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A Review on Various Techniques Used for Economic Load Dispatch in Power System

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ABSTRACT

Electrical power plays a pivotal role in the modern world to satisfy various needs. It is therefore very important that the electrical power generated is transmitted and distributed efficiently in order to satisfy the power requirement. The Economic Load Dispatch (ELD) problem is the most significant problem of optimization in forecasting the generation amongst thermal generating units in power system.

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I. INTRODUCTION

The ELD problem is to plan the output power for each devoted generating unit such that the cost of operation is minimized along with matching power operating limits, load demand and fulfilling diverse system limitations. The ELD problem is a significant problem in the operation of thermal/hydro generating station. It is considered an optimization problem, and is defined for minimized total generation cost, subject to various non-linear and linear constraints, in order to meet the power demand. The ELD problem is classified in two different ways, as convex ELD problem and non-convex ELD problem. The convex ELD problem is modeled by considering the objective function as minimizing the generator cost functions considering linear limitations/constraints. In the non-convex ELD problem the non-linear limitations/constraints are considered beside linear limitations while reducing cost function. The linear constraints, that is the generation capacity and power balance leads the ELD problem as approximate, simplified problem and the characteristics curve is assumed to be piecewise linear. A more precise and accurate problem is modeled by having the non-linear constraints such as prohibited operating zones, valve point effects and ramp rate limits. The problem of ELD is usually multimodal, discontinuous and highly nonlinear. Although the cost curve of thermal generating units are generally modeled as a smooth curve, the input output characteristics are nonlinear by nature because of valve-point loading effects, Prohibited Operating Zones (POZ), ramp rate limits and so on. Large steam turbine generators normally have multiple valves in steam turbines. These valves are opened and closed to keep the real power balance. However, this effect produces the ripples in the cost function. This effect is known as valve-point loading effect. Ignoring of valve-point effects leads to inaccurate generation dispatch. Besides this, the generating units may have definite range where operation is abandoned due to the physical limitations of mechanical components. The purpose of economic dispatch is to determine the optimal power generation of the units participating in supplying the load. The sum of the total power generation should equal to the load demand at the station. In a simplified case, the transmission losses are neglected. This makes the task of solution procedure easier. In actual practice, the transmission losses are to be considered. The inclusion of transmission losses makes the task of economic dispatch more complicated. A different solution procedure is to be employed to arrive at the solution.

II. STATEMENT OF THE PROBLEM

Economic dispatch, by definition is an on-line function, carried out after every 15-30 minutes or on request in Power Control Centers. It is defined as the process of calculating the power generation of the generating units in the system in such a way that the total system demand is supplied most economically. The current study is to analyze the economic Load Dispatch problem and to implement an Effective Modern Soft Computing Algorithm (EMSCA) for Economic Load Dispatch (ELD) problems in power system in order to obtain optimal economic dispatch with minimum generation cost. It is the standard industrial practice that the fuel cost of generator is represented by polynomial for economic dispatch computation (EDC). The key issue is to determine the degree and the coefficients such that the error between the polynomial and test data is sufficiently low. Traditionally, in the EDC, the cost function for each generator is approximately represented by a quadratic function which is convex in nature.

III. DEFINITIONS AND EXPLANATION TERMS

Electrical Power Industry

Electrical power industry is changing quickly and under the present commercial burden determining the optimal approaches to meet the demand for electricity, for a specific planning horizon is one of the most important concerns. These days chief challenge is to fulfill the consumer's demand for power at minimum cost. Any given power system consisting of many generating stations, having their own characteristic operating parameters, a reused to meet the total consumer demand.

Economic load dispatch problem

Economic load dispatch problem can be defined as allocating loads to plants or generators for minimum cost while satisfying various operational constraints. The generators are to be scheduled in such a way that generators with minimum cost are used as much as possible. In addition the growing public consciousness of environmental protection has enforced the utilities to adapt their operational policies to decrease the pollution and atmospheric emissions.

