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State of Art In Combined Economic And Emission Dispatch

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Abstract: Economic load dispatch (ELD) is one of the main problems of power system operation and management. The main objective of economic load dispatch of electrical power generation is to allocate the committed generating unit to meet the load demand at minimum operating cost while satisfying all equality and inequality constraints. Nowadays the main electric power demand is supplied by the thermal power plant. The thermal power plant produces gaseous pollution such as carbon oxides (COx), sulphuroxides (SOx) and oxides of nitrogen (NOx). However with the increasing public awareness of the environment pollution caused by the thermal power plant and the passage of the clean air amendments of 1990 and its acceptance by all the nations has forced the utilities to modify their operating strategies to meet the environmental standards. Economic load dispatch is the minimization of total fuel cost without considering emission limitation.The emission dispatch is the minimization of emission without considering the economic aspects. Therefore it is necessary to find the balance between operating cost and emission, this can be achieved by combined economic and emission dispatch (CEED). This paper reviews various techniques for solving combined economic and emission dispatch.

Key words: Optimal Power Flow · Economic load dispatch · Emission Dispatch · Combined Economic and Emission Dispatch

INTRODUCTION

Economic Load Dispatch (ELD) is the process of allocating the required load between the available generation units such that the cost of operation is minimized. The ELD problem is formulated as a nonlinear constrained optimization problem with both equality and inequality constraints. Economic Dispatch (ED) problem has become a crucial task in the operation and planning of power system [1]. It is very complex to solve because of a nonlinear objective function and a large number of constraints. ED in power system deals with the determination of optimum generation schedule of available generators so that the total cost of generation is minimized within the system constraints. Well known long-established techniques such as gradient method, lambda iteration method, linear programming, quadratic programming, lagrangian multiplier method and classical technique based on co-ordination equations are applied to solve ELD problems.

These conventional methods cannot perform satisfactorily for solving such problems as they are sensitive to initial estimates and converge into local optimal solution in addition to their computational complexity [2]. Traditionally, electric utilities dispatch generation using minimum fuel cost as the main criterion. However, the best economic dispatch does not lead to minimum emission and vice versa. The goal of emission dispatch is to determine the generation schedule that has the minimum emission cost. The two criteria are contradictory to each other and are in trade-off relationship. It, therefore, makes it difficult to handle such problem by conventional approaches that optimize a single objective function. One feasible approach to solving this kind of problem using conventional optimization method is to convert the bi-objective into a single objective function by giving relative weighting values. In this case, the emission dispatch is added as a second objective to the economic dispatch problem which leads to Combined Economic and Emission Dispatch

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(CEED). Environmental issues add complexity to the solution of the economic dispatch problem due to the nonlinear characteristics of the mathematical models used to represent emissions. In addition, the Combined Economic and Emission Dispatch (CEED) problem can be complicated even further if nonsmooth and nonconvex fuel cost functions are used to model generators, such as valve-point loading effects. All these considerations make the CEED problem ahighly nonlinear and a multimodal optimization problem. Several Combined Economic and Emission Dispatch (CEED) strategies have appeared in the literature over the years. Lagrange relaxation method, weighted sum method, e-constrained algorithm, Linear programming method, Goal programming technique are used to solve the CEED problem. But unfortunately, these methods are not able to find a solution with a significant computational time for medium or large-scale ED [3]. The various techniques used in the recent years for obtaining a solution for combined economic and solution dispatch is discussed below.

Literature Survey: Chowdhury and Saifur in 1990 proposed a survey of papers and reports which address various aspects of economic dispatch. The time period considered is 1977-88. This is done to avoid any repetition of previous studies which were published prior to 1977. Four very important and related areas of economic dispatch are identified and papers published in the general area of economic dispatch are classified into these. These areas are:- (i) Optimal power flow, (ii) economic dispatch in relation to AGC, (iii) dynamic dispatch and (iv) economic dispatchwith non-conventional generation sources. It is fairly obvious from this survey that optimal power flow has received a great deal of attention over the past two years or so. It is our belief that this trend will continue as long as faster computers keep evolving and more efficient optimization algorithms are utilized. It is now generally recognized that the reduced gradient method of Dommel and Timmey is not the most effective in solving the OPF although twenty years ago, it was considered the state of the art. Answering multitudes of questions regarding the impact on OPF of incorporating non-conventional generation (NCG) sources into the generation dispatch strategy is not performed. With the NCG's providing random input into the system, it becomes a matter of careful statistical study of all variables involved [24].

