TOPIC II - GAS PROPERTIES

Enthalpy (Lecture 2/2)

Contents:

4) Enthalpy (convenient for open systems), a combination property (U + p V)
5) Worked examples

Applications:

Used to find the efficiency of turbine performance.

A combination of internal energy (U) and energy required to expand gas against its surroundings (pV)

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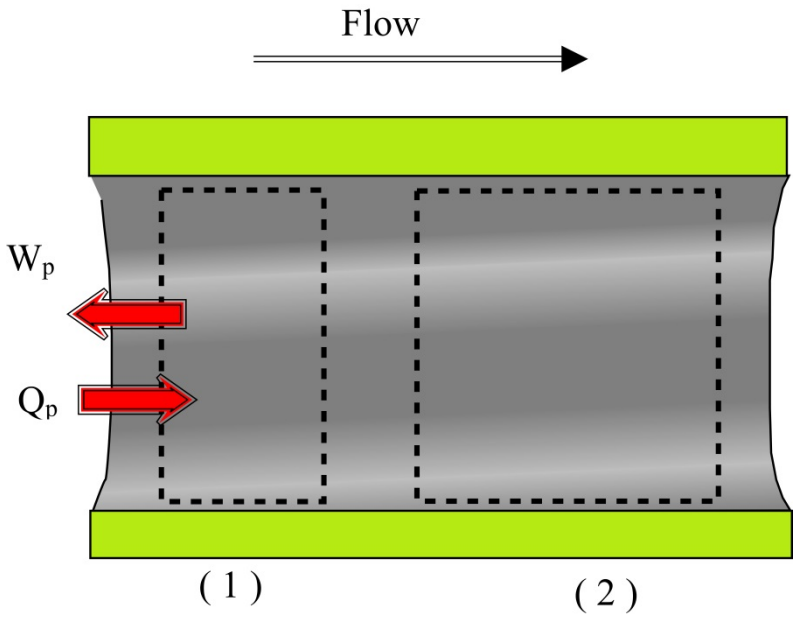
4. Enthalpy

Definition: Enthalpy is a combination property, the sum of internal energy and a term with the sense of work, pV.

$$H = U + p\,V$$

E.g. – heating of air flowing through a pipe



Air expands. Put a boundary around the constant mass. Work transfer from surroundings to system has negative value.

If $p \approx p_2 = p_1$

$$W_{flow} = - p\,\Delta V = - p\,(V_2 - V_1)$$

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Enthalpy = (reversible) heat addition at constant pressure. Apply NFEE:

$$Q_p = U_2 - U_1 - W_{flow}$$
$$Q_p = U_2 - U_1 - (- p\,(V_2 - V_1))$$

Noting $p = p_2 = p_1$

$$Q_p = (U_2 + p_2 V_2) - (U_1 + p_1 V_1)$$

Attribute bracketed terms to enthalpy:

$$Q_p = H_2 - H_1$$

Steam enthalpy is tabulated. Enthalpy of an ideal gas depends on <u>temperature only</u>

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Variation of H with T.

Noting:

$$H = U + p\,V$$

Last lecture on Internal Energy and Gas Law

$$U = m\,c_v\,(T - T_o) \text{ and } p\,V = m\,R\,T$$

set $T_o = 0 \Rightarrow H = m\,(c_v + R)\,T$

Group terms and set a non-zero datum:

$$c_p = c_v + R \qquad (9)$$

$$H = m\,c_p\,(T - T_o) \qquad (10)$$

c_p is specific heat capacity at constant pressure.

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*Definition: The **specific heat capacity at constant pressure** is the energy that must be added to raise the temperature of one unit mass of a fluid by one degree, given that the pressure of the fluid is constant.*

For air $c_p = 1.005 \text{ kJ kg}^{-1} \text{ K}^{-1}$.

Also $c_p = c_v + R = 3.5 R$.

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EX1. A pressure vessel is intended to hold 5 kg of air at a temperature of 623 K. The volume is 0.5 m^3. Find the pressure in this vessel. What is the pressure when the temperature is increased to 723 K?

EX2. A piston cylinder initially holds 5 grams of air at a temperature 623 K. If no change of volume occurs, find the heat required to raise the air temperature to 723 K? What is the change in internal energy?

EX3. A piston cylinder initially holds 5 grams of air at a temperature of 723 K. The air therein is allowed to expand adiabatically, thereby moving the piston and doing work. The temperature at end of process is 623 K. Estimate the amount of work done.

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Enthalpy (Lecture 2/2)

EX 4. A piston cylinder initially holds 5 grams of air at a temperature of 623 K and has a volume of 0.5 litres. The air therein is allowed to expand at constant pressure thereby moving the piston and doing work. The temperature at end of process is 723 K. Estimate the required heat addition and the amount of work done.

<u>Conclusions</u>

Enthalpy, H = U + p V, a property of state, follows from tables or

$$\Delta H = \mathbf{m}\, \mathbf{c_p}\, \Delta \mathbf{T} = Q_p$$

Usefully, $c_p = c_v + R$