Classical Approach to Solve Economic Load Dispatch Problem of Thermal Generating Unit in MATLAB Programming

Arunesh Dutt [1], Ashish Dhamanda [2]
[1]Assistant Professor (EEE), SGIET, NGBU, Allahabad, U.P, India
[2]Ph.d Student (EE), SSET, SHIATS, Allahabad, U.P, India

Abstract

The classical approach to the Economic Load Dispatch Problem (ELDP) seeks to minimize the cost of generation subject to the certain constraints. Economic load dispatch (ELD) problem is one of the most important in power system operation and planning. So many models by using different techniques have been used to solve these problems. Lambda iteration method (LIM) offers a suitable and classical approach to meet the objectives of to determine the optimal combination of power outputs of all generating units so as to meet the required demand at minimum cost while satisfying the generator constraint. This paper presents an improved fast and reliable technique to solve ELD Problem using Lambda iteration method (LIM) in MATLAB environment for two and three generator units, which are thermal generating units and two separate cases, has to be considered with and without generator constraints. Simulation results show that the each thermal generating unit for the proposed method is compared with the all cases and find out the optimum one from the compared response.

Keywords: *Economic Load Dispatch (ELD), Economic Load Dispatch Problem (ELDP), Lambda iteration method (LIM), Satisfying Constraints.*

1. Introduction

The increasing energy demand and the decreasing energy resources have made optimization a great necessity in power system operation and planning. Economic dispatch is the optimization scheme of generation system to determine the best generation schedule to supply a given load with minimum cost, while satisfying a set of constraints. Because of the increasing size and complexity of power system networks, such as multiple fuel options, more attention is being given to develop optimization methods that automatically account for such practical constraints. Fuel supplies for thermal can be coal, natural gas, oil, or nuclear fuel. The other costs such as costs of labour, supplies, maintenance, etc. being difficult to be determined and approximate, are assumed to vary as a fixed percentage of the fuel cost. Therefore, these costs are included in the fuel cost. Thus, the operating cost of a thermal plant, which is mainly the fuel cost, is given as a function of generation. This function is defined as a nonlinear function of plant generation. The cost of generation depends upon the system constraint for a particular load demand it means the cost of generation is not fixed for a particular load demand but depends upon the operating constraint of the sources [2],[3]. The ELD problem has been solved via many traditional optimization methods, including: Gradient-based techniques, Newton methods, Linear programming, and quadratic programming [6]. The economic operation of a thermal unit, input-output modeling characteristic is significant. For this function considers a single unit consisting of a boiler, a turbine, and a generator as shown in figure 1 [4],[5],[12].

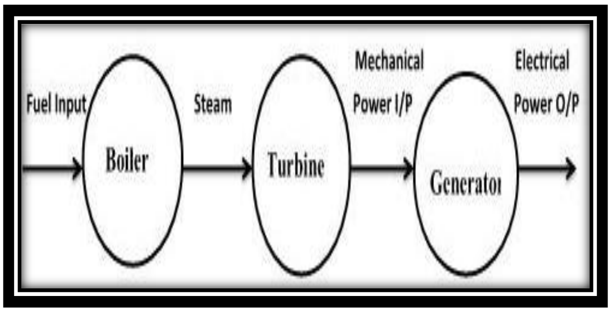


Fig. 1 Simple Model of Thermal Generation System

2. Problem Formulation

ELD is an important function in modern power system to schedule the power generator outputs with respect to the load demands, and to operate the power system most economically, the main objective of economic load dispatch is to allocate the optimal power generation from different units at the lowest possible cost while satisfying the system constraints. ELD problem can be mathematically formulated as follows-

2.1 Objective Function

The Objective function for ELD can be expressed mathematically as follows:-

Minimize $$C(Pgi) = \sum_{i=1}^{NG} Ci(Pgi) \quad (1)$$

Subject to:

The energy balance equation

$$\sum_{i=1}^{NG} Pgi = Pd \quad (2)$$

$$Ci(Pgi) = \sum_{i=1}^{NG} (ai * Pgi^2 + bi * Pgi + ci) ₹/hr \quad (3)$$

Where ai, bi and ci are the cost coefficients of i'th units.