Ahmed *et al.* 1995 proposed that the Optimization problem of real and reactive power and presents the new algorithm for studying the load shedding and generation reallocation problem in emergencies where a portion of the transmission system is disabled and an a.c. power solution cannot be found for the over loaded system. A novel and efficient method and algorithm to obtain the optimal shift in power dispatch related to contingency states or overload situations in power system operation and planning phases under various objectives such as the economy, reliability and environmental conditions is decribed. The optimization procedures basically utilize linear programming with bounded variables and it incorporates the techniques of the Section Reduction Method and the Third Simplex Method. The algorithm relies on the convergence of the power flow at each iteration andtherefore may be interrupted by a single solution divergence.The efficiency can also be improved by exploiting the sparsity of the problem [25].

In 1999 P. S. Kulkarni and A. G. Kothari proposed to design, train and test an improved Backpropagation Neural Network (BPNN) for application to the problem of combined economic and emission dispatch. Focus is on the reduction of single pollutant nitrogen oxide, NOx; transmission losses are included. The equality constraint of power balance and inequality generator capacity constraints are considered. The total load supplied is the input to the neural network. The thermal generator outputs and total system transmission loss are considered as outputs of the neural network. The proposed BPNN technique has been demonstrated through a sample system consisting of six thermal generators. The program for Optimization Technique using the Quick Method is developed in Matlab and the program for an improved BPNN is developed using the Matlab Neural Network Toolbox. The performance of an improved BPNN is compared with the Quick Method and it is observed that the proposed neural network technique is very fast and predicts accurate results while satisfying inequality generator capacity constraints at various load levels. It also offers a considerable saving in computer memory. There is a considerable saving in computational time and memory compared to the Quick Method. And from the 4 test cases it is inferred that the drawback is that the percentage error in total fuel cost and total NOx emission for a load demand of 1078 MW, the error is maximum; i.e., 2.167% in total fuel cost and 3.76% in total NOx emission [4].

P. Venkatesh *et al*. proposed in 2003 that the Combined economic emission dispatch (CEED) problem is obtained by considering both the economy and emission objectives. This biobjective CEED problem is converted into a single objective function using a price penalty factor approach. A novel modified price penalty factor is proposed to solve the CEED problem. Evolutionary computation (EC) methods such as genetic algorithm (GA), micro GA (MGA) and evolutionary programming (EP) are applied to obtain ELD solutions for three, six and 13-unit systems. Investigations showed that EP was better among EC methods in solving the ELD problem. EP-based CEED problem has been tested on IEEE 14-, 30- and 118-bus systems with and without line flow constraints. A nonlinear scaling factor is also included in EP algorithm to improve the convergence performance for the 13 units and IEEE test systems. The solutions obtained are quite encouraging and useful in the economic emission environment.

M.A. Abido in 2003 proposed a new multi objective evolutionary algorithm for Environmental/Economic power Dispatch (EED) problem. The EED problem is formulated as a nonlinear constrained multi objective optimization problem. A new Strength Pareto Evolutionary Algorithm (SPEA) based approach is proposed to handle the EED as a true multi objective optimization problem with competing and non-commensurable objectives. The proposed approach employs a diversity-preserving mechanism to overcome the premature convergence and search bias problems. A hierarchical clustering algorithm is also imposed to provide the decision maker with a representative and manageable Pareto-optimal set. Moreover, fuzzy set theory is employed to extract the best compromise non dominated solution. Several optimization runs of the proposed approach have been carried out on a standard test system. The results demonstrate the capabilities of the proposed approach to generate well-distributed Pareto-optimal solutions of the multi objective EED problem in one single run. The comparison with the classical techniques demonstrates the superiority of the proposed approach and confirms its potential to solve the multi objective EED problem [28].

