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Multi Objective Economic /Emission Dispatch Of Thermal Power Plant Using Hybrid Algorithm

Ritunjoy Bhuyan Electrical Engineering, HRH The Prince of Wells Institute of Engineering & Technology

Jorhat, ASSAM (INDIAN)

Abstract

Keeping in view the global economic scenario , it is always ideal to go for optimum economic dispatch of load in Electrical Engineering Power System. But in most of the cases of such economic load dispatch system , the environment aspects are normally overlooked . In practice, the thermal power stations have considerable amount of emission of harmful gases causing serious environmental pollution. The pollution can be reduced by proper load allocation to the various generating units of the plants sacrificing economic load dispatch level to some extent. This kind practice demands some compromise between the economic load dispatch and economic emission. This paper describes an approach for an ideal compromise solution for economic /emission dispatch of thermal power plant.

Keywords: *economic emission, environmental pollution, load allocation, optimum economic dispatch, thermal power plant.*

1. Introduction

Electrical Power, being the most refined form of energy, is associated with the system like generation, transmission, distribution of loads. The main aim of the electrical power system is to give high quality reliable cheapest power within certain limits and constraints on the generators. This leads to formulation of the economic load dispatch (ELD) problem for exploring the optimal combination of output power of all generators for a minimum cost within certain equality and non equality constraints. On the other hand, the energy conversion processes, particularly thermal power plants , are creating ever increasing threat to the environment in respect of pollution , which necessitates some steps to limit the emission of pollutants in economic power dispatch. Thus a combined economic emission dispatch (CEED) becomes an important optimization problem with an aim to dispatch the electric power, taking into account both economic and environmental concerns.

Power system optimization associates with complex and non –linear characteristics with many equality and non equality constraints. Either classical or evolutionary optimization techniques may be employed to solve the problems. Linear programming , quadratic Programming, Newton's method, Interior point method are the examples of Traditional optimization methods while Genetic algorithm, Particle swarm optimization, differential evolution, Ant-colony optimization etc are some evolutionary optimization methods.

In conventional optimization method , the function, which must have convexity and continuous variable, must be at least twice differentiable However power system optimization problems do not have these characteristics. As the input – output characteristic of generators are not always smooth, combined economic emission dispatch (CEED) is a non convex optimization problem , which is not easily solvable by traditional optimization method. In such situation, Evolutionary optimization become the alternative to solve optimization problem of power system with non-convex ,non-differentiable and discontinuous function. But premature convergence and stagnation become an obstacle for direct use of evolutionary optimization method in power system.

Therefore, a new and improved optimization technique for power system optimization problem become necessary . To over come the lacuna of both traditional and evolutionary optimization techniques, motivation to search a new improvised optimization technique become predominant.

The concept of hybrid algorithm ,combining conventional and evolutionary optimization, is an outcome of such motivation.

2. Objective

Study and application of hybrid algorithm for multi objective economic/ emission dispatch can be the main purpose of hybrid algorithm development's effort.

By combining evolutionary and traditional optimization techniques, the formation of a hybrid algorithm is a kind of challenging task . . The proposed hybrid model can be used for solving optimization problem with function without convexity and smoothness. Multiple objectives can be handled by the multi-objective evolutionary algorithm. This multi-objective algorithm will be tested on different power system problems.

2.1.Power System Optimization

The Important power system planning and operation problem have been formulated as mathematical optimization problem. These problems are solved for minimum operating cost within asset of equality and in equality constraints.

Mathematically

Min f(x)

Subject to

G(x)=0 (2.1.1)

h(x) ≤ 0 (2.1.2)

where x is a set of decision variable vector, f(x) is the objective function, g(x) is the equality constraints, and h(x) is the inequality constraints

3.Main Problem

When environmental criteria is considered, the economic dispatch may not be optimum. Harmful ecological effects by the emission of gaseous pollutant from fossil fuel power plant can be reduced by proper load allocation among the various generating units of the plant . But this load allocation can result increased operating cost. A balanced result between emission and cost is to be found out. This can be achieved by combined economic emission problem. This dual objective problem is converted to a single objective function using a price penalty factor approach,

3.1. Objective Function

Optimization of generation cost has been formulated based on classical ELD with emission and line flow constraints . The detailed problem is given [16] as follows.

$$F = \text{Min}\sum_{i=1}^{d} f_i(FC, EC) \quad (3.1.1)$$

Where F is the optimal cost of generation.

FC and EC are total fuel cost and emission costs of generators, respectively.

" d" represents the number of generators connected in the network.

The minimum value of the above objective function has to the found out subject to constraints given by the equations (2.1.1) and (2.1.2)

$$\sum P_i = P_D + P_L \quad (3.1.2)$$

Where P_D = Total load of the system

P_L =Transmission loss of the system

$$P_i^{min} \leq P \leq P_i^{max} \quad (3.1.3)$$

Where P_i^{min} =minimum real power at ith generator

P_i^{max} = maximum real power at ith generator

i-I

The power flow equation of the power network [16]

$$g(|V|,\delta) = 0 \quad (3.1.4)$$

Where

$$g(|V|,\delta) = \begin{matrix} P_1 & (|V|,\delta) - & P_1^{net} \\ Q_1 & (|V|,\delta) - & Q_1^{net} \\ P_{cal,m} & (|V|,\delta) - & P_{spec,m}^{net} \end{matrix} \quad (3.1.5)$$

Where P_1 and Q_1 are calculated real and reactive power for PQ bus i,

Respectively;

P_1^{net} and $P_{spec,m}^{net}$ are calculated and specified real power for PQ bus I,

Respectively;

$P_{cal,m}$ and $P_{spec,m}^{net}$ are calculated and specified real power for PV bus m,

Respectively;

$|V|$ and δ are voltage magnitudes and phase angles of different buses.

