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FUEL COST MINIMIZATION FOR A THERMAL POWER PLANT USING PSO ALGORITHM

P.Induja[1] M.S.Kamalesh[2] and N.Senthilnathan[3]

Dept of Electrical and Electronics Engineering, Kongu Engineering College, Erode
E-mails: [1]indujaperumalsamy@gmail.com; [2]kamaleshms@kongu.ac.in; [3]nsenthil_nathan@kongu.ac.in

ABSTRACT

This paper experiments the Particle Swarm Optimization (PSO) algorithm for solving the fuel cost of a thermal power plant. The PSO technique is easy to implement and it does not require more computation time. The objective is to minimize the fuel cost and it is obtained from the total power generated with respect to the proper load dispatch. So that the overall cost of the thermal power system operation can be reduced. Thermal power plant need to operate at the minimum cost for better profit, at the same time it should suit the load demand. The minimization includes various factors like total cost of the system, incremental cost of delivered power, etc. Power losses are evaluated for the simple test system. A MATLAB program was developed to solve the Economic load dispatch for a thermal plant with six-units by using PSO algorithm.

Index Terms: PSO, Fuel cost minimization, Thermal power plant operation and control, etc.,

I. NOMENCLATURE

N	Number of buses in the power plant.
CG	Number of thermal generators.
ND	Number of load/demands.
P_{ga}	Scheduled power for a^{th} thermal generator in MWs.
a_i,b_i,c_i	Cost co-efficient of thermal generator a.
ICC	Incremental cost curve.
P_{gc}	Incremental cost curve in reverse form.
P_{min}	minimum power output of nth generator (MW)
P_{max}	maximum power output of nth generator (MW)
B	B coefficients
PSO	Particle Swarm Optimization

II. INTRODUCTION

The objective of today's electric power system is to meet the power demand at the minimum cost. The problem is to find the total generation output of corresponding six units so that the total cost gets minimized. PSO Technique is used to solve the Economic Dispatch Problem but here they didn’t include the ramp rate and also the prohibited zone [1]. The Fuel Cost Minimization method to obtain the optimal power flow (OPF) problem was tested using IEEE 14 bus system. It was done with IP algorithm (Interior Point Method) which requires more computation time when compared to other methods [2]. Optimization of Load Dispatch problems using Evolution Technique is to minimize the fuel cost where the computation time and CPU time was slightly more when compared to other literature [3].Total Cost Minimization in Electric Power System within the security limits was proposed using PSO algorithm to demonstrate the IEEE 37-bus system and their performance was compared with genetic algorithm. These two algorithms were compared with lambda iteration method and it cannot give the best solution for economic dispatch problems [4]. Similar technique is used for the economic dispatch of power system to meet the load demand was given in [5]. Here artificial ant colony method was used but when compared to PSO the result obtained was not satisfactory. Cost analysis of a coal-fired power plant which includes the total direct and indirect cost was given by [6]. As above discussed in this session the fuel cost need to be determined with high accuracy with an efficient dynamic response of the load demand which is always a chaos to the power system operation and load dispatch center. This paper overcomes the hurdles faced by the literature and provides a possible and efficient solution of optimized fuel cost of thermal power plant with PSO technique.

III. OBJECTIVE FUNCTION

The main objective function to reduce the fuel cost of thermal generation can be mathematically expressed as

$$\mathbf{C_i (P_{ga}) = a_i + b_i P_{ga} + c_i P_{ga}^2}$$

Where,

$C_i(P_{ga})$ – Fuel cost of thermal Power Plant

a_i,b_i,c_i-Cost co-efficient of thermal power plant

P_{ga} – Scheduled power

A. Generation Limits

The output of the each generator should be laid between the minimum and maximum limits. The corresponding generator limits are expressed as

$$P_{min} \le P \le P_{max}$$

Where,

Pmin Minimum generation limit

Pmax Maximum generation limit

B. Six unit system

Test systems of thermal power plant with six generation units having different generation limits with different characteristics were considered. Their cost function characteristics are chosen from literature references [7,8,9] and they are shown below.

