ROHINI COLLEGE OF ENGINEERING AND TECHNOLOGY
ME 3391 ENGINEERING THERMODYNAMICS
DIGITAL NOTES

CONSTANT VOLUME PROCESS

For a constant volume process, work can only be done by some method of churning the liquid. There cannot be any □pdV work as no external force has been moved througha distance. Hence, W must be zero or negative. For a constant volume process, unless otherwise stated, work done is taken as zero. Thus energy equation for a constant volume process is usually written as

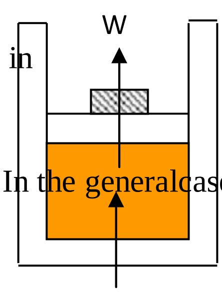
$$Q = u_2 - u_1$$

If, in addition to work being zero, it is stipulated that the heat is transferred by virtue ofan infinitesimally small temperature difference, then the process is reversible and the equation can be written in differential form as

$$dQ = du$$

CONSTANT PRESSURE PROCESS

A closed system undergoing at constant process is shown in Fig. The fluid is enclosedin a cylinder by a piston on which rests a constant weight. If heat is supplied, the fluid expands and work is being done by thesystem in overcoming the constant force; if the heat is extracted,



the fluid contracts and work is done on the system by the constant force. In the generalcase

$$Q - W = (u_2 - u_1)$$

If no paddle work is done on the system, and the process is reversible,dQ – p

$$dv = du$$

Since p is constant, this can be integrated to give

$$Q - p\,(v_2 - v_1) = (u_2 - u_1)$$

A further simplification is for constant pressure process if a new property is introduced. Since p is constant, p dv is identical to d(pv). Thus energy equation becomesdQ –

$$d(pv) = du$$

or $\quad dQ = d(u + pv) = dh$

where h = u + pv, known as enthalpy. Since enthalpy is a combination of properties u, pand v, it itself is a property. Hence

$$h = u + pv$$

and for any mass of fluid m, in a state of equilibrium $H =$

$$U + pV$$

Using this derived property, the energy equation for a reversible constant pressureprocess becomes

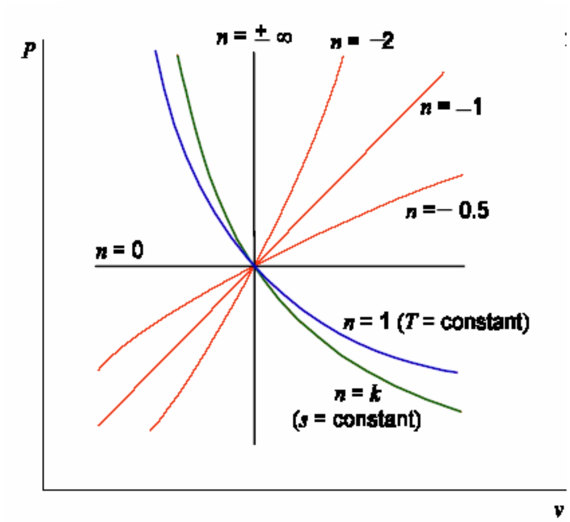
$$Q = (h_2 - h_1)$$

Thus heat added in a reversible constant pressure process is equal to increase of enthalpy, whereas it is equal to increase of internal energy in the reversible constant volume process.

POLYTROPIC PROCESS

The constant volume and constant pressure processes can be regarded as limiting cases of a more general type of processes in which both volume and pressure changein a certain specified way. In many real processes, it is found that the states during expansion or compression can be expressed as $pv^n = constant$, where n is a constant called the index of expansion or compression and p and v are average values of pressure and specific volume for the system. This is called *Polytropic process*. When $n=0$ the relation reduce to p = constant and when n = □ it reduces to v = constant.

Isobaric process: P=const, n=0
Isothermal process: T=const, n=1
Isometric process: v=const, n=∞;
Isentropic process: s=const, n=k



The integrated form of energy equation for a reversible polytropic process may thereforebe written as

$$Q - \frac{p_2 v_2 - p_1 v_1}{1-n} = (u_2 - u_1)$$

Relation between p,v,T

$pv = RT$

$$\frac{p_1 v_1}{T_1} = \frac{p_2 v_2}{T_2} \text{ or } \frac{T_2}{T_1} = \frac{p_2 v_2}{p_1 v_1}$$

Reversible Adiabatic Process (Isentropic Process)

The term ***adiabatic*** is used to describe any process during which heat is prevented from crossing the boundary of the system. That is, an adiabatic process is one undergone by a system, which is thermally insulated from its surroundings. For adiabatic non-flow processes, the energy equation reduces to

$- W = (u_2 – u_1)$

$pv^{\gamma} = \text{const.}$

ISOTHERMAL PROCESS

When the quantities of heat and work are so proportioned during a process such thatthe temperature of the fluid remains constant, the process is said to be ***isothermal***. Since temperature gradients are excluded by definition, the reversibility of the isothermal process is implied.

1.5 kg of liquid having a constant specific heat of 2.5 kJ/kg K is stirred in a well-insulated chamber causing the temperature to rise by 15°C. Find Δ E and W for the process.

Heat added to the system $= 1.5 \times 2.5 \times 15 \text{kJ}$

$= 56.25 \text{ kJ}$

$\therefore \quad \Delta E \text{ rise} = 56.25 \text{kJ}$

As it is insulated then $dQ = 0$

$\therefore \quad \Delta Q = \Delta E + W$

or $\quad 0 = 56.25 + W$

or $\quad W = -56.25 \text{ kJ}$