2.2. Constraints Function

The economic power system operation needs to satisfy the following types of constraints:

2.2.1 Equality Constraints

In equality constraints the sum of real power generation of all the various units must always be equal to the total real power demand on the system.

$$Pd = \sum_{i=1}^{NG} Pgi \quad (4)$$

Where Pgi is the total real power generation. Pd is the total real power demand.

2.2.2 Inequality Constraints

Inequality constraints for power generating units are as follows:

$$P_{gi}^{min} <= Pgi <= P_{gi}^{max} \quad (i = 1, 2…., NG) \quad (5)$$

Where P_{gi}^{min}, and P_{gi}^{max} are the minimum and maximum limit of power generation of a i'th plant.

2.3 Incremental Fuel Cost

The incremental fuel cost can be obtained from the following equation:

$$(IC)i = (2 * ai * Pgi + bi) ₹/hr \quad (6)$$

Where IC is incremental fuel cost. a is actual incremental cost curve. b is approximated (linear) incremental cost curve. Pg is total power generation [5],[12].

For dispatching purposes, the cost is usually approximated by one or more quadratic segments, so the fuel cost curve in the active power generation, takes up a quadratic form. Incremental fuel cost curve are shown in figure 2 as follows-

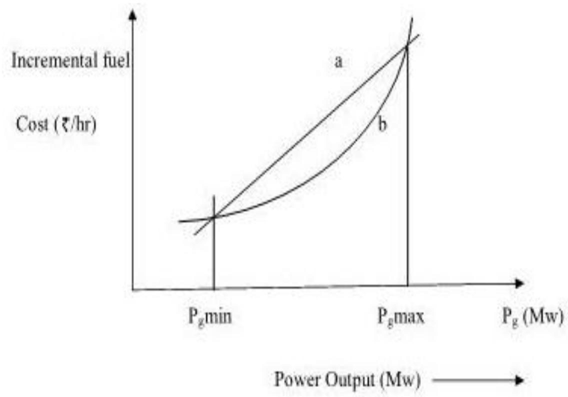


Fig. 2 Incremental Cost Curve of Generator i

3. Lambda Iteration Method

Lambda iteration method is more conventional to deal with the minimization of cost of generating the power at any demand. For more number of units, the Lambda iteration method is more accurate and incremental cost curves of all units are stored in memory.

Flow Chart of Lambda iteration method for ELD is given below:

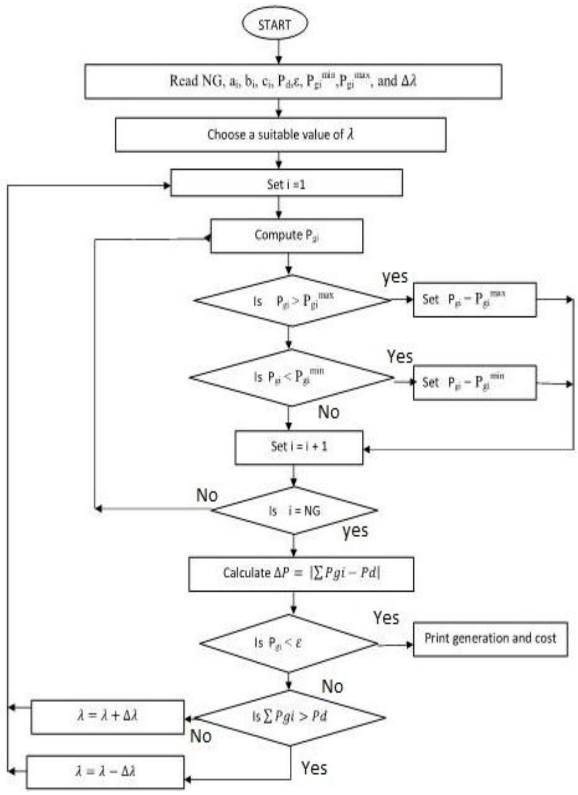


Fig. 3 Flow Chart of ELD with Generator Constraints

4. Numerical Example

Two and Three generating units have different characteristic. Their cost function characteristics are given by following equations [4],[5]-

