OPTIMAL LOAD DISPATCH USING B-COEEFICIENT

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ABSTRACT: In this paper, B-coefficient method is used for solving the problems related to the optimal load dispatch. The main emphasis of optimal load dispatch is; how to operate a power system network so that we have least cost of electric generation to meet the load demand. This work has been made by using MATLAB simulation to identify the best scheduling of generators.

KEYWORDS: Generating operating cost, Transmission losses, Loss coefficient factor, Optimal load flow, MATLAB

I. INTRODUCTION

The optimal system operation, in general, involved the consideration of economy of operation, system security, emissions at certain fossil- fuel plants, optimal releases of water at hydro generation, etc. All these considerations may make for conflicting requirements and usually a compromise has to be made for optimal system operation. In this paper we consider the economy of operation only, also called the economic dispatch problem or optimal load dispatch.

In the power system many type of power plants are connected in the system which have their considerable running cost like thermal power plant have appreciable cost but also hydro power plants have negligible cost of generation so the main aim in the economic dispatch problem is to minimize the total cost of generating real power (production cost) at various stations while satisfying the loads and the losses in the transmission links.

II. GENERATOR OPRATING COST

The total operating cost includes fuel, labour and maintenance costs. This is appreciable in case of thermal power plants and nuclear power plants while for hydro power plants, it is apparently free.

The input-output characteristics curve of a generating unit specifies the input energy rate $F_i\,(P_{Gi})$ MKcal/h or cost of fuel used. The curve can be determined experimentally. A typical curve is shown here –

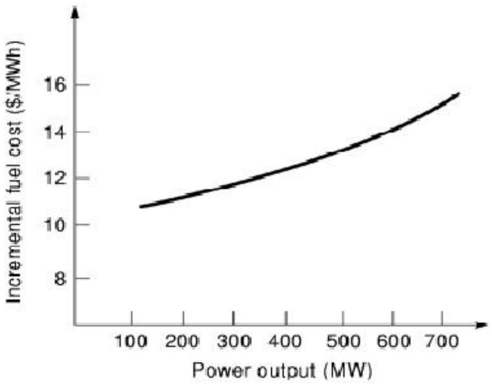

Fig 1: input-output characteristics curve

We next consider the heat rate curve $H_i\,(P_{Gi})$ which is the heat energy (obtained by combustion of fuel) in (MWh). Figure shows the approximate shape of the heat rate curve, which can be determined experimentally.

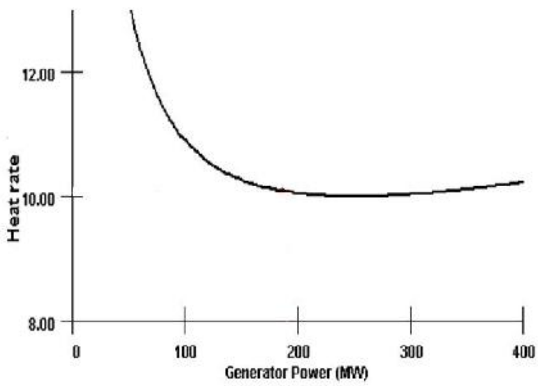

Fig 2: Heat rate curve

The input-output curve can be obtained from the heat-rate curve as

$$F_i\,(P_{Gi}) = P_{Gi}\,H_i\,(P_{Gi})\ \text{(MKcal/h)......(1)}$$

Where $H_i\,(P_{Gi})$ is the heat-rate in MKcal/MWh. The graph of $F_i\,(P_{Gi})$ is the input-output curve.