F_1=0.0324c_1+3.2b_1+471.6Rs/Hr
F_2=0.028c_2+8.1b_2+60Rs/Hr
F_3=0.00284c_3+8.1b_3+471.6Rs/Hr
F_4=0.039c_4+12b_4+100Rs/Hr
F_5=0.00284c_5+2b_5+471.6Rs/Hr
F_6=0.039c_6+2b_6+190Rs/Hr

Where, F_1 to F_6 represent the fuel cost of each unit.

The operating limit of minimum and maximum power is also different. The unit operating ranges are given below:

10MW=P1=120MW
10MW=P2=150MW
40MW=P3=175MW
47MW=P4=210MW
130MW=P5=325MW
125MW=P6=315MW

The B loss coefficient matrix is chosen from [5]

0.17 1.4 0.15 0.19 0.26 0.22
0.6 0.17 0.13 0.16 0.15 0.20
0.13 0.15 0.5 0.17 0.24 0.19
0.16 0.19 0.17 0.71 0.30 0.25
0.15 0.26 0.24 0.30 0.64 0.32
0.20.22 0.19 0.25 0.32 0.5

C. Network Losses

The network losses are accomplished with unit generation. Two methods are mostly used to calculate the network loss. First one is the penalty factors method and the second is the B coefficients method. Based on B coefficients method, network losses are represented as the below equation [1].

Power Loss = P_{max}*B*P

Where,

Pmax Maximum power of a thermal power plant
B B loss co-efficient
P Power

D. Cost Curve

The foremost component of the operating cost is the fuel input per hour considering the maintenance period contributes only to a small duration.

The different operating cost curves are follows:

i. Input- Output Curve (IOC)
ii. Incremental cost curve (ICC)

i. Input-Output Curve

If P stands for the output power in megawatts (MW) and $C_i(P_{ga})$ is the fuel cost, the input-output characteristic curve is illustrated in Fig 1.

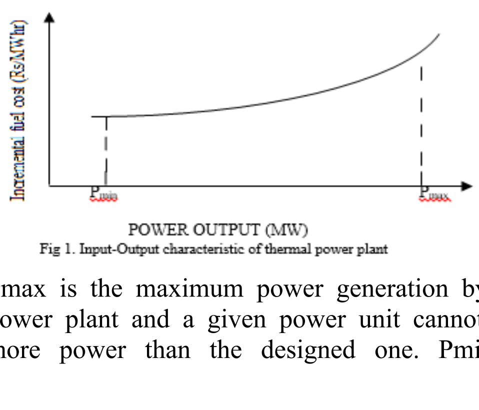

Fig 1. Input-Output characteristic of thermal power plant

Pmax is the maximum power generation by thermal power plant and a given power unit cannot produce more power than the designed one. Pmin is the minimum power produced by the establishment limit of a machine. If the power output of any generating unit for operation of the system is less than the specified value (i.e.) Pmin, then that unit is not given to the bus bar because it cannot operate at the low value of power from that unit.

ii. Incremental Cost Curve

The operating cost of a thermal generator is given by

$$C_i(P_{ga}) = a_i+b_i P_{ga}+c_i P_{ga}^2$$

Then the slope of the cost curve is called as Incremental Cost curve (ICC) and it is represented by

$$ICC=\frac{d_{Ci}}{dP_{ga}} = 2*c_i P_{ga} + b_i$$

The ICC is expressed in terms of Rs/MWhr. Fig.2.2 shows the ICC for better accuracy. It can be expressed as segment by segment. The inverse form of ICC is given by

