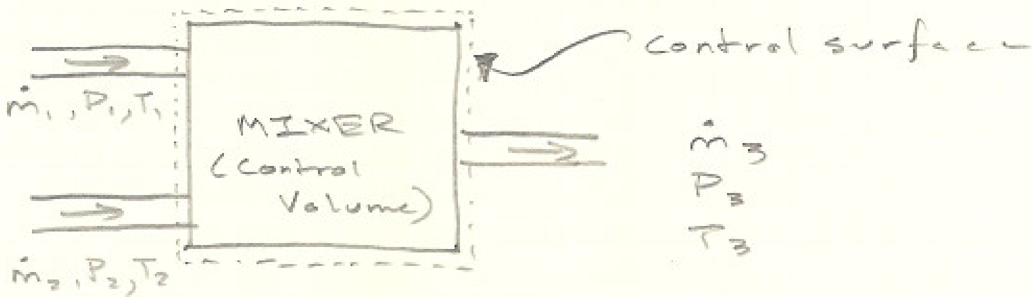
Some devices (open system or Control volumes) that are commonly used in engineering practice

- Nozzles
- Diffusers
- pumps
- fans
- turbines
- Throttling values.
- Heat Exchangers
- Mixing chambers
- pipes & ducts.

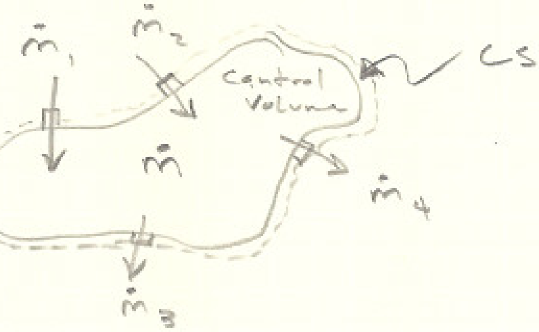
FIRST LAW OF THERMODYNAMICS, APPLIED TO OPEN SYSTEMS.

earlier, we defined opened system (control volumes) are those that exchange of mass. (in addition to energy)



CONSERVATION OF MASS PRINCIPLE

Consider.



the total $\dot{m}$ is all the mass rates in subtracting mass rates out.

$$\dot{m} = (\dot{m}_1 + \dot{m}_2) - (\dot{m}_3 + \dot{m}_4)$$

for a steady state flow process

$$\frac{d\dot{m}_{cv}}{dt} = 0$$

Therefore

$$\Sigma \dot{m}_{in} = \Sigma \dot{m}_{out}$$

REMARK: for a given flow rate $\dot{m}$.

$\dot{m} = \rho V A$ (kg/s)

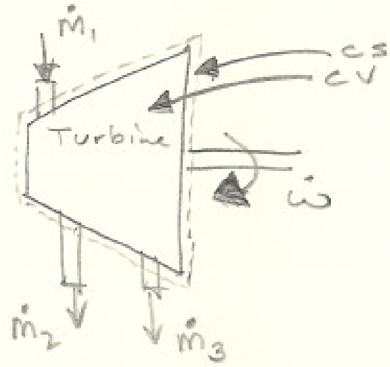
$\dot{m} = \rho \dot{\forall}$ (kg/s)

$\dot{\forall} = VA$ (m^2/s)

velocity.

EX. Consider a thermodynamic device such as a turbine, shown, opperating in SSSF.

Steady State Steady Flow.



