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Different Comparison of Heuristic Algorithms to Solve Economic Load Dispatch: A Literature Review

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Abstract: Economic load dispatch (ELD) is a sub problem of the optimal power flow (OPF) having the objective of fuel cost minimization. The fuel cost equation of a thermal plant is generally expressed as continuous quadratic equation. In real situations the fuel cost equations are non-convex and sometimes non-continuous. In order to solve such economic load dispatch problems, various methods are discussed in this paper. The results of these methods are compared and it is seen that artificial bee colony approach is very useful and efficient approach to solve economic dispatch problem among all the approaches.

Keywords: Economic load dispatch, Particle swarm optimization, Tabu Search Method, Social Spider Optimization, Gravitational Search Method, Teaching Learning Based Optimization, Krill Herd Method, Artificial Bee Colony.

I. INTRODUCTION

During the last decade, the electrical power market became more and more liberal and highly competitive. The main goal is to generate of a given amount of electricity at the lowest possible cost. This needs proper planning, operation and control of large existing complicated systems [2]. The operating cost of thermal power plant depends on fuel cost. Economic load dispatch problem can be defined as determining the least cost power generation schedule from a set of on line generating units to meet the total power demand at given time [10] of ELD, while satisfying equality and inequality constraints. The careful and intelligent scheduling of the generating units can not only reduce the operating cost significantly but also assure higher reliability and security of power system. Thus ELD has become an essential optimization area for economic operation and control of modern power system.

II. LITERATURE REVIEW

In conventional economic load dispatch, cost function for each generator is represented by a single quadratic function and is solved using lambda iteration method, Newton method, gradient-based method, etc. These methods require incremental fuel cost curves which are piecewise linear and monotonically increasing to find the optimal solution. For generating units, which actually having non-monotonically incremental cost curves, conventional methods ignores or flattens out portions of incremental cost curve that are not continuous or monotonically increasing. Unfortunately, input-output characteristics of modern units are inherently highly non-linear because of valve point loadings, ramp rate limits, prohibiting operating zones resulting in multiple local minimum points in the cost function. So, their characteristics have to be approximated to meet requirements of classical dispatch algorithms. However, such approximations may lead to huge loss of revenue over the time. Classical methods like Newton-based and gradient methods cannot perform very well for problems having highly nonlinear characteristics with large number of constraints and many local optimum solutions. Thus, developing a reliable, fast and efficient algorithm is still an active area for research in power systems. Various investigations on ELD have been explored till date, as better solutions would result in significant economical benefits like particle swarm optimization (PSO), genetic algorithm (GE), krill herd algorithm , artificial bee colony (ABC) are used Yang et al. presented a mathematical programming based method named quadratic ally constrained programming (QCP) to solve non-smooth and non convex ELD problem. Dervis developed artificial bee colony (ABC) optimization technique to solve multi-area economic dispatch (MAED) problem considering tie line constraints and nonlinearities like multiple fuels, valve point loading and prohibited operating zones. Cai et al. developed a fuzzy adaptive chaotic ant swarm optimization (FCASO) algorithm for solving the ELD problems of thermal generators in power systems. In this paper different intelligent methods are discussed.

III. PROBLEM FORMULATION

The primary goal of ELD problem is to minimize the total fuel cost while fulfilling the operational constraints of the power system. Suppose there is a station with N_g generators committed and the active power load demand P_d is given, the real power generation is P_{gi} , which is to be allocated in order to minimize the cost . In The fuel cost equation is given by:-

$$F(P_{gi}) = aiPgi^2 + biPgi + ci \quad Rs/h$$

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The objective of economic load dispatch is to minimize the total fuel cost given by equation:-

$$F_T = \sum_{I=1}^{Ng} Fi(Pgi)$$

Subjected to constraint

$$\sum_{I=1}^{Ng} P_{gi} = P_d + P_L$$

$$P_{gi}^{min} \le P_{gi} \le P_{gi}^{max}$$

Where

P_{gi} = Real power generation
P_d = Real power demand
PL = Power loss
F (P_{gi}) = operating fuel cost

Expressing the transmission losses as the function of generator power is through B – Coefficient as

$$P_L = \sum_{i=1}^{Ng} \sum_{j=1}^{Ng} P_{gi} B_{ig} P_{gj} \quad MW$$

The above equation is known as George's equation. P_{gi} and P_{gj} are real power generation at i_{th} and j_{th} bus. B_{ij} is the loss coefficient.

IV. VARIOUS INTELLIGENT METHODS

A. Particle Swarm Optimization

Particle swarm optimization (PSO) is suggested by Kennedy and Eberhart based on the analogy of swarm of birds and school of fish. PSO mimics the behaviour of individuals in a swarm to maximize the survival of the species. In PSO, each individual makes his decision using his own experience together with other individual's experiences. This algorithm is based on a metaphor of social interaction, searches a space by adjusting the trajectories of moving points in a multidimensional space .The individual particles are drawn stochastically toward the position of present velocity of each individual, their own previous best performance, and the best previous performance of their neighbours. PSO can be easily applied to nonlinear and non-continuous optimization problem. Hardiansyah et al. used the proposed method for a three units and six units system and the results were compared with quadratic programming method and it is concluded that PSO gives better result than conventional method [10].