4.1. For Two Generating Unit

$C_1 = 0.004P_1^2 + 9.2P_1 + 420$ ₹/hr (7)

$C_2 = 0.0029P_2^2 + 8.5P_2 + 350$ ₹/hr (8)

The unit operating ranges are-

$100 \text{ MW} \le P_1 \le 200 \text{ MW}$ (9)

$150 \text{ MW} \le P_2 \le 500 \text{ MW}$ (10)

Let us consider λ=12

4.2. For Three Generating Unit

$C_1 = 0.006P_1^2 + 8.4P_1 + 400$ ₹/hr (11)

$C_2 = 0.006P_2^2 + 8.93P_2 + 600$ ₹/hr (12)

$C_3 = 0.004P_2^2 + 6.78P_2 + 650$ ₹/hr (13)

The unit operating ranges are-

$100 \text{ MW} \le P_1 \le 600\text{MW}$ (14)

$60 \text{ MW} \le P_2 \le 300 \text{ MW}$ (15)

$300 \text{ MW} \le P_3 \le 650 \text{ MW}$ (16)

Let us consider λ=9 [4],[5]

5. Simulation And Result

The Lambda iteration method is applied in four cases with two generating unit to find out the minimum cost for any demand. The optimal results with the conventional Lambda iteration method will get.
In the first case transmission losses and generator constraints are neglected, in second case generator constraints are consider without transmission losses, in third case transmission losses are consider without generator constraint and the fourth case with transmission losses and generator constraint. All these simulation are done on MATLAB environment. The tables for each case are as follows-

5.1. For Two Generating Unit

S.No.	Lambda	Power Demand (MW)	Fuel Cost (F) ₹/hr
1	9.6684	260	3152.4
2	10.1391	400	4538.9
3	10.7443	580	6418.4
4	11.1142	690	7620.6

Table. 1: Economic Load Dispatch without generator constraints (For Case 1)

S.No.	Lambda	Power Demand (MW)	Fuel Cost (F) ₹/hr
1	9.4280	260	3164.2
2	10.1391	400	4538.9
3	10.7443	580	6418.4
4	11.3420	690	7631.3

Table. 2: Economic Load Dispatch with generator constraints (For Case 2)

5.2. For Three Generating System

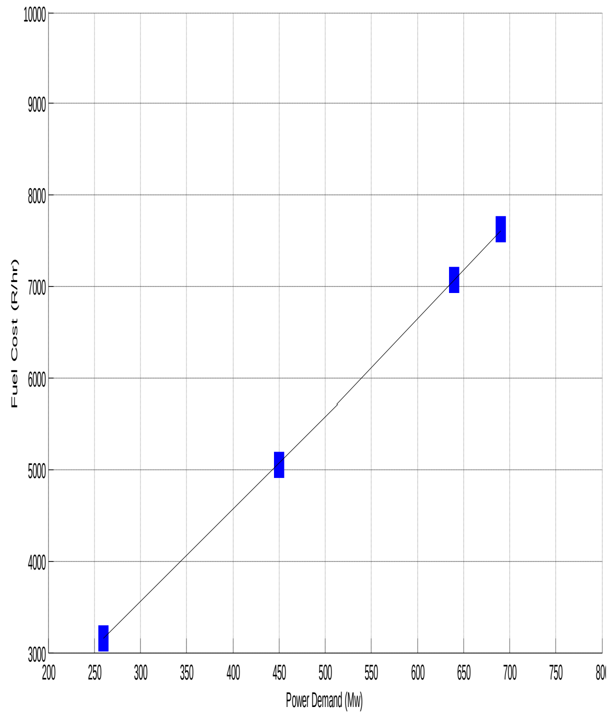
S.No.	Lambda	Power Demand (MW)	Fuel Cost (F) ₹/hr
1	9.7429	550	6357.2
2	11.2171	980	10864.0
3	11.9714	1200	13414.0
4	13.0000	1500	17160.0

