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An Improved Fire Fly Algorithm to Solve Economic Load Dispatch Problem including Practical Constraints

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ABSTRACT

The main objective of Economic Load Dispatch Problem of power generation is to schedule the committed generating units optimally so as to meet the required load demand while satisfying all the units with equal and inequality constraints. In this Paper an improved firefly algorithm has been implemented for the solution of economic load dispatch problem with non-smooth fuel cost curves considering the transmission loss coefficients and emission cost coefficientsbased on new version of firefly algorithm.Itis one of the evolutionary algorithm which is inspired by the idealized behavior of flashing characteristics of firefly to identify the nearest one. This approach considers the direct fireflies movement to global best if there is only one best solution in and around them. The effectiveness of the proposed method has been implemented to IEEE standard test system that demonstrates the capability of this approach in generating non dominated solutions of multi objective Economic Load Dispatch Problem.

Indexing terms/Keywords

Keywords: Economic Load Dispatch Problem, firefly algorithm,optimizationtechniques, price penalty factor, Emission constrains

Introduction

Restructuring of power industry has created a competition among the power industries. The Economic Load Dispatch problem is to identify the optimum combination of electric power output of all generating units to minimize the total fuel cost with maximum reliability while satisfying the load demand and operational constraints. In fact the Clean Air Amendment Act[4]in 1990 have been applied for reducing the pollutant such as NO_x, SO_x and CO_x releasing from the thermal plants due to burning of fossil fuels. Over the past years many optimization techniques have been implemented to solve the Economic Load Dispatch Problem such as genetic algorithm(GA), Evolutionary programming(EP),dynamic programming (DP), hybridEPcombinedwith sequential quadratic programming (SQP),and the particle swarm optimization (PSO) methodsto find an almost global optimal solution for ELDP with constraints[1-9]. These algorithms are based on the population strength that gives the several candidate solution in the solution space randomly instead of a single optimum solution. The evolutionary algorithms are capable of identifying the solution in the feasible area rather than identifying in the entire region of space.

In Conventional methods such as Lagragian Multiplier method, Lamda Iteration method, Gradient method, Newton's method, Interior point method in which the solution to economic load dispatch problem is obtained by representing the cost function of individual generators in terms of single quadratic function. But these techniques have initial assumptions that are capable of solving the linear incremental cost curve which is monotonically increasing. Although the dynamic programming is capable of solving nonlinear and discontinuous cost function but it suffers computational time and course of dimensionality. So the researchers start working with heuristic methods for overcoming those drawbacks with conventional methods still suffering to find an optimal solution with reasonable computation time.

Each method has its own advantages and disadvantages however the improved firefly algorithm has shown its excellence in obtaining the global optimal solution by considering practical constraints.

PROBLEM FORMULATION

Usually the economic dispatch problem is minimization of fuel cost considering both equality and in equality constraints. Here in this approach fuel cost and the emission combined together which are conflict in nature and the problem is considered as combined economic emission dispatch. The problem becomes more complex and it generates a set of solution which makes little tough to identify the best solution. So multi objective problem has been transferred as single objective problem using price penalty factor. The problem of objective function has been defined as

Minimize $H = \sum_{1=1}^{n} F_i(P_i) + \varphi \sum_{i=1}^{n} E_i(P_i)$

Where $F_i(P_i) = x_i + y_i(P_i) + z_i(P_i)^2$ - Fuel Cost Function in Rs/hr

x_i, y_i, z_i - cost coefficients.

