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CALCULATION OF ECONOMIC LOAD DISPATCH OF THERMAL POWER PLAT USING ACO

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Abstract: ***Ant colony algorithm is based on the behavior of ants used to find the optimal paths for searching food. The main objective is to determine the most economic loadings of the generators, such that the required load demands of the generation can be met. The operations such as equality and inequality constraints of the generator used for satisfactory operation of the thermal power plant. Economic load dispatch is a crucial optimization task in power system operation for allocating generation among the committed units and also the fuel cost in rupees per hour (Rs/h) are reduced. The economic load dispatch plays a very important role within the operation of power grid. For this operation, six generator system of Satpura Thermal Power Plant has been taken into account. The purpose of the proposed work is to find the optimal value of economic load dispatch in thermal power plant through Ant colony optimization (ACO) in order to solve the economic load dispatch problem.***

Keywords:- *Optimization, linear and nonlinear ELD problems, Ant colony optimization, Thermal power plant generation.*

1. Introduction

Power system has several generating power plants. Each generating power plant has several generating units. The total demand of the system is supplied by different generating power plant at any particular time. Economic load dispatch problem identifies the generated output power of each generating power plant and output power of each generating unit within a power plant in such a way to minimize the overall generation cost in order to provide the system load demand and not violate the constraints limits.

In the economic load dispatch the generations are not fixed but they are allowed to take values within certain limits so as to meet a particular load demand with minimum fuel cost. Economic load dispatch problem is really the solution of a large number of load flow problems and choosing the one which is optimal in the sense that it needs minimum cost of generation. Since total cost of generation is a function of the individual generation of the sources which can take values within different constraints, the cost of power generation depends on the operating constrains of the sources.

Economic load dispatch is an important optimization task in power system operation for allocating generation among the committed units such that the constraints imposed are satisfied and the energy requirements in terms of British thermal units per hour (Btu/h) or dollar per hour ($/h) or rupees per hour (Rs/h) are minimized. Improvements in scheduling the unit outputs can lead to significant cost savings.

The efficient and optimum economic operation of electric power systems has always occupied an important position in electric power industry. In recent decades, it is becoming very important for utilities to run their power systems with minimum cost while satisfying their customer's demand all the time and trying to make profit. Since the demand is very large and the power generation is limited so it is required to fulfill the load demand using committed generating units in minimum fuel cost.

2. Literature Review

In literature many classical methods known as deterministic algorithms were listed such as Lagrange multipliers, Linear programming method, Quadratic programming, Parametric quadratic programming, Harmony search method and Pattern search programming used for the solution of economic load dispatch problem.

Aoki and Sotah (1982) proposed parametric quadratic programming, the modified quadratic programming and the recursive quadratic programming algorithm for the solution of single objective economic load dispatch problem. Linear programming technique is a powerful and practical optimization techniques used for the solution of economic load dispatch problem.

Fan and Zhang (1998) proposed practical strategy based on Quadratic Programming techniques to solve the real-time economic load dispatch problem with a quadratic objective function based on the unit's cost curves in quadratic or piecewise quadratic forms.

Improved harmony search method proposed for solving economic load dispatch problems. The harmony search algorithm has been developed by **Geem et al. (2001).** It imitates the improvisation process of musicians to find the perfect state of harmony.

Fuzzy based techniques, Genetic algorithm, micro GA, PSO, Levenbermarquardt algorithm proposed by **Chaturvediet al. (2006)**, based on the multilayer feed forward neural network, and a modified bacteria foraging algorithm (BFA) have applied for the solution of ELD problem with environmental emission. ABC algorithm inspired by foraging behavior of honey bees proposed to solve combined economic and emissions dispatch problems is presented by **Dixit et al. (2011)**.

PSO has attracted many attentions and been applied in various power system optimization problems such as economic dispatch. **Ahmed et al. (2007)** proposed a particle swarm optimization approach to economic load dispatch problems with non-smooth objective functions.

For the satisfaction of this goal of ELD problem **Chen and Yeh (2006)** proposed an efficient particle swarm optimization with mutation mechanism, they also considered many non-linear characteristics of the generator, such as ramp rate limits and valve-point loading effects in their study.