IV. SIGNIFICANCE OF THE STUDY

In India, two third of the electrical power generated is from coal based power stations. The generation of electricity from coal releases several contaminants, like Sulphur Oxide (SOx), Nitrogen Oxide (NOx) and Carbon Oxide (COx) in atmosphere. This causes negative effects to human health and the quality of life. It also causes damage to vegetation, acid rain, reducing visibility and global warming. The detrimental influence to environment by discharge of gases from coal based power plants can be diminished by scheduling of appropriate load to each generator. But this may cause rise in the operating cost of generators. So, it is vital to discover out a solution which gives neutral result between emission and cost. This can be attained by Combined Economic Emission Dispatch problem. Power systems operation combines a highly non-linear and computationally difficult environment with a need for optimality. The economic operation and planning of power system are ranked high amongst the major tasks in the power generation. Power economic dispatch (ED) is necessary and vital step in power system operational planning and has always occupied an important position in the electric power industry.

V. METHODOLOGIES TO SOLVE ECONOMIC LOAD DISPATCH PROBLEM

The Unit Commitment is the essential and vital step in power system operational planning. In addition to the ED objective, environmental concern that arises from the emission produced by fossil fuel electric power plants becomes a major problem to be addressed. Now methods for solving this ELD problem are discussed below:

Lambda Iteration: In Lambda iteration method lambda is the variable introduced in solving constraint optimization problem and is called Lagrange multiplier [1]. It is important to note that lambda can be solved at hand by solving systems of equation. Since all the inequality constraints to be satisfied in each trial the equations are solved by the iterative method. This method has used equal increment cost criterion for systems without transmission losses and penalty factors B matrix for considering the losses.

Gradient Search Method: This method works on the principle that the minimum of a function, f(x), can be found by a series of steps that always take us in a downward direction. In this method the fuel cost function is chosen to be of quadratic form. However, the fuel cost function becomes more nonlinear when valve point loading effects are included.

Newton Method: Newton's method goes a step beyond the simple gradient method and tries to solve the economic dispatch by observing that the aim is to always drive the gradient of function to zero. Generally, Newton's method will solve for the correction that is much closer to the minimum generation cost in one cost in one step than would the gradient method.

Linear Programming: Linear programming (LP) is a technique for optimization of a linear objective function subject to linear equality and linear in-equality constraints. Informally, linear programming determines the way to achieve the best outcome (such as maximum profit or lowest cost) in a given mathematical model and given some list of requirements represented by linear equations. A linear programming method will find a point in the optimization surface where this function has the smallest (or largest) value. Such points may not exist, but if they do, searching through the optimization surface vertices is guaranteed to find at least one of them.

Base Point and Participation Factor: This method assumes that the economic dispatch problem has to be solved repeatedly by moving the generators from one economically optimum schedule to another as the load changes by a reasonably small amount. It is started from a given schedule called the base point. Next assumes a load change and investigates how much each generating unit needs to be moved in order that the new load served at the most economic operating point.

Evolutionary Programming (EP), Simulated Annealing (SA), Tabu Search (TS)

Although the heuristic methods do not always guarantee discovering globally optimal solutions in finite time, they often provide a fast and reasonable solution. EP can be a quite powerful evolutionary approach; however, it is rather slow converging to a near optimum for some problems. Both SA and TS can be quite useful in solving complex reliability optimization problems; however, SA is very time consuming, and cannot be utilized easily to tune the control parameters of the annealing schedule. TS is difficult in defining effective memory structures and strategies which are problem dependent.

Dynamic Programming (DP)

When cost functions are no-convex equal incremental cost methodology cannot be applied. Under such circumstances, there is a way to find an optimum dispatch which use dynamic programming method. In dynamic Programming is an optimization technique that transforms a maximization (or minimization) problem involving n decision variables into n problems having only one decision variable each. This is done by defining a sequence of Value functions V1, V2…..Vn, with an argument y representing the state of the system. The definition of Vi(y) is the maximum obtainable if decisions 1, 2 ...I are available and the state of the system is y. The function V1 is easy to find. For I=2,...n, Vi at any state y is calculated from Vi -1 by maximizing, over the I-th decision a simple function (usually the sum) of the gain of decision i and the function Vi -1 at the new state of the system if this decision is made. Since Vi -1 has already been calculated, for the needed states, the above operation yields Vi for all the needed states. Finally, Vn at the initial state of the system is the value of the optimal solution. The optimal values of the decision variables can be recovered, one by one, by tracking back the calculations already performed.

