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Optimal Economic Dispatch for Power Generation Using Genetic Algorithm

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Abstract--In this paper, an efficient and practical real- coded genetic algorithm (GA) has been proposed for solving the economic dispatch problem. The objective is to minimize the total generation fuel cost and keep the power flows within the security limits. For each problem of optimization in genetic algorithm (GA) there are a large number of possible encodings. The use of real valued representation in the GA has a number of advantages in numerical function optimization over binary encoding. The efficiency of the GA is increased as there is no need to convert chromosomes to the binary type, less memory is required, there is no loss in precision by discret to binary or other values, and there is greater freedom to use different genetic operators. The proposed technique improves the quality of the solution and speeds of convergence of the algorithm. The Coding are written and executed the values are plotted in graph for different values of MW loading.

Keywords: Economic dispatch(ED), multi-objective optimization, Genetic algorithm (GA), Unit Commitment (UC).

I. INTRODUCTION

Modern electric power systems are large, geographically distributed, yet highly interconnected. In the process of transmitting the generated power, an estimated 4%of the total energy produced is lost[1].The economic viability of power systems, especially in a competitive energy market, demands an optimum mix of all of the parameters that influence power generation and transmission. An approach to achieving this optimum is to include the transmission losses as one of the objectives in the economic dispatch (ED) problem. Thus, the economic dispatch problem becomes a multi-objective optimization in which the fuel cost and the transmission losses are minimized. In general, multi-objective optimization problems are solved by reducing them to a scalar equivalent. This is achieved by aggregating the objective functions into a single function.[2],[3].

Improve the reliability and efficiency of power systems, new communication technologies, and distributed energy Sources, and demand response programs have been introduced. These efforts are mainly motivated by the increasing Costs of fossil fuels, environmental changes, and energy security concerns coupled with investments in wind and solar generation to replace conventional CO-emitting energy sources. The increased flexibility of the power system results in a higher level of complexity for economic dispatch (ED) problems [4].

Real-time dispatch is, in general, computed in two stages. In the first stage, a unit commitment (UC) problem is solved to select generating units to meet the expected load during each hour [5],[6]. In the second stage, an ED problem is solved to compute the power outputs of the committed units for meeting the load. This ED decision takes place minutes to hours ahead of the time of implementation. Recent work has explored UC for planning purposes to accommodate generation/load forecasting uncertainties, mostly based on standard commercial solvers. However, the location-based marginal prices are found by solving the corresponding ED problem with fixed unit commitment decision[10]-16].

A. Motivation

The economic dispatch (ED) problem is one of the most important operational functions of the modern clay energy management system. The purpose of the ED is to find the optimum generation among the existing units, such that the total generation cost is minimized while simultaneously satisfying the power balance equations and various other constraints in the system. The literature of the ED problem and its solution methods are surveyed. However, it is realized that the conventional techniques become very complicated when dealing with increasingly complex dispatch problems, and are further limited by their lack of robustness and efficiency in a number of practical applications.

Recently, a global optimization technique known as GA which is a kind of the probabilistic heuristic algorithm has been studied to solve the power optimization problems. The GAs may find the several sub-optimum solutions within a realistic computation time.

The efficiency and the robustness of the proposed GA are demonstrated by test functions. Then the GA with simulated non uniform arithmetic crossover, elitism and a non uniform mutation are applied to ED problem.

