An Advancements Review paper on Economic Load Dispatch

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***Abstract*—a survey of papers covering the concept of economic load dispatch is presented in this paper. Economic load dispatch gives the best saving in cost for any power generation plant operation in which the methodology can be applied by various means from conventional to the advanced. In the past years up to 90s, the conventional techniques were used to make this happen but in the past decades AI techniques have fulfilled the requirements with satisfactory results that are being reviewed.**

***Index Terms*— ELD, Review of literature, Conventional methods, Artificial Intelligence techniques.**

INTRODUCTION

The electrical engineering field requires providing the constant supply of electricity without fail and with the cheapest cost. A t the generation end it is possible only through the Economic Dispatch to the generators. Economic Load Dispatch, ELD can be defined as the way of allocating the load level to the generators of the power plant in such a way that the total demand would be supplied in a most economic manner and completely. Here its survey of different papers is given.

Initially before 1930s, the practice for ELD was such that engineers give maximum capacity load to the most efficient generator and then the second most efficient is given the load and this method was called as the base load method. Another method was knows as best point loading method in which the generators were loaded according to their heat rate points successively. Earlier in 50s, the computational technique used in coordination equations solution was done with the consideration of transmission line loss and penalty factors. Also the differential analyzes working by the computer developed for ELD problem with both way operations like on-line and off-line. By the survey of many papers the area of ELD can be classified in main four types which are (i) Dynamic dispatch (ii) Economic dispatch with non-conventional generation sources (iii) Optimal power flow (iv) Economic dispatch in relation to AGC. [1]

DYNAMIC DISPATCH

This method refers the cost related to the changes in generating units. ELD considers the static problems only and the costing at change of load of generators is not considered. This results with the bad performance of transients.

How dynamic dispatch is different than the ELD is explained in [2]. This method works on the real power for the fixed time duration and reduces the operation cost. While meeting some instantaneous constraints as like power ramp limits temperature limits, etc. Other side the economic dispatch attempts to compute the real power, minimizing the operation cost while meeting constraints like actual power equilibrium, and many times computes power transmission security.

Ross in [3] discussed the application of a dynamic economic dispatch algorithm for generator controlling. When coupled with a short term load predictor, future based capability is given by the dynamic dispatch that coordinates predicted load changes with the rate of response capability of generation units. The dispatch algorithm also enables valve-point loading of generation units. The method that the authors use in their dispatch algorithm makes use of successive approximation dynamic programming. The authors claim that the algorithm is an improvement over the existing dynamic dispatch algorithm, in that the computer resources required are modest.

Raithel in [4] introduced a successive approximation dynamic programming to obtain the optimal unit generation trajectories that meet the presumed area load. They use vibrant optimization while compared to the stationary case, as the dispatch program determines the economic allotment of generation for the whole future phase of interest, via knowledge of both the current and the presumed load. The future demand potential provides the advantage of responding to unexpected severe changes in load demand. They settle in the successive approximation dynamic programming algorithm for handling valve-point loading of units. Valve-point loading is consummated via the depiction of the valve point in the generating unit production cost function.

ECONOMIC LOAD DISPATCH REVIEW WITH AI TECHNIQUES

Non linear process is approximated usually by condensed-order models, perhaps linear models which are noticeably related to the underlying process characteristics. Though, models by this process may be valid for limited specific operating ranges and another type of model may be required for the alternate operating conditions or the system would adopt the new type of model parameters. The artificial intelligence (AI) techniques, such as neural networks, have solved this problem to a great extent. The Artificial Neural Network offers lot more benefits in the wide region of nonlinear control issues, particularly when the working system is functioning under the nonlinear range. The applications of ANNs in electrical power system are referred in [5–12].

The authors explained neural networks application for nonlinear power system. For a two-area system they have suggested a feed-forward neural network controller that can reduce the transients in frequency with obtaining zero steady state frequency error. Back-propagation through time algorithm is used for the training of controller [5]. A. P. Birch in [6] has discovered the application of ANN as the intelligence control in conjunction with a standard adaptive LFC scheme. Also authors shown many ANN controller advantages above advanced adaptive control techniques.