Table. 3: Economic Load Dispatch without generator constraints (For Case 3)

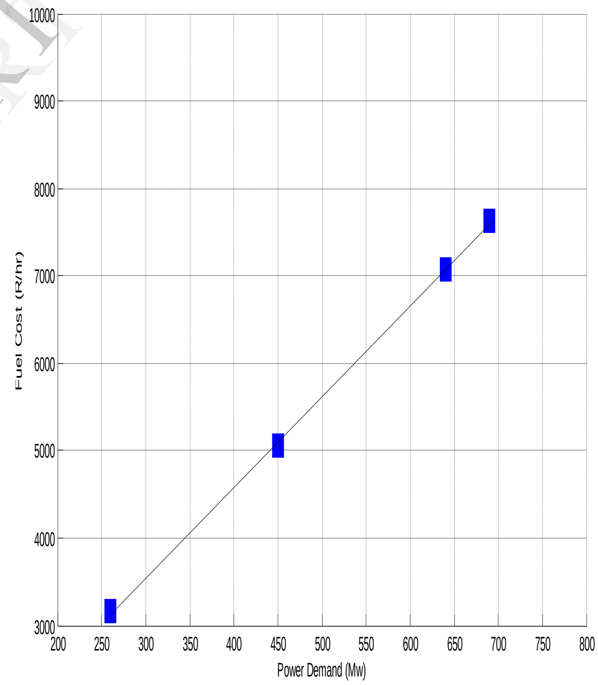
S.No.	Lambda	Power Demand (MW)	Fuel Cost (F) ₹/hr
1	9.7429	550	6357.2
2	11.2171	980	10864.0
3	11.9714	1200	13414.0
4	15.000	1500	17401.0

Table. 4: Economic Load Dispatch with generator constraints (For Case 4)

From the above tables, the response of two separate cases for two generating unit can be obtained-

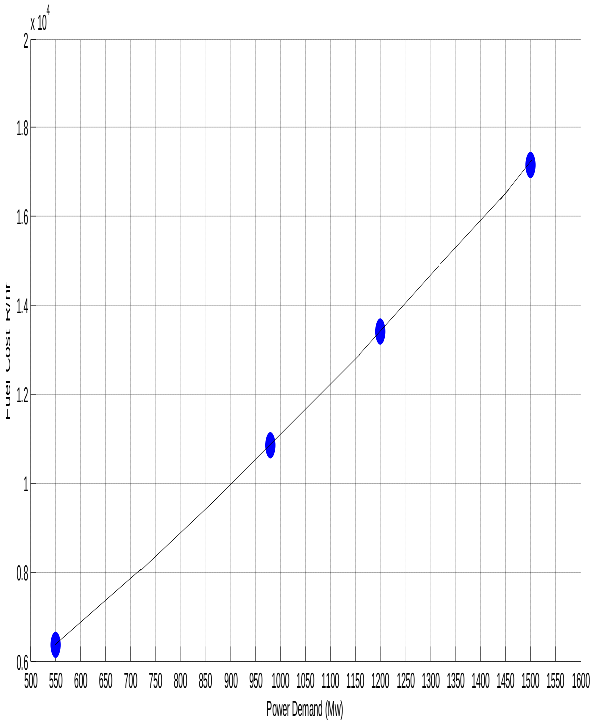


Graph.1: Between Power Demand (Mw) and Fuel Cost (₹/hr) (For Case 1)

