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Economic Load Dispatch using Metaheuristic Algorithms

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Abstract - *As we know that electrical energy plays a major role in day to day human life. It is not possible to imagine human life without electrical energy. This is because of the storage problem i.e. the electrical energy cannot be strong but is generated from natural sources and delivered as demand arises. An electrical engineer always tries to generate, transmit, and distribute the electrical energy at affordable cost while satisfying Constraints Economic Dispatch is the process of allocation of optimal load to each committed generators while satisfying the equality and inequality constraints. The objective is to minimize the fuel cost by maintaining the generation power in limits. The Economic Dispatch has been frequently solved by using classical optimization methods. In this proposed method of the Economic Dispatch problem is formulated and solved by using Metaheuristic Techniques like Artificial bee colony Algorithm, Genetic algorithm, Particle Swarm Optimization technique, and Simulated Annealing algorithms.*

***Key Words*: Artificial bee colony Algorithm, Genetic algorithm, Particle Swarm Optimization technique, and Simulated Annealing etc.**

1. INTRODUCTION

The main aim of modern electric power utilities is to provide high-quality reliable power supply to the consumers at the lowest possible cost while operating to meet the limits and constraints imposed on the generating units and environmental considerations.

These constraints formulates the economic load dispatch problem for finding the optimal combination of the output power of all the online generating units that minimizes the total fuel cost, while satisfying an equality constraint and a set of inequality constraints. Traditional algorithms like lambda iteration, base point participation factor, gradient method, and Newton method can solve this economic load dispatch problems effectively if and only if the fuel-cost curves of the generating units are piece-wise linear and monotonically increasing .Thus the resultant economic load dispatch becomes a challenging non-convex optimization problem, which is difficult to solve using Methods like simulation annealing, genetic algorithm, evolutionary programming, artificial intelligence, and particle swarm optimization, artificial bee colony algorithm solve non-convex optimization problems efficiently and often achieve a fast and near global optimal solution.

Economic dispatch is a sub-problem in determining unit commitment. As mentioned earlier unit commitment problem minimizes the total cost which includes both generation cost and costs associated with the start-up and shutdown of units. Precisely it determines which among the available units should be committed so as to meet the load demand by considering 'all possible number of combinations'. On the other hand, minimizes only the cost of generation for a given set of committed generators.

Therefore as name suggests economic dispatch distributes the given amount of load on to the committed generators economically while ensuring that all committed units are used at least at their minimum capacity to fulfil the load requirement. Both the optimization problems viz., unit commitment and economic dispatch are interrelated. Always in finding unit commitment, economic dispatch is solved as a sub problem as each of the commitment schedules requires an ED solution. The constraints Involved in solving ED are very limited. They are Dispatch should meet the load demand, Unit generation limits.

Objectives: To minimize the fuel cost of generating units of a thermal power plant by using Metaheuristic techniques.

1. Artificial Bee Colony algorithm
2. Genetic algorithm
3. Particle Swarm Optimization
4. Simulated Annealing

1.1 Methods to solve economic load dispatch

So to solve economic dispatch problem in power generation by keeping all system constraints in limits and to meet the demand by reducing fuel cost we use different methods and different algorithms Required for analysis of programs and simulation software are available to the operators to aid their decision making process and make power system operations more economic and reliable. Depending on the relative accuracy and computational burden, these programs are used in dispatch or pre-dispatch stages. Various methods used in early days and present days are:

Base load method: where the next most efficient unit is loaded to its maximum capability, then the second most efficient unit is loaded and so on.

Best point loading: where units are successively loaded to their lowest heat rate point, beginning with the most

efficient unit and working down to the least unit.

Some of conventional methods are Linear programming, Nonlinear programming, Quadratic Programming, Dynamic programming, Newton's method. Some of Intelligent Search Methods are Optimization neural networks, PSO, AntcolonyoptimizationGenetic algorithm, Bats algorithm, Artificial Bee Colony (ABC), Simulated annealing algorithms.