Authors in [6] represented a new ELD scheme to incorporate the nonconforming load problem in which an effort had been undertaken to develop algorithms competent of discriminating between uncontrolled short-term excursions and convenient long-term excursions. From the given two different techniques explained, one was developed with the use of neural network algorithm for the pattern detection of controllable signals, and the second technique was based on the detecting controllable signal with presence of a noisy arbitrary load using a arbitrary signal probability model. The test results exposed that neural network-based generation controlling implementation had a important improvement.

D. K. Chaturvedi in [7] represented a work which deals with the development of non-linear neural network controller that uses a generalized neural network. The authors showed that the drawbacks of neural networks existing that time had been overcome in the generalized neuron structure, which has been developed to control the deviations in frequency.

The author Demiroren in [8] has searched an implementation of layered ANN for AGC of the multi-area system. By using computing simulations on the interconnected power system with two areas (thermal-thermal) that include re-heater effect & the governor dead band effect, the author also described that the neural network control scheme is effective in damping of oscillations generated from load perturbations.

H. Shayeghi in [9] has proposed a nonlinear ANN controller based on μ-synthesis for AGC of power systems. With the simulations on the two-area system, they have showed that the proposed ANN controller was effective and gave good dynamic responses even in the presence of GRCs. They also showed that the proposed controller was superior to the conventional PI and μ-based robust controllers.

H. L. Zeynelgil in [10] has shown an application of multi layered ANN controller to study AGC problem in a four area interconnected system which had three thermal area and one hydro area. The authors also taken into account the nonlinearities like reheat effect of steam turbine and upper and lower constraints for generation rate nonlinearity of hydro turbine. They proposed only one ANN controller, which controlled the input of each area. The controller was trained with back propagation through time (BPTT) algorithm. They showed that the performance of the ANN controller was better than the conventional controllers.

Demiroren in [11] has discriminated the use of multi layered neural network controller to study LFC problems in power systems. They discussed the control scheme with three interconnected areas with two thermal and one hydro area. They have showed that the performance of the ANN controller was better than conventional integral controller. The fuzzy logic control concept departs significantly from traditional control theory, which is essentially based on mathematical models of the controlled process. Instead of deriving a controller via modeling the controlled process quantitatively and mathematically, the fuzzy control methodology tries to establish the controller directly from domain experts or operators who are controlling the process manually and successfully.

Talaq and Al-Basri [12] have proposed an adaptive fuzzy gain scheduling scheme for conventional PI and optimal load frequency controllers. The controller required much less training patterns than a ANN based adaptive scheme. The authors showed that the proposed adaptive fuzzy controller gave better performances than fixed gain controllers at different operating conditions.

K. P. Wong in [13] has reviewed the applications of artificial intelligence and neural networks in power engineering. He has reported the areas in power systems that artificial intelligence had been applied to. He has also summarized the AI techniques, which had been employed and made suggestions for the improvement of the then existing AI tools. Genetic Algorithm (GA) is also popular and widely used. GAs have been widely applied to solve complex nonlinear optimization problems in a number of engineering disciplines in general and in the area of AGC of power systems in particular.

D. Rerkpreedapong in [14] presented two robust decentralized control design methodologies for load frequency control. The first one was based on control design using linear matrix inequalities technique in order to obtain robustness against uncertainties. The second controller had a simpler structure and it was tuned by a novel robust control design algorithm to achieve the same robust performance as the first one. More specifically, genetic algorithm optimization is used to tune the control parameters of the proportional-integral controller subject to the constraints in terms of LMI. Both proposed controllers were tested on a three-area 23 power system with three scenarios of load disturbances to demonstrate their robust performances.

