Power Systems I

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EE342

ECONOMIC DISPATCH

Outline

- Generation Optimization.
- Generation Operating Costs Optimization.
- Economic Dispatch
  - Minimize the total generation operating cost (Objective function) subject to;
    - Equality Constraints; Load demand plus system losses equal to the total generation.
    - Inequality Constraints; The generator power NOT less min. and NOT more than its max. limits.

Optimization

- In practice and in power flow analysis, there are many choices for setting the operating points of generators
- In the power flow analysis, generator buses are specified by P and |V|
- There are many solution combinations for scheduling generation.

Optimization

- In practice, power plants are not located at the same distance from the load centers
- Power plants use different types of fuel, which vary in cost from time to time
- For interconnected systems, the objective is to find the real and reactive power scheduling so as to minimize some operating cost or cost function

7.3 OPERATING COST OF A THERMAL PLANT

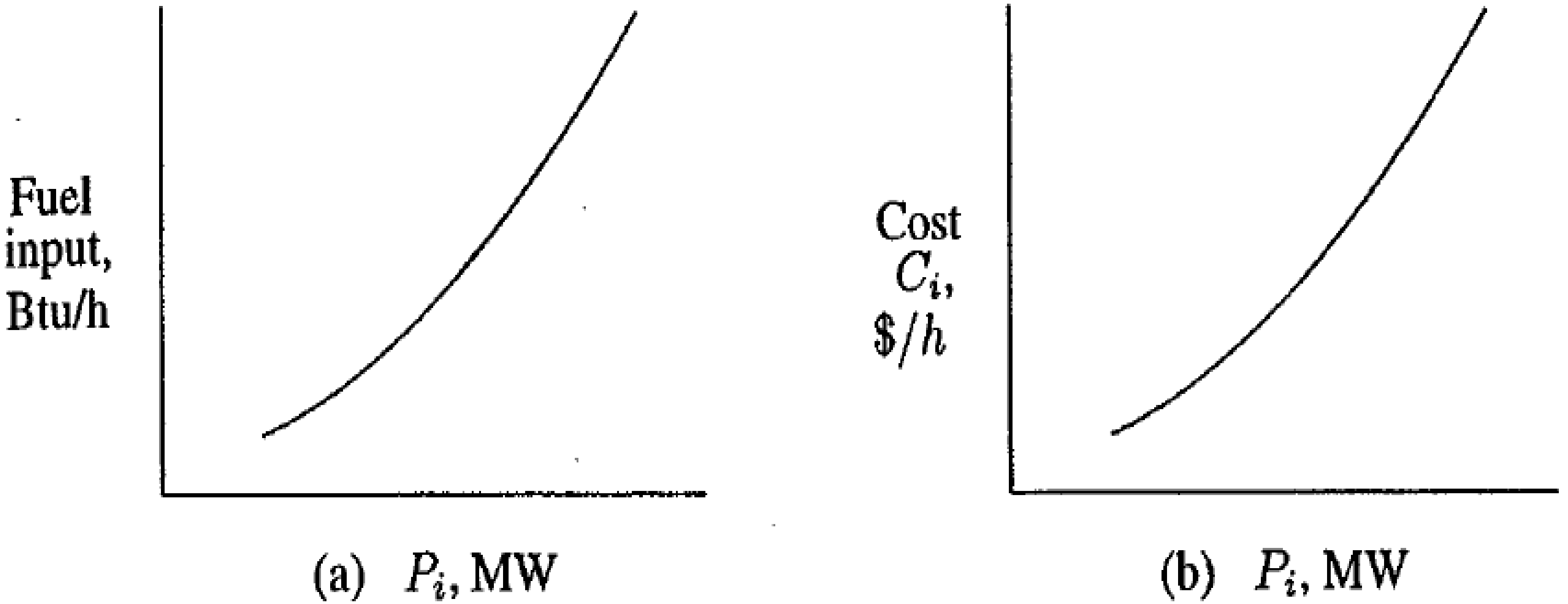

FIGURE 7.3
(a) Heat-rate curve. (b) Fuel-cost curve.