SIX BUS SYSTEM

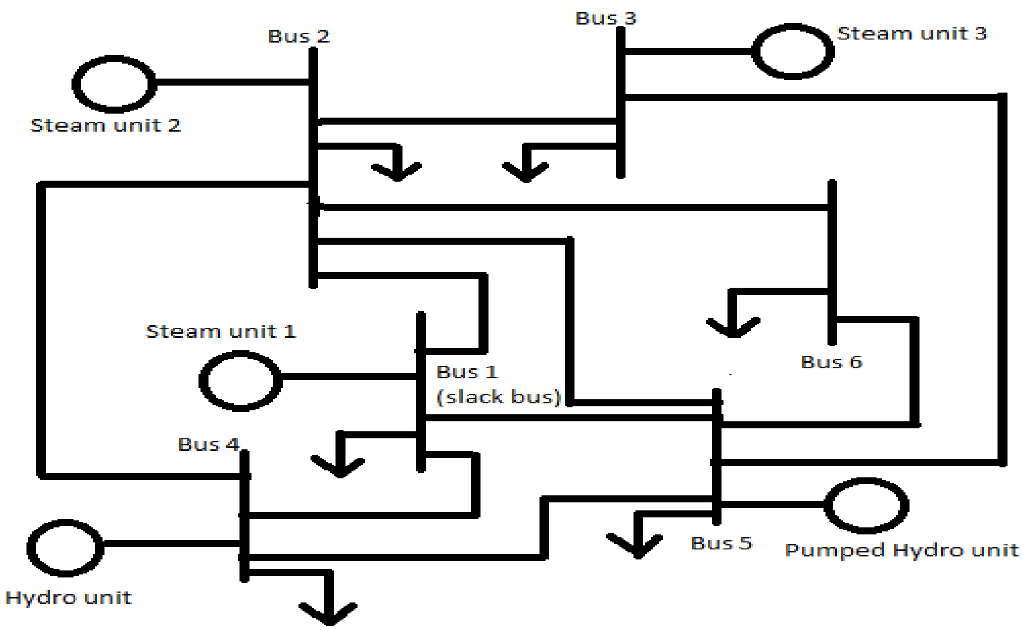

Fig.no.2.1 Diagram of six bus system

The ED problem can be expressed as:

$$\min \sum_{i=1}^{NG} F_i(P_{Gi}) \qquad (1)$$

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

Where ai, bi and ci are the cost coefficients of the generator and PGi is the real power output of the i-th generator (MW). Fi (PGi) is the operating cost of unit ($/h).Subjects to the following constraints.

$$P_{Gi}^{min} \leq P_{Gi} \leq P_{Gi}^{max} \qquad \text{for } i=1\ldots\ldots\ldots\ldots NG$$

$$\sum_{i=1}^{NG} P_{Gi} - D\text{-}P_L = 0 \qquad (3)$$

Where

$$P_L = \sum_{i=1}^{N}\sum_{j=1}^{N} P_{Gi} B_{ij} P_{Gj} + \sum_{i=1}^{N} B_{0i} P_{Gi} + B_{00} \qquad (4)$$

D =Total demand (MW)
P_L = Transmission loss(MW)
P_{Gi}^{min} =Minimum generation output of the i-th Generator
P_{Gi}^{max} =Maximum generation output of the i-th generator
B=Coefficient of Transmission losses

GA is a general stochastic optimization algorithm that was originally developed for solving unconstrained problems. By applying an exterior penalty function we transform a constrained non-linear ED problem into an unconstrained problem.

We rewrite the problem shown

II. PROBLEM STATEMENT

The ED problem (1) may be expressed by minimizing the fuel cost of generator units (2) under constraints. Depending on load variations, the output of generators has to be changed.

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$$F_m(P_G \cdot r_k) = \sum_{i=1}^{NG} F_i(P_{Gi}) + \frac{1}{r_k} \cdot B \cdot h^2 \qquad (5)$$

Where the value of the penalty coefficient r_k is checked at each iteration.
The constant B is defined as

$B>0$ if $h \neq 0$

$B=0$ if $h=0$

h is the equality constrained (6) defined as

$$h = \sum_{i=1}^{NG} P_{Gi} - D - P_L \qquad (6)$$

III. ECONOMIC DISPATCH

Economic dispatch (1) is the short-term determination of the optimal output of a number of electricity generation facilities, to meet the system load, at the lowest possible cost, while serving power to the public in a robust and reliable manner. The Economic Dispatch Problem is solved by specialized computer software which should honor the operational and system constraints of the available resources and corresponding transmission capabilities. This is defined as "the operation of generation facilities to produce energy at the lowest cost to reliably serve consumers, recognizing any operational limits of generation and transmission facilities.

A. Economic Dispatch Concept

The Economic Dispatch (1) is the operation of generation facilities to produce energy at the lowest cost to reliably serve consumers, recognizing any operational limits of generation and transmission facilities. Most electric power systems dispatch their own generating units and their own purchased power in a way that may be said to meet this definition.

