Combined Economic and Emission Load Dispatch using Price Penalty Factor using PSO

Azim Ambaliya
Department of Electrical Engineering
Marwadi Education Foundations Group of Institutions, Rajkot India

Abstract— This paper presents a new approach for Combined Economic and Emission Load (CEELD) problems incorporating wind power plant using Price Penalty Factor(PPF) method. As thermal Power Plant increase in power systems, its effects to conventional units should be analyzed. Also the total cost is dependent in specific period of time. Therefore the mathematical techniques are not appropriate to find the global optimum CEELD. In this paper, PPF is proposed to deal with thermal power plants in CEELD. To show efficiency of thermal power plant in reducing total cost is minimize.

Key words: Economic Dispatch, Emission Dispatch, combined economic and emission, price penalty factor Nonsmooth Cost Function

I. INTRODUCTION

Sustainable energy resources, especially wind power, are currently increasing on power systems. Advantages of this resource are as summarized as: 1.Reducing dependence on fossil resources. 2. Reducing greenhouse gas emissions and environmental protection. 3. Reducing the energy production cost . The economic load dispatch is an online process of allocating generation among the available generating units to minimize the total generation cost and satisfy the equality and inequality constraints. Since the civilization increases day by day the demand of electricity increases in the same ratio. For the satisfaction of the load demand large numbers of thermal power plants are installed and the capacity of coal burnt also increases. Due to burning large amounts of coal emitted many toxic gases like carbon dioxide (COx), sulphur dioxide (SOx), and nitrogen oxides (NOx) at thermal power plants and pollute the environment. Pollution is very harmful for the environment as well as living creatures.

Electric energy carries a great significance in the energy hierarchy because of its innumerable application for the domestic purposes, agricultural usage, industrial applications and even for transportation. Electricity is one of the form of energy which cannot be stored but can be transported form one place (probably the generating station) to the other place (area of its application) instantaneously. It can easily be controlled making it an attractive form of energy. The index for standard of living of people in a particular country depend on the per capita electric energy consumption. Electric energy demand is following a rapid increase in trend in India since 1947. This is because of the increased industrialization and its numerous usage for other purposes like home, agriculture, transport etc. Demand for electric energy is increased due to rise in population, increased requirement for housing and rural electrification.

The cost of generation of electric energy depends mostly on the purchasing cost, installation cost, cost of erection of equipment and auxiliary, fuel cost and miscellaneous cost like repairing cost, labor cost etc [5]. Fixed cost depends on investment cost of plant financial rates irrespective of quality of energy generated and operating cost/variable cost covers fuel expenses, labor charges, supervision etc. Both fixed and operating cost comes under generation cost.

A. Cost Function:

The fuel cost function of each thermal generator, with the valve- point effect is represented as the sum of sine and quadratic function. The fuel cost in terms of generation output can be expressed as:

$$F = \sum_{i=1}^{G}(a_iP_i^2+b_iP_i+c_i + |d_i\sin\{e_i(P_i^{min} - P_i)\}|) \quad (1)$$

Where

a_i, b_i, c_i, d_i, e_i are the cost coefficients.
F = Fuel cost function of thermal units.
P_i = Real generated power of i^{th} unit.
P_i^{min} = Least power of i^{th} unit.
G = Total number of generating unit.

B. Emission Function:

Emission (lb/h) of pollutants is sum of an exponential and quadratic function can be expressed as:

$$EM = \sum_{i=1}^{G}(\alpha_iP_i^2+\beta_iP_i+\gamma_i + \eta_i\exp(\delta_iP_i)) \quad \ldots(2)$$

Where

$\alpha_i, \beta_i, \gamma_i, \eta_i, \delta_i$ are the emission coefficients.
EM = Amount of emission released by thermal unit.

