Thermodynamics

Introduction

Thermodynamics is the branch of science which deals with energies possessed by gases and vapours their conversion in terms of heat and work and the properties of substance which are connected with heat and work. It deals with transfer of heat from one medium to another. The energy transfers are made during the processes which use certain fluid contained in of flowing trough a system. The system is limited by a boundary.

A device which converts heat energy in to mechanical energy is known as Heat Engine. The energy liberated by combustion of fuel is supplied to working at higher temperature.

THERMODYNAMIC SYSTEM:

Thermodynamic system may be defined as any space or prescribed region which contains quantity of matter or working fluid whose behavior is to be studied. Everything out side of the boundary of the system which would effect behavior of the system is called surrounding.

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b. The open system

c. Isolated system.

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Eg: In the air compressor

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If the boundaries of the system doesn't allow the matt or the energy to flow in to or out of the system is known as isolat system.
Eg: Total energy in the universe is constant.

PROPERTIES OF THERMODYNAMIC SYSTEM:

A property of a system is a characteristic of the syste which defines the state of the system and independent of the proce The properties of the system may be classified in to two types

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Intensive properties are those properties, which are t independent of the mass of the system

Eg: Pressure, Temperature, density, Specific Gravity, Specific volume, Surface tension, thermal conductivity etc.

EXTENSIVE PROPERTIES:

These properties of the system are dependent on the mass of the system.

Eg: Total energy, total mass, total weight, enthalpy, entropy, internal energy etc.

VOLUME:

Volume is defined as the space occupied by substance. It is represented by V. It is measured in m^3.

SPECIFIC VOLUME:

It may be defined as the volume occupied by unit mass of the substance. It is measured in m^3/kg.

DENSITY:

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Pressure may be defined the force exerted by it per unit area. It is measured in kgf/sq.m in M.K.S. system and in N/sq.m in S.I system.

ATMOSPHERIC PRESSURE:

Atmospheric pressure is the pressure exerted by air. Its value at mean sea level is 1.0332 kgf/sq.cm or 760 mm of hg.

One physical atmosphere = 760 mm of Hg
= 1.0332 Kgf/sq.cm
= 1.01325 bar
1 bar= 100000N/sq.m

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If the pressure of a system is less than atmospheric pre sure, the pressure gauge reads the negative side of atmospheric pre sure, This is called as vaccum pressure.

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Absolute pressure is the pressure exerted by the syste on its boundaries.

Pabs. = Pat + Pg (when the gauge pressure is positive}

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It means the temperature is at 15°C and pressure is 760 mm of Hg.

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Work is done by force when it acts upon a body moving in the direction of the force. The amount of work done is equal to the product of force and distance moved in the direction of force. It is measured in kg fm in MKS system and N/sq.m in SI system.

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The part of the energy which is stored in the gas and is used for rising its temperature is called internal energy of gas. When a certain amount of heat energy is supplied to a gas, some of it is converted into mechanical energy and the remaining is stored in the gas itself.

If T_1 is the initial temperature and T_2 is the final temperature.
Then T_2-T_1 is the rise in temperature then
The change in Internal energy is directly proportional to the change in the temperature of a gas.

$$\Delta U \;\alpha\; T_2 - T_1.$$
$$\Delta U = \text{Constant.} (T_2 - T_1)$$
$$\Delta U = Cv(T_2 - T_1)$$

$$\Delta U = m\, Cv(T_2 - T_1)$$

HEAT:

It is a form of energy which is transferred from one body to another body by virtue of temperature difference. Heat is not a form of stored energy but occurs only in transaction.

Heat may be transferred in three forms namely A. Conduction B. Convection C. Radiation.

The direction of heat transfer is towards the low ter perature of the body and is measured in Kilo calories and Kilo Joule

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Heat energy flows in to the system from the surroundi is taken as positive and heat energy flows from system to surrounding taken as negative.

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Enthalpy is defined as the total heat energy contained a gas. It is the sum of its internal energy and the external energy due to pressure and volume.

If H= Enthalpy in K J or Kcal
M= Mass of the gas in kg.
ΔU= Change in internal energy,
P= Pressure of the gas,
V= Volume of the gas
$H=\Delta U+PV$

SPECIFIC HEAT:

Specific heat is defined as the amount of heat required raise the temperature of its unit mass through oC.

SPECIFIC HEAT AT CONSTANT VOLUME (Cv):

The specific heat at constant volume may be defined the amount of heat required to raise unit mass of gas through one degr when it is heated at constant volume process.

Total heat supplied at constant volume process (H) = $M\, Cv (T_2 - T_1)$
Where m= mass of the gas
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T_1=Initial temperature.
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Cv= 0.172 Kcal/kg/k in MKS system
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∴ P= 1000 X 101.325/760 KN/sq.M

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1. Define thermodynamic system?

