Economic Load Dispatch with Modern Conventional Method using Lagrange's Method

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Abstract- In practical situations and under specific operating conditions, the generating capacity of power plants is more than the total losses and load demand. Also, power plants have different fuel costs and have different distance from load centres. Hence the need for developing improved methods of economic dispatch of generated power from mostly far away remote locations to major load centres in urban cities. Most methods adopted for optimal dispatch are either not economical in their computational approaches. This work proposes a fast and easy to use generic comparative work to aid in solving economic dispatch problems. The comparative method proposed in this work will try to estimate the optimal valve of real power to be generated with the least possible fuel cost. This will be based on the assumption of equal incremental cost and the result compared to conventional method.

I. INTRODUCTION

As there is a very large sector of electrical networks present in the current world, so the prices are rising to a new level day by day, that is why it is a major point to reduce the running costs of this form of energy that is electrical energy, hence to achieve this big aim of reducing running cost of electrical energy, there must be change in operation of the power system which will definitely reduce the cost along with the consumption of fuel. The most prior concern of the modern electrical power system is that to supply the high quality power supply which is also reliable for the consumers at the lowest cost which may be possible including the environmental considerations. Economic Load Dispatch (ELD) problem is formulation for knowing the optimised combination of output power of all generating units in online process which ultimately minimizes the cost of total fuel by also following an equality constraint along with a set of it. This ELD problem is solved by using various algorithms such as base point participation factor, Newton method, lambda iteration and gradient method only if the fuel cost curves practically recorded for the generating units monotonically increasing as well as piece wise linear. Input output characteristics, practically observed of these generating units are non-smooth, non-linear as well as discrete in nature. This makes the result a non-convex challenging problem, difficult to equate and solve by using these old methods. To make it solved and for obtaining a near global optimal solution genetic algorithm, artificial intelligence, dynamic programming are used which are fast and reliable also.

Depending on the ELD problem domain and its execution time limit, not only local optimal solution even global optimal solution can also be obtained by using modern intelligent techniques. These modern techniques are generalized methods which are based upon the theory of genetics and evolution for the natural system in the living beings. They are only difficult in stating the parameters but have the advantage of making result possible even in the large domain by thorough searching.

II. METHODOLOGY

ECONOMIC LOAD DIPSPATCH USING LAGRAGIAN METHOD

INTRODUCTION

At any demand of load generating cost power is to be minimized, which is practically made possible by Economic Load Dispatch problems. Analysis of the study of Economic Load Dispatch can be divided into two phases, one is excluding the transmission line losses and the other one is including the transmission line losses.

ELD Excluding Transmission Line Losses:

Economic Load Dispatch problem without transmission losses is stated as,

$$F_i = \sum_{k=1}^{N}(F_k) \quad \text{……………………………………… Eq}^{n.}\ (1)$$

$$P_t = \sum_{k=1}^{N}(P_k) \quad \text{…………………………………….. Eq}^{n.}\ (2)$$

Here, F_i represents the total input fuel for a system;

F_k is input fuel for k^{th} unit;

P_t represents the total demand of load and;

P_k is the generation for the k^{th} unit.

An auxiliary function which is obtained by using the Lagrangian multiplier is,

$$F_i = F_i + \lambda\, P_t - \sum_{n=1}^{N}(P_k)$$

Where, λ is known as Lagrangian multiplier.

By differentiating F with respect to P_k, and put it equal to

zero,
We get the condition for optimum operation of system.

$$\frac{\partial \partial F}{P_k} = \frac{\partial \partial F_i}{P_k} + \lambda(0-1) = 0$$

$$= \frac{\partial F_i}{\partial P_k} - \lambda = 0$$

Since, Fi= $F_1 + F_2 + F_3 + ... + F_k$
Therefore,

$$\frac{\partial F_i}{\partial P_k} = \frac{\partial F_k}{\partial P_k} = \lambda(0-1)$$

And, therefore
The final condition obtained for optimum operation is,

$$\frac{\partial F_1}{\partial P_1} = \frac{\partial F_2}{\partial P_2} = \ldots\ldots\ldots\ldots\ldots = \frac{\partial F_k}{\partial P_k} = \lambda$$

Where, $\frac{dF_k}{dP_k}$ = production cost increment of a plant k, in Rs / MW Hr.
The production cost increment of a plant over a specified limited range is given as,

$$\frac{\partial F_k}{\partial P_k} = F_k P_k + f_k$$

Where, F = slope of the incremental production cost curve
F = intercept of the incremental production cost curve

The equation for optimum operation means that machine should be loaded in such a way such that the incremental cost of production in each machine is equal. While deriving and solving the above equations, all the active power constrains are also considered. If there is any kind of violation occur in these constrains then, for a generator unit under specified limits, depending on the equal incremental cost of production decided remaining of load is distributed among the remaining generator units.

