	Model	Prototype
N	250 rpm	375 rpm
Q		15 m^3/s
H	2 m	35 m

$$\pi_1 = \frac{Q}{ND^3} \qquad \pi_2 = \frac{gH}{N^2D^2}$$

$$\left(\frac{gH}{N^2D^2}\right)_p = \left(\frac{gH}{N^2D^2}\right)_m$$

$$\left(\frac{D_p}{D_m}\right)^2 = \left(\frac{N_m}{N_p}\right)^2 \times \frac{H_p}{H_m} = \left(\frac{250}{375}\right)^2 \times \frac{35}{2} =$$

$$\frac{D_p}{D_m} = 2.79$$

$$\left(\frac{Q}{ND^3}\right)_p = \left(\frac{Q}{ND^3}\right)_m$$

$$Q_m = Q_p \times \frac{N_m}{N_p} \times \frac{D_m^3}{D_p^3}$$

$$= 15 \times \frac{250}{375} \times \left(\frac{1}{2.79}\right)^3 \quad m^3/s$$

$$= 0.46 \ m^3/s$$

$$P_m = (\rho Q g H)_m$$

$$= 1000 \times 0.46 \times 9.81 \times 2 \quad W$$

$$= 9.03 \ kW$$

$$P_p = (\rho Q g H)_p \qquad \pi_3 = \frac{P}{\rho N^3 D^5}$$

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Specific speed model $N_{ST} = N \dfrac{\sqrt{P}}{\sqrt{\rho}\,(gH)^{5/4}}$ rps

$$= \frac{250}{60} \times \frac{\sqrt{9030}}{\sqrt{1000} \times (9.81 \times 2)^{5/4}} \text{ rps}$$

$$= 0.303$$

Prototype $N_{ST} = N \dfrac{\sqrt{P}}{\sqrt{\rho}\,(gH)^{5/4}}$

$$= \frac{375}{60} \frac{\sqrt{5157000}}{\sqrt{1000}\,(9.81 \times 35)^{5/4}}$$

$$= 0.304$$

SFEE

22/8/2017

$$\dot{Q} - \dot{W} = \dot{m}\left(h + \frac{V^2}{2} + gz\right)_2 - \dot{m}\left(h + \frac{V^2}{2} + gz\right)_1$$

$$\dot{m}_1 = \dot{m}_2 = \dot{m}$$

$$q - w = \left(h + \frac{V^2}{2} + gz\right)_2 - \left(h + \frac{V^2}{2} + gz\right)_2$$

$\frac{J}{kg}$ or $\frac{W}{kg/s}$

$$h_0 = h + \frac{V^2}{2}$$

stagnation, total, dynamic

$$C_p T_0 = C_p T + \frac{V^2}{2}$$

$$T_0 = T + \frac{V^2}{2C_p}$$

$V = 150$ m/s $\quad C_p = 1.005$ kJ/kgK $\quad T = 1050$ K

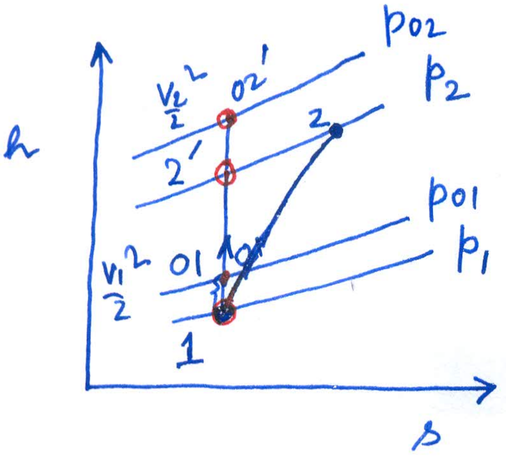
$$a = \sqrt{\gamma R T}$$

$$= \sqrt{1.4 \times 287 \times 1050} \text{ m/s}$$

$$=$$

$M = \frac{V}{a} = 0.23 \qquad M < 0.3$

$$\Delta p \propto M^2$$



$$q - w = (h + \frac{v^2}{2} + gz)_2 - (h + \frac{v^2}{2} + gz)_1$$

$$q = 0$$

$$-w = (h + \frac{v^2}{2} + gz)_2 - (h + \frac{v^2}{2} + gz)_1$$

$$\eta_c = \frac{h_2' - h_1}{h_2 - h_1}$$

$$-w = h_2' - h_1$$

$$(\eta_c)_{t-t} = \frac{h_{02}' - h_{01}}{h_{02} - h_{01}}$$

$$\boxed{-w = h_{02}' - h_{01}}$$ reversible

for stage between first stage and last stage

$$p_{01} = p_1 + \frac{\rho V_1^2}{2}$$

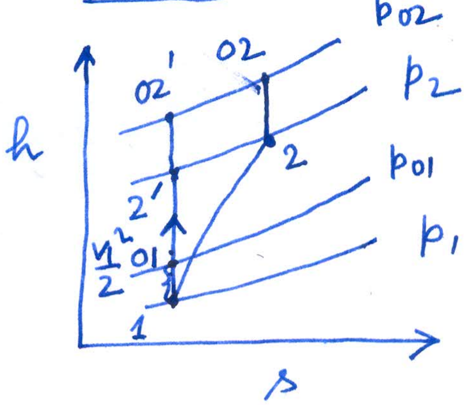
$$p_{02} = p_2 + \frac{\rho V_2^2}{2}$$

$$(\eta_c)_{t-s} = \frac{h_2' - h_{01}}{h_{02} - h_{01}}$$

last stage

$$\boxed{-w = h_{02} - h_{01}}$$ actual

$$(\eta_c)_{s-s} = \frac{h_2' - h_1}{h_{02} - h_{01}}$$



$$w = h_{02} - h_{01} = \frac{h_{02}' - h_{01}}{(\eta_c)_{t-t}}$$

$$= \frac{c_p (T_{02}' - T_{01})}{(\eta_c)_{t-t}}$$

$$\frac{T_2'}{T_1} = \left(\frac{p_2}{p_1}\right)^{\frac{\gamma-1}{\gamma}}$$

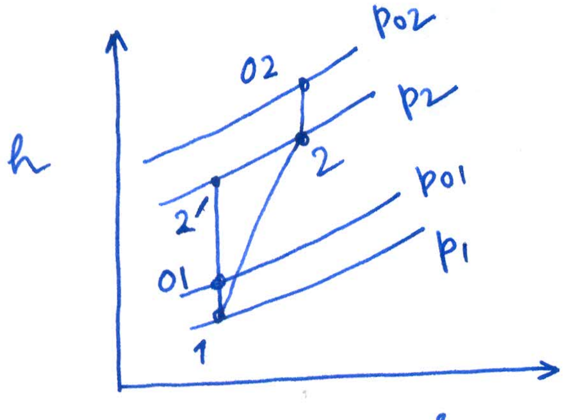
$$\frac{T_{02}'}{T_{01}} = \left(\frac{p_{02}}{p_{01}}\right)^{\frac{\gamma-1}{\gamma}}$$

$$= \frac{c_p T_{01}\left[\left(\frac{T_{02}'}{T_{01}}\right) - 1\right]}{(\eta_c)_{t-t}}$$

$$= \frac{c_p T_{01}\left[\left(\frac{p_{02}}{p_{01}}\right)^{\frac{\gamma-1}{\gamma}} - 1\right]}{(\eta_c)_{t-t}}$$

EX In an air compressor, the static pressure and static temperature at inlet are 100 kPa and 27°C respectively. The ratio of the outlet pressure to inlet pressure is 2. The required compressor work is 90 kW and mass flow rate is 1 kg/s. The air velocity at inlet is 20 m/s whereas the air velocity at outlet is 120 m/s. (a) Draw the process in an enthalpy-entropy identifying the state points. ~~(b) if~~ Find out the compressor efficiency (b) if the compressor is located in an intermediate stage, (c) last stage of a multistage compressor, (d) inlet and exit Mach number.

$\gamma = 1.4$, $c_p = 1.005$ kJ/kg-K $R = 287$ J/kg-K



$p_1 = 100$ kPa

$T_1 = 27°C = 300$ K

$V_1 = 20$ m/s

$\frac{p_2}{p_1} = 2$, $p_2 = 200$ kPa

$$\eta_{t-t} = \frac{h_{02}' - h_{01}}{h_{02} - h_{01}}$$

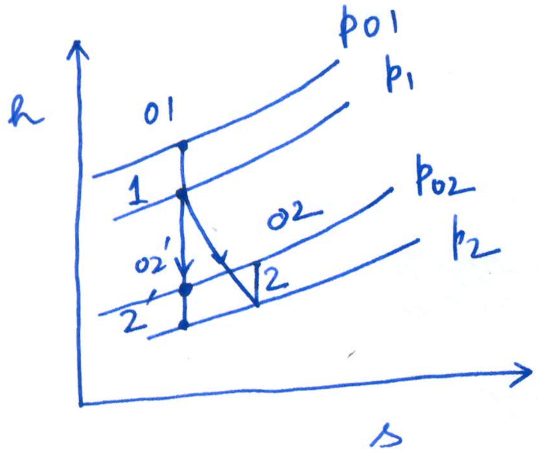
$$= \frac{\left(h_2' + \frac{V_2^2}{2}\right) - \left(h_1 + \frac{V_1^2}{2}\right)}{90}$$

$= 1.004 \times 365 + \frac{120^2}{2 \times 1000} -$

$$\frac{T_2'}{T_1} = \left(\frac{p_2}{p_1}\right)^{\frac{\gamma-1}{\gamma}} = 2^{\frac{1.4-1}{1.4}}$$

$T_2' = 365.$ K

Turbine



$$(\eta_t)_{t-t} = \frac{h_{01} - h_{02}}{h_{01} - h_{02'}}$$