C. Combined Economic and Emission Load Dispatch (CEELD):

The combined economic and emission dispatch problem is addressed as a single optimization problem with respect to fuel cost and emissions function as follows:

Min (Ft) = Fuel Cost Function + h × Emission Function

$$Min(F_t) = \sum_{i=1}^{N}[(a_i + b_iP_i + c_iP_i^2) + h_i(\alpha_i + \beta_iP_i + \gamma_iP_i^2)] \quad \ldots\ldots(3)$$

II. FORMULATION OF CEELD PROBLEM

In this paper, the present formulation treated emission constrained economic load dispatch problem which attempt to optimize the operating expenses with emission constraints, while fulfilling and considering both equality and inequality constraints. The given constraints and objective are take into account for the formulation of CEELD problem.

A. Constraints:

Depending on the nature of power system under study, the ECELD is subjected to many constraints. In ECELD two types of constraints are:

1) Equality constraints
2) Inequality constraints

1) Equality constraints:

– Power generation balance constraint

The total power generation from thermal units must meet the load demand and the real power losses in the transmission lines.

$$\sum_{i=1}^{G} P_i = P_D + P_L \quad \text{.......................................(4)}$$

Where

P_D is the demand load

P_L is the losses in transmission, which are approximated in terms of B-coefficient also called as Kron's loss formula:

$$P_L = B_{00} + \sum_{i=1}^{G}\sum_{j=1}^{G} P_i B_{ij} P_j + \sum_{i=1}^{G} B_{i0} P_i \quad \text{...............(5)}$$

2) Inequality constraints:

– Power generation limit constraint

The power generation of each thermal unit is under its extreme and least limit.

$$P_i^{min} \le P_i \le P_i^{max} \quad \text{...(6)}$$

Where

P_i^{min} and P_i^{max} are the least and extreme limit of generator output.

B. Emission Constraints:

The emission from generating units should be within allowed limit. The emission constraint can also be taken as.

$$EM(P_i) \le \alpha E^{max} \quad \text{...(7)}$$

III. Price Penalty Factor (PPF)

To find best optimal solution for minimum fuel cost and emission, the multi-objective problem is converted into single objective by incorporating the price penalty factor k. The price penalty factor can be evaluated as follows:

1) Calculated the fuel cost for each generating unit corresponding to the maximum generating power limit

$$F_i(P_{imax}) = \sum_{i=1}^{NG}[(a_i P_{imax}{}^2 + b_i P_{imax} + c_i) \text{(\$/h)……(8)}$$

2) Calculated the emission level for each generating unit corresponding to the maximum generating power limit.

$$E_i(P_{imax}) = \sum_{i=1}^{NG} (\alpha_i P_{imax}{}^2 + \beta_i P_{imax} + \gamma_i)$$

(kg/h)......................................(9)

3) The price penalty factor for each unit as:

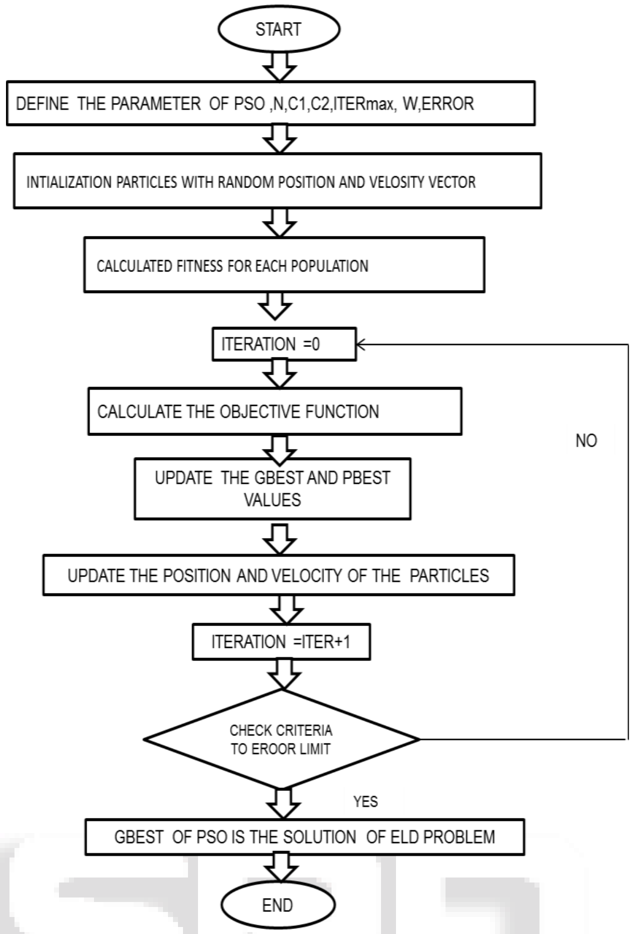
$$h_i = \frac{F_c(P_i^{max})}{E_T(P_i^{max})} \quad \text{...........................(10)}$$

