# Economic Load Dispatch

# 9

It deals with allocation of the loads amongst the various units in the service, in such a way that total cost of the generation is minimum. Economic scheduling is an optimization problem.

**Objective function:** Min($\Sigma$ $C_i$ ($P_i$)) subjected to the satisfaction of equality/inequality constraints.

- KVA loading on Generator = $\sqrt{P_p^2 + Q_p^2}$

  where, $P_p$ = Generator active power

  $Q_p$ = Generator reactive power

## Generator Constraints

- KVA loading on a generator should not exceed a prespecified value $C_p$ because of the temperature rise condition.

$$\boxed{P_p^2 + Q_p^2 \le C_p^2}$$

- Maximum active power generator of a source is limited by thermal consideration and minimum power generation is limited by the flame instability of a boiler.

$$\boxed{P_{p\,min} \le P_p \le P_{p\,max}} \quad \boxed{Q_{p\,min} \le Q_p \le Q_{p\,max}}$$

where, $P_{p,min}$, $P_{p,max}$ = Minimum and maximum active power generation of a source.

$Q_{p,min}$, $Q_{p,max}$ = Minimum and maximum reactive power generation of a source.

## Incemental Fuel Rate

The ratio of small change in input to the corresponding small change in output is called **incremental fuel rate.**

$$\text{Incremental fuel rate} = \frac{d(\text{input})}{d(\text{output})} = \frac{dF}{dP}$$

where, F = Fuel input (Btu/hr)

P = Power output (W)

- **Incremental efficiency** = $\frac{dP}{dF}$

## Economic Dispatch

### 1. Optimum Load Dispatch by Neglecting Losses

Economic dispatch problem is defined as

$$\boxed{\text{Min } F_T = \sum_{k=1}^{n} F_k}$$

Subject to

$$\boxed{P_D = \sum_{k=1}^{n} P_k}$$

where, $F_T$ = Total fuel input to the system

$F_K$ = Fuel input to $K^{th}$ unit

$P_D$ = Total load demand

$P_K$ = Generation of $K^{th}$ unit

- Auxiliary function

$$\boxed{F = F_T + \lambda\left(P_D - \sum_{k=1}^{n} P_k\right)}$$

*Condition for optimum operation*

$$\boxed{\frac{dF_1}{dP_1} = \frac{dF_2}{dP_2} = \dots\dots = \frac{dF_n}{dP_n} = \lambda}$$

where, $\lambda$ = Lagrangian multiplier

$\frac{dF_n}{dP_n}$ = incremental production cost of plant n

$$\boxed{\frac{dF_n}{dP_n} = F_{nn} P_n + f_n}$$

where, $F_{nn}$ = Slope of incremental production cost curve

$f_n$ = Intercept of incremental production cost curve.

### 2. Optimum Load Dispatch Including Transmission Losses.

Optimal load dispatch problem is defined as

$$\boxed{\text{Min } F_T = \sum_{k=1}^{n} F_k}$$

Subject to

$$\boxed{P_D + P_L - \sum_{k=1}^{n} P_k = 0}$$

where, $P_L$ = Total loss

- Auxiliary function

$$\boxed{F = F_T + \lambda(P_D + P_L - \Sigma P_n)}$$

- Co-ordination equations

*Condition for optimal load dispatch*

$$\boxed{\frac{dF_n}{dP_n} + \lambda \frac{\partial P_L}{\partial P_n} = \lambda}$$

where, $\frac{\partial P_L}{\partial P_n}$ = Incremental transmission loss at plant n

$\lambda$ = Incremental cost of received power

## Loss Formulae

- Total Losses

$$\boxed{P_L = \sum_m \sum_n P_m B_{mn} P_n}$$

where, $P_m, P_n$ = Source loadings

$B_{mn}$ = Transmission loss coefficients

- Incremental Transmission Losses

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

- Incremental Production Cost

$$\boxed{\frac{dF_n}{dP_n} = F_{mn} P_n + f_n}$$

$$\boxed{P_n = \frac{1 - \frac{f_n}{\lambda} - 2\sum_{m \neq n} B_{mn} P_m}{\frac{F_{mn}}{\lambda} + 2B_{nn}}}$$

- Penalty Factor

$$\boxed{L_n = \frac{1}{1 - \frac{\partial P_L}{\partial P_n}}}$$

where, $L_n$ = Penalty factor of plant n

■■■■