Conventional optimization methods are not able to solve problems such as an increase in cost and environmental concerns due to local optimum solution convergence. In 2009 Amita et al. proposed a Metaheuristic optimization techniques especially particle swarm optimization (PSO) has gained an incredible recognition as the solution algorithm for such type of ED problems in last decade. Particle swarm optimization has paid a lot of attention for the solution of such problems, as it will not suffer from stuck into local optimal solution, dependability on initial variables, premature and slow convergence and curse of dimensionality. In comparison to conventional optimization techniques, PSO has given an improved results within less computational time. Presentversions of PSO have slower convergence at a later stage and also not able to provide an optimal solution for real time scheduling problems [26].

K. Senthil and K.Manikandan in 2010 proposed that the Improved Tabu Search (ITS) solution to economic dispatch problem is very useful when addressing heavily constrained optimization problem in terms of solution accuracy. In this paper, an Improved Tabu Search (ITS) algorithm solves economic load dispatch (ELD) power system problem of three generator system, six generator system with emission constraints and thirteen generator system with valve point effect loading. The Improved Tabu Search (ITS) algorithm was used to check the validity, quality of the solution and the results are tabulated. The validity and quality of the solution obtained using proposed Improved Tabu Search (ITS) based economic load dispatch method are checked and compared with Hopfield Neural Network (HNN), Genetic Algorithm (GA), Tabu Search Algorithm (TSA) and Distributed Tabu Search Algorithm (DTSA).it obtains the solution with high accuracy. Results obtained from this technique clearly demonstrate that the algorithm is more efficient in terms of a number of evolution to reach the global optimum point. The result also shows that the solution method is practical and valid for real time applications. The solution is analytic in nature with high accuracy involving less computational time [27].

Provas Kumar Roy *et al*. proposed in 2010 the biogeography-based optimization (BBO) for solving different constrained economic load dispatch (ELD) problems combined with economic emission aspects in power system. Nonlinear characteristics of generators like valve point discontinuities, ramp rate limits and prohibited operating zones are considered in the problem. The simulation results show that the proposed BBO algorithm based solutions prove to be the best near-global optimal as compared to the solutions based on Newton–Raphson, Tabu search, genetic algorithm (GA), non-dominated sorting genetic algorithm (NSGA), fuzzy logic controlled genetic algorithm (FCGA), particleswarm optimization (PSO) and differential evolution (DE). BBO gives the best fuel cost.Itmay finally be concludedthat the proposed algorithm works very well for thenear-global optimization of combined economic and emissiondispatch problems [6].

In 2010 K. Senthil proposed Evolutionary programming (EP) method considering the power limits. The CEED is to minimize both the operating fuel cost and emission level simultaneously while satisfying the load demand and operational constraints. The sample test system of three and six generator system solves the CEED problem for various load demands. The numerical results have shown the performance and applicability of the proposed method. EP is an efficient tool for the economic scheduling for generating units with the given generator constraints. The quality of the solutions generated by the EP offers an excellent approach to solving the economic thermal power dispatch problem. The solution is analytic in nature with high accuracy and less computational time and it is used for any online application [26].

Nagalakshmi *et al.* 2011 proposed a new optimization technique IWD-CO to solve an optimization problem Combined Economic and Emission Dispatch (CEED). The CEED is a combination of Economic Load Dispatch and EmissionDispatch which aims at minimization of the fuel cost and emission cost of generating units while satisfying the load conditions and other constraints. The present algorithm is inspired by the natural river dynamics. Here the agents are water drops and they are used to find the optimal path in the search space. The IWD-CO is used in an efficient manner to solve large generating unit power system. The results of the IWD-CO to solve CEED are tested with 3 and 6 generator power systems and they are satisfactory. IWD-CO results are also compared with the Genetic Algorithm (GA) and Particle Swarm Optimization (PSO) to show the effectiveness of the algorithm. For 300MW load IWD-CO the best average iteration is 5.2667, the time of convergence is 0.2929sec and a total number of iterations are 10, where as those values in GA are 27.27, 0.374985sec, 50 and PSO are 95.5333, 0.0175sec, 100. So the convergence rate for IWD-CO is more as compared to the GA and PSO and it also true for other loads as well.IWD-COcannot be applied for optimization of online CEED problem and it is also used for other optimization problems in which even GA is giving better results [7].