3. Formulation of ELD Problem

The main concerns of ELD problem is the minimization of its objective function. For obtaining optimum results of economic load dispatch problem it is needed to formulate proper mathematical model with their constraints. Mathematical model of ELD problem can be formulated in many way as listed in literature such as, Single objective, Multi-objective, Linear model of ELD, Non-linear model, ELD model with emission effect, ELD model with nonconventional sources etc.

The objective of ELD problem for fuel cost is given as

$$\text{Minimize } FC_T = \sum_{i=1}^{N} FC_i(P_i) \quad (1)$$

$$FC_i(P_i) = a_i P_i^2 + b_i P_i + c_i \quad (2)$$

Where, FC_T is the total generation cost; FC_i is the power generation cost function of the i^{th} unit, N is the total number of generating units.

3.1 Constraints

The classical and non-classical models either with smooth or non-smoothed fuel cost functions are subjected to the following equality and inequality constraints.

3.1.1 Power balance constraint

Power balance constraints are also known as equality constraint. The equality constraints bring the power system to a principle of equilibrium between total load demand and total power generation since cost function is not affected by the reactive power demand and hence the power balance constraint is applied to the real power balance in the system. Power balance requires the controlled generation of variables P_{Gi} which obeys the constraints equation.

$$\sum_{i=1}^{n} P_i = P_D \quad (3)$$

Where, P_i is the output power of the ith generator and P_D is the load demand.

3.1.2 Power generation capacity constraint

Power generation capacity constraint is also known as inequality constraint. The lower (P_i^{min}) and upper (P_i^{max}) power generation limit of the generating units are directly related to the machine design. Each generator is constrained between its minimum and maximum limits as shown in equation (4)

$$P_i^{min} \le P_i \le P_i^{max} \quad (4)$$

Where P_i^{min} and P_i^{max} are the minimum and maximum power outputs respectively of ith generator.

4. Ant Colony Optimization

The ant colony optimization is based on the colony of ants cooperates in finding right solutions to difficult discrete optimization problems. Cooperation is a key design component of ACO algorithms. The desire is to allocate the computational sources to a hard and fast of quite easy agents that communicate indirectly with the aid of stigmergy. Good answers are an emergent property of the agent's cooperative interaction.

The Ant Colony Optimization (ACO) metaheuristic is proposed by **Dorigo (1992)**. The ant colony optimization metaheuristic can be seen as a higher-level optimization strategy that adopts the basic mechanisms underlying the foraging behavior of ant colonies which are enhanced by artificial intelligence techniques.

In AS, m ants construct trial solutions in parallel by utilizing the random proportional rule. It should be noted that the ants are given memory to store the constructed partial solution. The constructed partial solution sequence is the probability that an ant k adds c_j as the next component in x given by:

$$P(i,j) = \frac{[\tau(i,j)].[\eta(i,j)]^\wedge\beta}{\sum_{g\varepsilon allowed}[\tau(i,g)].[\eta(i,g)]^\wedge\beta} \quad (5)$$

Where τ(i,j) is the pheromone trail of arc(i, j), η(i,j) is the heuristic information of arc(i, j), α and β are the parameters that control the relative importance of pheromone and heuristic respectively.

Pheromone updating

In AS, pheromone evaporation reduces all existing pheromone trails by a factor given by:

$$\tau(i,j) = (1-\rho)\tau(i,j) \quad (6)$$

Where, τ(i,j) is the pheromone trail of arc(i,j) and $0<\rho<1$ is the pheromone evaporation rate.

After pheromone evaporation, all ants deposit pheromone on the arcs they have followed by the value which is given by:

$$\tau(i,j) = \tau(i,j) + \sum_{k=1}^{m} \Delta\tau(i,j) \text{for all i,j} \quad (7)$$

Where $\Delta\tau(i,j)$ is the pheromone deposited by ant k on arc(i,j).

5. TEST DATA AND RESULTS

In this study, Satpura Thermal Power Plant (MPPGCL) is considered to investigate the effectiveness of the proposed approach,

The data taken into consideration for the analysis of Satpura Thermal Power Plant having six generating unit system in which all units cost coefficients has been shown in Table I. The installed capacity and date of commissioning of the plant is shown in Table II. The results obtained through ACO are compared with PSO methods are tabulated in Table III, has been tested for the load demand of 50 % of the maximum loading capacity of the plant respectively. The total installed capacity of the plant is 1330MW.

