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Section-7

Q1

Ans → **Solution:-**

From steam tables, enthalpy at inlet to nozzle,

$h_0 = h_{g \text{ at } 15 \text{ bar}} = 2792.2 \text{ kJ/kg}$

Entropy, $S_0 = S_{g \text{ at } 15 \text{ bar}} = 6.4448 \text{ kJ/kg.K}$

Let dryness fraction at exit of nozzle be x_1 at 8 bar.

For isentropic expansion, $S_1 = 6.4448 \text{ kJ/kg.K}$

$S_1 = 6.4448 = S_{f \text{ at } 8 \text{ bar}} + x_1 \times S_{fg \text{ at } 8 \text{ bar}}$

$6.4448 = 2.0462 + (x_1 \times 4.6166)$

$\boxed{x_1 = 0.9528}$

$h_1 = h_{f \text{ at } 8 \text{ bar}} + x_1 \times h_{fg \text{ at } 8 \text{ bar}}$

$= 721.11 + (0.9528 \times 2048)$

$\boxed{h_1 = 2672.44 \text{ kJ/kg}}$

- Isentropic heat drop in nozzle $= (h_0 - h_1)$

$= 119.76 \text{ kJ/Kg}$

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- velocity at exit of nozzle, $C_1 = \sqrt{2(h_0 - h_1) + C_0^2}$

$$= \sqrt{2(119.76 \times 10^3 \times 0.9) + (150)^2}$$

$$\boxed{C_1 = 487.92 \text{ m/s}}$$

- For max. diagram efficiency the blade velocity can be obtained by,

$$\rho = \frac{\cos\alpha_1}{2} \Rightarrow \frac{U}{C_1} = \frac{\cos\alpha_1}{2}$$

$$U = 487.92 \times \frac{\cos 15}{2} \Rightarrow \boxed{U = 229.25 \text{ m/s}}$$

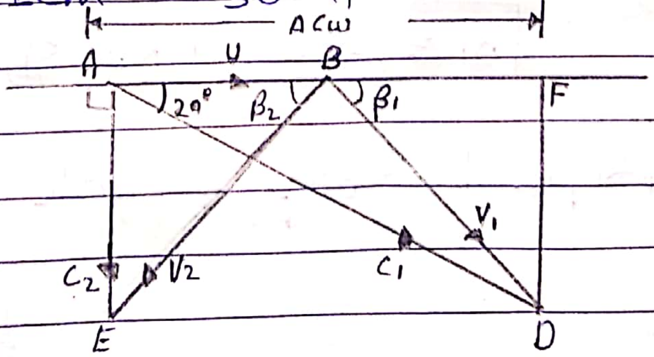
- velocity diagram is drawn considering $C_1 = 487.92$ m/s

$U = 229.25$ m/s

$\alpha = 20^\circ$

$\beta_1 = \beta_2$

Scale 1 cm = 50 m/s



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- From velocity diagram, length BD = 5.7 cm

i.e. $V_1 = 285$ m/s

- Since blades are smooth so,

$V_1 = V_2$

$C_2 = 150$ m/s (= length AE)

$\Delta C_w = 455$ m/s (= length AF)

$V_2 = 285$ m/s

$\beta_1 = 36° = \beta_2$

Blade angle at inlet = 36°
Blade angle at exit = 36°

Ans

- Work done per kg of steam, $U \cdot \Delta C_w$ =

(229.25×455)

$= 104.31 \times 10^3$ kJ/kg

- Kinetic energy supplied per kg of steam

$$= \frac{C_1^2}{2} = \frac{(487.92)^2}{2}$$

$= 119.03 \times 10^3$ J/kg

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- Blade Efficiency $= \frac{104.31 \times 10^3}{119.03 \times 10^3} = 0.8763$

Ans.

- Stage Efficiency = $\frac{\text{work done per kg of steam}}{\text{Energy supplied per kg of steam to stage}}$

$$= \frac{104.31 \times 10^3}{\left\{119.76 \times 10^3 + \frac{(150)^2}{2}\right\}}$$

$= 0.7962$

So,

Blading Efficiency = 87.63 %
Stage efficiency = 79.62 %

Ans.

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