

A Review on Economic Load Dispatch using Optimization Techniques

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ABSTRACT

With the advancement in the technology, an enhancement has been seen in the field of electrical power industry. Power industry which is based on electrical resources has again developed the vibrant and competitive market. Along with the various advancements, various issues such as scarcity of the energy resources, increase in demand for electrical energy, increasing power generation is required along with less cost. Catering to this economic load dispatch provides optimization method which divides demand of the power among online generators economically by satisfying different constraints. ELD can be concluded as scheduling of committed generating units by meeting up the demands of the consumers while reducing operational cost to the utilities while satisfying different constraints.

Keywords—*Electrical power Grids, Economic Load Dispatch, Optimum Load Dispatch.*

I.INTRODUCTION

Electrical power industry is one of the trending areas in power industry which restructured the vibrant and competitive market in terms of various aspects of the industry. As the advancements have done in the industry, scarcity of the energy resources, ever growing demand for electrical energy, increasing power generation cost necessitate optimal dispatch. Owing to this economic load dispatch provides optimization method which divides demand of the power among online generators economically by satisfying different constraints. Seeing as cost of the power generation is excessive in such case optimum dispatch can helps out in saving considerable amount of money. Thus optimal generation dispatch is one of the important problems in power system engineering. This technique is commonly used by operators for system operation in every day. The main idea of using this technique is that it allocates real and reactive power to the power system in order to obtain optimal state which can reduce cost and overall efficiency of the system[1]. ELD i.e. economic load dispatch problem allocates the real power to the online generating units which leads to the reduction in system cost. In the traditional formulation of economic load dispatch problem there were several problems. Basic model of the power system is acquired through power balance equation whereas generators are modeled with the smooth quadratic cost functions and last generator through output constraints. Thus in order to improve the power system studies several models have been developed which results in efficient system operation. These models provide more accurate representation of the system but on the other hand it may faces increased complexity of the

optimization problem due to the non-linearity associated with them. Existing algorithms such as lambda iteration, base point participation factor, gradient method are able to solve the optimization problem in such case where fuel cost curves of the generating units are piece wise linear. Basic property of ELD is that it considers power balance constraint rather than generating capacity limits. On the other hand ELD prefers ramp rate limits, prohibited operating zones, value point effects and lastly multi fuel options to provide complete formulation of the ELD[4][5]. As a result ELD provides solution to non-convex optimization problem which cannot be solved by existing methods of ELD. Practical ELD has been suffering from problems like non-linear, non-convex type objective function with intense equality and inequality constraints. Therefore in search of better results from complex optimization problems and several developments have to be done which is known as evolutionary algorithms. These algorithms bring in best alternative global optimal solutions especially in case of non-continuous, non-convex and highly solution spaces. Most of the algorithms are population based techniques which are helpful in obtaining several solutions rather than a single solution as being done by the classical techniques. Basically these techniques used or explored solution space randomly which then provides alternative solutions for a particular problem. Evolutionary algorithms have been successful due to its capability in finding solution with random exploration of the feasible region instead of exploring the complete region. Application of these algorithms has resulted into better and fast optimization process with less number of computational resources. Furthermore it also maintains capability of finding global optima. As in the existing techniques local optimum solution with convergence were used which was not able to solve such problems. Some of the algorithms which can be used to solve such problems are Genetic Algorithms, Particle Swarm Optimization and Differential Evaluation etc. Such algorithms have gained incredible recognition as the solution algorithm for ELD problems [6]. Economic dispatch is the short term word used for optimal output of a number of electricity generation facilities in order to acquire system load at the lowest cost while operating constraints [7]. Problem of economic dispatch have been solved by using computer software which takes operating system constraints of the variable resources as well as its transmission capabilities. In the US energy Policy act 2005 have defined ELD as the operation of generation facility which produces energy at the lowest cost so that it can serve consumers, recognizing operational limits of generation and transmission facilities. Total cost of load can be reduced by setting generators with lowest marginal cost. In other words, set of generators with the lowest marginal cost should be used first in order to reduce the total cost of the load. The marginal cost of the final generator is required to meet the load setting the system marginal cost. Thus acquired cost is the cost of delivering one additional MW of energy into the system [9]. This methodology of economic dispatch was introduced in order to manage fossil fuel burning power plants which relays on the calculations involving input and output characteristics of power stations.