$$C_i = \alpha_i + \beta_i P_i + \gamma_i P_i^2 \quad (7.21)$$

$$\frac{dC_i}{dP_i} = 2\gamma_i P_i + \beta_i \quad (7.22)$$

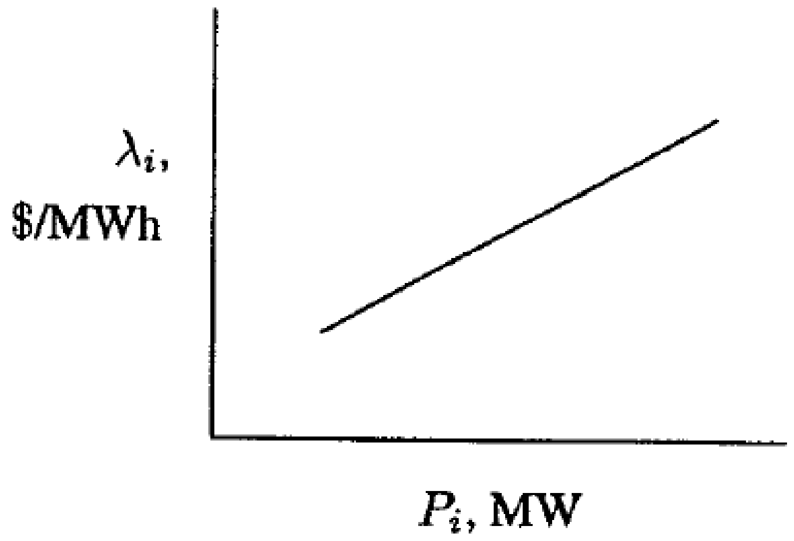

FIGURE 7.4
Typical incremental fuel-cost curve.

7.4 ECONOMIC DISPATCH NEGLECTING LOSSES AND NO GENERATOR LIMITS

The simplest economic dispatch problem is the case when transmission line losses are neglected. That is, the problem model does not consider system configuration and line impedances. In essence, the model assumes that the system is only one bus with all generation and loads connected to it as shown schematically in Figure 7.5.

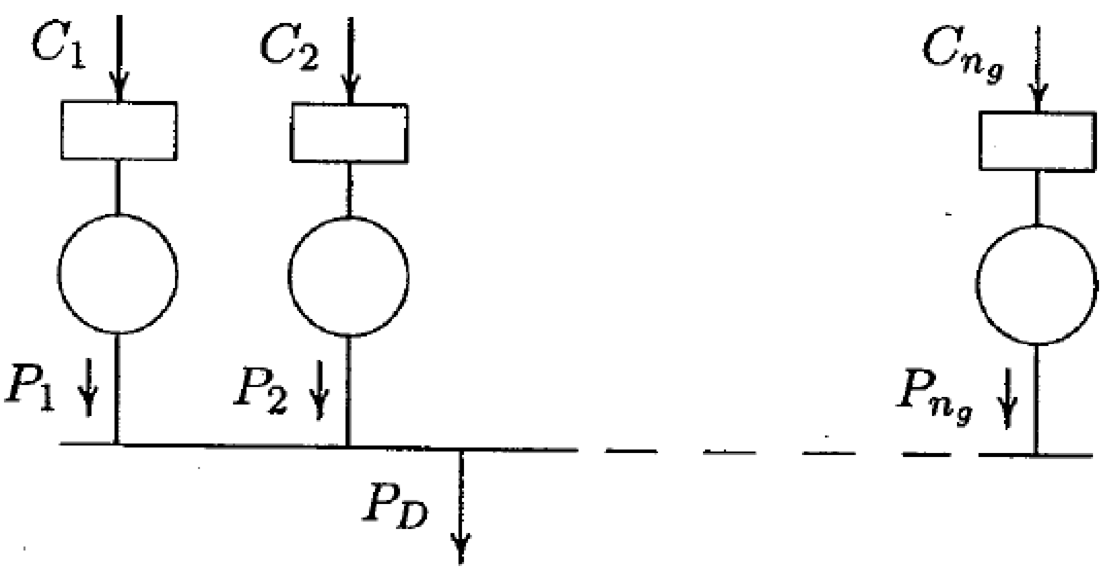

FIGURE 7.5
Plants connected to a common bus.

