A Traditional Approach to Solve Economic Load Dispatch Problem of Thermal Generating Unit Using MATLAB Programming

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Abstract

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. The main objective of the ELD problems is 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 constraints. This paper presents a traditional approach to solve the ELD problem using Lambda iteration method (LIM) in MATLAB environment for two generator units and four separate cases has to be considered with and without transmission losses and generator constraints. Result obtained for the proposed method is compared with the all cases and find out the optimum case.

Keywords: Economic Load Dispatch (ELD), Satisfying constraints, Lambda Iteration Method (LIM), MATrix LABoratory (MATLAB).

1. Introduction

The sizes of electric power system are increasing rapidly to meet the power demand so it becomes necessary to operate the plant units most economically and with large interconnection of the electric networks, the energy crisis in the world and continuous rise in the prices, it is very essential to reduce the running charges of the electric energy i.e. reduce the fuel consumption for meeting a particular load demand. The main factor controlling the most desirable load allocation between various generating units is the total running cost [1]. The operating cost of a thermal plant is mainly the cost of the fuel. 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 [1],[2]. The ELD problem has been solved via many traditional optimization methods, including: Gradient-based techniques, Newton methods, linear programming, and quadratic programming [5]. 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 [3],[4].

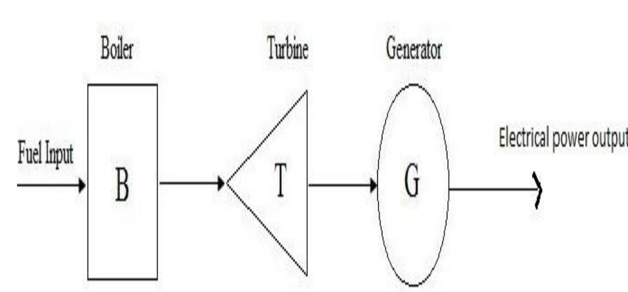


Fig. 1 Simple Model of Thermal Generation System

2. ELD 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

Minimize $F(Pgi) = \sum_{i=1}^{NG} Fi(Pgi)$ (1)

Subject to:

The energy balance equation

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

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

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

2.2. Constraints Function

Constraints details are given below:

2.2.1 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:

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

The transmission loss can be calculated by the following equations:

$$PL = \sum_{i=1}^{NG} \sum_{j=1}^{NG} Pgi\, Bij\, Pgj \quad (6)$$

Where P_{gi} and P_{gj} are the real power generations at $i^{'th}$ and $j^{'th}$ buses respectively. B_{ij} are the loss coefficients or B- coefficients.1

2.4 Incremental Fuel Cost

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

$$(IC)i = (2 * ai * Pgi + bi) ₹/hr \quad (7)$$

Where IC is incremental fuel cost. a is actual incremental cost curve. b is approximated (linear) incremental cost curve. Pg is total power generation [4].

Incremental fuel cost curve are shown in figure 2 as follows-

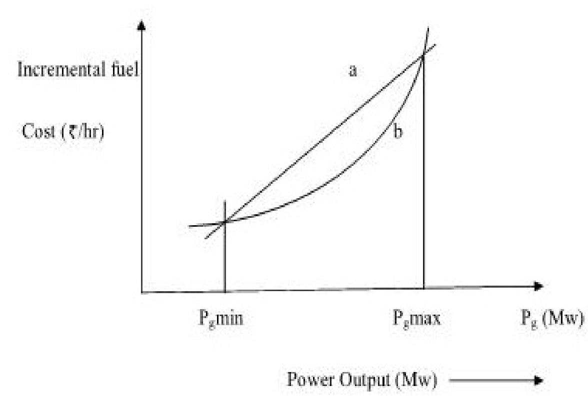


Fig 2. Incremental Cost Curve of Generator i

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.

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.
Algorithm for Lambda iteration method is given below:

1. Guess the initial value of λ^0 with the use of cost–curve equations.

2. Calculate P_{gi}^{0}

3. Calculate $\sum_{i=1}^{NG} P_{gi}^{0}$.

4. Check whether $\sum_{i=1}^{NG} P_{gi}^{0} = P_d$

$$\sum_{i=1}^{NG} P_{gi}^{0} - P_d \leq \varepsilon \text{ (atolerancevalue)}$$

5. If $\sum_{i=1}^{NG} P_{gi}^{0} < Pd$, set a new value for, i.e., $\lambda' = \lambda + \Delta\lambda$ and repeat from step (2) till the tolerance value is satisfied.

6. If $\sum_{i=1}^{NG} P_{gi}^{0} > Pd$, set a new value for, i.e., $\lambda' = \lambda - \Delta\lambda$ and repeat from step (2) till the tolerance value is satisfied.