Let the cost of the fuel be K Rs/ MKcal/h. Then the input fuel cost, $C_i\,(P_{Gi})$ is

$$C_i\,(P_{Gi}) = KF_i\,(P_{Gi}) = KP_{Gi}\,H_i\,(P_{Gi})\text{Rs/h.......(2)}$$

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The heat-rate curve may be approximated in the form-

$H_i\,(P_{Gi}) = (a_i'/P_{Gi}) + b_i' + c_i' P_{Gi}$ (MKcal/MWh)..........(3)

with all coefficients positive. Now we get a quadratic equation for input energy rate $F_i\,(P_{Gi})$ with positive coefficients in the form

$F_i\,(P_{Gi}) = a_i' + b_i' P_{Gi} + c_i' P_{Gi}^2$ MKcal//h.........(4)

Now we also get a quadratic equation for fuel cost $C_i\,(P_{Gi})$ with positive coefficient in the form

$C_i\,(P_{Gi}) = K a_i' + K b_i' P_{Gi} + K c_i' P_{Gi}^2$

$= a_i + b_i\, P_{Gi} + c_i\, P_{Gi}^2$ (Rs/h).......(5)

III. CALCULATION OF B-COEFFICIENT

B is called the loss coefficient factor of the system. The transmission losses of the system depend on this constant factor by the equations:

$P_L = \sum_{i=1}^{m} \sum_{j=1}^{m} P_i B_{ij} P_j$ ....(6)

The transmission losses are also given as the copper losses of the lines which is given by:

$P_L = I^2 R$.............(7)

For the calculation of B- coefficient we have to follow some steps as given below:

1. Provide the given data for the system on which B is to be calculated.
2. Perform the load flow to calculate the unknown variables on each bus of the system.
3. Calculate the current for the lines.
4. Now calculate copper losses by the given formula in eq. (7).
5. Now calculate B by the given formula:

$B_{ij} = \frac{P_L}{(P_i P_j)}$.........(8)

IV. ECONOMIC LOAD DISPATCH

As we know that, the fuel cost curve of a plant can be determined in the form of a polynomial of suitable degree by the method of least square fit. Fuel cost curve shows the relationship between fuel cost for the generation of particular load demand of electricity or power generation. It is not convenient to express the input output curve of fuel cost and generated power because the fuel cost can change monthly or daily**.** But somehow it is fine because we have taken approximate fuel cost that can change in a month. Another important factor is transmission losses, as transmission losses are neglected then the total system load can be optimally divided among the various generating plants. But it is not realistic that transmission losses are zero so we have to consider them when long distance transmission of power is involved.

As, overall cost of generation is given by

$C = \sum_{I=1}^{m} C_i\,(P_{Gi})$..........(9)

Where m =number of generators.
When transmission losses are not consider
Then,

$\sum P_{Gi} = \sum P_{Di}$............(10)

When transmission losses are consider
Then,

$\sum P_{Gi} - \sum P_{Di} - P_L = 0$........(11)

$\sum P_{Gi}$ = Generation of i[th] plant
$\sum P_{Di}$ = Load demand
P_L = Transmission losses
To solve this we have to write the Lagrangian of cost as-

$\bar{C} = \sum_{i=1}^{m} C_i(P_{Gi}) - \lambda\,|\sum_{i=1}^{m} P_{Gi} - P_D - P_L|$ ....(12)

As the transmission losses are function of generated power, to minimize the cost differentiating above equation with respect to the P_{Gi}. This is given as-

$\frac{\partial \bar{C}}{\partial P_{Gi}} = \frac{\partial C_i}{\partial P_{Gi}} - \lambda(1 - \frac{\partial P_L}{\partial P_{Gi}})$ .....(13)

V. REPRESENTATION OF TRANSMISSION LOSSES BY B-COEFFICIENT

It is the simplest and efficient method used to expressing transmission losses as a function of generator power is through B-coefficient.
The general form of the loss formula using B-coefficient is –

$P_L = \sum_{i=1}^{m} \sum_{j=1}^{m} P_i B_{ij} P_j$ ....(14)

P_i, P_j = real power injection at i[th], j[th] busses
B_{ij} = loss coefficient which are constant under certain assumed operating condition.
We obtain the incremental cost as

$\frac{\partial C_i}{\partial P_{Gi}} = b_i + 2c_i P_{Gi}$ Rs/MKcal ....(15)

From equation (13) we have,

$b_i + 2c_i P_{Gi} + \lambda \sum_{i=1}^{m} 2\,B_{ij} P_j = \lambda$............(16)

$b_i + 2c_i P_{Gi} + 2\lambda B_{ii} P_i + \lambda \sum_{i=1}^{m} 2B_{ij} P_j = \lambda$ ....(17)