The simplest problem is when system losses and generator limits are neglected

Example 7.4

The fuel-cost functions for three thermal plants in \$/h are given by

$$C_1 = 500 + 5.3P_1 + 0.004P_1^2$$
$$C_2 = 400 + 5.5P_2 + 0.006P_2^2$$
$$C_3 = 200 + 5.8P_3 + 0.009P_3^2$$

where P_1, P_2, and P_3 are in MW. The total load, P_D, is 800 MW. Neglecting line losses and generator limits, find the optimal dispatch and the total cost in \$/h

(a) by analytical method using (7.33)

(b) by graphical demonstration.

(c) by iterative technique using the gradient method.

Economic Dispatch Problem

$$C_t = \sum_{i=1}^{n_g} C_i$$

$$= \sum_{i=1}^{n} \alpha_i + \beta_i P_i + \gamma_i P_i^2 \qquad (7.23)$$

is minimum, subject to the constraint

$$\sum_{i=1}^{n_g} P_i = P_D \qquad (7.24)$$

Lagrange Solution

$$\mathcal{L} = C_t + \lambda \left(P_D - \sum_{i=1}^{n_g} P_i \right) \quad (7.25)$$

$$\frac{\partial \mathcal{L}}{\partial P_i} = 0 \quad (7.26)$$

$$\frac{\partial \mathcal{L}}{\partial \lambda} = 0 \quad (7.27)$$

$$\frac{\partial C_t}{\partial P_i} + \lambda(0 - 1) = 0$$

Since

$$C_t = C_1 + C_2 + \cdots + C_{n_g}$$

then

$$\frac{\partial C_t}{\partial P_i} = \frac{dC_i}{dP_i} = \lambda$$

and therefore the condition for optimum dispatch is

$$\boxed{\frac{dC_i}{dP_i} = \lambda \qquad i = 1, \ldots, n_g} \tag{7.28}$$

or

$$\boxed{\beta_i + 2\gamma_i P_i = \lambda} \tag{7.29}$$

$$P_i = \frac{\lambda - \beta_i}{2\gamma_i} \tag{7.31}$$

$$\sum_{i=1}^{n_g} \frac{\lambda - \beta_i}{2\gamma_i} = P_D \tag{7.32}$$

or

$$\lambda = \frac{P_D + \sum_{i=1}^{n_g} \frac{\beta_i}{2\gamma_i}}{\sum_{i=1}^{n_g} \frac{1}{2\gamma_i}} \tag{7.33}$$

The simplest problem is when system losses and generator limits are neglected

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The fuel-cost functions for three thermal plants in \$/h are given by

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where P_1, P_2, and P_3 are in MW. The total load, P_D, is 800 MW. Neglecting line losses and generator limits, find the optimal dispatch and the total cost in \$/h

(a) by analytical method using (7.33)

(b) by graphical demonstration.

(c) by iterative technique using the gradient method.

7.5 ECONOMIC DISPATCH NEGLECTING LOSSES AND INCLUDING GENERATOR LIMITS

$$P_{i(min)} \leq P_i \leq P_{i(max)} \qquad i = 1, \ldots, n_g \tag{7.40}$$

$$\begin{aligned} \frac{dC_i}{dP_i} &= \lambda && \text{for} \quad P_{i(min)} < P_i < P_{i(max)} \\ \frac{dC_i}{dP_i} &\leq \lambda && \text{for} \quad P_i = P_{i(max)} \\ \frac{dC_i}{dP_i} &\geq \lambda && \text{for} \quad P_i = P_{i(min)} \end{aligned} \tag{7.41}$$

Iterative solution

Assume $\lambda^{(1)}$ = the integer value of max. β_i, then calculate $P_i^{(1)}$

$$\Delta P^{(k)} = P_D - \sum_{i=1}^{n_g} P_i^{(k)} \tag{7.39}$$

$$\Delta \lambda^{(k)} = \frac{\Delta P^{(k)}}{\sum \frac{1}{2\gamma_i}} \tag{7.37}$$

$$\lambda^{(k+1)} = \lambda^{(k)} + \Delta \lambda^{(k)} \tag{7.38}$$

The ~~simplest~~ problem when the system with generator limits and losses are neglected

Example 7.6

Find the optimal dispatch and the total cost in \$/h for the thermal plants of Example 7.4 when the total load is 975 MW with the following generator limits (in MW):

$$\boxed{\begin{aligned} 200 &\le P_1 \le 450 \\ 150 &\le P_2 \le 350 \\ 100 &\le P_3 \le 225 \end{aligned}}$$


Thanks


Any Questions...
Just Ask!