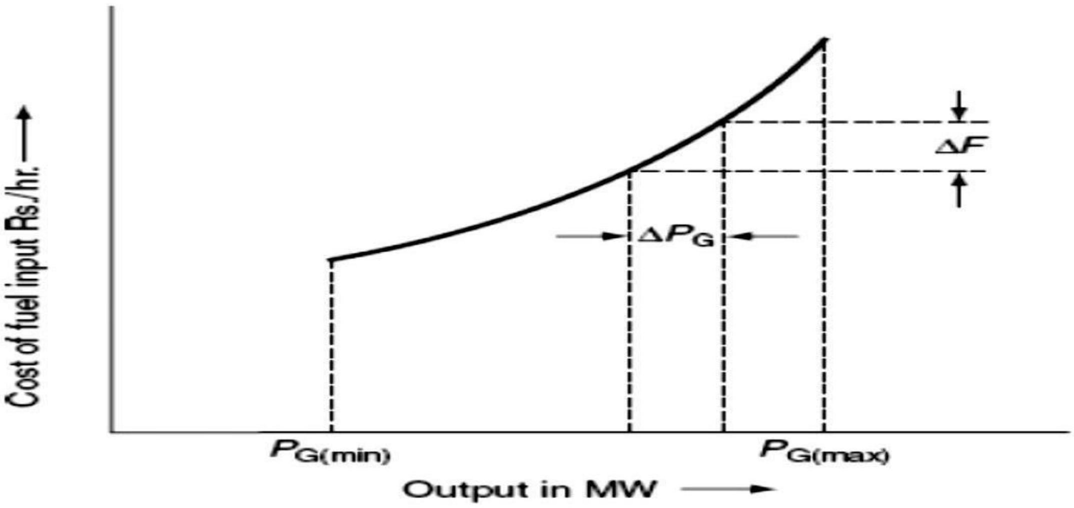
Incremental cost curve

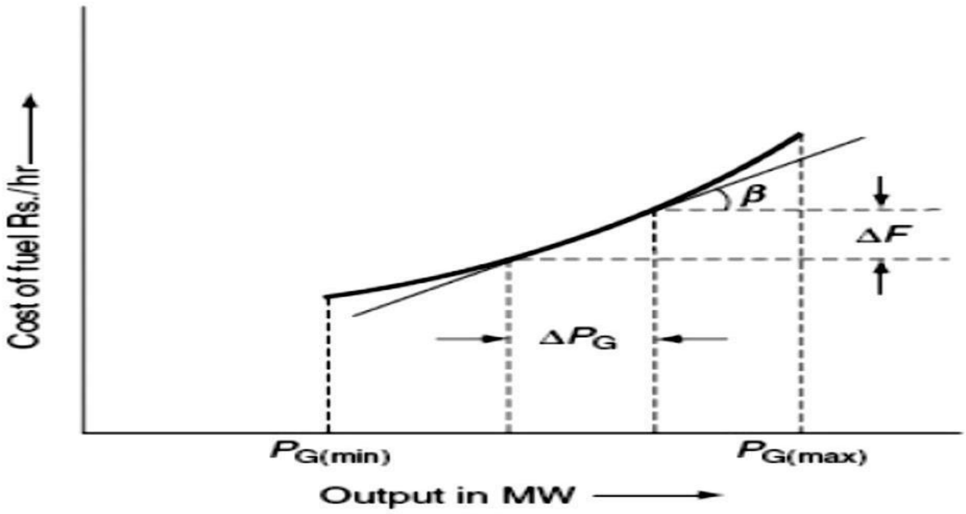
- From the input–output curves, the incremental fuel cost (IFC) curve can be obtained.
- The IFC is defined as the ratio of a small change in the input to the corresponding small change in the output

$$\text{Incremental Fuel Cost} = \frac{\text{Small Change in Input}}{\text{Small Change in Output}} = \frac{\Delta F}{\Delta P_G}$$

- where ΔF represents small changes. As the ΔP_G quantities become progressively smaller, it is seen that the IFC is $\frac{d(input)}{d(output)}$ and is expressed in Rs./MWh. A typical plot of the IFC versus output power is shown in Fig
- The incremental cost curve is obtained by considering the change in the cost of generation to the change in real power generation at various points on the input–output curves, i.e., slope of the input– output curve as shown in Fig