Conventional Methods for solving ELD Problem are

1. The Lambda –Iteration Method
2. The Gradient Search Method
3. Newton's Method

4. ED with Piecewise linear Cost Functions
5. Base Point & Participation factor.
6. Linear Programming.
7. Dynamic Programming, Fuzzy Logic and Particle Swarm Optimization methods

Economic dispatch problem can be modeled with an equation which maximizes the economic welfare W of a power network and meet all the system constraints.

$$\min_{I_k}(-W) = \min_{I_k} \{ \sum_{k=1}^n C_k(I_k) \} \quad (1)$$

Where n is the number of buses or nodes, I_k is the net power injection at bus k and $C_k(I_k)$ is the cost function of producing power at bus k . Unconstrained problem is given as in the equation no.1.

Constraints of the system which are required to balance the power as well as its flow on any line so that it should not be exceed its capacity. In such case of power balance sum of net injections at all the buses must be equal to the losses of the power in the branches of the network.

$$\sum_{k=1}^n I_k = L(I_1, I_2, \dots, I_{n-1}). \quad (2)$$

In the equation 2, L defines power loss which depends on the power flows in the network .

Now consider the second constraint which involves capacity constraints having flow on network lines and can be modeled as:

$$F_l(I_1, I_2, \dots, I_{n-1}) \leq F_l^{max} \quad l = 1, \dots, m \quad (3)$$

Where F_l is the flow on branch l and F_l^{max} represents maximum value of the flow allowance.

Above given equation can be combined within to obtain Lagrangian of the optimization problem such as:

$$\square = \sum_{k=1}^n C_k(I_k) + \pi [L(I_1, I_2, \dots, I_{n-1}) - \sum_{k=1}^n I_k] + \sum_{l=1}^m \mu_l [F_l^{max} - F_l(I_1, I_2, \dots, I_{n-1})] \quad (4)$$

Where π and μ are the Lagrangian multipliers of the constraints. The conditions for optimality are then:

$$\frac{\partial \square}{\partial I_k} = 0, \quad k = 1, 2, \dots, n \quad (5)$$

$$\frac{\partial \square}{\partial \pi_k} = 0 \quad (6)$$

$$\frac{\partial \square}{\partial \mu_l} = 0, \quad l = 1, 2, \dots, m \quad (7)$$

$$\mu_l \cdot [F_l^{max} - F_l(I_1, I_2, \dots, I_{n-1})] = 0 \quad \mu_l \geq 0 \quad k = 1, \dots, n \quad (8)$$

Last condition is helpful in handling the inequality constrained obtained on the line capacity. Computational complexity is higher due to which it can be simplified using a linear model also known as DC power flow.

II.OPTIMIZATION TECHNIQUES

Different optimization techniques that can be used for solving the ELD issues in power grid systems are as below:

PSO: Particle Swarm is an optimization technique that is specifically developed for solving the issues related to the optimal solutions in an n dimensional surface. In PSO, the particles are plotted in n dimensional surfaces and deployed at initial velocity and communication mediums among these employed particles. Then these swarm particles moves within the available space and evaluated as per some pre defined criteria after a time interval. After some time the swarm particles speed up their movement towards the particles with better fitness value within the communication group. The positive point of swarm optimization technique is that it is a suitable approach to resolve the global minimization strategies.

GA: GA stands for Genetic algorithm and this technique implements the optimization strategies. The parameters and operations used in this technique are as follows:

- Selection
- Crossover
- Mutation

Selection is a parameter which is used for selecting the various solutions which can be preserved or which can be able to reuse and which are not useful. The selection parameter aims to select the best solution and eliminate the worst solution which is not suitable. The best solution can be identified on the basis of fitness value. Fitness value is a parameter. Fitness function generates a value which quantifies the solution optimally. Then on the basis of various fitness values corresponding every solution best solution is selected Mutation operator allows introducing the new feature in the solution string. It is added to maintain the diversity in the population. Binary mutation changes the 1 into 0 and vice versa. The probability of binary mutation is generally low. Crossover is an operator which enables to create a new solution from existing large number of solutions. Crossover uses the process of encoding which represents the solution into the form of string so that it can be less complex to understand.

GWO: The grey wolf optimization technique is developed on the basis of the leadership and hunting nature of the grey wolves. For this, four types of grey wolves such as alpha, beta, omega and delta are considered for the development of this optimization technique. This optimization technique operates in different phases i.e. hunting, exploring prey, enclosing and attacking. The work flow of the GWO optimization technique is defined as below:

Generalized algorithm for GWO:

Step1: Number of grey wolves acts as a search agents in population size.

Step 2: Initialization of the population vector for locating and encircling the prey in both upper and lower bound region of the grey wolf.