Hopfield Neural Network (HNN)

Hopfield introduced in 1982[4] and 1984[5], the Hopfield neural networks have been used in many different applications. The important property of the Hopfield neural network is the decrease in energy by finite amount whenever there is any change in inputs. Thus, the Hopfield neural network can be used for optimization. Tank and Hopfield [13] described how several optimization problem can be rapidly solved by highly interconnected networks of a simple analog processor, which is an implementation of the Hopfield neural network. Park and others [6] presented the economic load dispatch for piecewise quadratic cost functions using the Hopfield neural network. The results of this method were compared very well with those of the numerical method in a hierarchical approach. King and Others [12] applied the Hopfield neural network in the economic and environmental dispatching of electric power systems. These applications, however, involved a large number of iterations and often shown oscillations during transients. This suggests a need for improvement in convergence through an adaptive approach, such as the adaptive learning rate method developed by Ku and Lee [2] for a diagonal recurrent neural network.

Genetic Algorithm (GA), Differential Evolution (DE)

GA ensures colony evolves and solutions change continually; however, sometimes it lacks a strong capacity of producing better offspring and causes slow convergence near global optimum, sometimes may be trapped into local optimum. Due to the premature convergence of GA, its performance degrades and its search capability reduces. Price and Storn [8] invented differential evolution (DE). It involves three basic operations, e.g., mutation, crossover, and selection, in order to reach an optimal solution. DE has been found to yield better and faster solution, satisfying all the constraints, both for uni-modal and multi-modal system, using its different crossover strategies. But when system complexity and size increases, DE method is unable to map its entire unknown variables together in a better way. In DE all variables are changed together during the crossover operation. The individual variable is not tuned separately. So in starting stage, the solutions moves very fast towards the optimal point but at later stage when fine tuning operation is required, DE fails to give better performance.

Particle Swarm Optimization (PSO)

In the mid 1990s, Kennedy and Eberhart invented PSO [10]. In PSO there are only a few parameters to be adjusted, which make PSO more attractive. Simple concept, easy implementation, robustness and computational efficiency are the main advantages of the PSO algorithm. A closer examination on the operation of the algorithm indicates that once inside the optimum region, the algorithm progresses slowly due to its inability to adjust the velocity step size to continue the search at a finer grain. So for multi-modal function, particles sometimes fail to reach global optimal point. When compared with other methods, the PSO is computationally inexpensive in terms of memory and speed. The most attractive features of PSO could be summarized as: simple concept, easy implementation, fast computation, and robust search ability. Artificial Immune System (AIS) Artificial Immune System (AIS) [11] is another population based or network-based soft computing technique in the field of optimization that has been successfully implemented in various power system optimization problems.

Bacterial Foraging Algorithm (BFA)

Inspired from the mechanism of the survival of bacteria, e.g., E. coli, an optimization algorithm, called Bacterial Foraging Algorithm (BFA) [7], has been developed. Chemo taxis, reproduction and dispersion are the three processes with the help of which global searching capability of this algorithm has been achieved. These properties have helped BFA to be applied successfully in several kinds of power system optimization problems. But constraints satisfaction creates little trouble in BFA.

Quantum-inspired Evolutionary Algorithm (QEAs)

The quantum-inspired evolutionary algorithms (QEAs) [9], is then proposed, are based on the concepts and principles of quantum computing, which can strike the right balance between exploration and exploitation more easily when compared with conventional EAs. Meanwhile, the QEAs can explore the search space with a smaller number of individuals and exploit global solution within a short span of time. In the research of the QEAs and PSO, quantum-inspired particle swarm optimization (QPSO) is proposed. Two main definitions used in the QEAs are introduced: quantum bit and quantum rotation gate. Quantum bit is used as probabilistic representation of particles, defined as the smallest information unit. A string of quantum bits consists of a quantum bit individual. Also, quantum rotation gate is defined as an implementation to drive individuals toward better solutions and eventually find global optimum.

Snake Algorithm

Snake Algorithm is demonstrated to overcome the drawbacks of traditional snake/ contour algorithms for contour tracking of multiple objects more effectively and efficiently. The experimental results of the tests carried out have proved that the proposed method is robust, effective and accurate in terms of finding the boundary solutions of multiple objects.

VI. CONCLUSION

Economic load dispatch (ELD) is a process of finding optimal generation scheduling of available generators in an interconnected power system to meet the demand of the system, at lowest possible cost, while satisfying various operational constraints on the system. More just, the soft computing method has received supplementary concentration and was used in a quantity of successful and sensible applications. Here, an attempt will be made to find out the minimum cost by using different algorithm techniques using the data of some generating units. In this work, data will be taken such as the loss coefficients with the max-min power limit and cost function. All the methods will be executed in MATLAB environment.

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