Data: $V_1 = 1$ m/s $\rho = 1.2$ kg/m3

D = diameter of the pipe = 25 cm

$\dot{m}_2 = 0.022$ kg/s

Required: $\dot{m}_3 = ?$

Analysis: because the system is steady state

$$\Sigma \dot{m}_{IN} = \Sigma \dot{m}_{OUT}$$

$$\dot{m}_1 = \dot{m}_2 + \dot{m}_3$$

now to find $\dot{m}_1$

$$\dot{m}_1 = \rho V A \qquad eq^1$$

where the area is

$$A = \left(\frac{D}{2}\right)^2 \pi$$

$$= \left(\frac{0.25}{2}\right)^2 \pi = 0.059 \ m^2$$

then substituding into eq^1

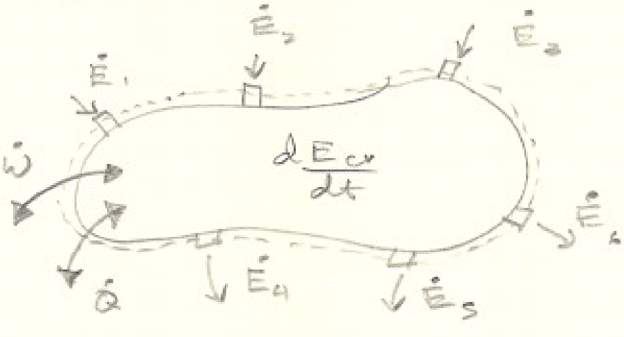
$$\dot{m}_1 = 1.2 \times 1.0 \times 0.059 = 0.059$$

then substituding into eq^2

$$\dot{m}_3 = \dot{m}_1 - \dot{m}_2$$

$$= 0.059 - 0.022 = 0.037 \ kg/s$$

CONSERVATION OF ENERGY PRINCIPLE (1ST LAW) APPLIED TO CONTROL VOLUMES.



where $\dot{E} = \dot{m}\hat{e}$; $\hat{e} = h + ke + Pe$

note: In the textbook, P. 144, $h_{TOT} = \hat{e}$

we say, h is the same as u, but since there is a flow, the substance has additional energy.

$$h = u + pV \text{ , with no flow}$$

$$h = u.$$

The first law of thermodynamics written in a CV can be written as.

$$\left({}_1Q_2 + \Sigma \dot{E}_{in}\right) - \left({}_1W_2 + \Sigma \dot{E}_{out}\right) = \frac{dE}{dt}$$

energy in — energy out — energy accumulation

note: move equations

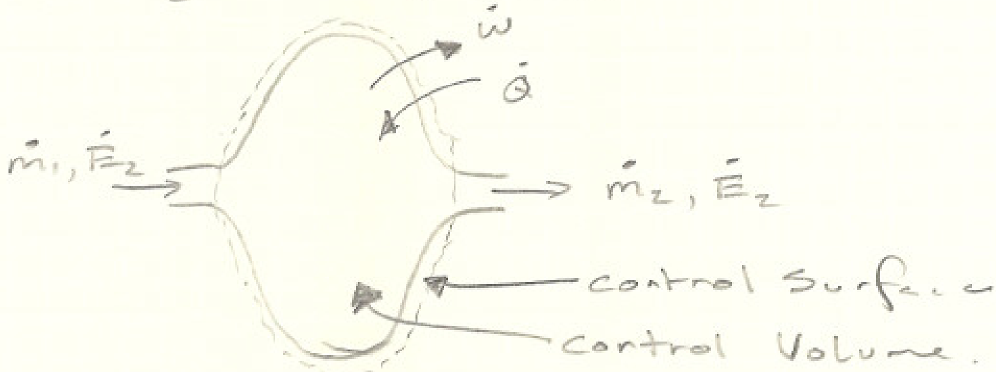
$$\dot{E}_i = \dot{m}_i \hat{e}_i$$

$$\dot{E}_e = \dot{m}_e \hat{e}_e$$

$$\hat{e} = h + ke + pe = h + \frac{1}{2}v^2 + gz$$

SPECIAL CASES

- single stream (one inlet, one exit) CV involving SSSF process.



from the first law

$$\dot{Q} - \dot{W} = \dot{E}_2 - \dot{E}_1$$

$$\dot{Q} - \dot{W} = \dot{m}_2\hat{e}_2 - \dot{m}_1\hat{e}_1$$