$$P_{ga} = \alpha_i + \beta_i (ICC)_i + \gamma_i (ICC)^2{}_i$$

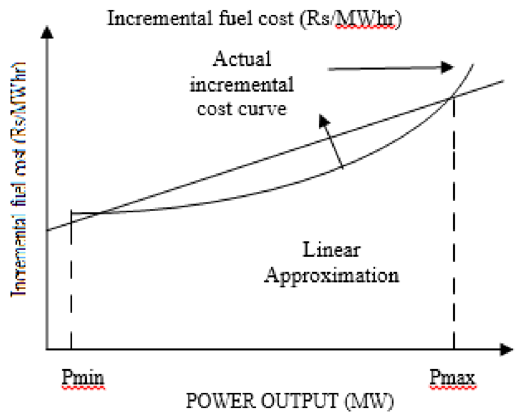

Fig 2. Incremental fuel cost vs power output

IV. METHODOLOGY

The PSO (Particle Swarm Optimization) technique is used for optimization. It is a robust optimization technique based on the movement and intelligence of swarms. Each particle keeps track of its coordinates in the solution space which are associated with the best solution called fitness. This value is called personal best, pbest. The entire best value acquired so far by any particle in the city is called gbest.

A. PSO Algorithm

PSO algorithm is used to search the near optimal generation quantity. The searching procedure of the proposed method is shown below.

Step 1: Indicate the upper and lower bounds of generation power of each unit (i.e.) P_{max} and P_{min}. Randomly initialize position and velocity according to the limits of each.

Step 2: To each individual P of the population, calculate the transmission loss with the help of B-coefficient.

Step 3: Calculate the estimated value of each generation in the solution space.

Step 4: Compare each individual value with its corresponding Pbest value and the best estimated value among the P_{best} is represented as G_{best}.

Step 5: Adjust the velocity V of each individual generation conciliatory to

v(i)=K*(W*v(i)+c1*rand()*(P_{best}_p(i)-p(i))+ c2*rand()* (Gbest_p-p(i)))] where i=1 to N and N be the population size.

Step 6: If V(t+1) > V_{max}, then V(t+1) = V_{max}.
If V(t+1) < V_{min}, then V(t+1) = V_{min}.

Step 7: Adjust the position of each individual generation with respect to P(t+1) = P(t) + v(t+1)

Step 8: If the estimated value of each individual is improved than the first best value then the approved value is set as the best value in the optimization problem. If P_{best} is more acceptable than G_{best}, then it is set as the best value.

Step 9: If the number of iterations gets satisfied, then go to step 10. Or else, go to step 2.

Step 10: The latest best value generated by each individual is the optimal generation power of each unit with the minimum total generation cost.

B. Flow chart

Fig 3. Shows the flowchart for PSO (Particle Swarm Optimization) Algorithm.

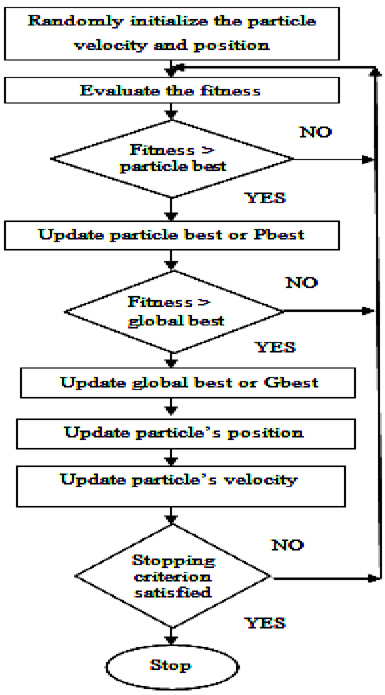

Fig 3.Flow chart for PSO Algorithm

C.Evolution of pso

Consider a system having N number of particles moving randomly in the solution space D. Let the position of the particles be P and the velocity be V. When the particles get move from one place to another in the solution space then its velocity is updated and then position of the particle is updated. The velocity is updated with the help of velocity rule,

v(i)=K*(W*v(i)+c1*rand()*(P_{best}_p(i)p(i))+c2*rand()* (G_{best}_p-p(i)))

Where,

C1	Weight of the local information
V	velocity
P	particle
p_{best}_p	particles Pbest
G_{best}_p	particles Gbest
W	weight
C_2	Weight of the global information
K	iteration number

The equation for W is given by

$W=W_{max}-((W_{max}-W_{min})*iter/itermax)$

Where,

W_{max}	Maximum weight
W_{min}	Minimum weight

The value of W can be varied from 0.4 to 0.9.