$E_i(P_i) = \alpha_i + \beta_i(P_i) + \gamma_i(P_i)^2$ -Emission Function in Kg/hr

$\alpha_i, \beta_i, \gamma_i$ - Emission Coefficients

$\varphi = F_i(P_{i\max}) / E_i(P_{i\max})$ - penalty factor in Rs/kg

Constraints

(i) In equality Constraints :

Limits of Generator $P_i^{\min} \le P_i \le P_i^{\max}$

(ii) Equality Constraints:

Inorder to create balance between the available power and the demand the total power generated must be equal to system demand addition with losses $P_D + P_L - \sum_{i=1}^{n} P_i = 0$

Proposed Method

The Improved firefly algorithm is a nature inspired population based algorithm introduced in 2010 by X.S.Yangwhich is based on the social behavior of fireflies[8-10]. Here for solving the optimization problem the fireflies social behavior such as the light emission, absorption of light and the attraction are considered as the important parameters. This is derived from the matting phase of firefly that utilizes the bioluminest communication. On comparing with the evolutionary algorithms it has major advantages like simpler concept, using of real values, easier to implement and less executing time[9,10]. The rules that are incorporated in this algorithm are

(i) Attraction of one fly with other since all flies are unisex.
(ii) Brightness i.e., the attraction is proportional to their brightness of flash that decreases with distance which absorbs while moving in any direction.
(iii) The objective function for optimization considers the flashing light brightness.

ATTRACTION

In this algorithm, the individual fireflies intensity of light is directly proportional to the quality of the solution where the fly is currently available. It has to update its intensity by moving towards the other fly that has brightness greater than its own.Variation of light intensity and the calculation of attractiveness are the two important things in this algorithm. We assume that the attraction depends on its brightness

$$\alpha = \alpha_0 \exp^{-\nu} l^k \text{ with } k \ge 1$$

Where α_0 - attraction at $l = 0$

l - distance between two flies

ν - Coefficient of light absorption

DISTANCE

The distance between two flies at two different positions are calculated using Cartesian distance.

$$l_{ij} = \| y_i - y_j \| = \sqrt{\sum_{k=1}^{d} (y_{i,k} - y_{j.k})^2}$$

$y_{i,k}$ - k^{th} component of the coordinate y_i of i^{th} fly

d - dimension

MOVEMENT

The movement of firefly i towards brighter firefly j is identified using

$$Y_i = y_i + \alpha_0 * \exp(-\nu l_{ij}^2) * (y_i - y_j) + \beta * (rand - 1/2)$$

Where y_i - current fly position

$\alpha_0 * \exp(-\nu l_{ij}^2) * (y_i - y_j)$ -relating the attraction

$\beta * (rand - 1/2)$ - parameter of randomization generates between [0,1]

ALGORITHM

Step 1: Read the data such as coefficients of cost, limit of powers, demand, loss coefficients, emission coefficients.

Step 2: Initialize the count of generation, constants of algorithm

Step 3: Set the iteration count to one

Step 4: Fitness value is calculated for all population and evaluate the solution quality

Step 5: Arrange the fitness values and identify the best fitness among the population

Step 6: Determine the value of beta β

Step 7: Iteration count has been increased and the optimum solution has been obtained when the iteration count reaches maximum.

RESULTS AND DISCUSSION

The algorithm has been implemented for standard test system using MATLAB 6.5 in 1.8GHz processor.The proposed method has been implemented to standard IEEE 30 bus system with six generators which has been connected through 41 transmission lines. The result shows that this method is more efficient than other methods. The performance of this method depends mainly on the input parameters so that it has to be chosen carefully. After several runs the parameters of the proposed method are population strength is 100, $\alpha_{0=1,}\alpha_{min}$=0.2 and light intensity is 1.The cost of fuel, generators power limit, emission quantity, loss coefficients and the load demand are fed as input to this improved firefly algorithm.

