Impulse and Reaction Machines

For an impulse machine *R = 0* , because there is no change in static pressure in the rotor. It is difficult to obtain a radial flow impulse machine, since the change in centrifugal head is obvious there. Nevertheless, an impulse machine of radial flow type can be conceived by having a change in static head in one direction contributed by the centrifugal effect and an equal change in the other direction contributed by the change in relative velocity. However, this has not been established in practice. Thus for an axial flow impulse machine $U_1 = U_2$, $V_{r_1} = V_{r_2}$. For an impulse machine, the rotor can be made open, that is, the velocity V_1 can represent an open jet of fluid flowing through the rotor, which needs no casing. A very simple example of an impulse machine is a paddle wheel rotated by the impingement of water from a stationary nozzle as shown in Fig.2.1a.

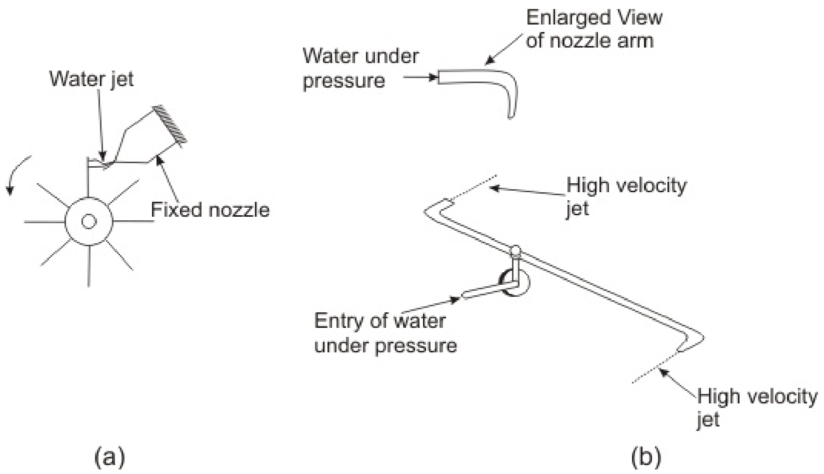

Fig 2.1 (a) Paddle wheel as an example of impulse turbine

(b) Lawn sprinkler as an example of reaction turbine

A machine with any degree of reaction must have an enclosed rotor so that the fluid cannot expand freely in all direction. A simple example of a reaction machine can be shown by the familiar lawn sprinkler, in which water comes out (Fig. 2.1b) at a high velocity from the rotor in a tangential direction. The essential feature of the rotor is that water enters at high pressure and this pressure energy is transformed into kinetic energy by a nozzle which is a part of the rotor itself.

In the earlier example of impulse machine (Fig. 2.1a), the nozzle is stationary and its function is only to transform pressure energy to kinetic energy and finally this kinetic energy is transferred to the rotor by pure impulse action. The change in momentum of the fluid in the nozzle gives rise to a reaction force but as the nozzle is held stationary, no energy is transferred by it. In the case of lawn sprinkler (Fig. 2.1b), the nozzle, being a part of the rotor, is free to move and, in fact, rotates due to the reaction force caused by the change in momentum of the fluid and hence the word ***reaction machine*** follows.

Efficiencies

The concept of efficiency of any machine comes from the consideration of energy transfer and is defined, in general, as the ratio of useful energy delivered to the energy supplied. Two efficiencies are usually considered for fluid machines-- the hydraulic efficiency concerning the energy transfer between the fluid and the rotor, and the overall efficiency concerning the energy transfer between the fluid and the shaft. The difference between the two represents the energy absorbed by bearings, glands, couplings, etc. or, in general, by pure mechanical effects which occur between the rotor itself and the point of actual power input or output.

Therefore, for a pump or compressor,

$$\eta_{hydraulic} = \eta_h = \frac{\begin{array}{l}\textit{useful energy gained by the fluid} \\ \textit{at final discharge}\end{array}}{\textit{mechanical energy supplied to rotor}} \qquad (2.4a)$$

$$\eta_{overall} = \frac{\begin{array}{l}\textit{useful energy gained by the fluid} \\ \textit{at final discharge}\end{array}}{\begin{array}{l}\textit{mechanical energy supplied to} \\ \textit{shaft at coupling}\end{array}} \qquad (2.4b)$$

For a turbine,

$$\eta_h = \frac{\textit{mechanical energy delivered by the rotor}}{\textit{energy available from the fluid}} \qquad (2.5a)$$

$$\eta_{overall} = \frac{\begin{array}{l}\textit{mechanical energy in output shaft} \\ \textit{at coupling}\end{array}}{\textit{energy available from the fluid}} \qquad (2.5b)$$

The ratio of rotor and shaft energy is represented by mechanical efficiency η_m .

Therefore

$$\eta_m = \frac{\eta_{overall}}{\eta_h} \tag{2.6}$$