Specific speed (N_s) :- dependent only on Shape

It is the speed of a turbine at which it would produce unit power when working under unit head. It is independent of size and use to select the type or shape of the runner (turbine)

$\rightarrow$ H , N, Q
P

$\rightarrow$ Velocity $\propto \sqrt{H}$
$\rightarrow$ Area $\propto D^2$

shaft power = $P = \eta_o \rho g Q H$

$$P \propto QH$$

$$P \propto [\underbrace{D^2}_{\text{Can not be taken as Const.}} \sqrt{H}] . H$$

$Q = A_f . V_f$

$A_f \propto D^2$

$V_f \propto \sqrt{H}$

$Q \propto D^2 . \sqrt{H}$

$u \propto \sqrt{H}$

$$u = \pi D N / 60$$

$$\boxed{u \propto DN \propto \sqrt{H}}$$

~~DH~~ $DN \propto \sqrt{H}$

$$D \propto \frac{\sqrt{H}}{N}$$

$$P \propto \left[\left(\frac{\sqrt{H}}{N} \right)^2 \cdot \sqrt{H} \right] H$$

$$\boxed{P = \frac{K \cdot H^{5/2}}{N^2}}$$

specific speed depends on no. of jet

$$N_s = \frac{N\sqrt{P}}{(H)^{5/4}}$$

if No. of Jet n in pelton wheel

$$N_s = \frac{N\sqrt{nP}}{(H)^{5/4}}$$

$$\boxed{N_s \propto \sqrt{n}}$$

N_s is define as

H = unit power = 1 m

SP = P = unit power

$\boxed{N = N_s}$ $P = 1\,kW$ (SI)

$P = 1\,HP$ (MKS)

$1\,HP = 735.5$ watt

$$\rightarrow \quad 1 = \frac{K \cdot 1^{5/2}}{N_s^2} \quad \Rightarrow \quad K = N_s^2$$

$$P = \frac{N_s^2 H^{5/2}}{N^2}$$

$$\boxed{N_s = \frac{N\sqrt{P}}{H^{5/4}}}$$

$N_s = 200$ (SI)

$= 200$ (MKS)

Specific Speed :- Turbine

- 0 – 60 ⟶ Pelton wheel
  - 0 – 30 ⟶ Single jet
  - 30 – 60 ⟶ Multi Jet.
- 60 – 300 ⟶ Francis
- 300 – 1000 ⟶ Kaplan & propeller
  - 300 – 600 ⟶ propeller
  - 600 – 1000 ⟶ kaplan

Model - Protype :- (diff. turbine)

Head Coefficient

$$u \propto DN \propto \sqrt{H}$$

$$H \propto D^2 N^2$$

$$\left.\frac{H}{D^2 N^2}\right|_M = \text{Constant} = \left.\frac{H}{D^2 N^2}\right|_P .$$

Discharge Coefficient

$$Q \propto D^2 . V_f \propto D^2 . \sqrt{H} \propto D^2 . DN$$

$$Q \propto D^3 N$$

$$\left.\frac{Q}{D^3 N}\right|_M = \text{Constant} = \left.\frac{Q}{D^3 N}\right|_P$$

Power Coefficient:

$$P \propto QH \propto D^3 . N . D^2 N^2$$

$$P \propto D^5 N^3$$

$$\left.\frac{P}{D^5 N^3}\right|_M = \text{Constant} = \left.\frac{P}{D^5 N^3}\right|_P$$

Specific speed $\boxed{N_s\big|_M = N_s\big|_P}$

$$\boxed{\frac{H}{D^2 N^2}, \quad \frac{Q}{D^3 N}, \quad \frac{P}{D^5 N^3}}$$

Unit Quantity:- (same turbine)

Unit quanity are the parameter of turbine which is define when turbine operates under unit head, used to calculate speed, discharge & power (N, Q, P) for same turbine under diff. heads.