2. Artificial bee colony algorithm

Artificial Bee Colony (ABC) is one of the most recently defined algorithms by DervishKaraboga in 2005, motivated by the intelligent behavior of honey bees. ABC as an optimization tool provides a population-based search procedure in which individuals called foods positions are modified by the artificial bees with time and the bee's aim is to discover the places of food sources with high nectar amount and finally the one with the highest nectar. 'Optimization is the art and science of allocating scarce resources to the best possible effect. Moving from world problem to the algorithm, model, or solution techniques known as the real analysis.

3. Genetic algorithm

A Genetic Algorithm (GA) is a search technique used in computing to find exact or approximate solutions to optimization and search problems. Genetic algorithms are categorized as global search heuristics. GA are implemented in a computer simulation in which a population of abstract representations (called chromosomes or the genotype of the genome) of candidate solutions (called individuals, creatures, or phenotypes) to an optimization problem evolves toward better solutions.

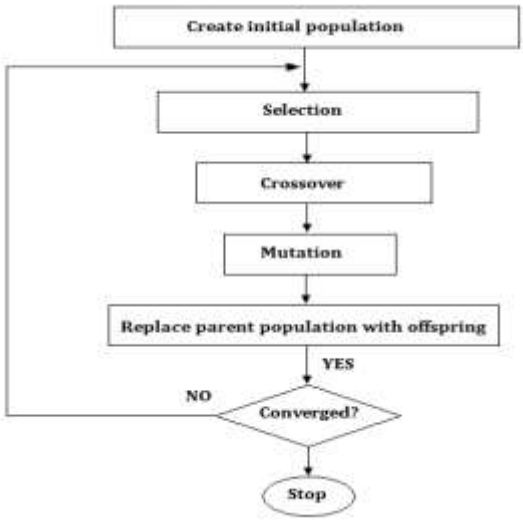

Fig-1 Flow chart of genetic algorithm

Traditionally, solutions are represented in binary as strings of 0s and 1s, but other encodings are also possible. The evolution usually starts from a population of randomly generated individuals and happens in generations.

In each generation, the fitness of every individual in the population is evaluated, multiple individuals are stochastically selected from the current population (based on their fitness), and modified (recombined and possibly randomly mutated) to form a new population. The new population is then used in the next iteration of the algorithm. Commonly, the algorithm terminates when either a maximum number of generations has been produced, or a satisfactory fitness level has been reached for the population. If the algorithm has terminated due to a maximum number of generations, a satisfactory solution may or may not have been reached. Once we have the genetic representation and the fitness function defined, GA proceeds to initialize a population of solutions randomly, and then improve it through repetitive application of mutation, crossover, inversion, and selection operators.

4. Particle Swarm Optimization

Most of the conventional computing algorithms are not effective in solving real-world problems Because of having an inflexible structure mainly due to incomplete noisy data and some multi-Dimensional problems. Natural computing methods are best suited for solving such problems. In General Natural computing methods can be divided into 3 categories.Epigenesis, Phylogeny, Ontogeny. PSO belongs to the Ontogeny category in which the adaptation of a special organism to its environment is considered.

In PSO, the potential solutions called particles fly through the problem space by following current optimum particles. The swarm is typically modelled by particles in multi-dimensional space that have a position and velocity. Each particle represents a candidate solution to the problem and particles change their positions by flying around in a multi-dimensional search space until computational limitations are exceeded. During the flight each particle adjusts its position according to its own experience and the neighboring particles, making use of the best position encountered by it and its neighbors. In a minimization optimization problem valve is become best particle. Members of a swarm communicate good positions to each other and adjust their own. Position and velocity based on these good positions

Velocity of a particle is influenced by three components, namely inertial, cognitive and social. The inertial component simulates the inertial behavior of the bird to fly in the previous direction. The cognitive component models the memory of the bud about its previous best position and the social component models the memory of the bird about the best position among the particles (interaction inside the swarm).

