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A new gumption approach for economic dispatch problem with losses effect based on valve-point active power

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ABSTRACT

Economic dispatch (ED) generally formulated as convex problem using optimization techniques. Various methods have previously been used for the solution of the problem. Among those Tabu search (TS), evolutionary programming (EP), and genetic algorithm (GA) are powerful methods but they are heuristic and do not always guarantee to achieve to global optimal solutions in finite time. They take longer time to converge to near optimal results. Reaching to the optimal solution faster depends on how the methods are programmed and applied. This paper proposes new simple approach to solve the economic dispatch problem with valve-point and losses effect. The proposed method is an optimization algorithm which minimizes the total cost of the plants and gives optimum generation schedule subject to the operating constrains of the system. It is based on valve-point active powers for different combinations of valve-points in all generation units. Three machines 6-bus system, IEEE 5-machines 14-bus, and IEEE 6-mchines 30-bus systems have been tested for validation of our approach. Results of the proposed scheme compared with results obtained from genetic algorithm (GA), hybrid genetic algorithm (HGA), and hybrid (H) method give significant improvements in the generation cost that confirm the applicability of the proposed method.

1. Introduction

Economic dispatch (ED) problem is considered a vital step in power system operation. It is the generation allocation problem in which minimizes the total generation cost among the committed units satisfying all units and system equality and inequality constraints [1]. The accurate economic dispatch depends mainly upon the accurate representation of nonlinear and non-smooth input–output curves of generators.

One could classify the ED problem as convex and non-convex economic dispatch. The input–output characteristics for convex ED are assumed piecewise linear and monotony increasing. Many techniques applied are based on mathematical programming such as λ iteration, as well as gradient method [2], Newton's method and dynamic programming [3–6] and base-point participation factor method [7,8]. In these methods, the fuel cost function is chosen to be in quadratic form. In real time power system operation, the non-convex ED problem represents non-smooth and nonlinear characteristic. It requires a fast, accurate solution methodology. Non-convex ED problem cannot be solved using mathematical programming based optimization methods. Generally heuristic search methods are used for the solution of complex optimization problem such as non-convex ED problem.

In practical systems, the power generation has to be altered to meet the demand changes. Many stochastic methods have been used to solve the problem. Evolutionary programming (EP) can be a quite powerful approach [9–11]. However, it is rather slow in converging to a near optimum for some cases [12]. Simulated annealing (SA) [13], Tabu search (TS) [14], are useful in solving complex reliability optimization problems. 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. The genetic algorithm (GA) is a potential heuristic tool for ED problem [15]. It has the ability to reach the global minimum in a short time, but then takes longer time to converge. Sometimes it may be trapped into the local optimum. Differential evolution (DE) is a very powerful algorithm with no doubt, but its greedy updating principle and intrinsic differential property usually lead the computing process to be trapped at local optima [16]. Particle swarm optimization (PSO) converges quickly, but has a slow fine-tuning ability of the solution [17,18]. Heuristic methods do not always guarantee enhancing globally optimal solutions in finite time [19], and depend on how the methods are programmed.

In this study, we propose a gumption method which minimizes the total cost of generating plants based on valve-point active powers. The proposed method calculates the generation

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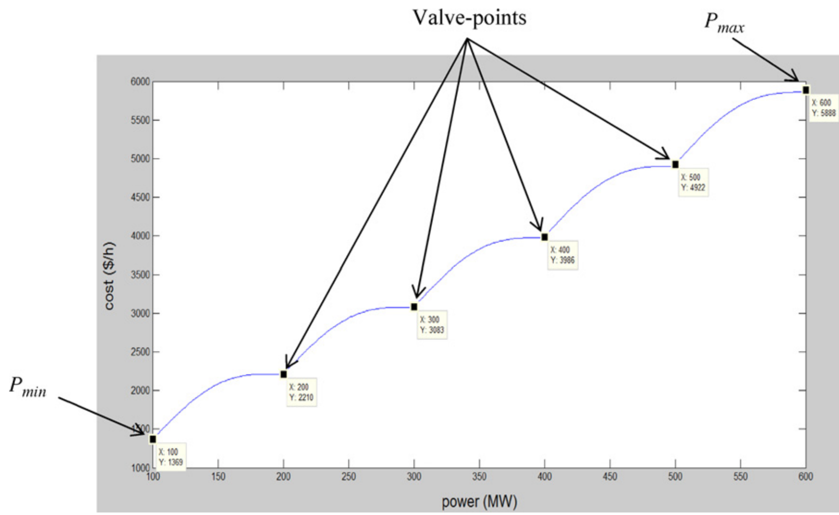