4) Arrange h_i in increasing order for i=1,2……NG generating units.
5) Add maximum generating capacity i.e. P_imax of each unit once at time, starting from the smallest h_i untill it does not exceed the total load power demand i.e$\sum_{i=1}^{NG} P_{imax} > P_D$.
6) During this process the values of h_i corresponding to that unit is the price penalty factor h in $/Kg.

IV. Implementation of Particle Swarm Optimization

Kennedy and Eberhart first time introduce PSO in 1995. It is population based tool. Fish schooling and bird flocking type simulation tool used as motivative for PSO. Power optimizer tool which is random particles and

A. Flow Chart of PSO:



simple and it is called swarms, information collect from respective position. By using velocity particles change its place or position. PSO optimize solution and search for updating generation of optima. In every iteration, n it can used best particles values. First best solution (Fitness) achieve and then continuously. This is called p-best. Second best value, obtained by swarm optimizer and that is called population. This is best for global and it is called g-best. After this particle update its position and velocity according to following equation.

B. Overview Of PSO:

In PSO, speed of each particle in swarm and corresponding location in search area are denoted by V and P.

Thus, positional coordinates of each of the particle in swarm is expressed as

$$P_i = [P_{i,1}, P_{i,2}, P_{i,3}, \ldots. P_{i,j}] \qquad (4.1)$$

The local best value of each particle can be expressed as

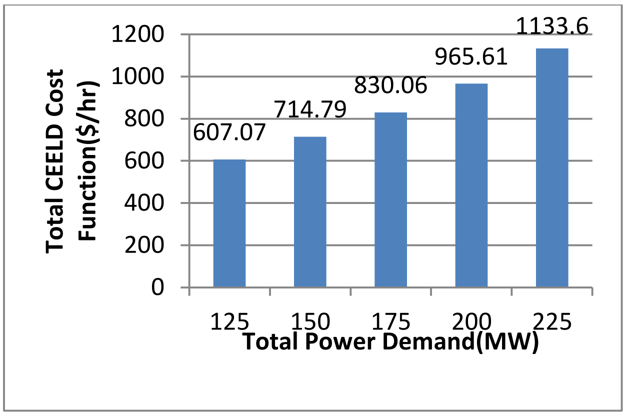
$$P_i^{best} = [P_{i,1}^{best}, P_{i,2}^{best}, P_{i,3}^{best}, \ldots. P_{i,j}^{best}] \qquad (4.2)$$

The global best value is basically the best solution among all the particles in the swarm which can be expressed as

$$G_i^{best} = [G_1^{best}, G_2^{best}, G_3^{best}, \ldots. G_i^{best}] \qquad (4.3)$$

The velocity with which the particle moves in the search space is expressed as

$$V_i = [V_{i,1}, V_{i,2}, V_{i,3}, \ldots. V_{i,j}] \qquad (4.4)$$



The particle updates its velocity and position to be 〖Pb〗_ij to G_j As shown in the following formulas:

$$V^{k+1}_{i,j} = W \times V^{k}_{i,j} + C_1 \times rand() \times (P^{best}_{i,j} - P^{k}_{i,j}) + C_2 \times rand() \times (G^{best}_{j} - P^{k}_{i,j}) \quad (4.5)$$

V. CONCLUSION

The problem of six generating units system two different method. In price penalty factor(PPF) method combined economic and emission load dispatch(CEELD) when the cost characteristic takes many number of iteration to converges. In PSO method the CEELD cost characteristic converges in less number of iterations.

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