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Anowar's Handbook on Elements of Mechanical Engineering

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Key note of handwritten book

This preprint book is helpful for mechanical engineers, textile engineers, machine designer, students, researchers, professors and professionals in the field of *Mechanical Engineering*. This handbook is written from author's notebook for exam preparation in Bachelor of Science in Textile Engineering.

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Element of Mechanical Engineering
ME-203, Nazifa Usmani

*** What do you understand by thermodynamic system?

Ans: The thermodynamics is that branch of engineering science which deals with the energies possessed by gases of vapours. It also includes the conversion of these energies in terms of heat and mechanical work and their relationship with properties of the system.

*** Discuss about thermodynamic system?

Ans: A thermodynamic system is defined as a quantity of matter or a region in space upon which attention is concentrated in the analysis of a problem.

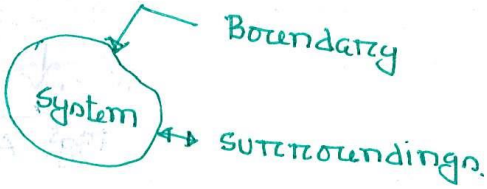

Fig: A thermodynamic system

Surrounding: Everything external to the system is called the surroundings or the environment.

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Boundary: The system is separated from the surroundings by the system boundary. The boundary may be either fixed or moving.

Classification: There are three classes of systems.

(a) closed system
(b) open system
(c) Isolated system.

(a) **closed system:**

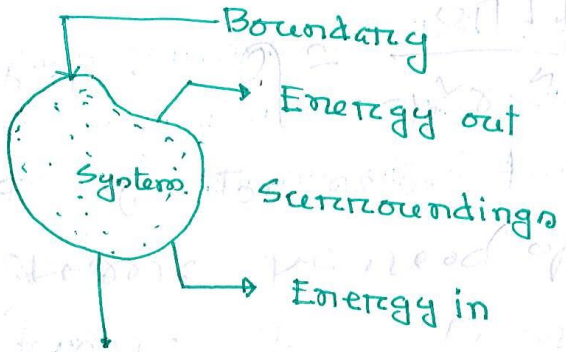

Fig: A closed system

1. There is no mass transfer across the system boundary
2. There may be energy transfer into or out of the system

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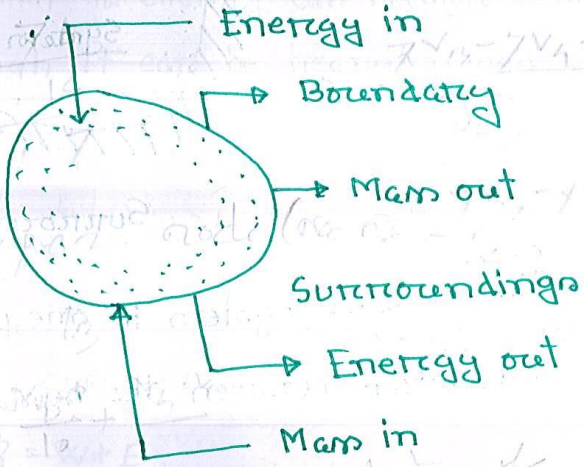
3. A certain quantity of fluid in a cylinder bounded by a piston constitutes a closed system.

Open system:



1. The open system is one in which matter crosses the boundary of the system.
2. There may be energy transfer also and mass transfer
3. Most of the engineering devices are generally open systems, An Example, An air compressor in which air enters at low pressure and leaves at high pressure and there are energy transfers across the system boundary.

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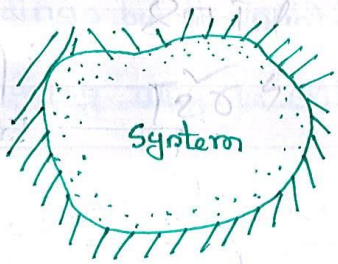
Isolated system:



1. The isolated system is one in which there is no interaction between the system and the surroundings.
2. It is of fixed mass and energy, and there is no mass or energy transfer across the system boundary.

*** Write down the laws of thermodynamics

Zeroth law of thermodynamics: When two bodies are in equilibrium with a third body, they are also in equilibrium with each other.

Explanation: When a body A is in thermal equilibrium with a body B, and also separately with a body C, then B and C will be in thermal equilibrium with

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First law of thermodynamics:

Heat and mechanical work are mutually convertible. This law also states that the energy can neither be created nor destroyed though it can be transformed from one form to another.

According to this law, the energy due to heat supplied (Q) must be balanced by the external work done (W), plus the gain in internal energy (E), due to rise in temp.

So other words, $Q = W + E$.

Second law of thermodynamics:

Clausius definition: It is impossible for self acting m/c working in a cyclic process to transfer heat from a body at a lower temp. to a body at a higher temp. without the aid of an external agency.

Kelvin-Planck definition: It is impossible for a heat engine to produce net work in a complete cycle if it exchanges heat only with bodies at a single fixed temperature.

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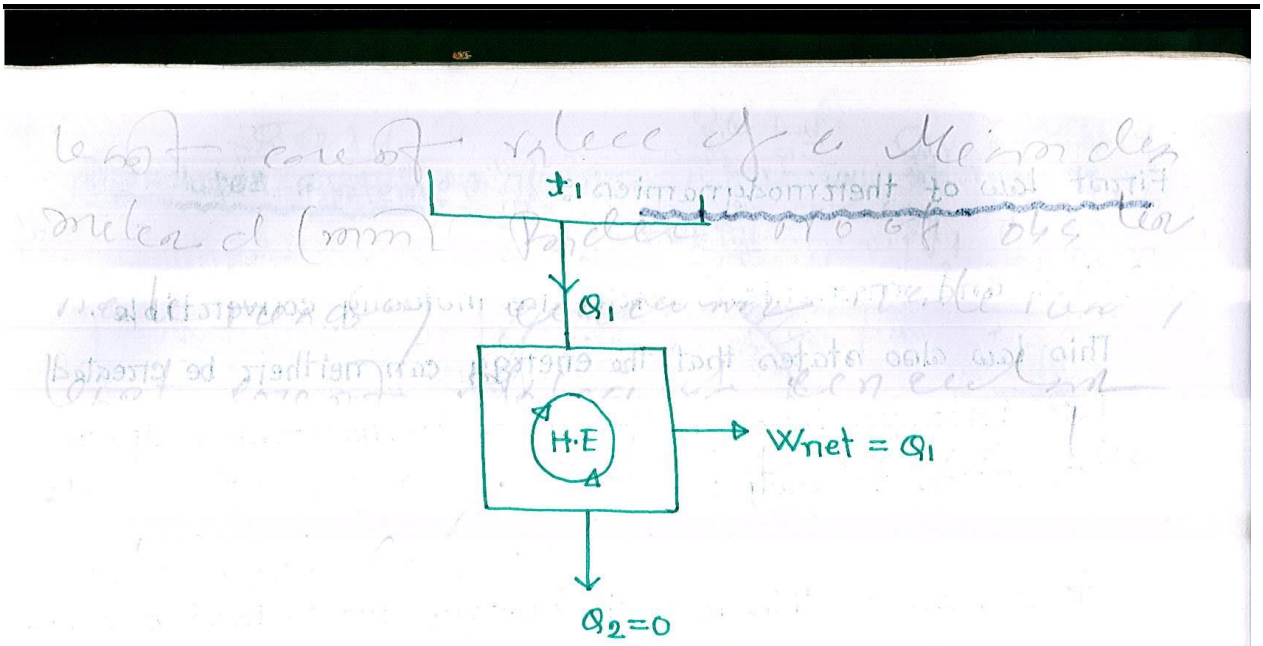

Fig: A perpetual motion machine

Kelvin's Definition: Temperature flows automatically from higher temperature to lower temperature.