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3. Define extensive property and give example?

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5. Distinguish between Intensive property and extensive property?

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1.How do you classify thermodynamic system and explain with example?

Intermediate

Vocational Course

First Year

Mechanical Technology

For the Course of
Rural Engineering Technician

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2005

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Introduction

Components of Sprinklers

Drip Irrigation system

Different components

Cleaning of filters nozzles, drips

Installation and pipe fittings

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CHAPTER-2
Laws of Thermo Dynamics

Introduction:

Thermodynamics is the branch of science, which deals with energy possessed by a fluid, conversion of heat into work and work into heat and relationship with properties of system. The energy conversion is based on certain thermodynamic process.

ZEROTH LAW OF THERMODYNAMIC:

It states that when two bodies are in thermal equilibrium seperately with third body, then the two bodies will be in therma l equilibrium with each other.

Let P and Q are thermal equilibrium with third body R seperately, i.e, there is no heat transfer from P to R or R to P and from Q to R or R to Q then P and Q will be in thermal equilibrium.

FIRST LAW OF THERMODYNAMICS:

It states that heat and Mechanical work are intercoverable i.e., Mechanical work is obtained by expenditure of heat or conversely heat is produced by spend o mechanical work.

Le t W is amount of work obtained from heat H

Then $W \alpha H$

$W=JH$

Where J is mechanical equivalent of work

1 Kcal=427Kgf-m

1 K.J = 1 KN-M

or

In a closed system undergoing cyclic process, the net work delivered to sorroundings is proportional to heat taken from the sorrounding .

$$\int \Delta Q \quad \alpha \int \Delta W$$

$$\int \Delta Q = 1/J \int \Delta W$$

Where $\int \Delta Q$ = The heat aken from sorroundings

$\int \Delta W$= Work delivered

J= Mechanical equivalent work

SECOND LAW THERMODYNAMICS:

It can be stated in two different ways

1. Clausius statement
2. Kelvin- Max Plank statement

CLAUSIUS STATEMENT:

It is impossible for the heat to flow from a body at low temperature to a body at high temperature without aid of external agen or heat flows from hot body to a cold body unaided.

This statement follows that a body can only absorb he from a source which at higher temperature than that of a body.

If it is required to lower the temperature of the body below that of its sorroundings mechanical energy have to be spent.

Eg. Heat pump. It takes in work and deliver heat continuous

KELVIN-MAX PLANKS STATEMENT:

It is impossible to construct an heat engine working or cyclic process, whose sole purpose is to conver all the heat supplied it into equivalent amount of work .i.e., No heat entine converts or c convert, more than small fraction of the heat supplied to it, into wo and large part of heat is necessarily rejected as heat.

The ratio of heat converted into work to heat taken in by the engine is called the thermal efficiency of the engine.

SUMMARY:

Zeroth law of thermodynamics: It states that when two bodies are in thermal equilibrium with third body, they are in thermal equilibrium with each other.

First law of thermodynamics It states that heat and work are mutually inter convertible.

Second law of thermodynamics:

Kelvin-maxplanks statement: It is impossible to construct an engine working cyclic process shows sole piurpose is to convert all the heat supplied to it into equivalent amount of work.

Clausius statement:

Heat can not flow from a body at lower temperature to another body at higher temperature without the aid of external agency.

WORKED EXAMPLES:

1. The heat transfer in a cycle of four processes are 1.5 Kcal, 17.5 kcal,-4 Kcal,-6 Kcal. Find the net work transfer during the cycle.

Solution:

Given data

Q_1=1.5 Kcal, Q_2=17.5 Kcal,Q_3=-4 Kcal, Q_4=-6 Kcal

$$\int \Delta Q = Q_1 + Q_2 + Q_3 + Q_4$$

$$= 1.5 + 17.5 - 4 - 6 = 9 \text{ Kcal}$$

We know $\Delta W = J \Delta Q = 427 \times 9 = 3843$ Kgf-m

2. The work transfer in a cycle of 5 processes are 40 Kj, 50Kj, -20Kj, 15Kj and –12KJ. Calculate the amount of heat transfer during the

cycle.

Solution:

Given data

W_1=40KJ W_2 =50KJ W_3=-20K0J W_4=15KJ W_5=-12KJ

According to the first law of thermodynamics,

$$\int dw + \int dq = 0$$

$$\int dq = -\int dw = -[40+50-20+15-12] = 73\text{KJ}$$

3. A Boiler contains steam of kg having heat 600 Kcal. Calcula the equivalent amount of work

Solution:

Given data

Q= 600 Kcal

Work = J Q

= 600 X 427 Kgf-m

4. A fluid contained in vessel is stirred by a pedal wheel. Th power input of pedal whel is 1 hp and heat transfer 625 Kcal/hr. calc late the change in Internal energy.