There are two fundamental components to economic dispatch:

Planning for Tomorrow's Dispatch
1. Scheduling generating units for each hour of the next day's dispatch
2. Based on forecast load for the next day
3. Select generating units to be running and available for dispatch the next day (operating day)
4. Recognize each generating unit's operating limit
5. Ramp rate (how quickly the generator's output can be changed)
6. Maximum and minimum generation levels
7. Minimum amount of time the generator must run
8. Minimum amount of time the generator must stay off once turned off.

Dispatching the Power System Today

1. Monitor and maintain system frequency at 60 Hz during dispatch according to NERC standards, using Automatic Generation Control (AGC) to change generation dispatch as needed
2. Monitor hourly dispatch schedules to ensure that dispatch for the next hour will be in balance
3. Monitor flows on transmission system
4. Keep transmission flows within reliability limits
5. Keep voltage levels within reliability ranges
6. Limiting new power flow schedules
7. Curtailing existing power flow schedules
8. Changing the dispatch
9. Shedding load.

IV. GENETIC ALGORITHM

A genetic algorithm (or short GA) is a search technique used in computing to find true or approximate solutions to optimization and search problems. Genetic algorithms are categorized as global search heuristics. Genetic algorithms are a particular class of evolutionary algorithms that use techniques inspired by evolutionary biology such as inheritance, mutation, selection, and recombination.GA is well-known stochastic methods of global optimization based on the evolution theory of Darwin. They have successfully been applied in different real-world applications. GA was originally developed for solving unconstrained problems. Recently, many variants of GA have been developed for solving constrained nonlinear programming. The basic idea behind GA is to mathematically imitate the evolution process of nature. The algorithms are based on the evaluation of a set of solutions, called population. The population is treated with genetic operations. At the iteration is the population Xi consists of a number of N individual's xj, that is, solutions, where N is called a population size. The population is initialized by randomly generated individuals. The individuals can be encoded using either binary or real numbers. We use the latter because of their popularity. Each individual xj= (x1…xn) is a vector of variables.

Each variable is a real number. The suitability of an individual is determined by the value of the objective function, to be called a fitness function. A new population is generated by the genetic operations selection, crossover and mutation. Parents are chosen by selection and new off springs are produced with

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crossover and mutation. All these operations include randomness. The success of the optimization process is improved by elitism where the best individuals of the old population are copied as such to the next population.

For each problem of optimization in GA there are a large number of possible encodings. Although binary representation is usually applied to power optimization problems, in this letter we use a GA switch is a modified GA employing real valued vectors for representation of the chromosomes. The use of real valued representation in the GA has a number of advantages in numerical function optimization over binary encoding. The efficiency of the GA is increased as there is no need to convert chromosomes to the binary type, less memory is required, there is no loss in precision by discretization to binary or other values, and there is greater freedom to use different genetic operators.
The genetic algorithm is capable of solving the constraint ED problem, determining the exact output power of all the generation units. In such a way, GA minimizes the total cost function of the generation units. To model the fuel costs of generation units, a piecewise quadratic function is used and B coefficient method is used to represent the transmission losses. The acceleration coefficients are adjusted intelligently and a novel algorithm is proposed for allocating the initial power values to the generation units. A new population is generated by the genetic operations selection, crossover and mutation. Parents are chosen by selection and new off springs are produced with crossover and mutation. All these operations include randomness. The success of the optimization process is improved by elitism where the best the old population are copied as such to the next population.