V. RESULTS AND DISCUSSION

The proposed coding for the fuel cost minimization of a thermal power plant is done with the help of Particle Swarm Optimization (PSO) Algorithm. It is tested with six unit systems and the output is obtained encircling the MATLAB. The economic dispatch is to understand the generation of nonstandard units of a power plant, to reduce the total cost and at the same time, the demand and losses at any moment must be met by the total generation. For optimization, many factors like optimal dispatch, total cost, incremental Cost, total losses of the system, loss coefficients are considered. The results for this method are tabulated in table 1. From the results it can be found that the PSO method always aid converged solution which does not obligate initial value of lambda.

Table 1.Result for PSO method

No. Units	a_i	b_i	c_i	Fuel cost (RS/hr)
1	471.6	3.2	0.0324	2710
2	60	8.1	0.028	685
3	471.6	8.1	0.00284	776.25
4	100	12	0.039	3191.09
5	471.6	2	0.00284	4067.25
6	190	2	0.039	2959.9

VI. CONCLUSION

In this work, fuel cost for a thermal power plant is developed using six thermal units. Fuel cost minimization is carried out using the Particle Swarm Optimization (PSO) technique. The main advantage of PSO technique when compared to other optimization techniques is that it doesn't need any crossover and mutation values for updating. Here the values are updated with the help of initial velocity and this technique is easy to implement. The evaluation is based on the movement of particles in the solution space to find the best value.

1V REFERENCES

1. Rao, L.V.N., PSO Technique for Solving the Economic Dispatch Problem Considering the Generator Constraints. International Journal of Advanced

Research in Electrical, Electronics and Instrumentation Engineering **3**(7): 10439- 10454 (2014).

[2]. Abdullah, U., A.S. Siddiqui and A. Naqui, Generation Fuel Cost Minimization of Power Grid Using Primal Dual Interior Point OPF (Optimal Power Flow) Method. International Journal of Innovative Research in Science, Engineering and Technology **3**(4): 11014-11024 (2014).

[3]. Deepti Gupta and Rupali Parmar, Optimization of Economic Load Dispatch Thermal Power Plant Using Differential Evolution Technique. International Journal of Engineering Trends and Technology (IJETT) **22**(4): 153-159 (2015).

[4]. Mohammed H. al-khafaji and Shatha S.Abdulla al-kabragyi, Particle Swarm Optimization for Total Operating Cost Minimization in Electrical Power System. Eng. & Tech. Journal **29**(12): 2539- 2550 (2011).

[5]. Bommirani, B. and K. Thenmalar, Optimization technique for the economic dispatch in power system operation. International Journal of Computer and Information Technology **2**(1): 158-163 (2013).

[6]. Ravinder Kumar, Avdhesh Kr. Sharma and P. C. Tewari, Cost analysis of a coal-fired power plant using the NPV method. J. Ind. Eng. Int. **11**: 495–504 (2015).

[7]. Amit Kumar, Power Economic Dispatch with Valve-Point Loading Effects and Multiple Fuels Using Chaotic Based Differential Evolution. MS Thesis submitted to Department of Electrical and Instrumentation Engineering, Thapar University, Patiala (2011).

[8]. Pazheria, F.R. and M. F. Othman, Environmental and Economic Power Dispatch for Hybrid Power System with Distributed Energy Storage. IEEE Symposium on Industrial Electronics & Applications (ISIEA2013), September 22-25, Kuching, Malaysia (2013).

[9]. Selvaraj Durai, Srikrishna Subramanian, Sivarajan Ganesan, Preferred Economic Dispatch of Thermal Power Units. Journal of Power and Energy Engineering **3**: 47-69 (2015).