B. Tabu Search Method

Tabu search was developed by Glover in 1987 who was motivated by the randomness of human behaviour given similar situations. Glover argued that such deviance from consistence might be to some advantage. Thus, Tabu search operates this way except that new courses are not chosen randomly and is an iterative search method. Tabu search proceeds to elude that there's no point in accepting a new solution unless it's to avoid a path already chartered. This ensures that the whole problem space will be investigated as we move away from local minima to alternatively find the desired solution. A list is used to record the moves in order to avoid retracing such path or reverse of the path. TS have traditionally been used on combinatorial optimization problems. Bakhta Naama et al. made the comparison between TS, GA and Mat-Power and concluded that proposed technique improves the quality of solution and reduces computation time [14].

C. Social Spider Algorithm

Social Spider Algorithm (SSA) was proposed by Yu and Li to solve global numerical optimization problems. It is a general purpose swarm intelligence algorithm utilizing the foraging behaviour of the social spiders to perform optimization tasks. SSA was initially designed to solve continuous unconstrained problems and made several essential modifications to adapt the algorithm to solve ELD efficiently.

In SSA, the solution space of an optimization problem is formulated as a hyper-dimensional spider web S on which the spiders can move freely. Each position on the web corresponds to a feasible solution to the optimization problem. James J.Q. Yu et al. applied this approach to solve five different test power systems with various numbers of power units and constraint configurations and concluded that SSA method gives satisfactory results for large number of units [7] .

D. Gravitational Search Algorithm

Gravitational search algorithm (GSA) is one of the recently improved heuristic algorithm based on the Newton's law of gravity and mass interaction. GSA has been verified high quality performance in solving different optimization problems in the literature. Serhat Duman et al. used GSA to solve the ELD problem which is formulated as a nonlinear optimization problem with equality and inequality in power systems. The proposed algorithm is tested for 3 bus systems, 10 bus systems and 18 bus systems and the results are compared to various different methods to show its effectiveness. From the outcome of the results, it is seen that the proposed approach can acquire satisfactory solution[11].

E. Teaching Learning Based Optimization

Teaching-learning-based optimization (TLBO) has been proposed by Rao et al. for constrained optimization problems. TLBO algorithm simulates the teaching-learning process that every individual tries to learn something from other individual to improve themselves. The method bases on the effect of influence of teacher on learners and the effect of learners each other. Rao et al. presented five different constrained benchmark test functions in order to demonstrate the robustness . The results obtained from TLBO were compared with the other meta-heuristic optimization methods. The comparisons showed that the TLBO showed better performance with less computational effort over other meta-heuristic optimization methods. Rao et al. developed TLBO method for large scale non-linear economic load dispatch problems for finding global solutions. The results proved that TLBO method is effective in terms of the computational effort, consistency and obtaining the near optimum solutions [15].

G. Krill Herd Algorithm

Krill herd algorithm (KHA) is recently developed powerful evolutionary algorithm proposed by Gandomi and Alavi to solve non-convex optimization problem. The proposed KHA method is heuristic algorithm based on the herding behaviour of krill individuals. It is a population based method consisting of a large number of krill in which each krill moves through a multi-dimensional search space to look for food. In this algorithm, the positions of krill individuals are considered as different design variables and the distance of the food from the krill individual is analogous to the fitness value of the objective function . Barun Mandal et al. applied this method on four different KHA techniques namely, KHA without any genetic operators (KHA-I); KHA with crossover operator(KHA-II); KHA with mutation operator (KHA-III); and KHA with crossover and mutation operators (KHA-IV) approaches are carried out on six different case studies namely, 6-unit, 10-unit, 15-unit, 40-unit without transmission loss, 40-unit with transmission loss and 80 unit systems of ELD problems[2] .

H. Artificial Bee Colony (ABC)

Artificial bee colony (ABC) is one of the most recently defined algorithms by Dervis Karaboga in 2005. It has been developed by simulating the intelligent behaviour of honeybees. In ABC system, artificial bees fly around in a multidimensional search space and the employed bees choose food sources depending on the experience of themselves. The onlooker bees choose food sources based on their nest mates experience and adjust their positions. Scout bees fly and choose the food sources randomly without using experience. Each food source chosen represents a possible solution to the problem under consideration. The nectar amount of the food source represents the quality or fitness of the solution. The number of employed bees or the onlooker bees is equal to the number of food sources or possible solutions in the population. A randomly distributed initial population is generated and then the population of solutions is subjected to repeated cycles of the search process of the employed bees, onlookers and scouts. Gaurav Prasad Dixit et al. tested third method on 3 generating unit system and 6 generating unit systems.

The result of proposed method was compared to conventional method, Simple Genetic Algorithm (SGA), Refined genetic algorithm (RGA), And Hibrid genetic algorithm. The results showed that ABC algorithm is more effective and results in least operating cost [12].

V. CONCLUSION

In this paper, the various intelligent optimization algorithm has been discussed to solve the different types of non-convex ELD problems. Their conclusions of different papers are analysed and an idea is obtained about better solution for economic load dispatch. PSO algorithm is basic intelligent method. It gives better convergence as compared to other methods. From the results of Tabu Search algorithm it seen that proposed technique improves the quality of solution and reduces computation time whereas KHA gives better results than GSA, SSA and TLBO. The ABC algorithm has superior features, including quality of solution, stable convergence characteristics and good computational efficiency. So, above conclusion shows that ABC is a promising technique for solving complicated optimizing problems in power system.

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