The static pressure rise through the impeller is due to the change in centrifugal energy and the diffusion of relative velocity component. Therefore, it can be written as

$$p_2 - p_1 = (\Delta p) = \frac{1}{2}\rho(U_2^2 - U_1^2) + \frac{1}{2}\rho(V_{r1}^2 - V_{r2}^2) \qquad (39.13)$$

The stagnation pressure rise through the stage can also be obtained as:

$$(\Delta p_0) = \frac{1}{2}\rho(U_2^2 - U_1^2) + \frac{1}{2}\rho(V_{r1}^2 - V_{r2}^2) + \frac{1}{2}\rho(V_2^2 - V_1^2) \qquad (39.14)$$

From (39.13) and (39.14) we get

$$(\Delta p_0) = (\Delta p) + \frac{1}{2}\rho(V_2^2 - V_1^2) \qquad (39.15)$$

From any of the outlet velocity triangles (Fig. 39.3),

$$\frac{V_2}{\sin\beta_2} = \frac{U_2}{\sin\{\pi - (\alpha_2 + \beta_2)\}}$$

or, $$\frac{V_2}{\sin\beta_2} = \frac{U_2}{\sin(\alpha_2 + \beta_2)} \qquad (39.16)$$

or, $$V_{w2} = V_2\cos\alpha_2 = \frac{U_2\sin\beta_2\cos\alpha_2}{\sin(\alpha_2 + \beta_2)}$$

$$\frac{V_{w2}}{U_2} = \frac{\sin\beta_2\cos\alpha_2}{\sin\alpha_2\cos\beta_2 + \cos\alpha_2\sin\beta_2}$$

or, $$\frac{V_{w2}}{U_2} = \frac{\tan\beta_2}{\tan\alpha_2 + \tan\beta_2}$$

Work done per unit mass is also given by (from (39.7) and (40.4)):

$$w = U_2^2\left(\frac{\tan\beta_2}{\tan\alpha_2 + \tan\beta_2}\right) \qquad (39.17)$$

Efficiency

On account of losses, the isentropic work $\frac{1}{\rho}(\Delta p_0)$ is less than the actual work.

Therefore the stage efficiency is defined by

$$\eta_s = \frac{(\Delta p_0)}{\rho U_2 V_{w2}} \qquad (39.18)$$

Number of Blades

Too few blades are unable to fully impose their geometry on the flow, whereas too many of them restrict the flow passage and lead to higher losses. Most of the efforts to determine the optimum number of blades have resulted in only empirical relations given below

(i) $$n = \frac{8.5\sin\beta_2}{1 - D_1/D_2} \qquad (39.19)$$

(ii) $$n = 6.5\left(\frac{D_2 + D_1}{D_2 - D_1}\right)\sin\frac{1}{2}(\beta_1 + \beta_2) \qquad (39.20)$$

(iii) $$n = \frac{1}{3}\beta_2 \qquad (39.21)$$

Impeller Size

The diameter ratio (D_1/D_2) of the impeller determines the length of the blade passages. The smaller the ratio the longer is the blade passage. The following value for the diameter ratio is often used by the designers

$$\frac{D_1}{D_2} = 1.2(\varphi)^{1/3} \qquad (39.22)$$

where

$$\varphi = V_{f2}/U_2$$

The following relation for the blade width to diameter ratio is recommended:

$$b_1 / D_1 = 0.2 \qquad (39.23)$$

If the rate of diffusion in a parallel wall impeller is too high, the tapered shape towards the outer periphery, is preferable..

The typical performance curves describing the variation of head, power and efficiency with discharge of a centrifugal blower or fan are shown in Figure 39.4

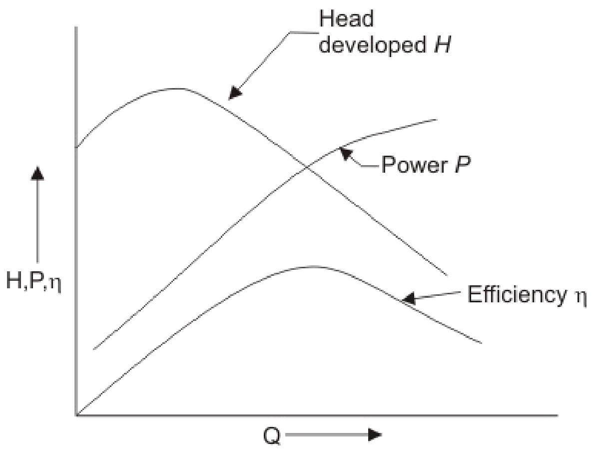

Figure39.4 Performance characteristic curves of a centrifugal blower or fan