In 2011 S. Dhanalakshmi *et al*. proposed a modified NSGA-II algorithm for economic and emission dispatch problem. The available NSGA-II has the drawbacks such as lack of uniform diversity in obtained non-dominated solutionsand absence of a lateral diversity-preserving operator among the currently-best non-dominated solutions. These two drawbacks have been overcome by introducing dynamic crowding distance (DCD) and controlled elitism (CE) into the NSGA-II. The developed algorithm MNSGA-II has been applied to a standard IEEE 14-, 30-, 57- and 118-bus systems to check its applicability. The results authenticate the potential and effectiveness of MNSGA-II algorithm for CEED problem. Moreover, in order to certify the results arrived, four different performance metrics gamma, delta, minimum spacing and Inverted Generational Distance (IGD) were used. These metrics will be supportive for evaluating the closeness to the reference pareto-optimal front. An approach based on Technique for Ordering Preferences by Similarity to Ideal Solution (TOPSIS) is used to decide the choice of a solution from all pareto-optimal solutions, as the best compromise solution. Improved convergence, diversity and robustness. Steps should be taken to reduce the computational time [8].

In 2012 R. Gopalakrishnan and Dr.A. Krishnan proposed that a power system operation at minimum cost is no longer the only measure for electrical power dispatch. The stability of the power system is also considered as an important factor in the performance of the power system. Several optimization techniques are slow for such complex optimization tasks and are not suitable for on-line use. An effective optimization algorithm is presented for solving security constrained combined economic emission dispatch problem. Also, the power system stability plays an important role in the power system. Power system stability criteria are also considered for better performance of theentire power system. An efficient optimization technique used isModified Artificial Bee Colony Optimization to solve the CEED problem. The performance of the proposed approach is compared with the other optimization techniques [9].

Evolutionary algorithms (EAs) are well-known optimization approaches to deal with nonlinear and complex problems. However, these population-based algorithms are computationally expensive due to the slow nature of the evolutionary process. Chatterjee et al. in 2012 proposed Harmony Search (HS) is a derivative-free real parameter optimization algorithm. It draws inspiration from the musical improvisation process of searching for a perfect state of harmony. A novel approach is proposed to accelerate the HS algorithm. The proposed opposition-based HS employs opposition-based learning for harmony memory initialization and also for the generation jumping. Both the near-optimality of the solution and the convergence speed of the proposed algorithm are found to be promising. When the environmental concernsthat arise from the emissions produced by fossil-fueled electricpower plants are combined with the ELD then the problem becomesthe CEED problem. This problem considers two objectivessuch as minimization of the fuel cost and the emission from thethermal power plants with both equality and inequalityconstraints. The proposed EA algorithm minimizes the fuel cost and the emission [10].

U. Güvenç *et al*. proposed in 2012 the Gravitational Search Algorithm (GSA) to find the optimal solution for Combined Economic and Emission Dispatch (CEED) problems. It is aimed, in the CEED problem, that scheduling of generators should operate with both minimum fuel costs and emission levels, simultaneously, while satisfying the load demand and operational constraints. Tthe CEED problem is formulated as a multi-objective problem by considering the fuel cost and emission objectives of generating units. The bi-objective optimization problem is converted into a single objective function using a price penalty factor in order to solve it with GSA. The proposed algorithm has been implemented on four different test cases, having a valve point effect with transmission loss and having no valve point effect without transmission loss. Results show that the GSA is more powerful than other algorithms. Although GSA is memoryless, it works efficiently like algorithms with memory. It is seen from the comparison that the proposed method confirms the effective high-quality solution for CEED problems [11].