Substituting $P_{Gi} = P_{Di} + P_i$ and collecting all terms of P_i, we have-

$2(c_i + \lambda B_{ii})\, P_i = -2\lambda \sum_{i=1}^{m} 2B_{ij} P_j - b_i + \lambda - 2c_i P_{Di}$ ....(18)

$P_i = \frac{(1 - \frac{b_i}{\lambda} + \frac{2c_i}{\lambda P_{Di}} - 2B_{ij} P_{ij})}{2(\frac{c_i}{\lambda} + B_{ii})}$.....(19)

Where i=1, 2, 3,.............. m

VI. ALGORITHM

1. Load the data for the given system.
2. Calculate the B-coefficient for given system using load flow.
3. Initially choose $\lambda = \lambda_0$.
4. Assume P_i =0; i=1,2,....,m.
5. Solve the equation of (19) for P_is.
6. Calculate
$$P_L = \sum_{i=1}^{m}\sum_{j=1}^{m} P_i B_{ij} P_j$$
7. If $P_{Gi} < P_{Gi}^{min}$
Replace P_{Gi} by P_{Gi}^{min}.
8. If $P_{Gi} > P_{Gi}^{max}$
Replace P_{Gi} by P_{Gi}^{max}.
9. Check if power balance equation is satisfied, i.e.
$(\sum_{n\neq1}^{k} P_{Gi} - P_D - P_L) < \varepsilon$ (a specified value)
If yes, stop. Otherwise, go to step 6.
10. Increase λ by $\Delta\lambda$ (a suitable step size);
if $(\sum_{n\neq1}^{k} P_{Gi} - P_D - P_L) < 0$ or decrease λ by $\Delta\lambda$ (a suitable step size); if $(\sum_{n\neq1}^{k} P_{Gi} - P_D - P_L > 0$, repeat from step3.

RESULT AND DISCUSSION

Find the generation schedule of a three –generator power system to meet a demand of 300 MW. The cost characteristics of generators are given as below:

$$F1=0.00525\,P_{G1}^2 + 8.663P_{G1} + 328.13 \text{ Rs/h}$$
$$F2=0.00609P_{G2}^2 + 10.040P_{G2} + 136.91 \text{ Rs/h}$$
$$F3=0.00592P_{G3}^2 + 9.760P_{G3} + 59.16 \text{ Rs/h}$$

The cost characteristics are valid for the following minimum and maximum limits of power generation.

$$P_{G1}^{min}=50 \text{ MW},\quad P_{G1}^{max}=250 \text{ MW}$$
$$P_{G2}^{min}=5 \text{ MW},\quad P_{G2}^{max}=150 \text{ MW}$$
$$P_{G3}^{min}=15 \text{ MW},\quad P_{G3}^{max}=100 \text{ MW}$$

The bus data for the system is given as:

Bus	Admittance	Charging
1-2	2-8i	0
1-3	1-4i	0
2-3	.666-2.664i	0

The admittance for the system is given as:

Bus no.	voltage	Load real power	Load reactive power	Angle
1.	1.06	-	-	0
2.	1	.5	-	-
3.	-	.4	.3	-

The scheduling for the generators connected is calculated as:

$$P_{G1} = 250 \text{ MW}$$
$$P_{G2} = 39.0256 \text{ MW}$$
$$P_{G3} = 30.3650 \text{ MW}$$

The transmission losses have been calculated as:

$$P_L = 18.4235 \text{ MW}$$

The fuel cost for each generator is calculated as:

$$F_1 = 2822 \text{ Rs.}$$
$$F_2 = 538 \text{ Rs.}$$
$$F_3 = 361 \text{ Rs.}$$

Thus total fuel cost is: **3721 Rs.**

CONCLUSION

The economic load dispatch is done with the help of MATLAB program. Before running the program some inputs are required which are to be given by the user. In this program the inputs are: 1. Provide the data of the bus given. 2. The number of generators. 3. Provide the cost coefficients. 4. Provide maximum and minimum limits of generators. 5. Provide the load demand.

The optimal load dispatch presented in this paper calculated the real power scheduling. We can also calculate the reactive power scheduling and other important considerations with the help of optimal load dispatch in the future work.

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