ECONOMIC LOAD DISPATCH USING GRADIENT METHOD

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Received: July 06, 2018 Accepted: August 20, 2018

ABSTRACT *The total electrical power system is an interconnected system to meet the load demand which is dynamic in nature and the line losses as the generating units are far away from the load centres. The interconnected system results in more effective and reliable, apart from that the power generated by the units should be cost effective to the consumers in view of fuel prices etc.the cost of generating power majorly includes the cost of fuel.So, in this paper Gradient method is used to solve the economic load dispatch (ELD) problem. The results obtained by using gradient method are compared with primitive methods like* **λ**-*iterative method and graphical method. This problem is solved in MATLAB environment.*

Keywords: *Economic load dispatch (ELD), Gradient method,* **λ**-*iterative method, MATLAB.*

1. INTRODUCTION

The major aim of economic load dispatch (ELD) of realistic power system is to minimize the fuel cost or operating cost of generating units without violating the system constraints. The electrical load demand is dynamic in nature. The generating units are to be scheduled to meet the varying load more economically by using ELD problem. In developing countries like India where the major portion of load demand is met by the power generating in thermal power plants which make use of coal as fuel. We can not simply switch on and switch off the thermal units easily. The minimum time required by the thermal units to bring into generating position is 8hrs. We have to allocate the load to the generating units to meet the load demand more economically. In addition to the fuel cost, the cost of generating power also includes the labour charges, salaries, transportation cost etc. The input and output characteristics of thermal power plants are normally expressed with a convex curve mostly a quadratic equation.Each generating unit has a maximum and minimum limits which means that the generating unit can't generate the power less than the minimum limit and greater than the maximum limit. The minimum power output of the unit is influenced by the technical factors of boiler and turbine.

A volume of articles are published by the researchers and a large more number of solution methodologies are proposed. J.Nanda proposed the Genetic algorithm application(GA) to the ELD including the transmission line flow constraints [2]. K.Brirring proposed the modified GA to ELD [3].T.D.King proposed and applied the modified Hopfield network algorithm to economic load dispatch problem [4,5]. A large amount of Neural network based algorithms and fuzzy logic and modified fuzzy logic applications are applied and tested to this problem [6]. K.P.Wong and C.C.Fung proposed the Simulated annealing based economic load dispatch in [7]. Swarm intelligence methods are also applied to solve the problem.In this paper we are using a Gradient method to solve the problem [1].

2. PROBLEM FORMULATION

The main objective of economic load dispatch is to minimize the cost of power generation without violating the system constraints. The objective function to be minimized as follows:

$$\min(C_t) = \sum_{i=1}^{n} C_i(P_{G_i})$$

Where

$C_t = total\ fuel$ cost

$n = total\ number\ of\ generators$

$P_{G_i} = real\ power output\ of ith\ generator$

The fuel cost of ith generator is represented by the following quadratic equation

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

Where a_i, b_i, c_i are cost function coefficients of each generator

Inequality Constraint: $P_{GiMin} \leq P_{Gi} \leq P_{GiMax}$

Equality Constraint: $\sum_{i=1}^{n}(P_{G_i})= P_D$ (While neglecting line losses)

$\sum_{i=1}^{n}(P_{G_i})= P_D+P_L$ (While considering line losses)

Where,

P_D = Total power demand

P_L = Total line losses

3. SOLUTION METHODOLOGY

3.1. λ-iterative method

The following shows the algorithm of λ-iterative method

Step-1: Initialize the value of λ^0 by using cost equations

Step-2: calculate the power generation of each unit for initial λ value by using $P^0{}_{G_i} = \alpha_i + \beta_i(\lambda^0)_i + \gamma_i(\lambda^0)_i^{\ 2}$ + …………

Step-3: Calculate $\sum_{i=1}^{n} P^0{}_{G_i}$

Step-4: check $\sum_{i=1}^{n} P^0{}_{G_i} = P_D$ or $(\sum_{i=1}^{n} P^0{}_{G_i} - P_D \leqslant \acute{\varepsilon}\ (tolerance\ value))$

Step-5: if $\sum_{i=1}^{n} P^0{}_{G_i} < P_D$ then we have to increase the λ value by $\lambda^{'} = \lambda^0 + \Delta\lambda$ and repeat the procedure from step-2 till the tolerance value is satisfied.

Step-6: if $\sum_{i=1}^{n} P^0{}_{G_i} > P_D$ then we have to decrease the λ value by $\lambda^{'} = \lambda^0 - \Delta\lambda$ and repeat the procedure from step-2 till the tolerance value is satisfied.

Step-7: Stop

3.2 Graphical method

The below figure shows the cost incurred while power generation by individual units. From that we have to evaluate the graph of load versus incremental fuel cost. After that initialize the **λ**value and then calculate the amount of power generated by each individual unit at that respective **λ**value and then evaluate the total power and compare it with the load demand. If the load demand is greater than the total power generation then decrease the **λ**value and repeat the same procedure else vice versa until the power generation must balance with the load demand.