A. Economic Dispatch Using Genetic Algorithm

Economic load dispatch problem (1) is allocating loads to plants for minimum cost while meeting the constraints. It is formulated as an optimization problem of minimizing the total fuel cost of all committed plant while meeting the demand and losses. The basic economic dispatch problem can described mathematically as a minimization of problem of minimizing the total fuel cost (7) of all committed plants subject to the constraints.

$$\text{Min} \sum_{i=1}^{N} F_i(P_i) \qquad (7)$$

The fuel cost equation (8) of the 'i'th plant is $F_i(P_i)$ and It is the variation of fuel cost ($ or Rs) with generated power (MW).Normally it is expressed as continuous quadratic equation.

$$F_i(P_i) = a_i + b_i P_i + c_i P_i^2 \qquad (8)$$

$$P_i^{min} \leq P_i \leq P_i^{max}$$

The total generation should meet the total demand and transmission loss. GA is a probabilistic search technique, which generates the initial parent vectors distributed uniformly in intervals within the limits and obtains global optimum solution over number of iterations. The fitness function is used to transform the cost function value into a measure of relative fitness.
1. Select a reference plant. For better convergence chose a plant which has maximum capacity and range. In this program is considered as plant 1. The reference plant allocation is fixed by the equations.
2. Convert the constrained optimization problem as an unconstrained problem by penalty function method.
3.The allocation minimum fuel cost and transmission losses can be determined.

V. MATLAB OUTPUT AND GRAPH

MATLAB is a high-level language and interactive environment for numerical computation, visualization, and programming. Using MATLAB, you can analyze data, develop algorithms, and create models and applications. The language, tools, and built-in math functions enable you to explore multiple approaches and reach a solution faster than with spreadsheets or traditional programming languages, such as C/C++ or Java. Although MATLAB is a program that was originally designed to simplify the implementation of numerical linear algebra routines. It has since grown into something much bigger, and it is used to implement numerical algorithms for a wide range of applications. The basic language used is very similar to standard linear algebra notation, but there are a few extensions that will likely cause you some problems at first.

A. Algorithm

Step 1:
Input the value of load demand, power demand and the values of cost coefficients, ai, bi, ci where i=1, 2…n.
Step 2:
Input the values of B_{mn} coefficients in the non linear equation.
Step 3:
Update the loss coefficients and find the total demand and the incremental fuel cost.
Step 4:
Assume $P_i = 0$ for i = 1, 2...n
Step 5:
Fix the limit for generating plant and solve equation iteratively for P_i.
Step 6:
Check if test unit 1 converges to load demand at its limit. Similarly check the conversion of the other plants.
Step 7:
Check if power balance equation is satisfied and otherwise go to step4.