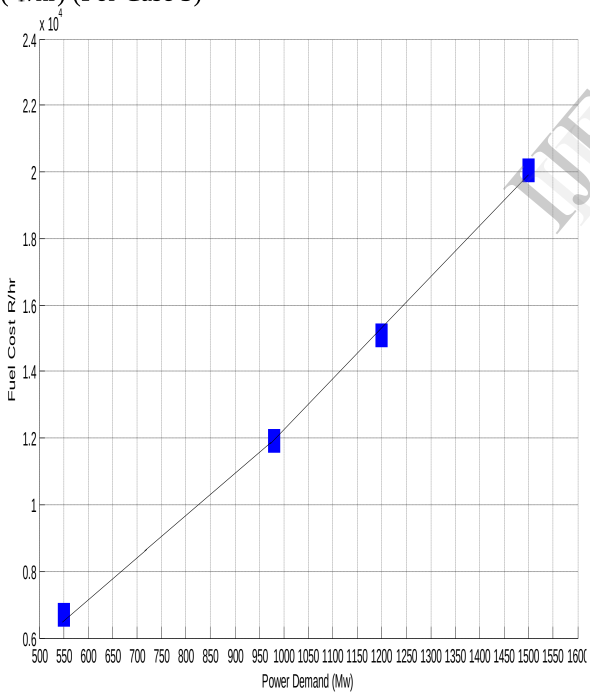


Graph.2: Between Power Demand (Mw) and Fuel Cost (₹/hr) (For Case 2)

The response of two separate cases for three generating unit can be obtained as follow-



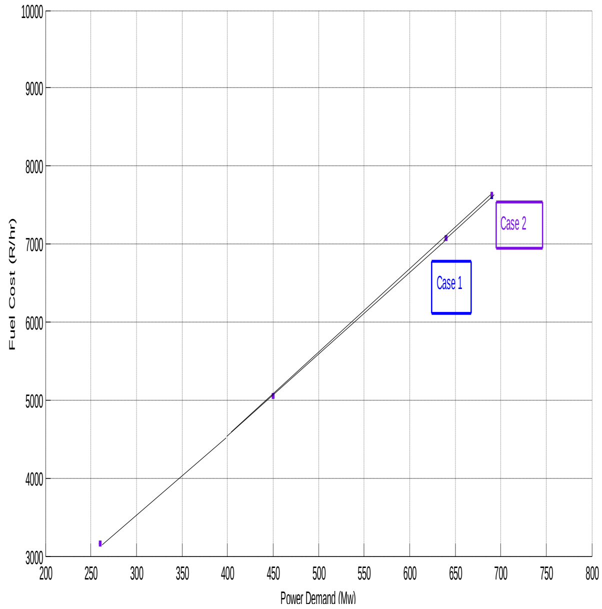
Graph.3: Between Power Demand (Mw) and Fuel Cost (₹/hr) (For Case 3)



Graph.4: Between Power Demand (Mw) and Fuel Cost (₹/hr) (For Case 4)

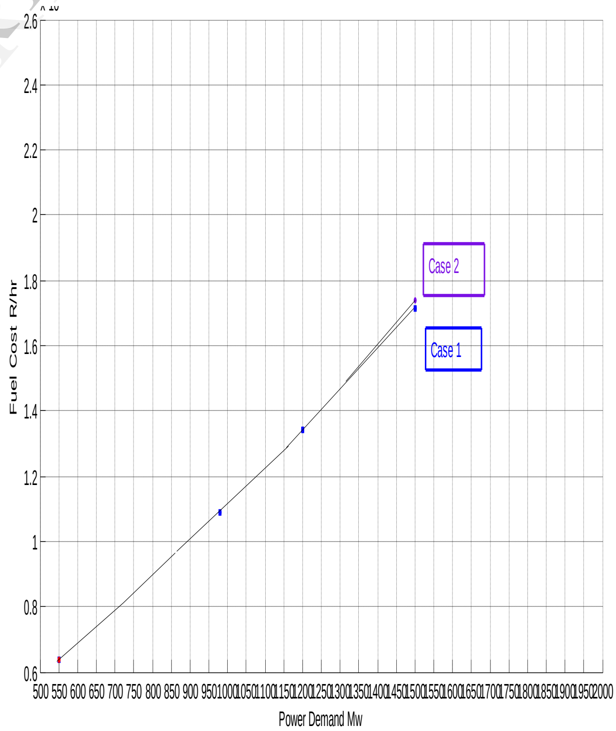
Comparison of above stated cases and respective graphs, the combined responses can be obtained between Power Demand (Mw) and Fuel Cost (₹/hr).