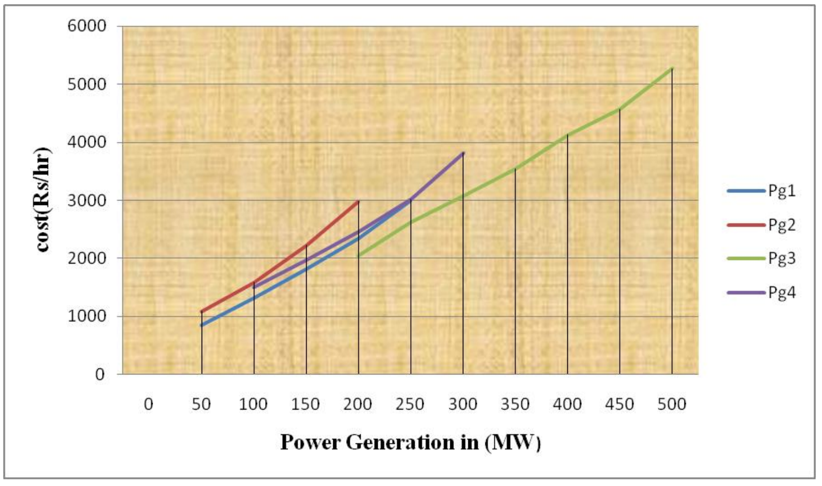

Figure 1 Load versus cost (Rs/hr) of Individual generating unit

3.3 Gradient method:

The main aim of this method is to minimize the cost function of the generating unit in series of steps. The sequence of steps of gradient method to economic load dispatch problem is as follows:

Step-1: Select the initial generating values $P^0{}_{G_1}, P^0{}_{G_2}, P^0{}_{G_3}, ------ P^0{}_{Gn}$

Step-2: For each unit compute initial $\lambda_i^{\ 0}$ value

$$\lambda_i^{\ 0} = \frac{dc_i(P_{G_i})}{\partial P_{G_i}}, i = 1,2,3, ---- n$$

Step-3: Calculate the initial mean incremental fuel cost λ^0

$$\lambda^0 = \frac{1}{n}\sum_{i=1}^{n} {\lambda_i}^0$$

Step-4: Calculate the gradient

$$[\Delta L^1] = \begin{bmatrix} \frac{dC_1(P^0{}_{G_1})}{dP_{G_1}} - \lambda^0 \\ \frac{dC_2(P^0{}_{G_2})}{dP_{G_2}} - \lambda^0 \\ \frac{dC_3(P^0{}_{G_3})}{dP_{G_3}} - \lambda^0 \\ \vdots \\ \frac{dC_n(P^0{}_{G_n})}{dP_{G_n}} - \lambda^0 \\ P_D - \sum_{i=1}^{n} {P_{G_i}}^0 \end{bmatrix}$$

Step-5: if $\Delta L = 0$, solution converges. Stop the iteration, otherwise go to next step.
Step-6: Select έ for getting the convergence.
Step-7: Calculate the new valuesof $P^1{}_{G_1}, P^1{}_{G_1}, P^1{}_{G_2}, - - - P^1{}_{G_n}, \lambda^1$ using

$x^N = x^{N-1}$-ΔL, where N is the iteration number

$$x^N = \begin{bmatrix} P^N{}_{G_1} \\ P^N{}_{G_2} \\ \vdots \\ P^N{}_{G_n} \\ \lambda^N \end{bmatrix}$$

Step-8: Substitute the new values in equation present in stpe-4 and recalculate the gradient.

4. RESULTS AND DISCUSSION

The below Table 1 shows the cost coefficients of generating units with constraints

Table 1 Cost coefficients and real power limits of generating units

Unit	Cost coefficients			$P_{Gi_{min}}$(MW)	$P_{Gi_{max}}$(MW)
	a_i	b_i	c_i		
1	0.006	8.45	410	50	250
2	0.007	8.95	620	25	150
3	0.004	6.80	670	250	500
4	0.009	6.95	720	100	300

Table 2 cost incurred to meet different loads with different methods

S.No	Load Demand(MW)	Fuel cost (Rs/hr)		Incremental Cost(λ)	
		λ iterative method	Gradient method	λ iterative method	Gradient method
1	550	6956.6771	6897.8962	9.331	9.309
2	650	7847.2573	7723.9167	9.6314	9.498
3	950	10062.5016	10022.4107	10.5260	10.486

The above table represents the total cost incurred to meet different load demands which are solved using λ iterative method and gradient method. The results obtained by solving with graphical method are almost similar with the results obtained through λ iterative method.

5. CONCLUSION

In this paper gradient method is used to solve the economic load dispatch problem and the results obtained are compared with the primitive methods of λ iterative method and graphical method. Definitely there will be the saving in fuel cost on allocating the load to generating units through Economic load dispatch by gradient method, the results are satisfactory. The total work is done in MATLAB environment.

REFERENCES

1. jizohngzhu " optimization of power system operation" wiley-IEEE press ISBN: 978-1-118-85415-0, Pages 664
2. J. Nanda , R.B. Narayanan , " Application of genetic algorithm to economic load dispatch with Line - flow constraints , " Electrical Power and Energy Systems , Vol. 24 , 2002 , pp. 723 – 729 .
3. G.B. Sheble , K. Brittig , " Refined genetic algorithm - economic dispatch example , " IEEE Trans on Power System , Vol. 10 , No. 1 , 1995 .

4. J.H. Park , Y.S. Kim , I.K. Eom , and K.Y. Lee , " Economic load dispatch for piecewise quadratic cost function using Hopfield neural networks , " IEEE Trans on Power System , Vol. 8 , No. 3 , 1993 , pp. 1030 – 1038 .
5. T.D. King , M.E. El - Hawary , and F. El - Hawary , " Optimal environmental dispatching of electric power system via an improved Hopfield neural network model , " IEEE Trans on Power System , Vol. 10 , No. 3 , 1995 , pp. 1559 – 1565
6. K.Y. Lee , A.S. Yome , and J.H. Park , " Adaptive neural networks for economic load dispatch , " IEEE Trans on Power System , Vol. 13 , No. 2 , 1998 , pp. 519 – 526 .
7. K.P. Wong and C.C. Fung , " Simulated - annealing - based economic dispatch algorithm , " IEE Proc. Part C , Vol. 140 , No. 6 , 1993 , pp. 509 – 515 .