$N, P, \underline{Q}$

T → η - max

→ Head same

$H = 1\,m$

→ Unit speed (N_u)

→ Unit Discharge (Q_u)

→ Unit power (P_u)

Unit speed

$$U \propto \underbrace{D}_{\text{Can be taken as Constant}} N \propto \sqrt{H}$$

$$N \propto \sqrt{H}$$

$$\frac{N}{\sqrt{H}} = k = \text{Const.}$$

For $H = 1\,m$ $\quad N \rightarrow N_u$

$$\frac{N_u}{\sqrt{1}} = k \Rightarrow k = N_u$$

$$\frac{N}{\sqrt{H}} = N_u = \text{Const.}$$

$$\boxed{\frac{N_1}{\sqrt{H_1}} = \frac{N_2}{\sqrt{H_2}}}$$

Unit discharge:-

$$Q \propto D^2 . V_f \propto \underbrace{D^2}_{\text{Const.}} \sqrt{H} \propto \sqrt{H}$$

$$\frac{Q}{\sqrt{H}} = k = \text{Const}$$

For $H = 1\,m$

$$Q_u = K$$

$$\boxed{\frac{Q_1}{\sqrt{H_1}} = \frac{Q_2}{\sqrt{H_2}}}$$

Unit power:

$$P \propto QH \propto \sqrt{H} \cdot H$$

$$P \propto H^{3/2}$$

$$\frac{P}{H^{3/2}} = K = \text{Constant}$$

for $H = 1\,m$ $\quad P \rightarrow P_u$

$$\frac{P_u}{\sqrt[3]{1}} = K \quad \Rightarrow K = P_u$$

$$\frac{P}{H^{3/2}} = P_u$$

$$\boxed{\frac{P_1}{H_1^{3/2}} = \frac{P_2}{H_2^{3/2}}}$$

*

Q.10

$$\left.\frac{N\sqrt{P}}{H^{5/4}}\right|_A = \left.\frac{N\sqrt{P}}{H^{5/4}}\right|_B$$

$$1000\sqrt{400} = N_B\sqrt{100}$$

$$N_B = 2000 \text{ rpm}$$

Q.12

A – 1

B – 4

C – 5

D – 2

Q.13

$$\frac{P_1}{(H_1)^{3/2}} = \frac{P_2}{(H_2)^{3/2}} \Rightarrow \cancel{60\left(\frac{40}{8}\right)^{3/2}} =$$

$$\frac{\sqrt{60}}{(8)^{5/4}} = \frac{\sqrt{P}}{(40)^{5/4}}$$

Q.15

$$\frac{P}{H^{3/2}} = k \Rightarrow \frac{1000}{(40)^{3/2}} = \frac{P}{(20)^{3/2}}$$

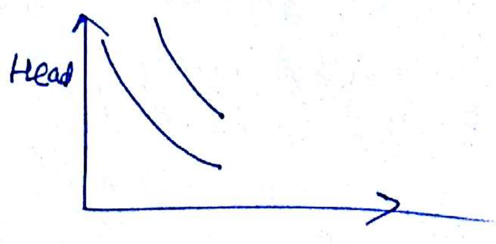
$$P_2 = 353.55 \text{ kW}$$

Q.18

$$N_s = \frac{145\sqrt{7000}}{(25)^{5/4}} = 217, \text{ Francis}$$

Q.23

$$N_s \propto \frac{1}{H^{5/4}}$$



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(P)	(M)
$P_1 = 300$ KW	P_2
$N_1 = 1000$ rpm	$N_2 = 500$
$H_1 = 40$	$H_2 = 10$

$$\frac{D_M}{D_p} = \frac{1}{4}$$

$$\cancel{\frac{1000}{\sqrt{40}} = \frac{N_2}{\sqrt{10}}}$$

$$\cancel{N_2 = 500}$$

$$\cancel{\frac{1000\sqrt{300}}{(40)^{5/4}} = \frac{500\sqrt{P}}{(10)^{5/4}}}$$

$$\cancel{P = 37.5}$$

$$\cancel{P = \frac{37.5}{4} = 9.375}$$

$$\left.\frac{P}{D^5 N^3}\right|_M = \left.\frac{P}{D^5 N^3}\right|_P$$

$$P_m = \left(\frac{D_M}{D_p}\right)^5 \times \left(\frac{N_m}{N_p}\right)^3 \times P_p$$

$$\left.\frac{H}{D^2 N^2}\right|_M = \left.\frac{H}{D^2 N^2}\right|_P$$

$$\frac{H_m}{H_p} \times \left(\frac{D_p}{D_m}\right)^2 \times N_p^2 = N_m^2$$

$$\frac{10}{40}(4)^2 \times 1000^2 = N_m$$

$$N_m = 2000 \text{ rpm}$$

$$P_m = \left(\frac{1}{4}\right) \times \left(\frac{2000}{1000}\right)^3 \times 300 \Rightarrow P_M = 2.34 \text{ KW}$$