Step 3: Evaluation of the fitness values corresponding to individual solution. The fitness value is evaluated to represent the distance of the prey from individual wolf. Then on the basis of the best maximum fitness value three wolves i.e. alpha, beta and gamma is categorised.

Step 4: reset the location of search agents.

Step 5: Repeat the step 3 and 4 until the prey is reached.

Step 6: Stop processing when the specified number iteration is completed.

III.RELATED WORK

Parmvir Singh Bhullar, (2015) [3], Economic load dispatch is the main problem arises in the power system. It exists in the operational planning of the power system. When valve point loading effect is introduced then the formulations of objective vary with a small difference. In this work a new enhanced PSO (Particle Swarm Optimization) is introduced in order to solve the problem of economic load dispatch problem. The efficiency and reliability of the proposed work is evaluated after simulating it in MATLAB. The results are also presented in the work.

Bhagyashree Hosamani, (2014) [4], in this paper the goal of ELD has been achieved by using Fuzzified Particle Swarm Optimization. FPSO is able to solve the problem of multi-constrained dynamic ELD. The proposed FPSO is more superior over traditional techniques. The proposed technique is combination of PSO and fuzzy logics. PSO is used because of its various features such as simplicity; less complexity etc. the PSO has a major drawback that it needs number of iterations. Hence the problem of premature convergence rises. In order to avoid premature convergence the fuzzy logics is combined with PSO.

Nishant Chaturvedi, (2014) [5], ELD is Economic load Dispatch it is a short term used to define the process that how to get an optimal results or output of the various electricity generation amenities in order to fulfill the need of required load along with the reduced cost of transmission and operational constraints. The traditional techniques used for solving the problem of economic load dispatch only works for reducing the generation cost. The PSO is a optimization technique which works on every aspect related to the problem. It works in iterative form so that to meet the solution of the problem from each and every aspect. PSO is used for finding the most efficient low cost, reliable operations of power system by using or dispatching the available source of energy to transfer the load on the system. This work is an overview to the problem of ELD.

Hamed Aliyari¹, (2014) [6], Economic Load Dispatch is a problem that exist in various power generating plants. ELD refers to take an input from various power units and as output it should lead to the minimization in total fuel cost incurred on power generation process. There are various techniques which can be used for

optimizing the fuel cost. In this paper a new GA algorithm is defined. The proposed work is based on stochastic Genetic Algorithm technique. Genetic Algorithm is based on biological nature. It is a solution for ELD. It considers various power generator plants. To prove the efficiency of the proposed technique the GA is applied on 13 and 40 unit generation power plant. The result section shows that the proposed work has more accuracy and higher quality as compare to traditional techniques.

Nguyen Trung Thang, (2013) [7], this paper proposed a new technique for handling economic emission load dispatch problem. The proposed technique is named as Hopfield Lagrange Network i.e. (HLN). The technique is proposed to solve EELD with MFO i.e. Multiple Fuel Option. It is preferable to add co₂ emission to the power generation units because they not only use fuels but consequently they release some emission in the air. This process of releasing emission in the air converts ELD to EELD. The proposed work is developed by combining two techniques first is Lagrange function and other is Hopfield neural network. In this study 10 generating units are considered for testing the proposed work. From obtained solution best fitness value is selected and then compared with lambda-iteration method. The result shows that the proposed work is more efficient and effective than traditional techniques.

Jaya Sharma, (2013) [8] PSO stands for Particle Swarm Optimization. It is an optimization technique with less complexity and calculations. The advantages of PSO are that it is quite simple, less complex calculations, robust technique, and fast convergence. PSO is used for solving optimization problems in various fields. ELD is one of the problems that can also solved by implementing PSO. Economic Load Dispatch is a concept which is facilitates economic conditions of a power system. ELD is a process which is an aid to deciding that how to minimize the cost, attains the effective power system. It is done by dispatching existing electrical sources to transmission of load to system. This paper is a review to the ELD using PSO.

IV.CONCLUSION

Economic Load Dispatch is the process known for distributing load in such a way so that economic cost of the power system should be used less and requirement of the consumer fulfilled. This is a review study to the concept of economic load dispatch and issue related to optimum dispatch and also comprised of a review to the work that had been done in this domain to resolve the issue of ELD. From the previous work it has been analyzed that various optimization techniques were used by the authors to solve the issue of ELD in electrical power systems but were not able to produce effective results. Hence in future more advance and prominent optimization technique can be applied to ELD.

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