In 2013 Gopalakrishnan and Krishnan proposed an efficient and reliable technique for combined fuel cost economic optimization and emission dispatch using the Modified Ant Colony Optimization algorithm (MACO) to produce a better optimal solution. The proposed approach is used to reduce the total system operating cost and emission levels. The proposed method for CEED problem is evaluated using the six-generator system. The proposed technique is tested by varying the power demand such as 400MW, 500MW, 600MW, 700MW, 800MW, 900MWand 1000MW. The result clearly suggests that the proposed technique is better as it involved a lesser cost for the system operation when compared to other techniques. The emission resulting from using the proposed optimization technique is much reduced when compared to the other techniques. It can be observed that the proposed technique required lesser iterations for optimization when compared to other techniques. Also, the time required for optimization is much reduced for the proposed technique when compared to other techniques [12].

Yun and Josue in 2014 proposed The idea consists of normalizing the two conflicting objective functions, ED and MED, using The idea consists of normalizing the two conflicting objective functions, ED and MED, using the mean and standard deviation of the members contained in the population-based meta-heuristic algorithms implemented thus preventing units and scale differences when optimizing the CEED problem. The mathematical model for each problem (ED, MED and CEED) is optimized implementing a nonlinear optimization package named TOMLAB available for MATLAB, which helps us to determine the best possible solution for the tested instances. A novel meta-heuristic named Virus Optimization Algorithm (VOA) is implemented along with seven well-known algorithmic tools, which are the Genetic Algorithm (GA), Particle Swarm Optimization (PSO), Harmony Search (HS), Differential Evolution (DE), FireFly algorithm (FF), Gravitational Search Algorithm (GSA) and Seeker Optimization Algorithm (SOA). A comprehensive statistical study is performed to determine the quality of the solutions delivered by the algorithmic tools when compared with TOMLAB. From the test instances, it was observed that the proposed normalization method does not only show to be feasible but also helps the algorithms to achieve similar results from that coming when solving the ED and MED separately. Furthermore, among the eight meta-heuristic tools (VOA, GA, PSO, HS, DE, FF, GSA and SOA), VOA showed outstanding performance in both solution quality and computational efficiency. In the case of TOMLAB, an average and standard deviation values cannot be estimated. Testing different instances with the proposed approach as well as other meta-heuristics is complicated [13].

Dog¢an Aydin *et al*. in 2014 proposed that Incremental Artificial Bee Colony algorithm with Local Search (IABC-LS) is one of efficient variant of artificial bee colony optimization which was successfully applied to economic power Incremental Artificial Bee Colony algorithm with Local Search (IABC-LS) is one of efficient variant of artificial bee colony optimization which was successfully applied to economic power dispatch problems before. However, IABC-LS algorithm has some tunable parameters which are directly affecting the algorithm behavior. A new algorithm namely Artificial Bee Colony with Dynamic Population size (ABCDP) which is using similar mechanisms defined in IABC-LS without using many parameters to be tuned is proposed. To prove the efficiency and robustness of algorithm in power dispatch, the algorithm is used for the combined economic and emission dispatch problem which is converted into single objective optimization problemThe results of the algorithms indicate that ABCDP is giving good results in both systems and very competitive with the state-of-the-art [14].

The Spiral Optimization Algorithm (SOA) is an optimization technique developed recently (2011) by K. Tamura and K. Yasuda at Tokyo Metropolitan University-Japan. SOA is a metaheuristic based on an analogy of spiral phenomena in nature and it is simple in concept, few in parameters and easy in implementation.

LahouariaBenasla in 2014 proposed that SOA is proposed for solving the Combined Economic and Emission Dispatch (CEED) problem. It is aimed, in the CEED problem, that scheduling of generators should operate with both minimum fuel costs and emission levels, simultaneously, while satisfying the load demand and operational constraints. The CEED problem is formulated as a multi-objective problem by considering the fuel cost and emission objectives of generating units. The bi-objective optimization problem is converted into a single objective function using a price penalty factor. The proposed algorithm has been implemented on three test systems with 3, 6 and 40 generating units, with different constraints and various cost curve nature. Results are quite encouraging showing the good applicability of SOA for CEED problem. The SOA has several advantages including its few control variables, local searching capability, fast results, easy using process, simple structure and introduction of both phases of diversification and intensification in the same process. SOA should include more objective functions or constraints with regard to more realistic problems, as well as other data sets and standard test problems [3].