The inequality constraints on voltage of each PQ bus

$$V_{mean}(i) \leq V_1 \leq V_{max}(i) \quad (3.1.6)$$

Where

$V_{mean}(i)$ and $V_{max}(i)$ are minimum and maximum voltage at bus I,

Respectively;

The maximum power limit on transmission line is given by

$$Lf_{nl}^{calMVA} \leq Lf_{nl}^{ratedMVA} \quad (3.1.7)$$

Where nl represents number of lines,

Lf_{nl}^{calMVA} is the calculated line flow of each transmission line,

$Lf_{nl}^{ratedMVA}$ is the rated line flow of each transmission line.

Total fuel cost of generation FC in terms of control variables generator powers can be expressed as follows

$$FC(P) = \sum_{i=1}^{d}(a_iP_i^2 + b_iP_i + c_i)\ \$/h \qquad (3.1.8)$$

Where P_i is the real power output of an i^th^ generator in MW ,

i represents the corresponding generator,

a_i , b_i , c_i are the fuel cost coefficients of generators.

The total emission release can be expressed [16] as

$$EC(P) = \sum_{i=1}^{d}(\alpha_iP_i^2 + \beta_iP_i + \gamma_i)\ kg/h \qquad (3.1.9)$$

(Where α_i , β_i , γ_i are emission coefficients of generators.)

The dual-objective combined economic emission dispatch problem is converted into single optimization problem by introducing a price penalty factor h as follows,

$$\text{Minimize}\,\Phi_i = FC + h \times EC \qquad \$/h \qquad (3.1.10)$$

Subjected to the power flow constraints of equation[(2.1.1),(2.1.2),(3.1.1),(3.1.2) and (3.1.3)]. The price penalty factor **h** blends the emission with fuel cost and Φ_i is the total operating cost in \$/h.

The price penalty factorh$_i$ is the ratio between the maximum fuel cost and maximum emission of corresponding generator,

$$h_i = \frac{FC(P_i^{max})}{EC(P_i^{max})} \qquad \$/kg \quad I = 1,2,\ldots\ldots\ldots,d \quad (3.1.11)$$

The following steps are used to find the price penalty factor for a particular load demand;

1. Find the ratio between maximum fuel cost and maximum emission of each generator
2. Arrange the values of price penalty factor in ascending order.
3. Add the maximum capacity of each unit (P_i^{max}) one at a time, starting from the smallest h_i until$\sum(P_i^{max}) \geq P_D$.
4. At this stage , h_i associated with the last unit in the process is the price penalty factor h for the given load.

The above procedure gives the approximate value of price penalty factor computation for the corresponding load demand. Hence a modified price penalty factor (h_m) is used to give the exact value for the particular load demand . the first two steps of h computation remain the same for the calculation of modified price penalty factor. Then it is calculated by interpolating the values of h , corresponding to their load demand values.

3.2. Evolutionary Algorithm(EA)

Evolutionary Algorithm can handle discontinuous non-smooth and mix integer problem vary efficiently. Most of the EA follow a certain natural phenomenon in the process of searching an optimal solution. Genetic algorithm, Evolutionary programming, Particle swam optimization, ant colony optimization, Bee colony optimization, differential evolution, harmony search etc are some example of evolutionary algorithm.

3.3. Differential Evolution(DE)

DE was forwarded by Price and Storm, which is a population based algorithm and is very simple & efficient. It starts with initial set of population and evolves using mutation, cross over and selection. Mutation is done by arithmetical operation on randomly selected vector.

3.4. Harmony search algorithm(HS)

It was put forwarded by Geem . It is a nature inspired algorithm which follow music players. The harmony in music is analogous to the optimization solution vector , and the musician's improvisations are analogues to the local and global search scheme in optimization techniques. The HS algorithm uses a stochastic random search, instead gradient search.

3.5. Sequential Quadratic Proigramming(SQP)

The SQP method is the best non linear programming method in terms of efficiency, accuracy, and percentage of success for constrained optimization problems. It is very much similar to Newton's method for constrained optimization. At each iteration an approximation is made of vthe Hessian of the Langrangian function using Broyden-Fletcher-Goldfarb-Shanmo quasi Newton updating method. The result is then used to generate a quadratic programming (SQP) problem[13] whose solution is used to form a search direction for a line search procedure.

3.6. Hybrid Method

A traditional optimization method can be combined with EA to form a hybrid algorithm for solving CEED.[14] The algorithm will be combined in two ways. EA will used as global optimizer and traditional method as a local optimizer to make the optimum solution from EA as accurate as possible

4.Conclusions

A hybrid method combining a traditional optimization method with a evolutionary method for Economic Emission Dispatch is quite relevant as the classical method is applicable to find global optimum for function with convexcity and smoothness but for non-convex and non smooth function , the method will not work efficiently. However evolutionary method is independent of the function space but stagnation and pre mature convergence is the main drawback of evolutionary algorithm.[10] In such situation the hybrid method can be the only answer .

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