the formulation needs to be continuous. The basic ELD considers the power balance constraint apart from the generating capacity limits. However, a practical ELD must take ramp rate limits, prohibited operating zones, valve point loading effects, and multi fuel options [6] into consideration to provide the completeness for the ELD problem formulation. The resulting ELD is a non-convex optimization problem, which is a challenging one and cannot be solved by the traditional methods.

The work considered here has explored the application algorithm to solve the problem of real power dispatch. Genetic algorithms are stochastic search techniques based on the mechanism of natural selection and survival of the fittest. Also, they combine solution evaluation with randomized, structured exchanges of information among solutions to obtain optimality. As a robust and powerful adaptive tool for solving search and optimization problems, they have been applied to various power system problems such as economic dispatch, unit commitment, reactive power control etc [2-4].

One recognized disadvantage inherent in CGA is the large number of function evaluation resulting in long computational time. A survey of the existing population studies [5] revealed that a larger population (20 - 200) is generally thought to be first proposed the application of a small population size in GA so as to reduce its computational time. The application of the so-called Refined-GA has been reported in [7], proving to be conceptually simple to implement and an effective search technique. To confirm its effectiveness, a micro-GA approach has been applied in this paper to solve the ED problem. It uses a relatively small population size compared with CGA and premature convergence is avoided by frequent call of a “start and restart” procedure, through which a diversity of the population string introduce generating unit, 6-bus test system. Tests performed on this network under two different loading conditions using both approaches revealed better results when compared with published results obtained are much better than the obtained from other conventional methods. [2] Approaches depicting their feasibility and effectiveness. More significantly, both GA techniques have been extensively applied.

The paper is organized as follows: Following the introduction, the problem of economic dispatch is presented in section II. In section III, the concept of GA is briefly reviewed and in section IV implementation of GA based ELD is discussed in detail. Simulation results are given in section V. Finally, brief and pertinent conclusions are drawn.

II. PROBLEM FORMULATION

Consider a system consisting of n thermal units connected to a transmission network. The object of ED is to supply a given power demand at a minimum generation cost subject to various constraints. The ED problem is a constrained optimization that can be formulated as follows.

$$F_T = F_i(P_i) \quad (1)$$

where F_T is total generation cost .

The quadratic cost function of unit i is given by:

$$F_i(P_i) = a_i P_i^2 + b_i P_i + c_i \quad (2)$$

$$i=1,2,3\text{------} N$$

Where is total cost of generating unit
a_i , b_i , c_i, - cost coefficient
P_i - real power output in MW
N -total no. of generating unit to be dispatch

To minimize the total generation cost, total generation cost should be equal to demand and transmission losses.

For balancing the real power

$$P_i = P_D + P_L$$

Total transmission losses is given by equation

$$P_L = \sum B_{0i} P_i \quad (3)$$

P_D - system power demand,
B_{0i} - loss coefficient
P_L - system transmission real power losses,

The generation cost should be between maximum and minimum limits.

$$P_{i\,min} \leq P \leq P_{i\,max} \quad (4)$$

P_{imax} and P_{imin} are minimum and maximum power output of individual generating unit.
F_T = system total generation cost,
$F_i(P_i)$ = generation cost of unit 'i' when the power output is P_{Gi}..

Where a_i,b_i and c_i are respectively constant, linear and quadratic cost coefficients of unit i. Using the B-coefficient method, network losses are expressed as:

$$P_L = \sum B_{0i} P_i \quad (5)$$

Where B_{0i} and these generalized loss formula coefficients.

$$€ = P_d + P_L \sum_{i=1}^{NG} P(i) \quad (6)$$

$$f = 1 \div [1 + \alpha\, €/ P_D] \quad (7)$$

Where € is tolerance and f is required fitness value which should be nearly equal to 1.

III. GENETIC ALGORITHM CONCEPT

Genetic Algorithms (GAs) are numerical optimization algorithms based on the principle inspired from the genetic and evolution mechanisms observed in natural systems and population of living being [5]. Binary encoding GA is dealing with binary strings, where the number of bits of each string simulates the genes of an individual chromosome, and the number of individuals constitutes a population. Each parameter set is encoded into a series of a fixed length of string symbols usually from the binary bits, which are then concatenated into a complete string called chromosomes. Sub-strings of specified length are extracted successively from the concatenated string and are then decoded and mapped into the value in the corresponding search space. Generally, GAs implementation comprises the procedures of initial population generation, fitness evaluation and genetic operations of selection, crossover and mutation [8]. It is expected of GA to be able to find an acceptable solution within a reasonable time when solving the optimization problem. One of the features that distinguish GAs from other conventional search methods is the characteristics to simultaneously deal with a population of points (solutions), thus leading To disadvantage of requiring a relatively large number of functions evaluations. As previously noted, a population of between 20 and 200 will, broadly speaking, enable global optimum to be found in few generations. Thus a small population size as proposed in [6],often results in the so-called Refined GA.