In 2015 MohdHerwanSulaiman et al. proposed the application of Cuckoo Search Algorithm (CSA) in solving the combined economic and emission (CEED) dispatch problem. As been known, CEED can be formulated as a multi-objective optimization problem which is involving two objectives that conflicting each other. The objective is to find the tradeoff between minimizing the costs of fuel as well as minimizing the emission levels simultaneously while satisfying all the constraints. The bi-objective function is transformed into a single objective function by introducing the price penalty and weighting factors. In order to show the effectiveness of CSA in solving CEED, two test systems are used: 6-units and 40-units generator systems. The comparison with other recent techniques shows that the fuel cost is 1.25701 x 105 $/h and the emission level is 1.95125 x 105 kg/h obtained by CSA which is the best results compared to others. The implementation of CSA to solve CEED problem for the more complex system does not include the practical constraints and losses [16].

Jordan Radosavljeviæ in 2016 proposed a new hybrid algorithm based on particle swarm optimization (PSO) and the gravitational search algorithm (GSA) for solving the combined economic and emission dispatch (CEED) problem in power systems. The performance of this approach for the CEED problem is studied and evaluated on three test systems with 3, 6 and 40 generating units, with various cost curve nature and different constraints. Those results show that the proposed algorithm provides an effective and robust high-quality solution of the CEEDproblem. It is clear that the proposed hybrid PSOGSA algorithm canconverge to its global best in fewer iterations compared with PSO and GSA algorithm and another advantage include providing an effective and robust high-quality solution [17].

In 2016 A.Y. Abdelaziz proposed an implementation of Flower Pollination Algorithm (FPA) to solve ELD and CEED problems in power systems.FPA is investigated to determine the optimal loading of generators in power systems. Simulations results for small and large scale power system considering the valve loading effect are implemented to indicate the robustness of FPA. Results obtained by the proposed FPA are compared with other optimization algorithms for various power systems. The results introduced in this paper show that the proposed FPA outlasts other techniques even for large scale power system considering valve point effect in terms of total cost and computational time.The proposed algorithm cannot be applied to multi area power system integrated with wind farms and PV system [18].

Combined economic and emission dispatch (CEED) is a key challenge for the system operator in the open access regime and is used to operate generators that produce energy in a power plant with least costs as well as least emission simultaneously. Stability issues must, therefore, be considered during CEED. A multi-objective formulation of CEED in a power system is presented with the competing objective functions of minimizing fuel cost and emission. In 2016 Arup and Ajoy proposed a Non-dominated Sorting Multi Objective Opposition based Gravitational Search Algorithm (NSMOOGSA) is used as an optimization tool. The fuzzy decision maker is used to extracting the best compromise non-dominatedsolution. The proposed method has been tested on the IEEE 30-bus system. The quality of the results establishes the efficacy of the proposed approach in solvingdifferent CEED problem. From the simulation results, it is also observed that the applied method yields optimal setting of the control variables of the test power system and also confirms the better-quality solution, robustness and superiority to solve CEED problem [19].

India Electrical Energy is generated mainly Coal based Thermal Power stations and hydro Electric Power Stations. The main aim of power generating company is to provide good quality and reliable power to consumers at minimum cost. The problem of Combined Economic and Emission Dispatch deals with the minimization of both fuel costand emission of pollutants such as oxides of Nitrogen and Oxides of Sulphur. In power system, the emission is a major problem created that's why in nowadays we move from a green energy source or renewable energy such as Sunlight, Wind, Tides, Wave and Geothermal Heat Energy. The Emission constrained Economic Dispatch problem treats the emission limit as an additional constraint and optimizes the fuel cost. Combined Economic and Emission Dispatch problem are optimized by using two different optimization method such as Artificial Bee Colony (ABC) and Genetic Algorithm (GA). S. Bhongade andSourabh in 2016 proposed the ABC Algorithm has been successfully implemented is to IEEE 30 bus and Indian Utility sixty two Bus System. The simulation result is compared and found the algorithm is effective for Combined Economic and Emission Dispatch problem. The main advantages of the ABC algorithm over other optimization methods for solving optimization are simplicity, high flexibility, strong robustness, few control parameter, ease of combination with other methods, ability to handle the objective with stochastic nature and fast convergence [20].

