$$L = F_T + \lambda(P_D - \sum_{i=1}^{n_g} P_{Gi} - P_L)$$

The minimum point is obtained when

$$\frac{\partial L}{\partial P_{Gi}} = \frac{\partial F_T}{\partial P_{Gi}} - \lambda(1 - \frac{\partial P_L}{\partial P_{Gi}}) = 0 \qquad i=1,2,\ldots\ldots\ldots\ldots n_g$$

$$\frac{\partial L}{\partial \lambda} = P_D - \sum_{i=1}^{n_g} P_{Gi} - P_L = 0 \qquad \text{(same as the constraint)}$$

Since $$\frac{\partial F_T}{\partial P_{Gi}} = \frac{dF_i}{dP_{Gi}}$$

$$\frac{dF_i}{dP_{Gi}} + \lambda \frac{dP_L}{dP_{Gi}} = \lambda$$

$$\lambda = \frac{dF_i}{dP_{Gi}} \left(\frac{1}{1 - \frac{dP_L}{dP_{Gi}}} \right)$$

The term $\frac{1}{1 - \frac{dP_L}{dP_{Gi}}}$ is called the penalty factor of plant *i*, L_i. The coordination equations including losses are given by

$$\lambda = \frac{dF_i}{dP_{Gi}} L_i \qquad i=1,2,\ \ldots\ldots\ldots\ldots, n_g$$

The minimum operation cost is obtained when the product of the incremental fuel cost and the penalty factor of all units is the same, when losses are considered.

A rigorous general expression for the loss P_L is given by

$$P_L = \sum_m \sum_n P_{Gm} B_{mn} P_{Gn}$$

Where B_{mn} is called loss coefficient, depends on load composition.

For a two plant system

$$P_L = B_{11}P_{G1} + 2P_{G1}B_{12}P_{G2} + B_{22}P_{G2} \qquad \text{as } B_{12}=B_{21}$$

AUTOMATIC LOAD DISPATCH

Economic load dispatching is that aspect of power system operation wherein it is required to distribute the load among the generating units actually paralleled with the system in such a manner as to minimize the cost of supplying the minute to minute requirements of the system. In a large interconnected system it is humanly impossible to calculate and adjust such generations and hence the help of digital computer system along with analogue devices is sought and the whole process is carried out automatically; hence called automatic load dispatch. The objective of automatic load dispatch is to minimise the cost of supplying electricity to the load points while ensuring security of supply against loss of generation and transmission capacity and also maintaining the voltage and frequency of the system within specified limits. Since the interconnection is growing bigger and bigger in size with time, the control engineer has to make adjustments to various parameters in the system. Hence automatic control of load dispatch problem is required. The chosen control system is invariably based on a digital computer working on-line.

The components for automatic load dispatching are

Computer-The computer predicts the load and suggests economic loading. It transmits information to machine controller.

$$P_{Hj}^{\max} \geq P_{loadj} \qquad \text{j=1,2,.........j}_{\max}$$

The energy available from the hydroplant is insufficient to meet the load.

$$\sum_{j=1}^{j_{\max}} P_{Hj} n_j \leq \sum_{j=1}^{j_{\max}} P_{loadj} n_j \qquad n_j \text{ is the no of hours in period j}$$

$$\sum_{j=1}^{j_{\max}} n_j = T_{\max} = \text{Total Interval}$$

Steam plant energy required is

$$\sum_{j=1}^{j_{\max}} P_{loadj} n_j - \sum_{j=1}^{j_{\max}} P_{Hj} n_j = E$$

Where $E = \sum_{j=1}^{N_s} P_{sj} n_j$ $\qquad$ N_s is the no of periods the steam plant is on

$$\sum_{j=1}^{N_s} n_j \leq T_{\max}$$

So the scheduling problem and the constraint are

$$\text{Min } F_T = \sum_{j=1}^{N_s} F(P_{sj}) n_j$$

$$\text{Subject to } \sum_{j=1}^{N_s} P_{sj} n_j - E = 0$$

Lagrange function is $\qquad L = \sum_{j=1}^{N_s} F(P_{sj}) n_j + \alpha\left(E - \sum_{j=1}^{N_s} P_{sj} n_j\right)$

$$\frac{\partial L}{\partial P_{sj}} = \frac{dF(P_{sj})}{dP_{sj}} - \alpha = 0 \qquad \text{for j=1,2,...............N}_s$$

$$\frac{dF(P_{sj})}{dP_{sj}} = \alpha$$