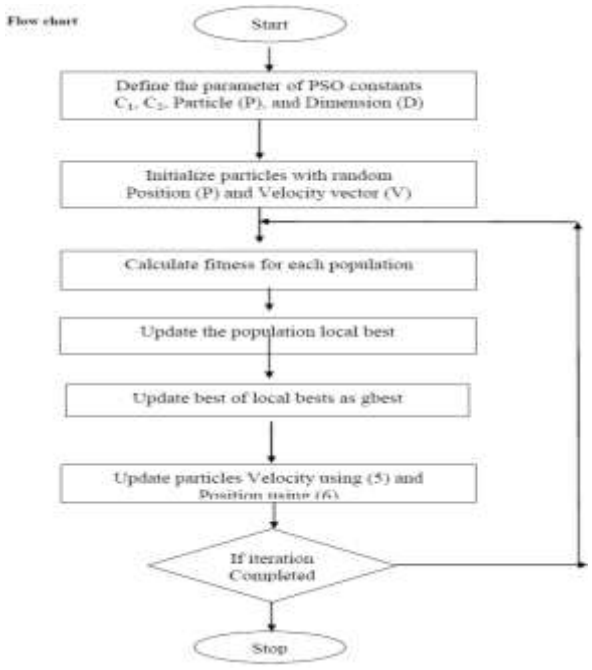

Fig-2 Flow chart of PSO algorithm

5. Simulated annealing algorithm

Simulated annealing (SA) is a generic probabilistic Metaheuristic for the global optimization problems that distinguishes between different local optima. The name and the inspiration come from annealing in metallurgy and its algorithm is based on the slow cooling process in the thermodynamic area. Give an initial point, such algorithm takes a step and the function is evaluated. The notion of slow cooling is implemented in the Simulated Annealing algorithm as a slow decrease in the probability of accepting worse solutions as it explores the solution space. And accepting worse solutions is a fundamental property of Metaheuristic because it allows for a more extensive search for the optimal solution.

Since SA algorithm has very limited assumptions when solving limited optimization problem, it is quite robust with respect to non-quadratic surfaces. However, the process of simulated repeated annealing with schedule is quite slow as it may cost a large amount of computation fee especially if the cost function is expensive to compute. And because of its probability acceptance, the method cannot find an exactly absolute optimal point compare to the other different algorithms before seen.

Firstly, in simulate annealing we will keep a temperature variable to simulate the heating process. We initially set it as Initial Temperature and then let it slowly cool down as the algorithm runs. At the beginning, Initial Temperature should be set at a higher value, thus the algorithm will be allowed, with more frequency, to accept solutions. This gives the algorithm the ability to jump out of any local optimums it finds itself in early on in execution.

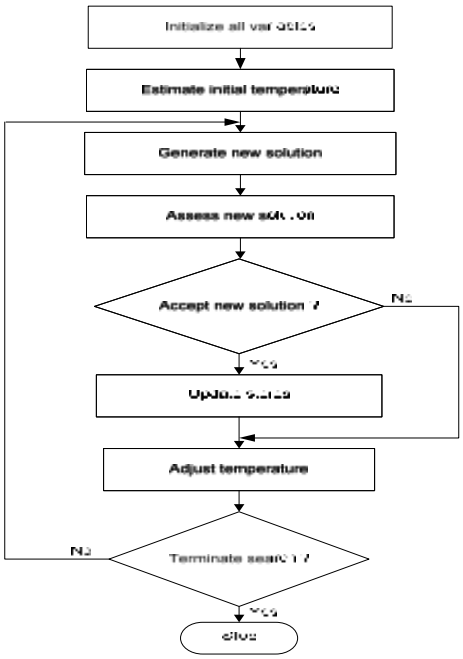

Fig-3 Flow chart of simulated Annealing algorithm

6. CONCLUSION

By economic dispatch means, to find the generation of the different units in a plant so that the Total fuel cost is minimum and at same time the total demand and losses at any instant must be met by the total generation. The classical optimizations of continuous functions have been considered. Various factors like optimal dispatch, total cost, and incremental cost of delivered Power, total system losses, loss coefficients and absolute value of the real power mismatch are Evaluated for a simple system calculation, economic dispatch is solved through Metaheuristic algorithms like Artificial Bee Colony algorithm, Genetic algorithm, Particle Swarm Optimization technique, Simulated Annealing gives optimum solutions to economic Dispatch Problems by developing mat lab programs.

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