Thermodynamics

ME 267

Fundamentals of Mechanical Engineering

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www.mislam.info/ocw.html

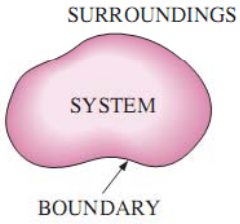
Principles of Thermodynamics

System

A thermodynamic system is defined as a quantity of matter or a region in space chosen for study.

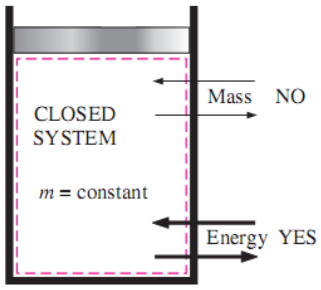
Boundary

The real or imaginary surface that separates the system from its surrounding Is called boundary.



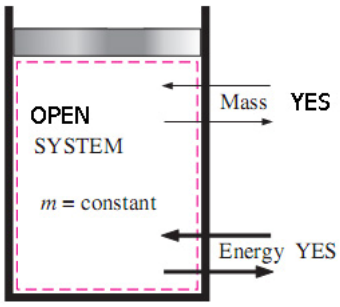
Closed System (Control Mass)

It consists of fixed amount of mass and no mass can cross its boundary i.e. no mass can enter or leave a closed system. But energy in the form of heat and work can cross the boundary and the volume does not have to be fixed.



Open System (Control Volume)

In this kind of system both mass and energy in the form of heat and work can cross the boundary.



Property

Any characteristics of a system is called a property. The change in the value of a property depends on the initial and final state of the system and it is independent of the process undergone.
For example- pressure, temperature, volume etc.

State

The state of a system at any instant is its conditions characterized by the values of its properties. At a given state all the properties of a system have values.

Process

When any of the properties of a system change, the state changes and the system is said to have undergone a *process.* A process is a transformation from one state to another.

Cycle

A thermodynamic cycle is a sequence of processes that begins and ends at the same state. At the conclusion of a cycle all properties have the same values they had at the beginning

Internal Energy

Internal energy of a system may be defined as the amount of energy summing all the energies (i.e. kinetic and potential energies) of all the atoms, ions and molecules of that system.

The value of internal energy depends on temperature and pressure. Measurement of total internal energy is not possible. But change in internal energy is equal to amount energy transferred by heat and work together.

First law of Thermodynamics

When any closed system is taken through a cycle, the net work delivered to the surrounding is proportional to the net heat taken from the surroundings and the converse is also true.

These statements may be expressed in mathematical form by –

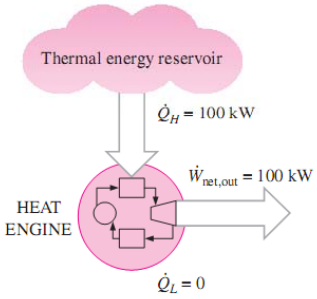
$$\Sigma dQ \propto \Sigma dW$$

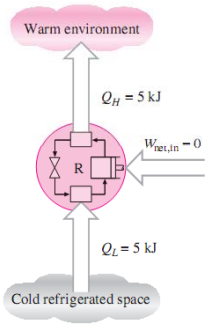
$$dQ = dU + dW$$

It is also known as ***Conservation of Energy Principle***.

Second law of Thermodynamics

It is impossible to construct a system which will operate in a cycle, extract heat from a reservoir, and do an equivalent amount of work on the surroundings. In other words, it is impossible to construct a system which will operate in a cycle and transfer heat from a cooler to a hotter body without work being done on the system by the surrounding.





Enthalpy

Enthalpy is a thermodynamic property of a system that can be defined as the summation of internal energy and the product of pressure and volume of that system. A change in enthalpy under constant pressure condition is equal to the change in internal energy of the system and the work done by the system on its surroundings.

$$\Delta H = \Delta U + \Delta(PV)$$

Entropy

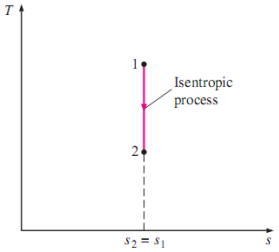
Entropy can be viewed as measure of molecular randomness. It is a non conserved property and there is no such thing as the conservation of entropy principle. Entropy is conserved during the idealized reversible processes only and increases during all actual processes.

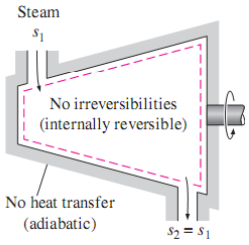
Isentropic Devices

Entropy of a fixed mass can be changed by - Heat transfer and Irreversibility.