Table 1: Capacity of Generators

Unit	P_{min}	P_{max}	x_i	y_i	z_i
1	100	500	240	7.0	0.0070
2	50	200	200	10.0	0.0095
3	80	300	220	8.5	0.0090
4	50	150	200	11.0	0.0090
5	50	200	220	10.5	0.0080
6	50	120	190	12.0	0.0075

Table 2: Simulation results of various algorithm

S.No	Particulars	GA	SA	BBO	IFFA
1.	P_1(MW)	0.1011	0.1202	0.1200	0.1011
2.	P_2(MW)	0.2883	0.2867	0.2858	0.288
3.	P_3(MW)	0.5852	0.5822	0.5834	0.5792
4.	P_4(MW)	0.9832	0.9937	0.9927	0.9912
5.	P_5(MW)	0.5271	0.5249	0.5268	0.5226

6.	P_6(MW)	0.3749	0.3520	0.3508	0.3504
7.	Fuel Cost (Rs/hr)	606.111	606.003	605.6795	605.45
8.	Emission(ton/hr)	22.05	20.49	20.488	20.30
9.	Power Loss (MW)	25.87	25.6	25.5	25.33

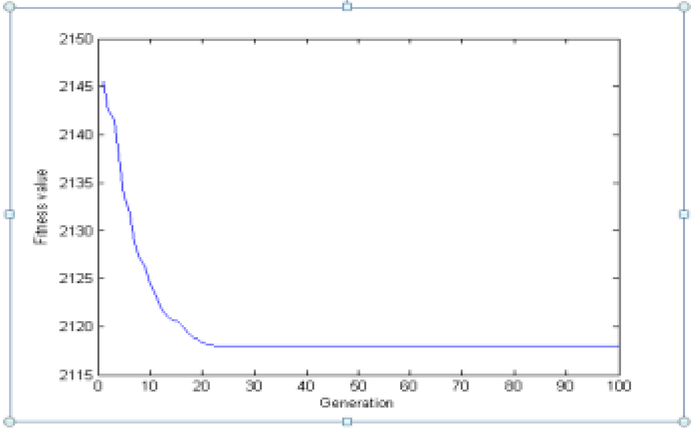

Figure 1. Convergence Characteristics

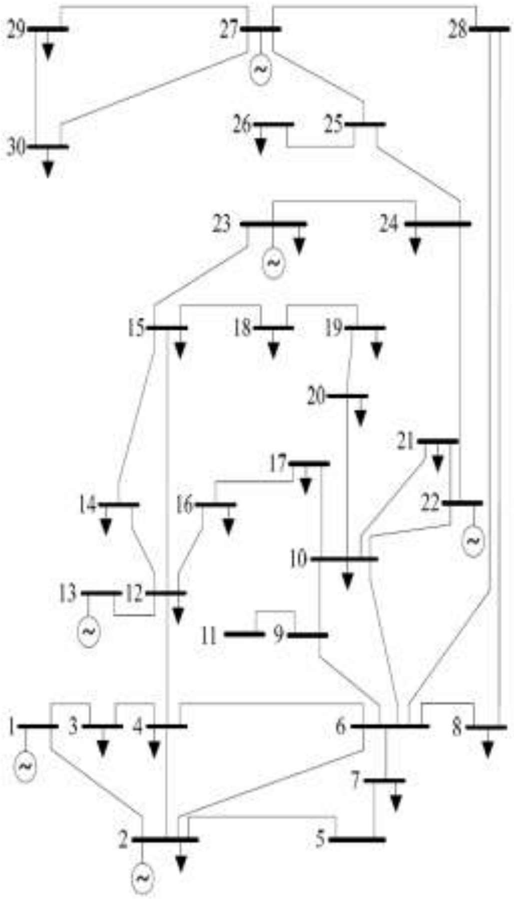

Figure 2. Standard IEEE Bus System

CONCLUSION

In this proposed work an attempt has been made to solve the problem of economic dispatch in power system by incorporating the emission cost coefficients along with fuel cost coefficients. In order the prove the effectiveness of the proposed algorithm has been implemented the standard test system which shows the high order quality solution with excellent computational efficiency and also it reduces the problem of global warming by the way of reducing the emission of sulphur oxides and carbon dioxide to space while burning the fossil fuels.Simulation results proves that this will be a promising technique in solving multi objective problem which is superior to earlier techniques.

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