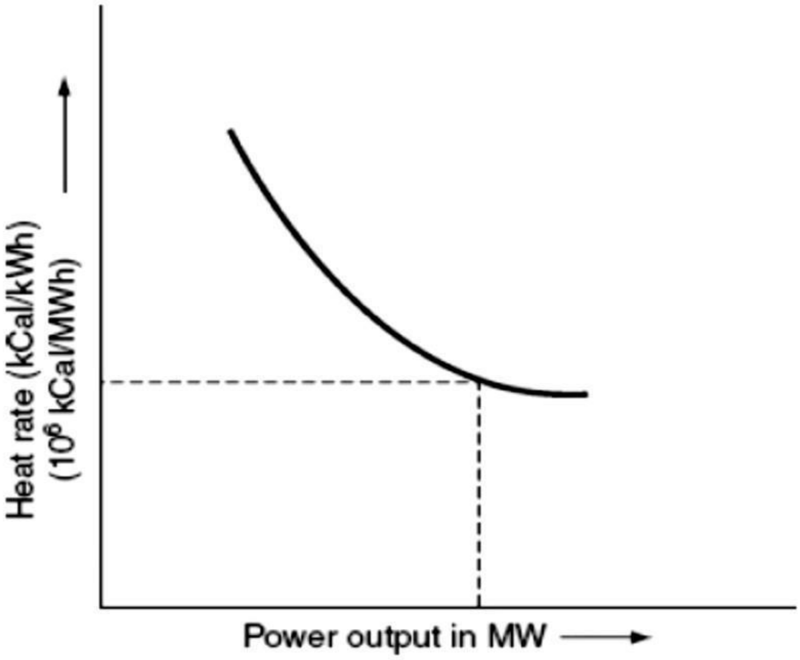
(a)



(b)

Heat Rate Curve

- The heat rate characteristic obtained from the plot of the net heat rate in Btu/kWh or kCal/kWh versus power output in kW Let Hi be the heat rate in kCal/kWh which is the heat energy obtained by the combustion of the fuel in Kcal needed to generate one unit of electric energy.



- The thermal unit is most efficient at a minimum heat rate, which corresponds to a particular generation P . The curve indicates an increase in heat rate at low and high power limits.
- Thermal efficiency of the unit is affected by the following factors: condition of steam, steam cycle used, re-heat stages, condenser pressure, etc.

$$\text{Normally, Heat Rate} = \frac{Input\ in\ Rs/Hr}{Output\ in\ MW}$$

<u>Incrémental Heat Rate:</u>

- It is the ratio of change in input to the corresponding change in output at any operating point.

$$\text{Incremental Heat Rate} = \frac{\Delta input}{\Delta output} = \frac{\Delta F}{\Delta P}$$

<u>Incremental Efficiency:</u>

- The reciprocal of the incremental fuel rate or heat rate, which is defined as the ratio of output energy to input energy, gives a measure of fuel efficiency for the input

$$\text{Incremental Efficiency} = \frac{\Delta output}{\Delta input} = \frac{\Delta \boldsymbol{P}}{\Delta \boldsymbol{F}}$$

Cost Function

Let the cost of the Fuel be K Rs/Mkcal. Then the fuel input cost $C_i(P_{Gi})$ is

$$C_i(P_{Gi}) = K\, F_i(P_{Gi})$$

Here C_i is the cost expressed in Rs/hr of producing energy in the generator unit i. $F_i(P_{Gi})$ is the Fuel Energy input

$$F_i(P_{Gi}) = P_{Gi}\, H_i\, (P_{Gi})$$

$H_i\,(P_{Gi})$ is obtained from the heat rate curve

Substitute the value of $F_i(P_{Gi})$ in $C_i(P_{Gi})$

$$C_i(P_{Gi}) = K\, P_{Gi}\, H_i\, (P_{Gi})$$

The heat rate curve can be approximated why because the initial portion of curve decrease, reaches minimum point and then increases.

$$H_i\,(P_{Gi}) = \frac{c'_i}{P_{Gi}} + b'_i + a'_i P_{Gi}$$

Where a_i, b_i and c_i are positive coefficients

Input Energy Rate $F_i(P_{Gi}) = P_{Gi}\, H_i\, (P_{Gi}) = P_{Gi}\, [\frac{c'_i}{P_{Gi}} + b'_i + a'_i P_{Gi}]$

$$= a' P^2{}_{Gi} + b'\, P_{Gi} + c'_i$$

Fuel Cost $C_i(P_{Gi}) = K\, F_i(P_{Gi})$

$$\boxed{C_i(P_{Gi}) = a P^2{}_{Gi} + b\, P_{Gi} + c_i}$$