7. Stop [3].

4. Numerical Example

Two generating units considered are having different characteristic. Their cost function characteristics are given by following equations-

$$F_1 = 0.004P_1^2 + 9.2P_1 + 420 \quad ₹/hr \tag{8}$$

$$F_2 = 0.0029P_2^2 + 8.5P_2 + 350 \quad ₹/hr \tag{9}$$

The unit operating ranges are-

$100 \text{ MW} \leq P_1 \leq 200 \text{ MW}$

$150 \text{ MW} \leq P_2 \leq 500 \text{ MW}$

The transmission line losses can be calculated by the given expression

$$P_{L(pu)} = 0.0346\ P_{1(pu)}^2 + 0.00643\ P_{2(pu)}^2 \tag{10}$$

Let us consider λ=12

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-

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: ELD without transmission line losses and 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: ELD without transmission line losses and with generator constraints (For Case 2)

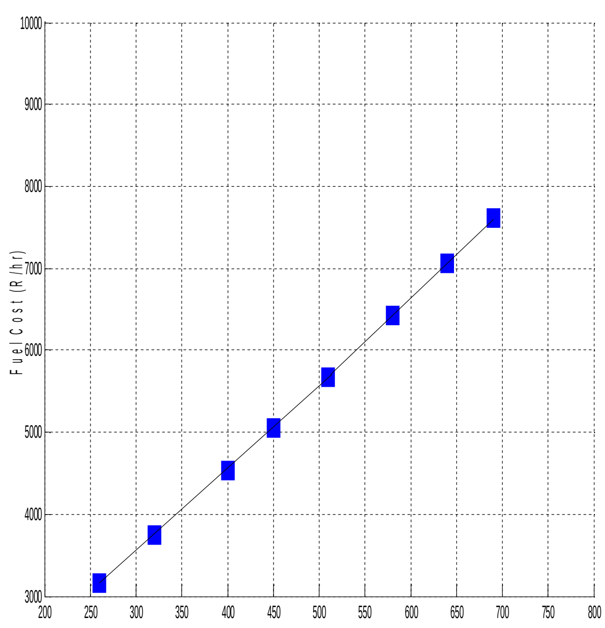
S. No.	Lambda	Power Demand (MW)	Fuel Cost (F) ₹/hr
1	9.6236	260	3161.0
2	10.6508	400	4540.8
3	11.7426	580	6661.1
4	12.3427	690	7637.3

Table. 3: ELD with transmission line losses, without generator constraints (For Case 3)

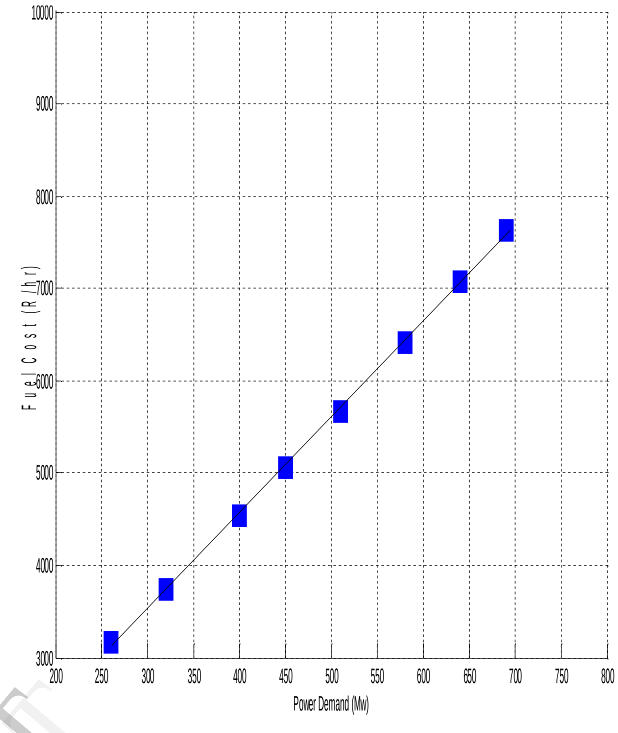
S. No.	Lambda	Power Demand (MW)	Fuel Cost (F) ₹/hr
1	9.9927	260	3189.8
2	10.7291	400	4639.8
3	11.7426	580	6661.1
4	12.4023	690	7988.8

Table. 4: ELD with transmission line losses and generator constraints (For Case 4)

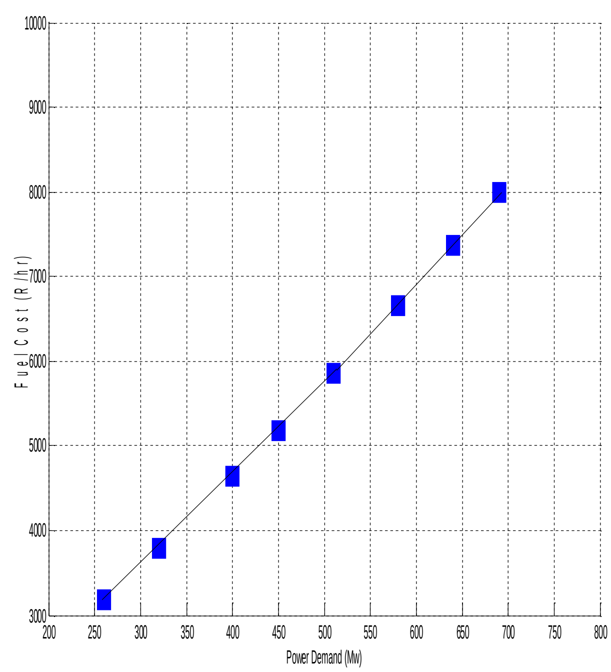
From the above tables the response of four separate cases can be obtained:



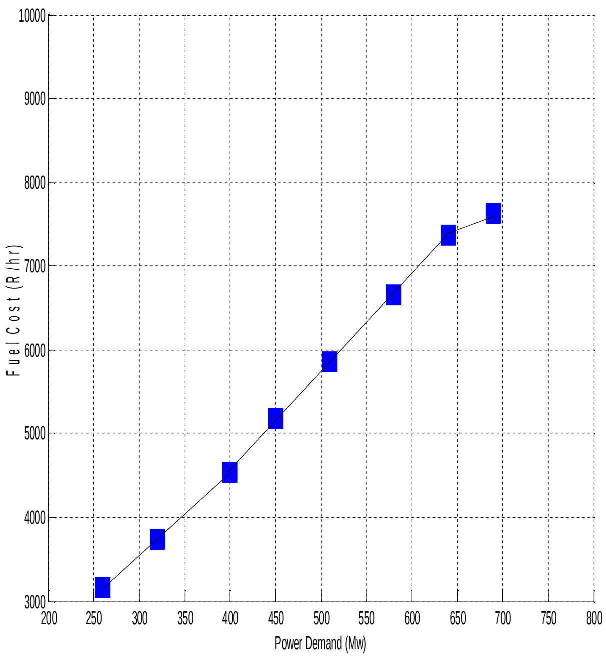
Graph. 1: Between Power Demand (Mw) and Fuel Cost (₹/hr) (For Case 1)



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

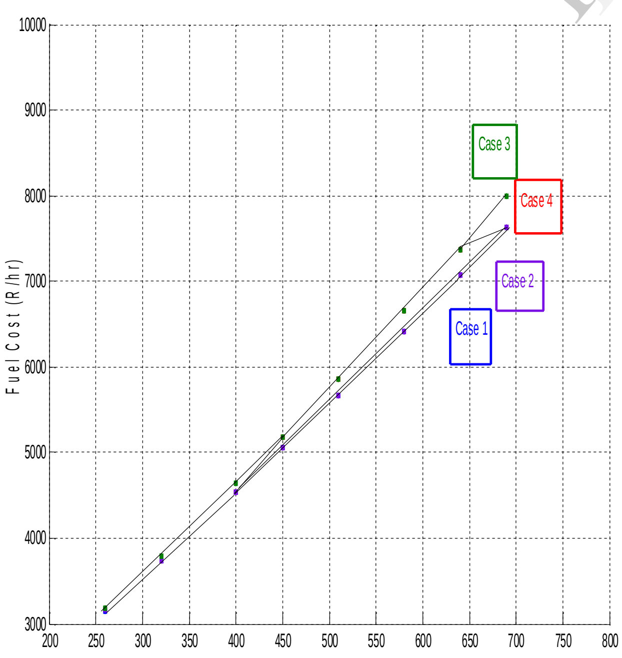


Graph. 3: Between Power Demand (Mw) and Fuel Cost (₹/hr) (For Case 3)



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) as follow:



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

6. Conclusion

For solving economic load dispatch problem of thermal generating units, we considered two generating units and each generating unit have four different cases. The first case is economic load dispatch(ELD) without transmission loss and generator constraints, second case is ELD without transmission loss and with generator constraints, third case is ELD with transmission loss and without generator constraints, and fourth case is ELD with transmission loss and with generator constraints. For each case a separate table and corresponding response we have 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] Ashfaq Husain, “Electrical Power System”, CBS Publishers and Distributors, Fifth Edition (2007).

[2] C.L. Wadhwa, “Electrical power system”, 5th Edition, Economic load dispatch, (2009).

[3] S. Sivanagaraju, G. Sreenivasan, “Power System Operation and control”. (2011).

[4] D.P. Kothari, J.S. Dhillon, “Power System Optimization”, PHI, Second Edition (2010).

[5] 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).

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

[7] 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).

[8] M. Sailaja Kumari, M. Sydulu, "A Fast Computational Genetic Algorithm for Economic Load Dispatch", International Journal of Recent Trends in Engineering Vol. 1, No. 1, May (2009).

[9] Y. Labbi, D. BenAttous, "A Hybrid ga–ps Method to Solve the Economic Load Dispatch Problem", Journal of Theoretical and Applied Information Technology. (2010).

[10] Biswajit Purkayastha, Nidul Sinha, "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).

[11] Surya Prakash, S.K. Sinha, "Artificial Intelligent & PI in Load Frequency Control of Interconnected Power System", International Journal of Computer Science & Emerging Technologies (E-ISSN: 2044-6004), Volume 1, Issue 4, December (2010).