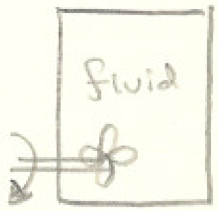
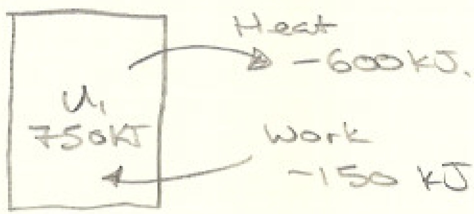
EX

given: a rigid tank with a paddle wheel is used to cool a hot fluid, shown. Initially, the internal energy of the fluid is 750 kJ. Due to the cooling process, the fluid loses 600 kJ. The Paddle wheel induces 150 kJ of work on the fluid.



REQUIRED: find the internal energy of the system. at the end of the cooling process

ANALYSIS: This system (fluid) is a closed system since there is no mass transfer across the boundry.



There is no mention of changes in KE & PE. so they can be neglected.

$$\Delta KE = 0 = \Delta PE$$

Recall.

$$Q_{12} - W_{12} = \Delta U + \Delta KE + \Delta PE$$

$$Q_{12} - W_{12} = \Delta U = U_2 - U_1$$

$$-600 - (-150) = U_2 - 750$$

$$U_2 = 300 \text{ kJ}$$

EX

GIVEN: An isulated rigid tank of volume $0.2 m^3$ contains air with an initial density of $1.2 kg/m^3$. A paddle is used to transfer energy to the fluid at a constant rate of 4W for 20 min

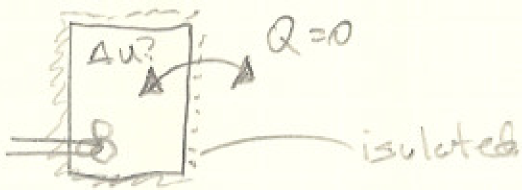
REQUIRED: Determines the internal energy of air in kJ/kg

(A) ΔU

(B) Δu

ANALYSIS: neglecting KE & PE

$$\Delta KE = \Delta PE = 0$$



−4W for 20 min

therefore to find total work, we multiply the rate of work by the time it is done.

$$W = \dot{W} \cdot t$$
$$= (-4 W) \cdot (20 \cdot 60)$$
$$= -4800 J$$

then we can use the first law of thermodynamics where $\Delta KE = 0$ and $\Delta PE = 0$

$${}_1Q_2 - {}_1W_2 = \Delta U$$
$$0 - (-4800) = \Delta U$$
$$\therefore \Delta U = 4.8 kJ.$$

Part B.

$$u = \frac{U}{m}$$

$$\Delta u = \frac{\Delta U}{m}$$

$$= \frac{\Delta U}{\rho \cdot V}$$

$$= \frac{4.8\ k}{0.24}$$

$$= 20\ kJ/kg.$$

EX.

Calculate the changes of kinetic and potential energies of a system having mass of 2kg whose velocity increases from 15m/s to 30 m/s while the elevation decreases by 10m at a rate of $9.81 m/s^2$.

ANALYSIS:

$$\Delta KE = KE_2 - KE_1$$

$$= \frac{1}{2} m v_2^2 - \frac{1}{2} m v_1^2$$

$$= \frac{1}{2} m (v_2^2 - v_1^2)$$

$$= \frac{1}{2}(2)(30^2 - 15^2)$$

$$= 675 J$$

$$\Delta PE = mgh$$

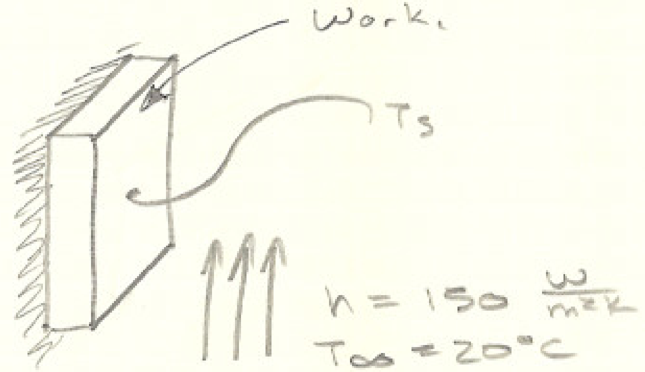
$$= (2)(9.81)(10)$$

$$= -197 J$$

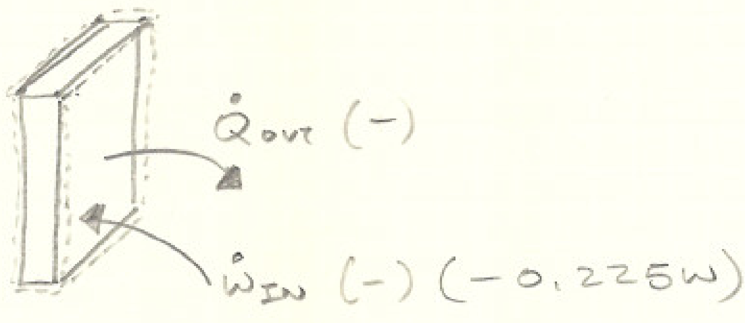
EX.

An electronic chip with dimesions 5mm × 5mm × 1mm as shown, is embedded in a substrate. At steady state operation of the chip, the chip has an input of electrical power 0.225 W. The top surface of the chip is exposed to a cooling fluid, whose temp is 20°C, and an average heat transfer coefficient of convection of 150 $\frac{W}{m^2K}$. If the heat transfer between the chip and substrate is negledgable,

REQUIRED: Determine the surface temp of the chip in °C.



ANALYSIS:



Application of the first law would be appropriate

$$\dot{Q} - \dot{W} = \frac{dE}{dt}$$

since the chip is in steady state there is no change in energy.

$$\frac{dE}{dt} = 0$$

$$\dot{Q} - \dot{W} = 0$$

$$\dot{Q} - (-0.225\,W) = 0$$

$$\dot{Q} = 0.225\,W$$

to the law of cooling.

$$\dot{Q} = -hA_s(T_s - T_\infty)$$

$$T_s = \frac{-\dot{W}}{hA_s} + T_\infty$$

$$= \frac{0.225}{(130)(25\times10^{-6})} + 20°C = 80°C = 353°K$$

SPECIFIC HEATS.

the spec heat is the energy required to raise 1 kg, 1 °C (1 °K)

TYPES OF SPEC HEAT.

Constant Volume:

$$C_v = \left(\frac{\partial u}{\partial T}\right)_v$$

Constant Pressure

$$\left(\frac{kJ}{kg \cdot C}\right)$$

$$C_p = \left(\frac{\partial h}{\partial T}\right)_p$$

$u(T, v)$

$h(T, p)$

Δh, Δu, C_v, & C_p FOR IDEAL GASES.

$$Pv = RT$$

it is know that an ideal

$$u = u(T)$$

we know that.

$$h = u + pv$$

$$h = u + RT \Rightarrow h(T) \text{ for an ideal gas.}$$

so that

$$C_{v_0} = \left(\frac{\partial u}{\partial T}\right)_{v_0} ; \quad C_{v_0} = C_{v_0}(T)$$

$$C_{p_0} = \left(\frac{\partial h}{\partial T}\right)_{p_0} ; \quad C_{p_0} = C_{p_0}(T)$$

for a process when an ideal gas changes from state 1 to state 2, Δu & Δh during the process can be obtained by

$$\Delta u = u_2 - u_1 = \int_1^2 C_{v_0}(T)\,dT$$

$$\Delta h = h_2 - h_1 = \int_1^2 C_{p_0}(T)\,dT.$$

REMARK: To carry out the integrations, relations C_{v_0} and C_{p_0} as functions of T.

$$C_{p_0} = C_{v_0} + R.$$

Another Ideal Gas property is the specific heat Ration

$$K = \frac{C_{p_0}}{C_{v_0}}$$

if K is not sig $K \approx$ Constan