The major difference between the Refined GA and the conventional GA (CGA) lies therefore in the choice of the population size. In the initial very small population, typically of four or five individuals is randomly generated It is then processed by the three main GA operators such that the mutation rate is fixed at 0.0. The algorithm thus converges quickly within a few function evaluations. A restart procedure in which new individuals are randomly generated while keeping a copy of the best individual of the previous converged generation ensures the infusion of the new genetic information and the retention of the previous best individual. The genotype convergence is said to occur when less than 5% of the bits of other individuals differ from the best individual. Comparison is made between both micro and conventional GAs in the investigation of ED problem for the IEEE 3-generating unit, 6-bus test system and the Nigerian thermal generating units.

IV. IMPLEMENTATION OF GA & REFINED GA BASED ECONOMIC DISPATCH

The general procedure involved in the implementation of both refined □and CGA describe below is as shown in Fig. 1. The GA based ED starts with the choice of appropriate GA parameters and actualization of all the necessary power system data required for the computational process. The encoding in which the problem is to be represented in the GA must be carefully designed to utilize the GA's ability to efficiently transfer information between chromosomes (strings) and the problems objective function. Binary representation is normally employed for GA analysis because of the ease of binary number manipulation and the fact that GA theory is based on the binary alphabet. At the start of the evolution process, an initial population is randomly created within generating unit's minimum and maximum loading limits. The evaluation process computes the fitness of each individual as a solution to the optimization problem. Changes in each unit power output computed as control variable are mapped into the data of their respective power units. The power flow program is then actuated or using eqn.5, delivering the power losses associated with each individual schedule, and the fitness of each individual constituting the population is then computed using: constant expressed as a fraction of the base power value S base, is the power balance tolerance and □is the penalty term. After computing the fitness of each individual, the parents then undergo the genetic operation of selection and crossover; each pair creates a child having some mix of the two parents. The process of selecting and mating of individuals continues until a new generation is reproduced. The chromosome of each individual constituting the population is subjected to mutation. The elite preserving strategy is also applied. Subsequently, the fitness of the individuals of the new generation is evaluated, and this procedure continues until the preset convergence criterion is reached. Finally, the optimal generation schedule, the total generation cost and the total system network losses are determined.

V. SIMULATION, RESULTS AND DISCUSSION

Both the conventional GA and Refined -GA based ED were implemented using the Matlab 10.05 version .In this two method GA and refined are compared to get better result.

A. Case Study 3-Generating Units, 3 Test Systems. This example is a 3-bus test system fed by three thermal generating units [10]. The cost input function for each unit is quadratic and the necessary cost coefficients given in Table I. The power loss expression for the network is given by:

$$B_{loss}= \begin{matrix} .0075 & .0005 & .00015 \\ .0019 & .0001 & .00045 \\ .0005 & .0075 & .0001 \end{matrix}$$

F_1=.00156 P_{12} + 7.92 P_1+ 561

F_2=.0019 P_{22} + 7.85 P_2+310

F_3==.00482 P_{32} + 7.97 P_3+78

Max. and Min. limit of power platns 1 , 2 and 3.

$100 \leq P_1 \leq 600$

$100 \leq P_2 \leq 400$

$50 \leq P_3 \leq 200$

CGA approaches were applied to this system under two different loading conditions. The results obtained are compared with the classical GA and Refined GA approaches [2] as summarized in fig. II.