ELD by Genetic Algorithm method used and advancements contributed by several researchers' as given in [15] by A. Bakritzs, V. Perirtridis and S. Kazarlis that ELD problems solved using Genetic Algorithm method and found its merits are, the non restriction of any convexity limitations on the generator cost function and effective coding of GAs to work on parallel machines, GA is superior to Dynamic programming, as per the performance observed in ED problem and the run time of the second GA solution proportionately increases with size of the system.

Po-Hung Chen and Hong-Chan Chang in [16] solved Large Scale Economic Dispatch problem by Genetic Algorithm and designed new encoding technique where in, the chromosome has only an encoding normalized increamental cost. There is no correlation between total number of bits in the chromosome and number of units. The unique characteristic of Genetic Approach is significant in big and intricate systems which other approaches fails to accomplish. Dispatch is made more practical by flexibility in GA, due to consideration of network losses, ramp rate limits and prohibited zone's avoidance. This method takes lesser time compared to Lambda –iteration method in big systems.

L. L. Lai and J. T. Maimply in [17] provided solution by employing Improved Genetic Algorithm for optimal power flow in regular and contingent conditions. Contingent condition implies circuit outage simulation in one branch resulting in crossing limits of power flow in the other branch. The approach gives good performance and discards operational and insecure violations. The dynamical hierarchy of the coding procedure designed in this approach, enables to code numerous control variables in a practical system within a suitable string length. This method is therefore able to regulate the active power outputs of Generation, bus voltages, shunt capacitors / reactors and transformer tap settings to minimize the fuel costs. IGA obtains better optimal fuel cost of the normal case and global optimal point compared to gradient based conventional method.

A. G. Bakirtzis and P. N. Biskas in [18] solved Optimal Power Flow with both continuous and disconnected control variables, by Enhanced Genetic Algorithm, that is quite superior to old Simple Genetic Algorithm. Unit active power outputs and generator bus voltage magnitudes are considered as continuous control variables, and the transformer-tap settings and switchable shunt devices are treated as disconnected control variables. Branch flow limits, load bus voltage magnitude limits and generator reactive capabilities are incorporated as penalties in the GA fitness function (FF). Algorithm's effectiveness and accuracy are improved by using advanced and problem-specific operators.

T. Bouktir, L. Slimani and M. Belkacemi in [19] provided solution to optimal power flow problem of large distribution system using simple genetic algorithm. The aim inculcates fuel cost minimization and retaining the power outputs of generators, bus voltages, shunt capacitors / reactors and transformers tap-setting in their safe limits. Constraints are bifurcated in to active and passive to reduce the CPU time. Active constraints are incorporated in Genetic Algorithm to obtain the best possible solution, because they have just direct right to use to the cost function. Conventional load flow program is employed to modify passive constraints, one time after the convergence on the Genetic Algorithm optimal power flow i.e., attaining the optimal solution.

L. G. Sewtohul, Robert T.F. Ah King in [20] provided solution for Economic Dispatch with valve point effect using Genetic Algorithm. In this method, four Genetic Algorithms named as, Simple Genetic Algorithm, Simple Genetic Algorithm with generation – differ than elitism, Simple Genetic Algorithm with atavism and Atavistic Genetic Algorithm are used to get solution on three test systems: 03 generator system, 13 generator system and the standard IEEE 30 bus test system. On comparison of results, it is observed that all GA methods mentioned above are better than Lagrangian method with no valve effect. With valve point effect and ramping characteristics of Generators, AGA is superior to other GAs and the Tabu search. Furthermore, the AGA alone itself circumvents entrapment in local solution. It is ascribed to equilibrium in selective pressure and also population diversity.

CONCLUSION

A review of papers and reports related to various aspects of economic load dispatch has been represented in this paper. An attempt to include more relevant of the contents possible in order to include the important and unique aspects of each paper and presenting a justification of the availability of research in the area of economic load dispatch so that a researcher in this area can identify problems and seek their solutions. Many authors have implemented different algorithms very efficiently but the difference was simply convergence.

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