GAS LAWS

Boyle’s Law: PV = C

Charles’ Law:

THERMODYNAMIC EQUATIONS FOR THERMODYNAMIC PROCESSES

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General equation for work is given as

General equation for work in terms of power ,

For a polytropic process , ,

General Gas Equation

The area under a P-V graph is the work done

Work and heat transfer are process functions. This means that they occur when there is a change in state.

On the other hand, temperature, pressure, and volume are state functions. They only depend on the initial and final state of the system.

Isochoric Process

For an Isochoric process

[Gay Lussac’s Law]

When you hear the term “Rigid” or “Rigid Cylinder”, then the volume is constant

Isobaric Process

Isothermal

Adiabatic process

For monoatomic gas,

For diatomic gas,

For triatomic gas,

For monoatomic ideal gas,

For diatomic gas,

For triatomic gas,

Thermodynamics is a sense is the relationship between heat, mechanical work and internal energy

First Law of Thermodynamics

[change in amount of energy contained within a system during some time interval] = [net amount of energy transferred in across the system boundary by heat transfer during the time interval] - [net amount of energy transferred out across the system boudary by work during the time interval]

In any process of a closed system, the energy of the system increases or decreases by an amount equal to the net amount of energy transferred across its boundary

A system is at steady state if none of its properties change with time. In real applications, when property variations with time are small enough to ignore

For a steady state system

Ways of transferring Energy

1. Mechanical work: Applying a force through a distance will increase kinetic energy

2. Heat Energy: Applying heat will increase KE of its molecules as temperature increases

when heat flows into system

Q = -ve when heat flows out of the system

An increase in heat energy increases the internal energy of the system

Work Output = +W

Work Input = -W

When you do work (your work output), your internal energy decreases

Work output = Work done by the system, therefore internal energy decrease

Work input = Work done on the system, internal energy increases

When you hear compression,

Compression is work done on the system:

Expansion is work done by the system:

SPECIFIC WORK AND ENERGY

The specific work is work done per unit mass. Its unit is kJ/kg. To find the work done, we multiply the unit work my mass.

Similarly, the internal energy of a system can be expressed in terms of its specific internal energy

TYPES OF SYSTEMS

1. Open Systems: In this system, matter can flow in or out of the system. Also, heat can flow in or out of the systsem.

2. Closed Systems: In this system, natter cannot flow in or out but energy can flow in or out of the system.

The equation ,is applied for closed systems

3. Isolated System: In this system, neither energy nor work can go in or out of the system

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Change in total energy = Change in internal energy + Change in kinetic energy + Change in Potential Energy

Rate of heat transfer

PROCESS IN THROMODYNAMICS

This is the energetic development of a thermodynamic system proceeding from an initial state to a final state

Processes can be classified into Reversible and Irreversible processes

TRAJECTORY IN THERMODYNAMICS

Trajectory is also known as path. It it a way/path in which a process can be achieved.

For example, to make a chemical there are different steps you can take. The connection of all these steps is called the trajectory.

Initial state → Step1 → step2 → final state

initial state → Step1 → step4 → step3 → Final state

You can see that the initial and final states are the same but the path taken is different. This difference in path can affect work and heat in or out of the system.

ENTHALPY

This is the equivalent to the internal energy when applied to an open system. However, when working with closed systems, we don’t use enthalpy, we use the actual internal energy

Enthalpy is a created (or artificial) property.

Enthalpy helps us a lot to calculate process change

A vapour-liquid mixture is also called “**Wet Vapour**”

The **quality**, x of a vapour is essentially the percentage by mass of the vapour in the mixture (total).

At saurated liquid states,

At saturated vapour states,

Superheated refrigerant vapout is in a gaseous phasee. This phase occurs when the refrigerant continues to absorb heat beyond its saturation point at a constant pressure

Superheated refrigerant vapour and superheated water vapour are all superheated vapour phase

But

But

Dividing through by

But,

[Take note]

We can use the same theoretical concepts for other functions

For internal energy

For enthalpy

For entropy

For volume

Properties marked “lg” can be found in tables

If x=0, it is totally fluid

If x=1, it is totally gaseous

Vapour Tables

When solving questions or equations on vapour tables, we are usually given a specific temperature and specific pressure and the values we are looking for are:

1. Specific Volume [usually in ]

2. Specific Enthalpy

3. Specific Internal Energy

4. Specific Entropy.

We are also looking for these values at different states like:

1. Saturated Ice

2. Saturated Liquid

3. Saturated Vapour

4. Sub-cooled solid

5. Sup-cooled liquid

6. Superheated Vapour

We will find all these data in vapour tables (typically) or in graphs (not common)

Saturated steam: This is steam and water in equilibrium. If you know the pressure, the temperature is automatically fixed and if you know the temperature, the pressure is automatically fixed.

Superheated Steam: You’ll need both the temperature and the pressure to solve your properties because you ae beyond vapour-liquid equilibrium.

QUESTIONS TO SOLVE

1. A closed system of mass 10kg undergoes a process during which there is energy transfer by work from the system of 0.14kJ per kg, an elevation decrease of 50m and an increase in velocity from 15m/s to 30m/s. The specific internal energy decreases by 5kJ/kg and an acceleration due to gravity is 9.7m/s^2. Determine the heat transfer for the process in kJ.

2.If the gas undergoes a process for which and , determine the heat transfer in kJ keeping the initial pressure and volume fixed.

Answer:

3. What is the quality of a liquid-vapour mixture

a. If there is a total amount of 123.6kg of water

b. We boil 87.5kg of that liquid to a vapour

3. During a steady state operation, a gearbox receives 60kW through the input shaft and delivers power through the output shaft. For the gearbox system, the rate of energy convection heat transfer is given by where . K is the transfer coefficient, is the outer surface of the gearbox, T\_b = 300K(27C) is the temperature of the outer surface and T\_f = 293K(20C) is the temperature of the surrounding air away from the immediate vicinity of the gearbox. For the gearbox , evaluate the heat transfer rate and power delivered through the output shaft in kW.

Answers:,

4. Four-tenths kilogram of a certain gas is contained within a piston-cylinder assembly. The gas undergoes a process for which the pressure-volume relationship is . The initial pressure is 3bar. The initial volume is and the final volume is . The change in specific internal energy of the gas in the process is . There are no significant changes in kinetic or potential energies. Determine the net heat transfer for the process.

Answers: ,

5. The quality of a two-phase liquid vapour mixture of water at 40C with specific volume of is what?

6. Determine the phase or phases in a system consisting of water at the following conditions

- p=10bar, T=179.9C Answer: Saturate vapour

- p=10bar, T=150C Answer: Superheated vapour phase(Superheated refrigerated vapour)

- p=0.5bar, T = 100C Answer: gas

- p=50bar, T=20C: Compressed Liquid

- p=1bar, T = -6C: Superheated refrigerant

7. Determine the specific volume in for the following properties and locate the states on a T-v diagram

- p = 20MPa, T = 400C Answer: 0.00994

- p = 20MPa, T = 40C Answer: 0.9992

- p=2MPa, T=40C Answer: 0.001004

8. Four kg of water at 100C fills a closed container having a volume of

a. If the water at this state is vapour, determine the pressure in bar

b. If the water is a two-phase liquid-vapour mixture, determine the quality

9. Using the tables for water, determine the specified property data at the indicated states.

- At p=2MPa, T=300C. Find u, in kJ/kg

- At p=2.5MPa, T=200C, Find u, in kJ/kg

- At p=1.5bar, T=100C

- p = 50bar, , Find h, in kJ/kg

- p=1bar, T=-6C

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