Table I:Cost coefficients of six generating unit data

Units	a_i	b_i	c_i
1	100	200	10
2	120	150	10
3	40	180	20
4	60	100	10
5	40	180	20
6	100	150	10

Table II: Installed capacity, date of commissioning and status of Satpura Thermal Power Station [Data taken from MPPGCL India]

Generating Unit No.	Installed Capacity	Date of commissioning	Status
1	200	July, 1979	Running
2	210	Sep. 1980	Running
3	210	Jan. 1983	Running
4	210	Feb. 1984	Running
5	250	March 2013	Running
6	250	Dec. 2013	Running

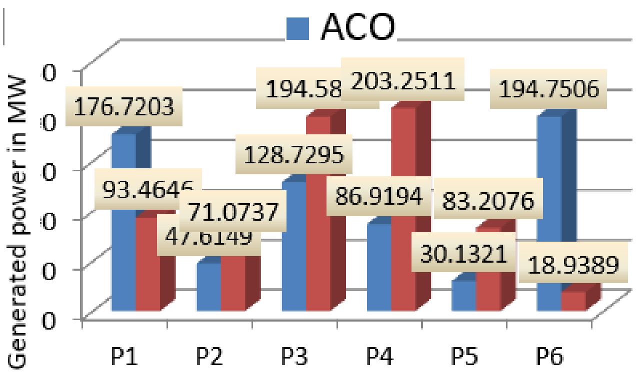

Figure 1: Comparison between ACO and PSO method at 50% of the maximum loading of generators

Case I :

In this case, economic load dispatch problem is solved for Satpura Thermal Power Station at 50% of the maximum loading of generators. Figure 1 shows the load demand at different generating units of the generators using the two methods for comparison ACO and PSO. Figure 2 shows the convergence characteristic of the ACO for six generator system at Satpura Thermal Power Station at 50% of the maximum load demand.

Table III :Results of 6 generating unit system for the 50 % of maximum demand

Unit Power Output	PSO	ACO
P1(MW)	93.4646	176.7203
P2(MW)	71.0737	47.6149
P3(MW)	194.5813	128.7295
P4(MW)	203.2511	86.9194
P5(MW)	203.2511	30.1321
P6(MW)	83.2076	194.7506
Total Power Output(MW)	665	665
Total Cost(Rs/h)	1553258	1248831

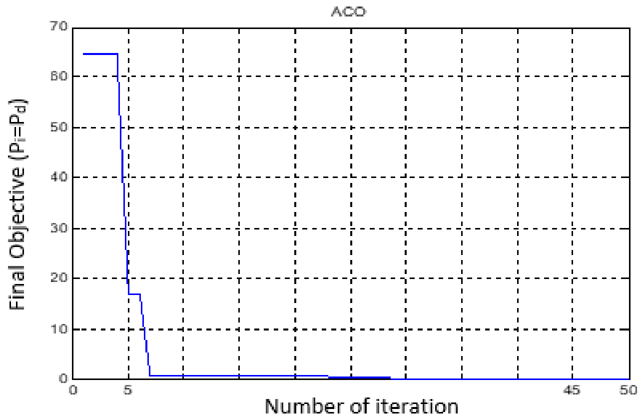

Figure 2 : Convergence characteristic of the ACO for six generator system for 50% of the maximum load demand

6. Conclusions

Electrical power sector is running in crisis in terms of unremitting gap between demand and supply. Looking at present strength of India and to achieve target in field of electrical power sector it is necessary to adopt change in form of efficient operation methodology for thermal power plant generation. Thermal power plant located at various parts of India contributes major share in installed power capacity of India. This research is the first effort in state to determine the optimal power generation schedule for thermal power plants. The various aspects of economic load dispatch like cost optimization, minimization of cost, and the cost optimization with equality and inequality constraints are studied.

In this work, evolutionary techniques such as ant colony optimization (ACO) and its results compared by PSO, are formulated and implemented to find the optimum solution of the economic load dispatch problem.

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