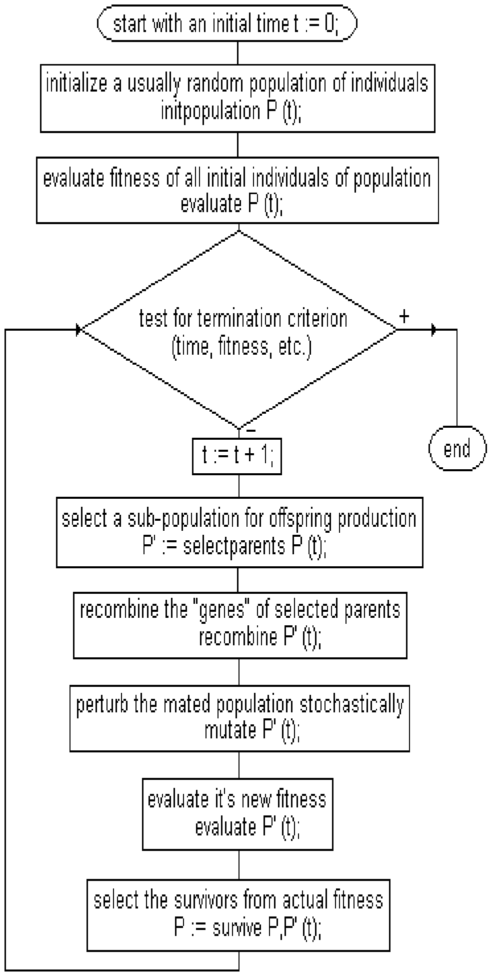

Fig. 1. Flow chart of GENETIC ALGORITHIM

From the results depicted in Table II, for both loading conditions GA returned better results than the classical CM, despite the convex nature of the cost functions used in this case study. The superior results observed with respect to GA derive principally from the specifications of their convergence criteria and the degree of convexity near the global optimum in the functional space. Note, however, from the results obtained via CGA that the unit real power allocations are, to all intents and purposes, very close to those obtained through the classical CM. However, the total production costs obtained through CGA □are slightly lower when compared with the other two methods (CM and PHN). Micro- GA returned an appreciable difference in both power allocations and the production cost. For all the cases, the network losses are much smaller with GA than those obtained B. 10 bus system test :

In this a 24-bus, 330-kV network interconnecting four thermal generating stations and three hydro stations to various load points. The quadratic cost functions for the various thermal units have been developed as the best curve fits to their actual operating cost data over a period of one year. Table II presents the cost coefficients so obtained for the four thermal units and their minimum and maximum loading limits. The network and its parameters suppressed herein can be found in [11]. The power loss is computed from (6) with the loss coefficients obtained via parameter estimation based on several power flow scenarios [12] for its largely radial network structure. The estimated loss formula coefficients are given in matrix form below:

$$B=\begin{bmatrix} .0037 & .0074 & .0005 & .0120 & .0076 & .0036 \\ .0074 & .0076 & .0023 & .0130 & .0042 & .0152 \\ .0005 & .0023 & .0056 & .0149 & .0004 & .0096 \\ .0120 & .0130 & .0149 & .0935 & .0248 & .1354 \\ .0076 & .0042 & .0005 & .0248 & .0127 & .0649 \\ .0036 & .0152 & .0096 & .1354 & .0649 & .0769 \end{bmatrix}$$

In this case study, Subsequently, both RGA □and CGA approaches were then applied to schedule the thermal units with the transmission losses considered. The results obtained and the parameters used for the GA settings are as shown in Table IV for the two approaches. RGA again offers better results with a difference of about N3,100.00 per hour when compared with the results obtained through CGA. In addition, required less computational time (66% time saving) compared with CGA. From the results summarized in Table III, GA using the B-Coefficient yielded better results. The total production costs and the executions time obtained via GA method are also lower when compared with the values obtained using the CGA approach. Furthermore, CGA yielded much smaller network losses when compared with GA method. Figure 2 is a plot of maximum fitness against number of generations for the two cases. From the graph, it can be seen that GA reached the maximum fitness faster that the CGA. On the other hand, CGA started with a very low fitness and gradually reached the peak.

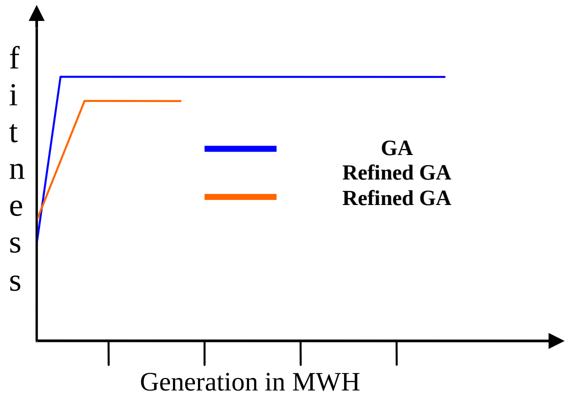

Fig.2. Graph of maximum fitness against generations

VI. CONCLUSION

In this paper both conventional GA and Refined GA based economic dispatch of load for generation cost reduction were comparatively investigated on two sample networks (a 3-bus IEEE test and 6 bus system). The results obtained were satisfactory for both approaches but it was shown that the Refined GA performed better than CGA from the economic and computational time (average of 62% time reduction) viewpoints. This is because RGA retained the advantages of the GAs over the classical approaches while eliminating the main disadvantage of the CGA long execution time most especially with respect to the 10 – bus power supply grid. This will form the basis of our further research work.

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