So the entropy of a fixed mass does not change during a process that is internally reversible and adiabatic. A process during which the entropy remains constant is called an isentropic process.

i.e. **Pumps, Turbine, Compressor** are **ISENTROPIC DEVICE.**

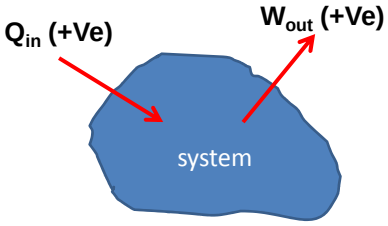




Steady Flow Energy Equation

$$\dot{Q} - \dot{W} = \dot{m}\left[h_2 - h_1 + \frac{V_2^2 - V_1^2}{2} + g(z_2 - z_1)\right]$$

SIGN CONVENTION



Q = rate of heat transfer between the control volume and its surroundings

W=rate of work transfer between the control volume and its surroundings

m = mass flow through the control volume

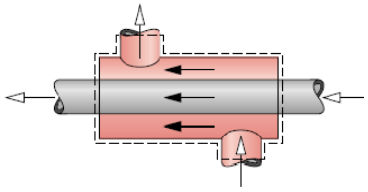
h = specific enthalpy of the working fluid

V = velocity of the working fluid

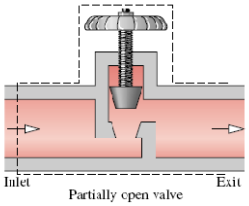
z = reference height of the system

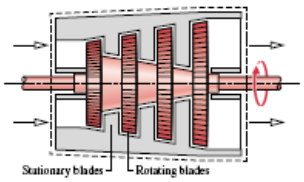
Steady Flow Energy Equation

Heat Exchanger (Boiler & Condenser)

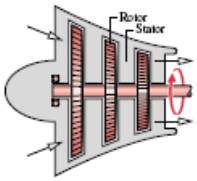


Expansion Device





Turbine

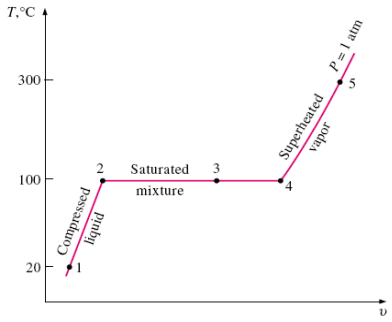


Compressor

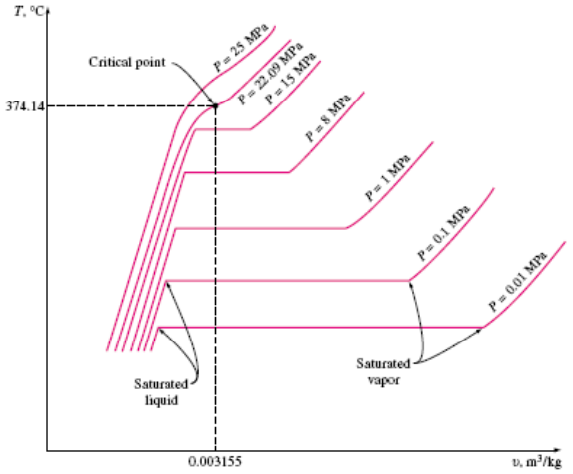
Saturation Pressure and Temperature

At a given pressure, the temperature at which a pure substance changes phase is called the saturation temperature $\mathbf{T_{sat}}$.

Likewise, at a given temperature, the pressure at which a pure substance changes phase is called the saturation pressure $\mathbf{P_{sat}}$. At a pressure of 101.325 kPa, $\mathbf{T_{sat}}$ of water is 99.97°C.



Saturation Pressure and Temperature



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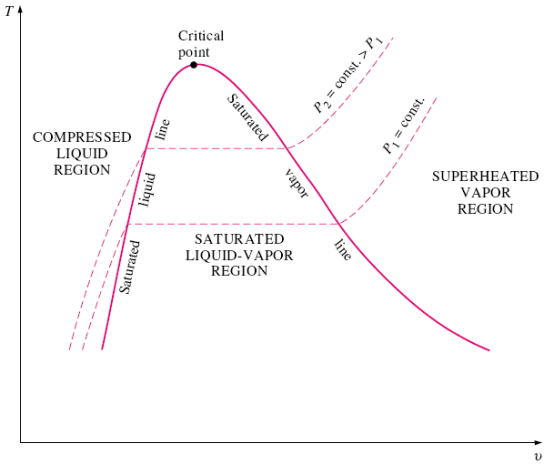

That's all about today