Solution:

Given data,

Work done by paddle wheel= 75 kgf-m/sec

=75X60X60/427 = 632.4 Kcal/hr.

Heat transfer =625Kcal/Hr.

According to the first law of thermodynamics,

$$Q = U + W$$

$$U = Q - W = 625 - 632.4 = -7.4 \text{ KcaL/hr.}$$

(Negative indicates decreases

5. In a cycle, there are four heat transfers , Q_1=15KJ, Q_2= 4KJ, Q_3=-10 KJ, Q_4= 3 KJ and work done at above three stages are W_1= 4 KJ, W_2=0.5KJ, W_3=2.5 KJ Find the workdone at the fourth stage ?

Solution:

Given data

Q_1=15 KJ, Q_2= 4KJ, Q_3=-10KJ , Q_4=3KJ,

W_1= 4KJ , W_2 =0.5KJ, W_3=2.5KJ, W_4=?

$\int \Delta Q = 15+4-10+3=12$ KJ,

$\int dw = 4+0.5+2.5 +W$

According to the first law of thermodynamics,

$$\int dq = \int dw$$

$$12 = 7+W$$

$$W = 5 \text{ KJ}$$

SHORT ANSWER QUESTIONS:

1. Define zeroth law of thermodynamics?

State the first law of thermodynamics?

State the Second law of thermodynamics?

CHAPTER - 3

LAWS OF PERFECT GASES:

Introduction: A gas is the state of any substance of which the evaporation from the liquid state is completed. The fluids like oxygen, air, Nitrogen and Hydrogen, etc., may be regarded as gases with in the temperature limits of applied thermodynamics. Where as a vapouir contains partially evaporated liquid and the contents of the pure gaseous state together with the particles of liquid in suspension.
Eg: Steam, CO_2, SO_2, etc.,

A vapour becomes dry when it is completely evaporated. If the dry vapour is further heated, then it is called as super heated vapour. The behavior of super heated vapouirs is similar to perfect gas.

PERFECT GAS:

A Perfect gas is one which obeys all gas laws at all conditions of temperature and pressure. A ctually there is no gas obeys all gas laws and all conditions temperatures and pressures.

But certain temperatures limits gases like O_2, H_2, N_2 etc. may be regarded as perfect gases.

The behavious of perfect gas is giverned by certain gas laws, they are,

1. Boyles law
2. Charles law,
3. Avagadros law,
4. Joules law,
5. Regnaults law,

BOYLES LAW:

It states that the volume of a given mass of gas vari inversly proportional to its absolute pressure, when the temperatu remains constant.

Let

P= Absolute pressure of a gas,
V=Volume of a given mass of a gas,
Then, By Boyles law,
$V \propto 1/P$
$PV = \text{Constant}$

In other words, the product of the absolute pressure of a gas ar its volume is constant when the temperature remains constant. Let th initial pressure of a gas is P1, volume is v1, If it is expanded or co tracted at a constant temperature process, then its pressure becom P2, and volume V2,

According to Boyles law,

$$P_1V_1 = P_2V_2$$

CHARLES LAW:

It states that, the volume of a given mass of gas vari directly proportional to its absolute temperature, when its pressure kept constant.

Let V=Volume of given mass of a gas
T=Absolute temperature,
Then, According to the charles law,

$$V \propto T$$
$$V/T = \text{Constant.}$$

If V1 and T1 are the initial volume and absolve temperatu then it is heated at constant pressure
Process, its volume becomes v2 and temperature T2, then,

According to the Charles law,

$$V_1/T_1 = V_2/T_2 \quad ($$

pressure kept constant)

The volume of a given mass of a gas is increased or decreased by 1/273 times of its original volume at 0 °C.

AVOGADROS LAW:

It states that equal volumes of all gases at the same temperatures and pressures contain equal number of molecules, in other words, If two ideal gases are contained in two vessels of equal volume and the same temperatures and pressures, each gas have the same number of ;molecules.

Let M_1, M_2 are the molecular weights and m_1 and m_2 are mases of two gases then

According to Avogadros law,

$$m_1 = kM_1 n \quad , m_2 = kM_2 n$$

$$m_1 / m_2 = M_1 / M_2$$

JOULES LAW:

It states that the internal energy of a given gas depends only its temperatures and independent of of its pressures and volumes. In other words, the change of internal energy perfect gas is directly proportional to the change of temperatures.

If the heat is added at constant volume process, all the heat supplied is stored as internal energy.