ELD with loss
Economic Load Dispatch problem with transmission losses is stated as,

$$F_i = \sum_{k=1}^{N} (F_k)$$

Subjected to $P_t + P_s - \sum_{k=1}^{N} (P_k)$

Here, P_s is the total loss in the system assumed to be a function of generation which have its significance.
By making it with Lagrangian multiplier λ, obtained auxiliary equation is represented as,

$$\mathrm{F} = F_i + \lambda\,(P_t + P_s - \sum (P_k)$$

After the partial differentiation of the above equation and equating it to zero, we get,

$$\frac{\partial F}{\partial P_n} = \frac{\partial F_t}{\partial P_n} + \lambda\,(\frac{\partial P_L}{\partial P_n} - 1) = 0$$

$$\frac{\partial F}{\partial P_n} + \lambda \frac{\partial \mathrm{P}}{\partial P_n} = 0$$

Here the incremental transmission loss is as $\frac{\partial P_L}{\partial P_n}$ and λ is the incremental cost of received power in Rs.Per MWhr. The equation (5.8) is a set of n equations with (n + 1) unknowns. λ and n generations both are unknown. These equations are known as coordination equations

Because they coordinate the incremental transmission losses with the incremental cost of production.
To solve these equations the loss formula equation is expressed in terms of generations and is approximately expressed as

$P_L = \sum\sum P_m B_{mn} P_n$- -
Mn

Where P_m and P_n are the source loadings, B_{mn} the transmission loss coefficient. The formula is derived under the following assumptions.

1. The equivalent load current at any bus remains a constant complex fraction of the total equivalent load current.
2. The generator bus voltage magnitudes and angles are constant
3. The power factor of each source is constant.

The solution for coordination equation requires the calculation of

$$\frac{\partial P_L}{\partial P_n} = 2\sum_m P_m B_{mn}$$

Also

$$\frac{\partial F_n}{\partial P_n} = F_{nm} P_n + F_n$$

The coordination equation can be written as:-

$$F_{nm}P_n + F_{n+\lambda}\sum_m 2\, P_m\, B_{mn} = \lambda$$

Solving for P_n we obtain

$$P_n = \frac{1 - \frac{f_n}{\Lambda} - \sum_{m \neq n} 2 B_{mn} P_m}{\frac{f_{mn}}{\Lambda} + 2B_{mn}} \quad \text{- (5.11)}$$

LAGRANGES METHOD

Now we will find out the results from lagranges method as the below equation applied in this method. We will find the best results by applying this method. We discussed with three and six generator system of this method.

For Three generator Unit

Power demand is 150MW.

Table 1: Values of Pmin and Pmax and Alpha, Betha and Gamma

Generator No	Alpha	Beta	Gamma	Pmin	Pmax
1	200	7.00	0.0080	10	85
2	180	6.30	0.0090	10	80
3	140	6.80	0.0070	10	70

B= [0.000218 0.000093 0.000028; 0.000093 0.000228 0.000017; 0.000028 0.000017 0.000179]

The individual power Input is as for three generators.

Table 2: Individual Power Inputs

Generator No	Lagrenges Method	Conventional Method
1	32.72	33.4701
2	67.9810	64.0974
3	51.6898	55.1011

Transmission losses when including. The individual methods becomes

Table 3: Transmission Losses between Conventional and Lagranges Method

	Conventional Method	Lagranges method
Transmission loss	2.34	2.39

The total Output we see is

Table 4: Total Output Lagranges and Conventional Method

	Lagranges Method	Conventional Method
Total Output	152.3850	152.3419

The Total cost is as

Table 5: Total Cost between Lagranges and Conventional Method

	Lagranges Method	Conventional Method
Total Cost	1597.77	1599.98

For Six Generator System

Table 6: Values of Pmin and Pmax and Alpha, Betha and Gamma

Generator	Alpha	Beta	Gamma	Pmin	Pmax
1	240	7.00	0.0070	100	500
2	200	10.0	0.0095	50	200
3	220	8.50	0.0090	80	300
4	200	11.0	0.0090	50	150
5	220	10.5	0.0080	50	200
6	190	12.0	0.0075	50	120

B coefficient Matrix is as

[0.001700 0.001200 0.000700 -0.00010 -0.00050 -0.00020;0.001200 0.001400 0.000900 0.000100 -0.00060 -0.00010;0.000700 0.0000900 0.003100 0.000000 -0.00100 -0.00060;-0.00010 0.000100 0.000000 0.002400 -0.00060 -0.00080;-0.00050 -0.00060 -0.00100 -0.00060 0.012900 -0.00020;-0.00020 -0.00010 -0.00060 -0.00080 -0.00020 0.015000]

The individual power Inputs is as for six generators.

Total Power Demand is as 1263MW.

Table 7: Power input between PSO, GA and Lagranges Method

Generator No	PSO Method	GA method	Lagranges method
1	446.71	474.81	446.85
2	173.01	178.64	171.366
3	265.00	262.21	264.22
4	139.00	134.28	125.33
5	165.23	151.90	172.117
6	86.78	74.18	83.70

Transmission losses when including. The individual methods becomes

Table 8: Transmission Losses between PSO, GA and Lagranges Method

	PSO Method	GA method	Lagranges method
Transmission loss	12.733	13.022	12.495

So the Total cost is as given below for different methods.

Table 9: Cost comparison between PSO, GA and Lagranges Method

	PSO Method	GA method	Lagranges method
Total Cost	15447	15459	15284

So we find out the Lagranges method is somewhat of convenient than the conventional method and GA methods.

III. CONCLUSION

Through lagranges method cost saving in output is also functions as the above results also shows the optimum values taken out through lamda iteration method for the n values to be taken in consideration.

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