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B.Flowchart

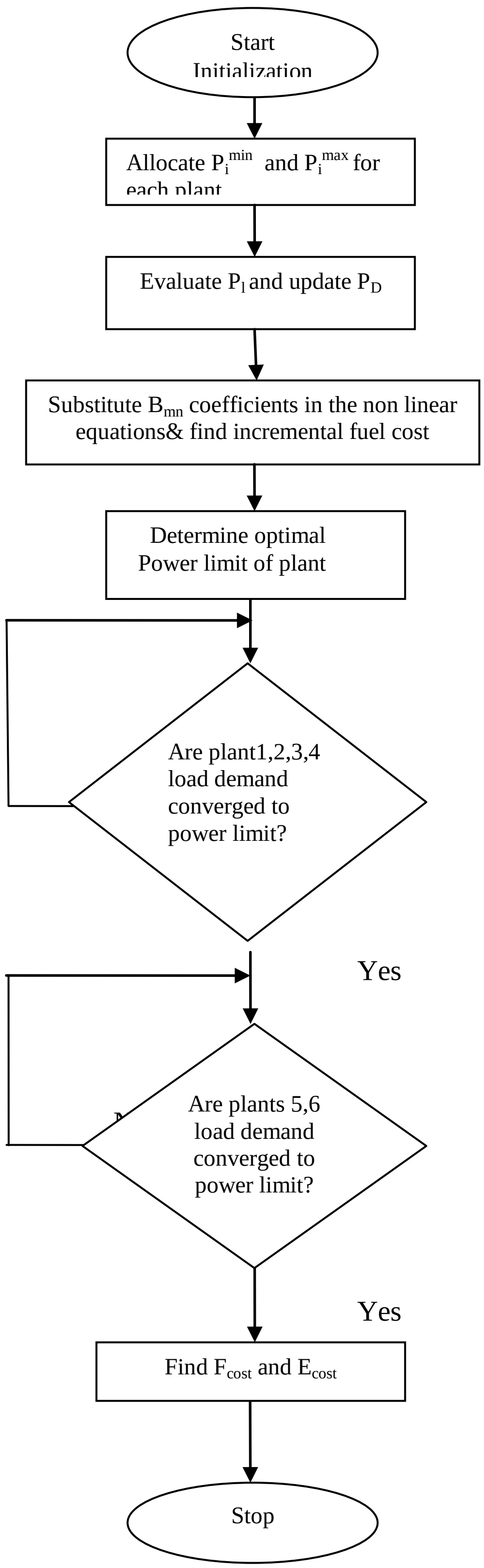

Fig.no.5.1 Flowchart of Economic Dispatch

Step 8:
Find total fuel cost.

Step 9:
Stop.

C.Matlab output

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F =

9.5657e+03

P1 =

349.7275 91.5384 181.8450 52.3976 83.2510 55.7673

Pl =

14.5268

D.Power demand versus optimized power chart

power demand	unit1 optimized power
500	354.3868
600	274.4185
700	320.9227
800	355.078
900	380.207
1000	406.8564

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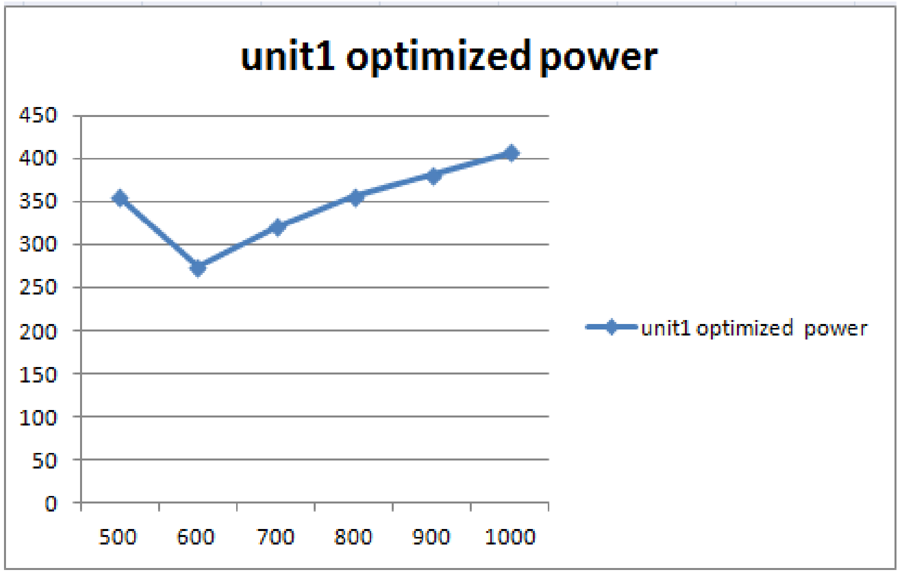

Fig.no.5.2 optimized power graph

VI. CONCLUSION

In this paper, an approach based on a genetic algorithm has been successfully presented and applied to the generation cost in electric power network to obtain the optimum solution of economic dispatch (ED). Operators are used in lagrangian to generate a set of solutions for this problem. Lagrangian method is most useful for large power systems, it lagrangian have well results and it is much faster and more effective than iterative method. Methods are compared for solving an economic dispatch problem with two generators. Test results have shown GA algorithm can provide highly optimal solutions and reduces the computation time than those with the iterative method. An advantage of the GA solution is the flexibility it provides in modeling both time dependent and coupling constants. Another advantage of the GA approach is the ease with which it can handle arbitrary kinds of constraints and objectives.

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BIOGRAPHY

Dr.Govindaraj Thangavel born in Tiruppur , India , in 1964. He received the B.E. degree from Coimbatore Institute of Technology, M.E. degree from PSG College of Technology and Ph.D. from Jadavpur University, Kolkatta, India in 1987, 1993 and 2010 respectively. His Biography is included in Who's Who in Science and Engineering 2011-2012 (11th Edition). Scientific Award of Excellence 2011 from American Biographical Institute (ABI). Outstanding Scientist of The 21st century by International Biographical centre of Cambridge, England 2011.

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