Ismail *et al*. in 2016 proposed a combined economic and emission power dispatch (CEED) when the fuel cost function can be presented as a cubic function. Max/max price penalty factor is considered in the multi-objective function of (CEED). The fuel cost is presented with 4 parameters (a, c, d and e). The simulated annealing approach is our method to find the optimal solution. The simulated annealing algorithm is used to minimize the fuel cost and the gas emissions as SO2, NOx and CO2 in the same time. In order to evaluate the proposed method, we applied it on 6-unit system with cubic fuel cost and cubic emission functions. The results obtained from SA method are compared with Lagrange method and particle swarm optimization. The results show that the SA algorithm is better than the others at solving such the problem of combinedemission and power dispatch. The construction and implementation of a heuristic method using the simulated annealing that solvesthe combined economic and emission dispatch problem ispresented. The use of the simulated annealing method tosolve the CEED problem is, therefore, justifiable if themethod produces optimal solutions and outperforms nearoptimalsolver with respect to computation time [21].

In 2016 Jordan proposed that a new hybrid algorithm based on particleswarm optimization (PSO) and the gravitational search algorithm (GSA) for solving the combined economic and emission dispatch (CEED) problem in power systems. The performance of this approach for the CEED problem is studied and evaluatedon three test systems with 3, 6 and 40 generating units, with various cost curve nature and different constraints. The results show that the proposed algorithm provides an effective and robust high-quality solution of the CEED problem [22].

The dispatch of power at the minimum operational cost of thermal energy sources has been a significant part of research for decades. Recently, with increasing interests in renewable energy resources, the optimal economic dispatch has become a challenging issue. Naveed Ahmed Khan et al. in 2016 proposed combined emission economic dispatch model for a solar photo voltaic integrated power system with multiple solar and thermal generating plants. Mixed integer binary programming problem subject to various practical constraints is formulated. A decomposition framework is proposed where the original problem is split into two sub-problems. Particle swarm optimization, Newton_Raphson method and binary integer programming techniques are exploited to find the joint optimization solution. The proposed model is tested on the IEEE 30 bus system. The simulation results demonstrate the effectiveness of the proposed model. Better performance of the proposed algorithm in terms of cost minimization and maximization of the solar share [23].

For electric power generation and dispatching problems, the cost is not any more the only criterion to be met. Environmental considerations have become one of the major management concerns. The harmful ecological effects caused by the emission of particulate and gaseous pollutants like sulfur dioxide (SO2) and nitrogen oxides (NOx), can be reduced by an adequate distribution of load between the plants of a power system. However, this leads to a noticeable increase in the operating cost of the plants. In order to eliminate this conflict and to study the trade-off relation between fuel cost and emissions, an approach to solving this multi objective environmental/economic load dispatch problem, based on an efficient multiobjective fuzzy optimization technique, is proposed bySamir Sayah et al. The obtained results reveal the performance of the proposed method for dealing with the multi +objective nature of power dispatch problem [25].

CONCLUSION

A general survey of papers and reports addressing various aspects of solution for combined economic and emission dispatch has been presented in this paper. The time period covered is 1990-2016. We have tried to include as many descriptions of the contents as possible in order to include the important and unique aspects of each paper. Some interactions among papers by the same authors over the period or among similar papers by different authors arepresented to the extent that is allowable within the limitations of asingle paper. Our attempt is not directed at evaluating and comparing relative performances of the existing algorithms but at presenting a clear picture of what is available so that a researcher in the area of generation dispatch can identify problems and seek their solutions.

It is fairly obvious from this survey that the problem of Combined emission and economic dispatch has been received a great deal of attention over the past twenty years or so. It is our belief that this trend will continue as long as more efficient optimization algorithms are utilized. Many authors have formulated and implemented more efficient and accurate algorithms; the only difference in the performance of these was the convergence property. Solution implies the minimization of instantaneous cost of active power generation on an operating power system subject to preventing violations of operating constraints in the event of any planned contingencies. Such an on-line implementation requires fast execution times and minimum storage allocations. Undoubtedly, these constraints elevate the nature of solving the combined economic and emission dispatch to a high level of complexity.

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