*** What do you understand by thermodynamic processes of perfect gases.

Ans: The process of heating or cooling of a gas is defined as a thermodynamic process. During a thermodynamic process, change take place in various properties of the gas such as - pressure, volume, temp, specific energy, enthalpy etc.

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The following thermodynamic processes are important.

(1) Constant volume process or isochronic process

(2) Constant temp. process or ~~isochronic process~~ isothermal process

(3) Constant pressure process or iso-thermal process or, isobaric

(4) Adiabatic process or isentropic process

(5) Polytropic process

(6) Hyperbolic process

Constant temp. process: When temperature becomes constant and another (Pressure, volume, specific energy, enthalpy etc) can be changed, that is called constant temperature process. From Ideal gas Equation, $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

Since Gas is heated at constant temp: $\therefore P_1V_1 = P_2V_2$
$T_1 = T_2$

Constant volume process: When volume becomes constant and another (Temp. pressure, specific energy, enthalpy etc) can be changed, that is called constant volume process.

P_1, V_1, T_1 = Pressure, volume and temp. at initial state-1

P_2, V_2, T_2 = Pressure, volume and temp. at initial state-2

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Constant pressure process: When pressure becomes constant and another (Temp. volume, Specific energy, enthalpy etc) can be changed, that is called constant pressure process.

Adiabatic process: A process, in which the working substance neither receives nor gives out heat to its surroundings, during its expansion or compression, is called an adiabatic process.

Polytropic process: The polytropic process is also known as the general law for the expansion and compression of gases and is given by the relation:

$$PV^n = \text{constant}$$

Where n is a polytropic index, which may have any value from zero to infinity, depending upon the manner, in which the expansion or compression has taken place.

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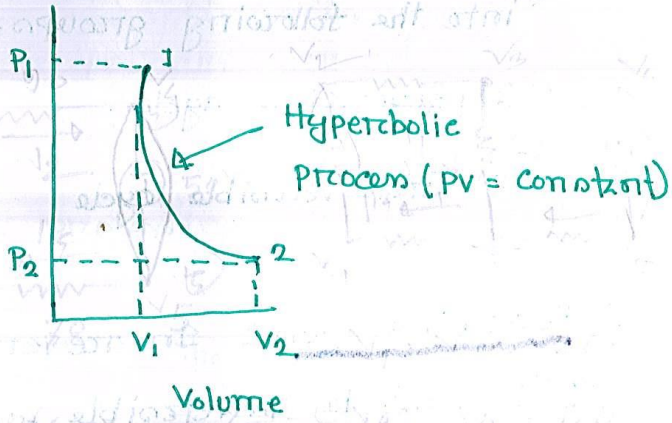
Hyperbolic process: A process, in which the gas is heated or expanded in such a way that the product of its pressure and volume remains constant, is called a hyperbolic process.



**** When a gas is heated at a constant volume, its temperature and pressure will increase. Since there is no change in its volume, therefore no work is done by the gas.

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*** Write down the classification of Thermodynamic cycles.

Ans: The thermodynamic cycles are classified into the following groups. such as:

(I) Reversible cycle

(II) Irreversible cycle.

(I) Reversible cycle: In reversible process, the cyclic will be reversible and the initial conditions are restored at the end of the cycle.

Characteristics of reversible cycle:

1. ~~Ext~~ All the processes, taking place in the cycle of operation, must be extremely slow.

2. It controls the equilibrium of thermodynamics.

3. Example:
   I. Peltier effect
   II. Thomson effect.

3. The working parts of the engine must be

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Irreversible cycle: An irreversible cycle, the cyclic will not be reversible and the initial conditions are not restored at the end of the cycle.

Characteristics:

1. It is a quick process.
2. It does not control the equilibrium of thermodynamics
3. Example: Diffusion, Conduction, radiation
4. Mechanical and fluid friction.

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*** What do you understand by Efficiency of a cycle ?

Ans: It is defined as the ratio of work done to the heat supplied during a cycle.

Mathematically,

$$\text{efficiency, } \eta = \frac{\text{Work done}}{\text{Heat supplied}}$$

$$= \frac{\text{Heat supplied} - \text{Heat rejected}}{\text{Heat supplied}} \times 100$$

It is expressed as percentage.

*** What do you understand by Carnot cycle.

Ans: Carnot cycle: A working substance starting from a given initial condition of temperature, pressure and volume is made to undergo two successive expansions (one isothermal and another adiabatic) and then two successive compressions (one isothermal and another adiabatic), then brought back finally to its original condition.

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Who discovered : French Engineer Sadi Carnot. (1796-1832)

When discovered : 1824

Why discovered : To calculate the efficiency of heat engine.

Explanation :

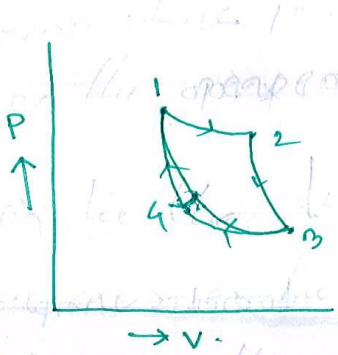

Fig: PV-Diagram

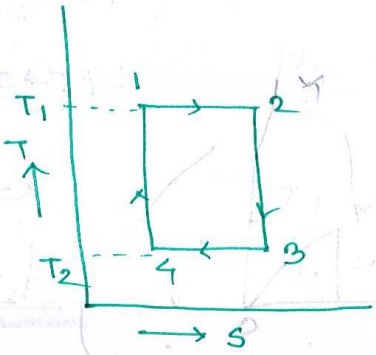

Fig: T-S Diagram

In figure, P = Pressure. V = Volume

T = Temperature. S = Entropy

1-2 = isothermal expansion

2-3 = isentropic expansion

3-4 = isothermal compression

4-1 = isentropic compression

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Carnot's efficiency,

$$\eta = \frac{\text{Work done}}{\text{Heat supplied}} \times 100$$

$$= \frac{T_1 - T_2}{T_1} \times 100$$

$$= \left(1 - \frac{T_2}{T_1}\right) \times 100$$

Where, T_1 = Highest temp.

T_2 = Lowest temp.

It is expressed as percentage.

*** The max^m and min^m temp. of a Carnot cycle is 30°c and 50°c. Determine the eff^n of cycle.

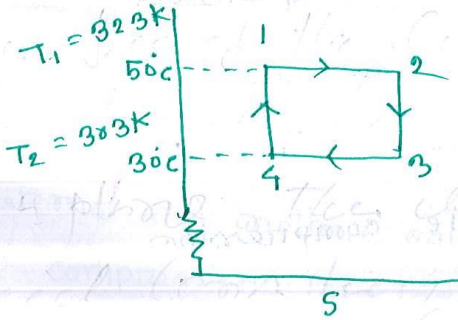

Fig: T-S Diagram

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Given,

Maximum temperature, $T_1 = 50^\circ C = (50+273)K$
$= 323K$

Minimum temperature, $T_2 = 30^\circ C = (30+273)K$
$= 303K$

$$\eta = \frac{323-303}{323} \times 100$$

$$= 0.619 \times 100$$

$$= 6.19\%$$

*** Discuss about stirling cycle?

Stirling cycle: The stirling cycle consists of two reversible isotherm and two reversible isochoren.

Who discovered: Stirling

When discovered: 1827

Why discovered: Heat engine

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Explanation :

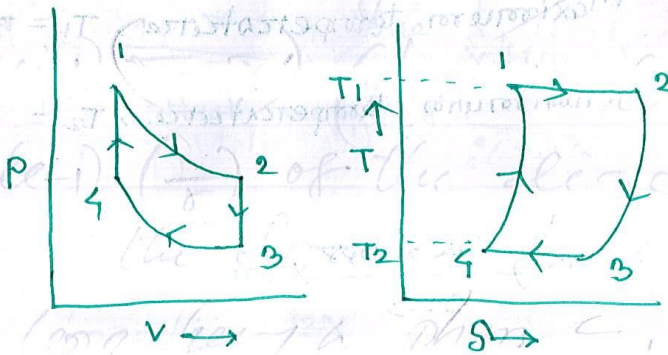

Fig: PV-Diagram

Fig: TS-Diagram

1-2 = Isothermal expansion

2-3 = Isochronic expansion

3-4 = Isothermal compression

4-1 = Isochronic heat addition

Efficiency of stirling cycle,

$$\eta = \frac{T_1 - T_2}{T_1} \times 100$$

$$= \left(1 - T_2/T_1\right) \times 100$$

It is expressed as percentage.

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Discuss about Ericsson cycle?

Ericsson: The Ericsson cycle consists of two reversible isotherms and two reversible isobars.

Who discovered: Ericsson

When discovered: 1850

Why discovered: Heat engine / gas engine

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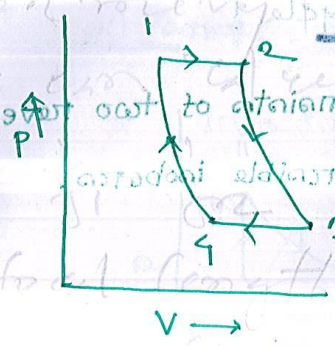

Fig: PV Diagram

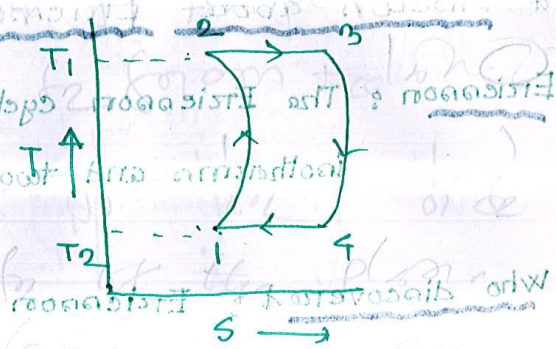

Fig: TS- Diagram

In figure, P = Pressure

V = Volume

T = Temperature

S = Entropy.

1-2 = Isobaric heat addition

2-3 = Isothermal expansion

3-4 = Isobaric heat rejection

4-1 = Isothermal compression.

Efficiency of Ericsson cycle:

$$\eta = \frac{T_1 - T_2}{T_1} \times 100$$

$$= \left(1 - \frac{T_2}{T_1}\right) \times 100$$

T_1 = Highest temp.

T_2 = lowest temp.

It is expressed as percentage

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*** What do you understand By Boiler.

Ans: A steam generator or boiler is usually a closed vessel made of steel. Its function is to transfer the heat heat produced by combustion of fuel (solid, liquid or gaseous) to water and ultimately to generate steam.

The selection of type and size of a steam boiler depends upon the following factors:

(1) The power required and working pressure.
(2) The geographical position of the power house.
(3) The fuel and water availability
(4) The probable permanency of the station
(5) The probable load factor.

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Write down the classification of steam boiler ?

Ans: 1. According to the content in the tube may be classified as :

(a) Fire tube or smoke tube boiler

and (b) Water tube boiler

Fire tube boiler : In fire tube steam boilers, the flames and hot gases, produced by the combustion of fuel, pass through the tubes (called multi tubes) which are surrounded by water. The heat is conducted through the walls of the tubes from the gases to the surrounding water.

Example : 1. Simple vertical boiler
2. Cochran boiler
3. Lancashire boiler
4. Cornish boiler
5. Scotch marine boiler
6. Locomotive boiler
7. Velcon boiler

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Water tube boiler : In water tube steam boilers, the water is contain inside the tubes, which are surrounded by flames and hot gases produced by combustion of fuel.

Example :

1. Babcock and Wilcox boiler
2. Stirling boiler
3. La-Mont boiler
4. Benson boiler
5. Yarrow boiler
6. Loeffler boiler

2. According to the position of the furnace, the steam boiler are classified as :

(1) Internally fired.

(2) Externally fired.

(1) Internally fired : In internally fired steam boilers, the furnace is located inside the boiler shell. Most of the fire tube steam boilers are internally fired.

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Externally fired : In externally fired steam boiler's, the furnace is located outside the boiler shell. Most of the water tube steam boilers are externally fired.

3. According to the axis of the shell :

(1) Vertical steam boiler

(2) Horizontal steam boiler

(1) Vertical steam boiler : In vertical steam boiler, the axis of the shell is vertical. Ex: 1. Simple vertical boiler 2. Cochran boiler

(2) Horizontal steam boiler : In horizontal steam boiler, the axis of the shell is horizontal. Ex: 1. Lancashire boiler 2. locomotive boiler 3. Babcock and wilcox boiler.

4. According to the number of tubes :

(1) Single tube

(2) Multi tubular

Single tube : In single tube steam boiler's there is only one fire tube/water tube.

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Example : (1) Simple vertical boiler

(2) Cornish boiler.

Multitubular boilers : In multi tubular steam boilers, there are two or more fire tube or water tube.

Ex: (1) Lancashire boiler

(2) locomotive boiler

(3) Cochran boiler

(4) Babcock and Wilcox boiler.

**** Describe about of boiler Mountings ?

Ans :

(1) Water level indicator :

1. It indicates the water level inside the boiler to an observer.

2. It is a safety device upon which the correct working of the boiler depends.

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(2) Pressure gauge :

** It is used to measure the pressure of the steam inside the steam boiler.

3. Safety valve : It prevents explosions due to excessive internal pressure of steam.

4. Steam stop valve :

(a) To control the flow of steam from the boiler to the main steam pipe.

(b) To shut off the steam completely when required.

5. Blow off cock :

(a) To empty the boiler whenever required.

(b) To discharge the mud, scale or sediments which are accumulated at the bottom of the boiler.

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6. Feed check valve :

(a) It's function is to regulate the supply of water, which is pumped into the boiler by the feed pump.

7. Fusible plug : It avoids the explosion which may have take place due to overheating of the furnace plate.

*** Write down the classification of safety valves.

Ans :

(1) Lever safety valve.

(2) Dead weight safety valve.

(3) High steam and low water safety valve.

(4) Spring loaded safety valve.

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*** Discuss about Boiler Accessories?

Ans: These are the devices which are used as integral parts of a boiler and help in running efficiently.

Types of Accessories:

(1) Feed pump
(2) Superheater
(3) Economiser
(4) Air preheater.

(1) Feed pump: A feed pump may be of centrifugal type or reciprocating type. The reciprocating pumps are run by the steam from the same boiler in which water in to be fed. These pumps may be classified as simplex, duplex and triplex pumps according to the number of pump cylinders.

(2) Superheater: Its purpose is to increase the temperature of saturated steam without raising its pressure.

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(3) Economizers : An economiser is a device used to heat feed water by utilising the heat in the exhaust flue gases before leaving through the chimney. As the name indicates, the economiser improve the economy of the steam boilers.

Advantages :

(1) There is about 15 to 20% of coal saving.

(2) It increases the steam raising capacity.

(3) short time.

(4) Air preheaters : An air preheaters is used to recovers heat from the exhaust flue gases.

Advantages :

1. It increases the evaporative capacity
2. There is an increase of about 2% in the boilers efficiency for each 35-40°c
3. It results in better combustion with less soot, smoke and ash.

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What do you understand by boiler efficiency?

Ans: It may be defined as the ratio of heat actually used in producing the steam to the heat liberated in the furnace.

$$\text{Boiler efficiency, } \eta = \frac{\text{Heat actually used in producing steam}}{\text{Heat liberated in the furnace}}$$

$$= \frac{m_e (h - h_f)}{C}$$

$$= \frac{m_s (h - h_f)}{m_f \times C} \quad \left[\because m_e = \frac{m_s}{m_f}\right]$$

Where,

m_e = Mass of water actually evaporated in kg/kg of fuel.

h = Total heat of steam in kj/kg of steam.

h_f = sensible heat of feed water in kj/kg of steam.

C = Calorific value of fuel in kj/kg of fuel.

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m_s = Total mass of water evaporated into steam in kg.

m_f = Mass of fuel used in kg.

Internal Combustion Engines

*** What do you understand by Ic Engines?

Ans: The internal combustion engines are those engines in which the combustion of fuel taken place inside the engine cylinder.

Ex: (I) Petrol engine

(II) Diesel engine

(III) Gas engine.

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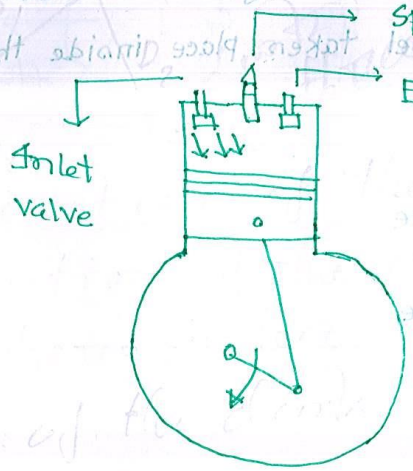
*** Discuss about four stroke cycle Petrol engine?

Petrole Engine: A petrol engine draws a mixture of petrol and air during suction stroke.

Four stroke:

(I) **Suction or charging stroke:** The carburator is employed to mix air and petrol in the required proportion and to supply it to the engine during suction stroke. In this stroke, the inlet valve is opens.



and chage is sucked into the cylinder as the piston moves downwards.

Fig: Suction or charging stroke.

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(2) Comprression stroke : [The injector or Quttomizer is employed to inject the fuel at the end of comprression stroke] In this stroke, both the Valves are closed and the air is comprressed as the piston moves upwards. It comprressed the mixing of water by trransverrsing piston.

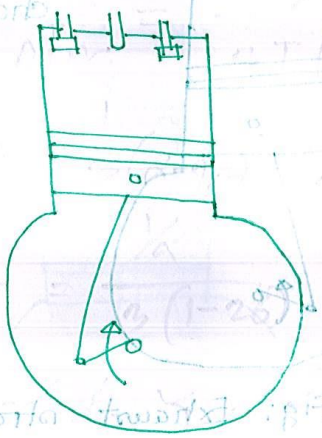
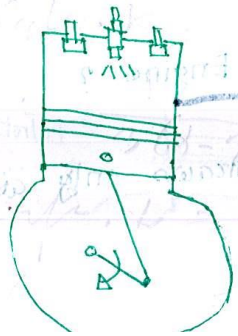


Fig: comprression stroke.

(3) Working stroke : The charge is ignited with the help of spark plug. During this expansion, some of heat energy produced is transformed into mechanical work.



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Exhaust stroke: On this stroke, the exhaust valve is open as the piston moves. This movement of the piston pushes out the products of combustion from the engine cylinder. This complete cycle, the engine cylinder is ready to suck the charge again.

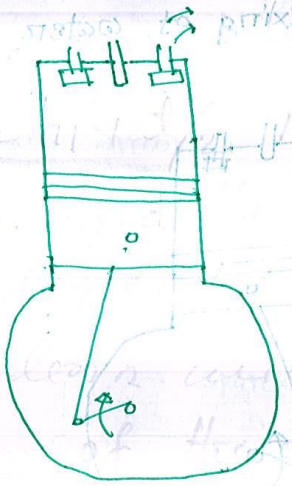

Fig: Exhaust stroke

Uses: The four stroke cycle petrol engine are usually employed in light vehicles such as cars, jeeps and aeroplanes.

*** Discuss about Diesel Engine ?

Ans: A diesel engine draws only air during suction stroke.

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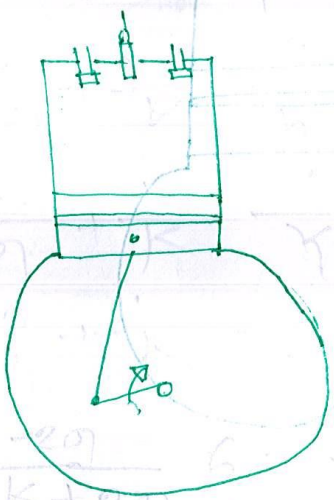
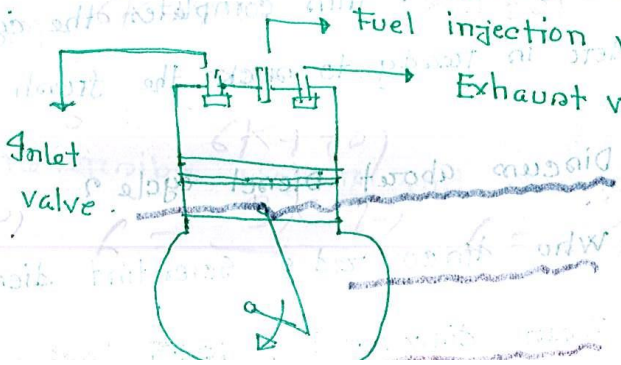
Four stroke :

Compression

(I) Suction or charging stroke : The injector or automizer is employed to inject the fuel at the end of compression stroke. In this stroke, both the valves are closed and the air is compressed as the piston moves upward.



Suction : In this stroke, the inlet valve opens and pure air is sucked into the cylinder as the piston moves downwards.



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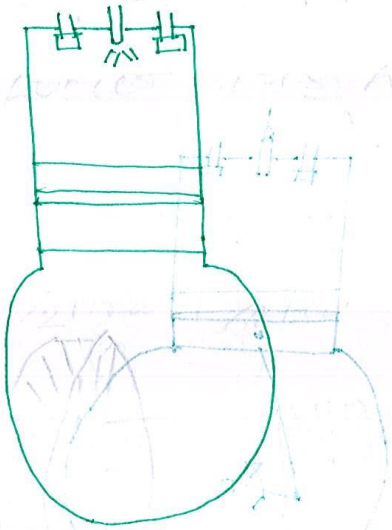
Expansion : The fuel is injected in the form of fine spray. During this expansion, some of the heat energy is transformed into mechanical work.



Exhaust stroke : In this stroke, the exhaust valve is open as the piston moves. This movement of the piston pushes out of the products of combustion from the engine cylinder. This completes the cycle and the engine cylinder is ready to suck the fresh air again.

*** Discuss about Diesel cycle ?

Who discovered : Scientist diesel.

When discovered : [illegible]

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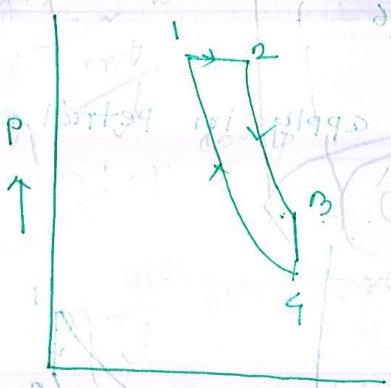
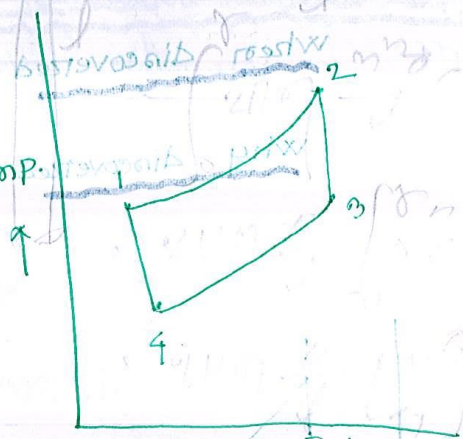
Why discovered: To apply in diesel engine.

Explanation:



P-V diagram



T-S Diagram

1-2 = Isobaric heat addition

2-3 = Isentropic expansion

3-4 = Isochoric expansion heat addition

4-1 = Isentropic comptression

The diesel cycle composed of two reversible isentropic/adiabatic, one reversible isobaric and one reversible isochore.

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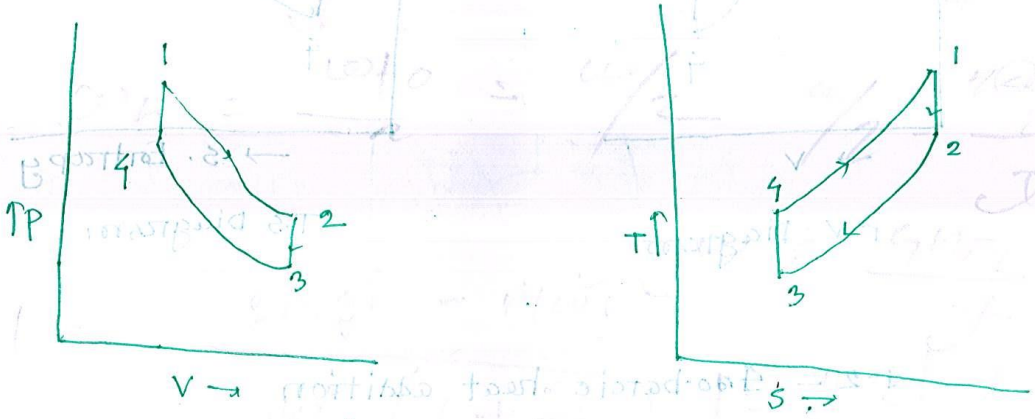
Discuss about Petrol / otto cycle?

Ans: Who discovered: Scientist otto

When discovered: 1876

Why discovered: To apply in petrol engine



1-2 = isentropic expansion

2-3 = isobaric isochronic expansion

3-4 = isentropic compression

4-1 = isobaric isochronic heat addition

The Petrol/otto cycle consist of two reversible isentropic and two reversible iso-chronic.

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For a boiler the calorific value of fuel used is 3500000 J/kg. mass of water actually evaporated is 25 kg/kg of fuel. total heat of steam is 10000000 of steam. sensible heat of feed water is 5000000 J/kg of steam. Calculate the boiler efficiency.

Ans: Here,

Calorific value of fuel, $c = 3500000$ kJ/kg

$= 3500$ kJ/kg

Mass of water actually evaporated kg/kg of fuel, $m_e = 25$ kg/kg.

Total heat of feed water, $h_{fd} = 5000$ kJ/kg

Total heat of steam, $h = 10000$ kJ/kg

∴ Boiler efficiency $\eta = \frac{m_e(h - h_{fd})}{c} \times 100$

$= \frac{25(10000 - 5000)}{3500} \times 100$

$= 357.14 \times 100$

$= 35714\%$

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*** In a Boiler the Calorific value of fuel used is 3500000 J/kg, mass water actually evaporated in .0025 kg/kg of fuel, total heat of steam in 1000 J/kg of steam, sensible heat of feed water in 500 J/kg of steam. Calculate the boiler efficiency

Here,

$C = 35\,000\,00$ J kg

$= 3500$ kj/kg

$me = .0025$ kg/kg

$h = 1000$ J/kg

$= 1$ kj/kg

$h_{fe} = 500$ J/kg

$= .5$ kj/kg

$$\eta = \frac{me\,(h - h_{fe})}{C} \times 100$$

$$= \frac{.0025\,(1 - .5)}{3500} \times 100$$

$= .0000357 = 3.6 \times 10^{-5}\%$ Ans.

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For a boiler the calorific value of fuel used is 3500000 J/kg, total mass of evaporated water evaporated into steam is 0.25 kg. Total heat of steam is 100 kJ/kg. Sensible heat of feed water is 200000 J/kg of steam. Calculate the mass of fuel in kg. Efficiency of boiler = 30%.

Here, $c = 3500000 \text{ J/kg} = 3500 \text{ kJ/kg}$

$m_s = 0.25 \text{ kg}$

$h = 1000 \text{ kJ/kg}$

$h_{fd} = 200000 \text{ J/kg} = 200 \text{ kJ/kg}$

$\eta = 30\%$

$$\eta = \frac{m_s (h - h_{fd})}{m_f \times c}$$

$$\Rightarrow \frac{30}{100} = \frac{0.25 (1000 - 200)}{m_f \times 3500}$$

$$\Rightarrow 30 \times m_f \times 3500 = 0.25 \times 100 \times 800$$

$$\Rightarrow m_f = \frac{20.000}{105\,000}$$

$$= 0.190 \text{ kJ/kg} \quad \text{Ans.}$$

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Heat Transfer

According to second law of thermodynamics heat transfer or heat flow taken place from a body at a higher temp. to a body at a lower temp.

Methods of heat :

1. **Conduction** (Solid) : It is a process of heat transfer from one particle of the body to another in the direction of fall of temp.

2. **Convection** (Liquid) : It is process of heat transfer from one particle of the body to another by convection element.

3. **Radiation** (Air) : It is a process of heat transfer from a hot body to a cold body.

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Write down the Fourier's law of heat conduction

Ans:

From the fourier's law,

$$Q \propto A\frac{dT}{dx}$$

where,

Q = Amount of heat flow through a body in a unit time.

A = Surface area of heat flow

dT = Temperature difference on the two faces of the body.

dx = Thickness of the body through which the heat flows, taken along the direction of the heat flow

k = Constant of proportionality, known as the thermal conductivity

$$\Rightarrow k = \frac{Q\,dx}{A\,dT}$$

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Thermal conductivity depends on :-

(1) Directly proportional to the amount of the heat flow through a body in a unit time and thickness of the material

(2) Inversely proportional to the surface area of heat flow and temperature difference on the two faces of the body.

Finally - The amount of heat flow through a body unit 1 area, unit temp, unit thickness in a unit time is called heat conductivity.

**** Discuss about fourier's law of heat flow ?

From the fourier's law -

$$Q \propto A \frac{dT}{dx}$$

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where,

q = Amount of heat flow through a body in a unit time.

A = Surface area of heat flow.

ΔT = Temperature differences on the two faces of the body.

x = Thickness of the body through which the heat flows, taken along the direction of heat flow.

[Constant of proportionality, known as the thermal conductivity].

Amount of heat flow through a body in a unit time depends on —

(1) Directly Proportional to the surface area
(2) Directly proportional to temp.
(3) Inversely proportional to thickness
(4) On the material of the body.

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*** What do you understand by Thermal conductivity?

Ans: Amount of heat flow through a body in a unit time

$$Q = kA\frac{dT}{dx}$$

$$= kA\frac{T_1 - T_2}{dx}$$

If "t" is the time through which the heat flows in a solid slab of thickness "x" then total amount of heat flow through the body.

$$Q = kA\left(\frac{T_1 - T_2}{x}\right) \times t$$

In this equation, if we substitute, $A = 1m^2$, $T_1 - T_2 = 1K$, $t = 1s$, $x = 1m$, then $Q = k$

Then thermal conductivity of a material is numerically equal to the quantity of heat (in joules), which flows in one second through a slab of the material of area $1m^2$ and thickness 1m, when its faces differ in temp. by 1k. It may also defined as the quantity of heat in joules that flows in one second through

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cube of material when opposite faces are maintained at a temp. diff of one kelvin.

Prob≠ The thermal conductivity of a material is ·025 kW/mk. The surface are is 35 m², highest temp. 50°c, lowest temp. 25c, the thicknem of the slub is 500 mm. Calculate the amount of heat flow through the body in unit time.

Ans:

Thermal conductivity of a material, $K = 0.025$ kW/mk

Surface area, $A = 35\ m^2$

Highest temp, $T_1 = 50°c = 50+273 = 323\ k$

Lowest temp, $T_2 = 25°c = 25+273 = 298\ k$

Thickness of the slub, $x = 500$ mm
$= 0.5$ m

time, $t = 1$

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We know,

$$Q = KA \frac{T_1 - T_2}{x} \times t$$

$$= .025 \times 35 \times \frac{323 + 298}{.5} \times 1$$

$$= 8.75 \times 50$$

$$= 43.75 \text{ kj} \quad \text{Ans.}$$

When, $t = 5$,
total amount, $Q = 43.75 \times 5$

- T+S → Expansion + compression
- P → Heat addition + rejection
- V → Expansion + compression

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Hydraulics and Fluid mechanics

What do you understand by Hydraulics and fluid mechanics

The word "Hydraulics" has been derived from a Greek word "Hydour" which means water. The subject Hydraulics is that branch of Engg. science which deals with water at rest or in motion.

The subject fluid mechanics is that branch of engg. science which deals with the behaviour of fluid under the condition of rest and motion.

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Write down the important factors / important terms used in hydraulics and fluid mechanics

Ans:

(1) **Density and mass density:** It is defined as the mass per unit volume of a liquid at a standard temp. and pressure. It is usually denoted by ρ.

Mathematically, $\rho = \frac{m}{V}$

where, m = Mass of the liquid

V = Volume of the liquid

Unit: $kg\,m^{-3}$

(2) **Specific volume:** It is defined as the volume per unit mass of the liquid. It is denoted by v.

Mathematically,

Specific volume, $v = \frac{V}{m} = \frac{1}{\rho}$

where, v = volume of liquid

m = mass of liquid

Unit: $m^3\,kg^{-1}$

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3. Specific gravity : It is defined as the ratio of specific weight of liquid to the specific weight of pure water at a temperature 4°c . It has no units.

The specific gravity of pure water is taken as unity

*** Write down the properties of liquid ?

Ans:

(1) Viscosity : It is defined as the property of a liquid which offers resistance to the movement of one layer of liquid over another adjacent layer of liquid. It is also known as absolute viscosity or dynamic viscosity

(2) Kinematic viscosity : It is defined as the ratio of dynamic viscosity to the density of the liquid.

(3) Compressibility : It is that property of liquid by virtue of which liquids undergoes a change in the volume with the change in pressure.

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4. Surface tension : It is that property of a liquid which enables it to resist tensile stress. It is denoted by σ. It is expressed in N/m

5. Capillarity : This is defined as a phenomenon of rise or fall of liquid surface in a small vertical tube.

*** What do you understand by Atmospheric pressure

Ans : The atmospheric air which exerts a normal pressure upon all surfaces with which it is in contact and it is known as atmospheric pressure. It is also known as barometric pressure. The atmospheric pressure at sea level is called standard atmospheric pressure and its value is given as follows :

Standard atmospheric pressure = 101.325 KN/m^2 or KPa

= 760 mm of Hg

= 10.3 m of water.

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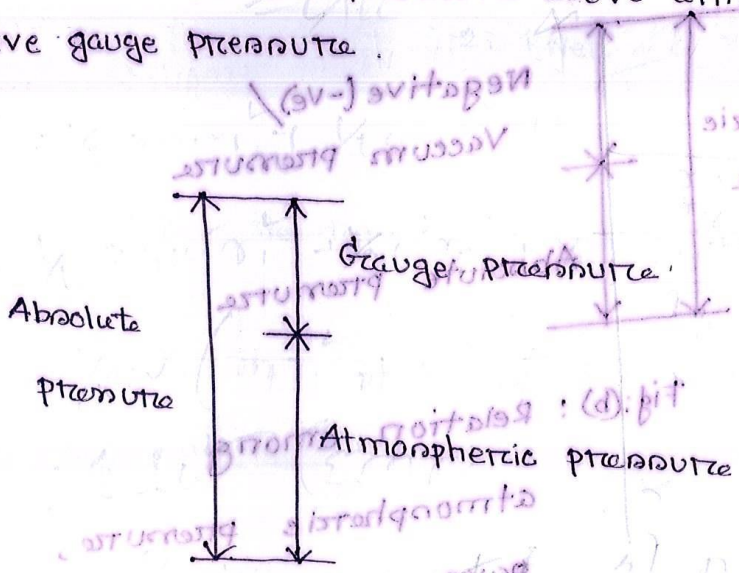
*** What do you understand by Gauge pressure?

Ans: The pressure measure in the help of a pressure gauge, is known as gauge pressure. All the pressure gauge record the difference between the actual pressure and atmospheric pressure. The actual is known as the absolute pressure.

Mathematically absolute pressure = atmospheric pressure + gauge pressure (+ve)

This relation is used for pressure above atmospheric i.e for positive gauge pressure.



Fig(a): Relation among atmospheric, gauge pressure and absolute pressure.

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For pressure below atmospheric the gauge pressure will be negative. This negative gauge pressure is known as Vaccum pressure.

Mathematically,

Absolute pressure = Atmospheric pressure − gauge pressure (-ve)/ Vaccum pressure.

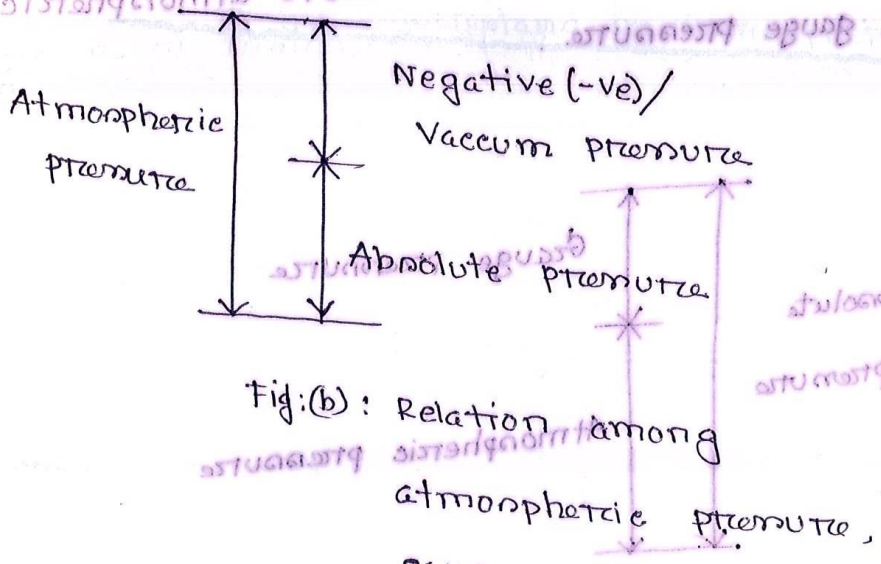

Fig:(b): Relation among atmospheric pressure, gauge pressure and absolute pressure.

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*** What do you understand by pipes and channels?

Ans: A pipe is a closed conduct (বদ্ধ নালা) (generally of circular section) which is used for carrying fluids under pressure. The fluid completely fills the cross-section of the pipe. When the pipe partially full of fluid, it then behaves like an open channel.

Example of open channel: 1. Drainage
2. River

*** Write down the types of forces present in the moving liquid.

Ans:
(a) Inertia force
(b) Viscous force
(c) Gravity force
(d) Surface tension force
(e) Pressure force
(f) Elastic force.

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(a) Inertia forces: It is the product of mass of acceleration of the following liquid.

(b) Viscous force: It is the product of shear stress due to viscosity and cross sectional area of the flowing liqd.

(c) Gravity force: It is the product of mass and acceleration due to gravity of the flowing liqd.

(d) Surface tension force: It is the product of surface tension per unit length and the length of the surface of the liquid.

(e) Elastic force: It is the product of elastic surface stress and the area of flowing liqd.

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(4) Pressure force : It is the product of intensity of the pressure and the area of the flowing liqt.

*** Write down the types of Dimensionless numbers ?

Ans : There are five types of dimensionless numbers.

(1) Reynold's Number
(2) Froude's Number
(3) Weber's Number
(4) Euler's Number
(5) Mach's Number.

(1) Reynold's Number : It is the ratio of inertia force to the viscous force.

(2) Froude's Number : The ratio of inertia force to the gravity force is called Froulder's Number.

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3. Weber's Number : The ratio of inertia force to the surface tension force is called weber's Number.

4. Euler's Number : The ratio of inertia force to the premeure force is called Euler's Number.

5. Mach's Number : The ratio of inertia force to the elastic force is called Mach's Number.

~~***~~ The diameter of a pipe is 5 cm. The discharge of the liquid is $50 m^3/s$. Determine the velocity of the liquid flow.

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Here, Diameter, $d = 1.5m$ $\therefore r = 1.5/2 = .25$ m

Cross-sectional area, $a = 5cm = .5m$

$\pi r^2 = .196$

Discharge of the liquid, $Q = 50 m^3/s$

Now,

$\because$ Diameter, $v = \frac{Q}{a}$

$= \frac{.50}{.196} = 2.55$ Ans.

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*** Write down the different types of energies and head of the liquid on motion.

Ans: There are three types of energies or head:

(a) Potential energy or potential head.

(b) Kinetic energy or kinetic head.

(c) Pressure energy or Pressure head.

(a) Potential energy or Potential head: It is occur due to the position of some suitable datum line. It is denoted by z.

(b) Kinetic energy or kinetic head: It is occur due to the velocity of the flowing liquid. Its value is given by $V^2/2g$. where "V" is the velocity and g is the acceleration due to gravity.

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(c) Pressure energy and pressure head: It is occur due to the pressure of the flowing liquid. This value is given by "$\frac{p}{\gamma}$" where p is the pressure and "γ" is the weight density of liquid.

(d) Total energy or head of the liquid:

The total energy or head of the liquid particle in motion is given as follows:

Total energy or head H = Potential energy or head +
Kinetic energy or head +
Pressure energy or head

$$\therefore E = z + \frac{v^2}{2g} + \frac{p}{\gamma}$$

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*** What do you understand by Bernoulli's Equation.

Ans: For a perfect incompressible liquid flow in a continuous stream (ধারা), the total energy of a particle remains the same, while the particles move from one point to another point.

Mathematically :-

$$z_1 + \frac{v_1^2}{2g} + \frac{p_1}{\gamma} = z_2 + \frac{v_2^2}{2g} + \frac{p_2}{\gamma}$$

$$= \text{-----1-----}$$

$$= \text{Constant.}$$

Where, z = Potential energy or head.

$\frac{v}{2g}$ = Kinetic energy or head

$\frac{p}{\gamma}$ = Pressure energy or head.

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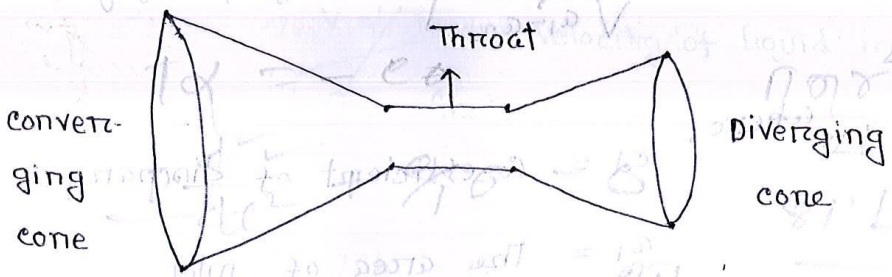
*** What do you understand by Venturimeter.

Ans: It is an instrument to measure the discharge of liquid flowing in a pipe. It consists of three parts.

(a) Converging cone

(b) Throat

(c) Diverging cone



The length of a divergent cone is made about 5 to 4 times longer than that of convergent cone in order to avoid tendency of breaking away the stream of liquid and to minimize the frictional losses.

It is noted that,

(a) The velocity of liquid at throat is higher than that of inlet.

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(b) The pressure of liquid at throat is lower than that of inlet.

(c) The pressure and velocity of flowing liquid through the divergent portion decreases.

The discharge of a venturimeter is given by,

$$Q = \frac{C_d\, a_1 a_2}{\sqrt{a_1 - a_2}} \sqrt{2gh}$$

where,

C_d = Co-efficient of discharge

a_1 = The area of inlet

a_2 = The area of outlet

h = Venturi head / energy

*** What do you understand by orificemeter?

Ans: Orificemeter is a device for using for measuring the discharge of the liquid which is flowing in the pipe. It is cheaper than venturimeter. It works on the same principles as that of venturimeter.

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*** Write down the major loss of orificemeter ?

Ans:

Loss of head due to friction in the pipe: According to Darcy's Law the loss of head due to friction in the pipe.

$$h_f = \frac{flv^2}{2gd}$$

where,

f = Darcy's co-efficient

l = length of the pipe

V = Mean velocity of liquid in the pipe.

g = Acceleration due to gravity

D = Diameter of the pipe.

*** Write down the Minor loss of orificemeter ?

Ans:

Cause:

(1) Loss of head due to sudden inlargement.

$$he = \frac{(v_1 - v_2)^2}{2g}$$

where, v_1 = Velocity before enlargement

v_2 = Velocity after enlargement

g = Acceleration due to gravity.

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(2) Loss of head into sudden contraction.

$$h_c = \frac{v_2^2}{2g}\left(\frac{1}{C_c} - 1\right)$$

where,

C_c = Coefficient of contraction

V = Velocity of liquid

(3) Loss of head at the inlet of the pipe.

$$h_i = .5 \times \frac{v_i^2}{2g}$$

where,

V_i = Inlet velocity

g = Acceleration due to gravity.

(4) Loss of head at the outlet of the pipe.

$$h_o = \frac{v_o^2}{2g}$$

where,

V_o = Outlet velocity

g = Acceleration due to gravity.

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*** Write down the equation of continuity?

Ans: If an incompressible liqd is continuously flowing through, a pipe or a channel (whose cross sectional area may or may not constant) the quantity of liqd passing per second is same at all sections.

Mathematically,

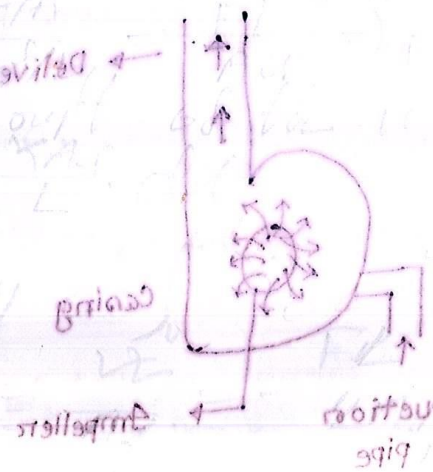
$$Q_1 = Q_2 = Q_3 = \dots$$

$$\Rightarrow a_1V_1 = a_2V_2 = a_3V_3 = \dots$$

where,

a = cross sectional area

V = velocity



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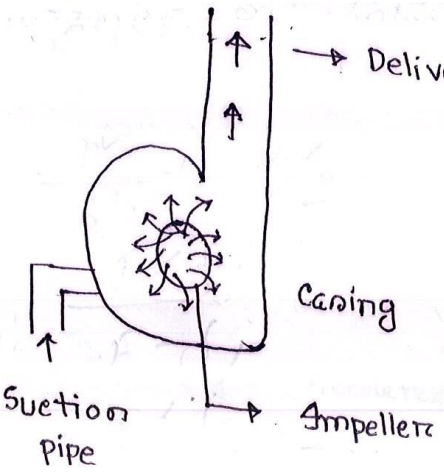
*** What do you understand by orifice

Ans: It is a small opening on the wall or base of vessel through which the fluid flows.

*** What do you understand by Mouthpiece.

Ans: The mouthpiece is an attachment in the form of a small tube or pipe fixed to the orifice. Its length is usually 2-3 times than the diameter of orifice. It is used to increase the amount of discharge.

*** What do you understand by centrifugal pump?



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Suction pipe : Water is passed into casing.

Impeller : Impeller is a rotating device.

Casing : In casing, water prepared for delivery pipe.

Delivery pipe: Water flown to upward direction.

A centrifugal pump is a m/c which converts kinetic energy energy of the water into pressure energy before the water leaving its casing.

The basic principle of which a centrifugal pump works is that, when a certain mass of liquid is made to rotate by external force, it is thrown away from the central axis of rotation and a centrifugal head is impressed which enables it to rise to high level.

What do you understand by Monometric head ?

Ans: It is the actual heat of water against which, centrifugal pump has to work.

Mathematically,

Monometric head = Energy per kg at outlets of impeller − Energy per kg at inlet of impeller

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*** What do you understand by ~~Monometric head~~ Discharge of centrifugal pump?

Ans: The discharge of a centrifugal pump is given by, $Q = \pi D b V_f$

where,

Q = Discharge of centrifugal pump.

D = Diameter of impeller

b = Width of impeller

V_f = Velocity of flow at inlet

*** What do you understand by Monometric efficiency?

Ans: The monometric efficiency of a centrifugal pump is defined as the ratio of monometric head to the energy supplied by the impeller.

Mathematically,

Monometric efficiency,

$$\eta_{mo} = \frac{\text{Monometric head}}{\text{Energy supplied by the impeller}} \times 100$$

It expressed as percentage.

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*** What do you understand by Mechanical efficiency

Ans: The mechanical efficiency of a centrifugal pump is defined as the ratio of the energy available at the impeller to the energy supplied to the pump.

Mechanical efficiency,

$$\eta_{me} = \frac{\text{Energy available at the impeller}}{\text{Energy supplied to the pump}} \times 100$$

It is expressed as percentage.

*** What do you understand by overall efficiency ?

Ans: It is defined as the ratio of energy supplied to the pump to the energy available at the impeller.

Overall efficiency,

$$\eta_o = \frac{\text{Energy supplied to the pump}}{\text{Energy available at the impeller}} \times 100$$

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*** What do you understand by reciprocating pump?

Ans: The reciprocating pump is a positive displacement pump as it discharges a definite quantity of liquid during the displacement of its piston or plunger which executes a reciprocating motion in closely fitted cylinder. It is best suited for low discharge and higher heads.

(a) Discharge (Reciprocating pump):

$$Q = \frac{LAN}{60}$$

Q = Discharge of liquid (m^3/s)

L = Length of piston in m

A = Cross sectional area of piston in m^2

N = Speed of crank in rpm

(b) Power required to drive the pump:

$$P = \gamma Q (H_s + H_d)$$

Q = Discharge of liquid.

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γ = Density of liquid in N/m^3

H_s = Suction head of pump

H_d = Delivery head of the pump.

(c) Slip: The difference between the theoretical discharge and the actual discharge is called the slip of the pump.

(d) Air vessel: The air vessel in a reciprocating pump is a cast iron closed chamber having an opening at its base. It is fitted on the suction pipe and the delivery pipe.

Advantages of Air vessel:

1. To get continuously supply of liquid at the uniform rate.
2. To save the power.

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Difference between the petrol and diesel Engine:

Petrol engines	Diesel Engines
1. A petrol engine draws a mixture of petrol and air during suction stroke	1. A diesel engine draws only air during suction stroke.
2. Pressure at the end of compression is about 10 bar.	2. is about 35 bar.
3. Compression ratio approximately 6 to 10	3. 15 to 25
4. The running cost of petrol engine is high because of the higher cost of Petrol	4. Less cost.
5. The maintenance cost is less	5. More.
6. High speed engine	6. Low speed engine.

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Two stroke engine: When the working cycle is completed in two strokes of the piston or one revolution of the crank shaft, then it is called two stroke engine.

Four stroke engine: When the stroke working cycle is completed in four strokes of the piston or two revolution of the crank shaft, then it is called four stroke engine.

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