5.3. For Two Generating Unit



Graph.5: Between Power Demand (Mw) and Fuel Cost (₹/hr)

5.4. For Three Generating Unit



Graph.6: Between Power Demand (Mw) and Fuel Cost (₹/hr)

6. Conclusion

For solving economic load dispatch problem of thermal generating units, we considered two and three generating units and each generating unit have two different cases. The first case is economic load dispatch (ELD) without generator constraints, second case is ELD with generator constraints. For each case a separate table and corresponding response we obtained and the combined response of all separate cases also obtained after comparison of the above cases we find that the first case (ELD without transmission line losses and generator constraints) give the optimal value in comparison to the other cases. Thus we can conclude that the Lambda iteration method gives the better result and useful to solve ELD problem.

REFERENCES:-

[1] C. Rani, M. Rajesh, Kumar, K. Pavan, "Multi-objective Generation Dispatch Using Particle Swarm Optimization", IEEE – IICPE 2006 Indian International Conference on power Electronics Chennai (2006).

[2] Ashfaq Husain, "Electrical Power System", CBS Publishers and Distributors, Fifth Edition (2007).

[3] C. L. Wadhwa ,"Electrical Power System", 5th Edition, Economic load dispatch, (2009).

[4] S. Sivanagaraju, G. Sreenivasan, "Power System Operation and Control". (2011).

[5] D. P. Kothari, J.S.Dhillon,"Power System ptimization", PHI, Second Edition (2010).

[6] Samir SAYAH, Khaled ZEHAR,"Using Evolutionary Computation to Solve the Economic Load Dispatch Problem", Leonardo Journal of Sciences ISSN 1583-0233, Issue 12, January-June (2008).

[7] C. Srinivasa Rao, S. ShivaNagaraju, P. Sangameswara Raju, M. Rajendra Reddy, "Optimized Integral Controller for Economic Load Dispatch in a Two Area System Based on Hooke-Jeeves Algorithm", RPN Journal of Engineering and Applied Sciences. vol. 2, no. 6, December (2007).

[8] M. Zarei, A. Roozegar, R. Kazemzadeh, J. M. Kauffmann, "Two Area Power Systems Economic Dispatch Problem Solving Considering Transmission Capacity Constraints", World Academy of Science, Engineering and Technology (2007).

[9] Biswajit Purkayastha, NidulSinha, "Optimal Combined Economic and Emission Load Dispatch using Modified NSGA-II with Adaptive Crowding Distance", International Journal of Information Technology and Knowledge Management, Volume 2, No. 2, pp. 553-559, July-December (2010).

[10] Surya Prakash, S.K. Sinha, "Automatic Generation Control of Three Area Hydro-thermal Reheat Interconnected Power System Using Artificial intelligence Control Approach", DRDO Sponsored Eighth Control Instrumentation System Conference, CISCON-2011(An International Conference) (2011).

[11] C. Rani, Afshin Yazdani, "Emission Constrained Economic Dispatch Using Various PSO Algorithm", International Journal Of Power System Operation and Energy Management (IJPSOEM) Volume-1, Issue-1 (2011).

[12] Ashish Dhamanda, Arunesh Dutt, Surya Prakash, A. K. Bhardwaj, "A Traditional Approach to Solve Economic Load Dispatch Problem of Thermal Generating Unit Using MATLAB Programming", IJERT vol.2 Issue 9 September- (2013).