Fig. 1. Generator cost curve with valve-point.

costs for different combinations of valve-points in all generation units. Among those combinations we search for the one which gives minimum total generation cost for the committed units satisfying all units' system equality and inequality constraints, with losses effect included. Comparing to the prevalent methods of non-convex ED problem, our method results in a unique answer, while the others depend on how the methods are programmed. Our proposed method has been tested on three different test systems; 3-machines 6-bus, IEEE 5-machines 14-bus, and IEEE 6-machines 30-bus systems [20]. The corresponding results from these tests are compared with the results gathered from genetic algorithm (GA), hybrid genetic algorithm (HGA), and hybrid (H) method which combines the genetic algorithm (GA) with active power optimization (APO) based on the Newton's second order approach (NSO) [20]. The remaining paper has been organized as follows. The brief review of ED problem is given in Section 2. Section 3 gives the proposed method for solving the non-convex ED problem. In Section 4, we apply the method on three different test systems and discuss on the numerical results. In Section 5, overall conclusion is given.

2. Economic dispatch problem

2.1. Smooth economic dispatch problem

The economic dispatch is a non-linear programming optimization problem. The main objective is to minimize the total fuel cost at thermal plants subject to the operating constraints of power system. The most simplified cost function of each generator can be represented as a quadratic function given in (1) which can be solved by the mathematical method.

$$C_i(P_i) = A_i + B_iP_i + C_iP_i^2 \tag{1}$$

And the objective function is:

$$Minimize\ C_T = \sum_{i=1}^{n} C_i(P_i) \tag{2}$$

Subject to equality constraint:

$$P_D + P_L = \sum_{i=1}^{n} P_i \tag{3}$$

And inequality constraints:

$$P_{i,\min} \le P_i \le P_{i\max} \tag{4}$$

where C_T is the total cost; C_i is the fuel cost of the ith generating unit; A_i, B_i, C_i are the fuel cost coefficients, n is the number of generating units, and P_D is the total load; $P_{i\,min}$ is the minimum active power generation; $P_{i\max}$ is the maximum active power generation.

$$P_L = \sum_{i=1}^{n}\sum_{j=1}^{n} P_iB_{ij}P_j + \sum_{i=1}^{n} B_{0i}P_i + B_{00} \tag{5}$$

P_L is the transmission loss; B_{ij}, B_{0i}, B_{00} are transmission loss formula coefficients.

2.2. Non-smooth power economic dispatch

Real time system consists of a number of generator units. Large steam turbine generators will have a number of steam valves that are opened in sequence to control the power output of the units. Any increase in unit load makes the unit input to be increased and incremental heat rate will be decreased between the openings of any two valves. In general, the valve-point show ripples when every steam valve begins to open. The economic dispatch cost objective function considering the valve-point effects, is generally described as mathematical superposition of sinusoidal function and quadratic cost function, this non-smooth curve is represented as [3]:

$$C_T = \sum_{i=1}^{n} A_i + B_iP_i + C_iP_i^2 + |e_i \sin(f_i(P_{i\min} - P_i))| \tag{6}$$

where e_i, f_i are the cost coefficients for ith generator reflecting valve-point effects.

3. Proposed method

The method is based on a gumption approach and has been applied for the solution of non-convex ED problem. The key point of the method is the value of active power in valve-points. Fig. 1 shows a unique cost function curve with valve-points for some thermal unit.

From the analytical point of view the algorithm can be summarized as follows: