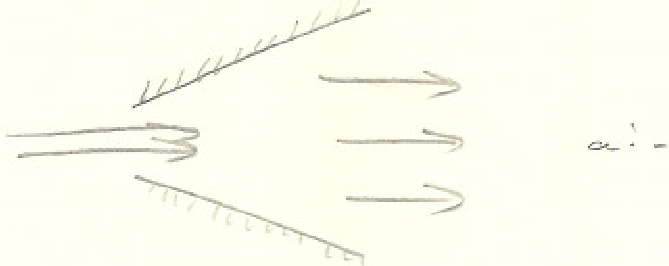
EX.

consider difuser device shown. A device that increases the pressure of a fluid by



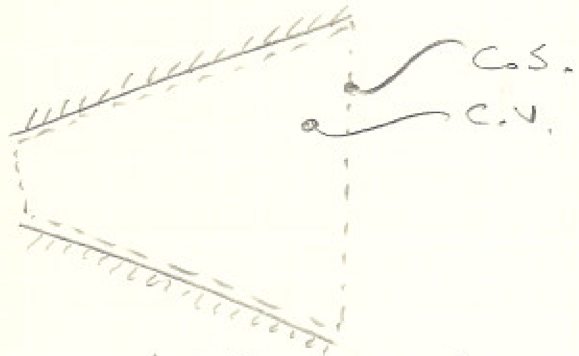
Aire enters the diffuser steadily with a velocity of 200 m/s. The inlet area of the difuser is 0.4 m². The air exits the difuser with a negligible velocity (comperied to the inlet. The inlet pressure and tempertuse of air are 80 kPa & 10°c

Determine the mass flow rate of air, $\dot{m}_{air} = ?$ and the tempertune of the air leaving the difuser.

ANALYSIS:

the difuser is a C.V. since mass flow across the control surface.

the flow here is a single stream (one inlet) (one exit)



The flow here occurs steadily (no change in time as given in the problem) so SSSF.

This difuser here is an adibatic walls (given). No work is involved.

Negligible or no change in elevation of flow.

Inlet Conditions	Outlet
$P_1 = 80$ kPa	$V_2 \cong 0$
$T_1 = 10°C$	$\dot{m}_2 = ?$
$V_1 = 200$ m/s	$T_2 = ?$
$A_1 = 0.4$ m²	
$m_1 = ?$	

Recall the first law of thermodynamics.

$$\not{q} - \not{w} = \Delta h + \Delta ke + \Delta \not{pe}$$

$\not{q} \rightarrow = 0$ (adiabatic)

$\not{w} \rightarrow = 0$ no work

$\Delta \not{pe} \rightarrow = 0$ (no change in z)

therefore

$$0 = \Delta h + \Delta ke$$

$$0 = (h_2 - h_1) + \frac{1}{2}(v_2^2 - v_1^2)$$

making the assumtion as an ideal gas

$$\Delta h \cong C_p \Delta t$$

$$(h_1 - h_2) = C_p (t_2 - t_1)$$

substituding

$$0 = C_p(t_2 - t_1) + \frac{1}{2}(0 - v^2)$$

Rearrange

$$T_2 = T_1 - \frac{200^2}{2C_p} \qquad = 29.9°C$$

$$C_{p\,air} = 1.005 \, kJ/kg \cdot °C$$

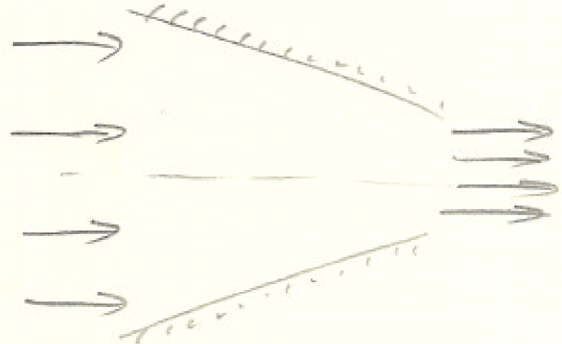
Recall

$$\Sigma \dot{m}_i = \Sigma \dot{m}_e \quad \therefore \quad \dot{m}_1 = \dot{m}_2 = \dot{m}_{air}$$

$$\dot{m}_{air} = \rho v A$$

$v = ?$ use idean

REMARKS: Nozzles are devices commonly used in jet engines (like difusers). The function of a nozzle device is to increase velocity of fluid at the expence of pressure.



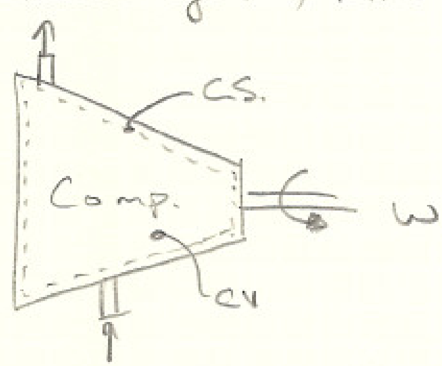
TURBINES are devices commonly used in power plants, jet engines, etc., to produce work.

COMPRESSORS as well a pumps and fans, are devices used to increase pressure of a fluid.

EX. Consider a compressor used to compress air at 100 kPa at 7°C to 600 kPa at 127°C. The mass flow rate of air is 0.02 kg/s and a heat loss of 16 $\frac{kJ}{kg}$ occurs during the steady flow process. Assuming the changes in potential and kinetic energies are negligible and air can be treated as an Ideal gas. Determine the nessasary work into the compressor. ($\dot{w}$=?)

ANALYSIS

SSSF ⇒ $\dot{m}_1 = \dot{m}_2$; Air ideal gas ; $\Delta PE = \Delta KE = 0$



RECALL FIRST LAW

$$\dot{Q}_{12} - \dot{W}_{12} = \dot{m}_2(h_2 + \tfrac{1}{2}v_2^2 + gz) - \dot{m}_1(h_1 + \tfrac{1}{2}v^2 + gz)$$

be know that $\dot{m}_1 = \dot{m}_2 = \dot{m}$, substituting and rearranging we get.

$$\dot{Q}_{12} - \dot{W}_{12} = \dot{m}(h_2 - h_1)$$

$$\frac{\dot{Q}_{12}}{\dot{m}} - \frac{\dot{W}_{12}}{\dot{m}} = h_2 - h_1$$

$$q - w = h_2 - h_1$$

for air as an ideal gas. $\Delta h = C_p \Delta T$

$$q - w = C_p(T_2 - T_1)$$

$$-16\,\frac{kJ}{kg} - w = (1.007)(7°C - 127°C)$$

$$w = 136.84$$

$$\dot{W} = \dot{m}\,w = 0.02 \cdot 136.84 = 2.737\ kW.$$