REGNAULTS LAW:

It states that the two specific heats of perfect gas don't change with change in temperatures. However, this law is assumed to hold good with in small range of temperatures. The ratio of specific heats Cp and Cv of any gas is constant.

$$Cp/Cv = \text{Constant.}$$

CHARACTERISTIC GAS EQUATION:

Consider one kg of gas be initially at pressure P1, vo ume V1, and temperature T1 respectively. This can be represented o P-V diagram at point 1. Suppose the gas expands or contracts at co stant temperature to its volume V_1 such that, the corresponding value its new absolute pressure is P_2.

According to Boyles law, $P_1 V_1 = P_2 V'_1$

$V'_1 =, \quad P_1 V_1$ /

2

Now the gas expands or contracts further such that the pressu remains constant and its volume changes from V'_1 to V_2 and temper ture from T_1 to T_2, then

According to Charles law,

$V'_1 / T_1 = V_2 / T_2$, $V'_1 =$ V

$_2/T_2 \times T_1$

Then from the above equations

$$P_1 V_1 = P_2 V_2 / T_2$$

'PV/T = Constant..

Since, V_1 is the volume of unit mass of gas, this constant usual represented by R, it is called as the characteristic g constant.

Therefore,

$$PV/T = R$$

$$\text{or } PV = RT$$

If m= mass of a gas

V= volume of a gas ,

Therefore,

$PV = mRT$ or $R = PV/mT$

Units of R : N-M/Kg/K

Value R = 29.27 Kgf-m/Kg/K

= 287J/Kg/k

UNIVERSAL GAS CONSTANT:

It is the product of Molecular weight and gas constant of the gas. It is denoted by Ru.

Ru= MR Where M is ;molecular weight.

R is The gas constant.

It is same for all gases. Ru = 848 Kgf-m/Kg-Mol/K in MKS system,

=8314 J/Kg-Mole/K in SI system.

WORKED EXAMPLES:

1. Calculate the final pressure of a gas having volume of 4 cub.m and pressure 8 bar. Which is heated at constant temperature when the final volume is 8 cub.m.

Solution:

Given data,

$V_1 = 2\ m^3$, $P_1 = 6$ bar, $V_2 = 8\ m^3$, $P_2 = ?$

By Boyles law, $P_1V_1 = P_2V_2$

$\therefore P_2 = P_1V_1/V_2 = 6X2/8 = 1.5$ bar.

2. A gas of volume of 2 cub.m and temperature is 27 °C receives heat at constant pressure so that final volume is 4 cub. m Calculate final temperature?

Solution:

Given data,

$T_1 = 27+273 = 300K$,

$V_1 = 2$ cub.m

$V_2 = 4$ cub.m P= constant

$T_2 = ?$

$V_1/T_1 1 = V_2/T_2$, $T_2 = V_2/V_1 X T_1 = 4/2X300 = 600K$

$T_2 = 600-273 = 327oC$

3. A gas of volume of 0.2 cub .m is compressed in a cylinder to fin volume 0.02 cub.m and pressure is 60 bar. Intial temperature ar pressure are 27oC and 3 bar respectively. Calculate final temper ture.

Solution:

Given data,

$V_1 = 0.2$ cub.m, $V_2 = 0.02$cub.m, $T_1 = 27+27 = 300K$, $P_1 = 3$ bar,

$P_2 = 60$ bar, $T_2 = ?$

We know, $P_1V_1/T_1 = P_2V_2/T_2$, $T_2 = P_2V_2T_1/P_1V_1 = 60x0.002x300/3x.2 = 600$

=600-273=327c

SUMMARY:

A perfect gas obeys all gas laws at all temperatures and pressures

Boyles law PV = Constant,

Charles law V/T = Constant,

Characteristic gas equation PV = mRT,

Joules law states that Internal energy of a gas is function of its temperature.

Renaults law The specific heat ratio of gas is constant.

SHORT ANSWER QUESTIONS:

1. Define perfect gas?

2. State Boyles law?

4. State Charles law?

5. Define Regnaults law?

6. Joules law?

ESSAY TYPE QUESTIONS:

Derive the characteristic gas equation of perfect gas?

CHAPTER 4

THERMODYNAMIC PROCESSES IN GASES:

The different methods of heating or cooling and expanding or contraction of gases are

1. Constan Volume process(Iso choric process)
2. Constant pressure process(Iso baric process)
3. Isothermal process
4. Isentropic process
5. Polytropic process

CONSTAN T VOLUME PROCESS:

When a gas is heated at constant volume process, i.e., in a closed vessel, Its pressure and temperature increases. Since there is no change in volume and no external wokdone on gas. All the heat suppllied during the process is stored in the gas as internal energy.

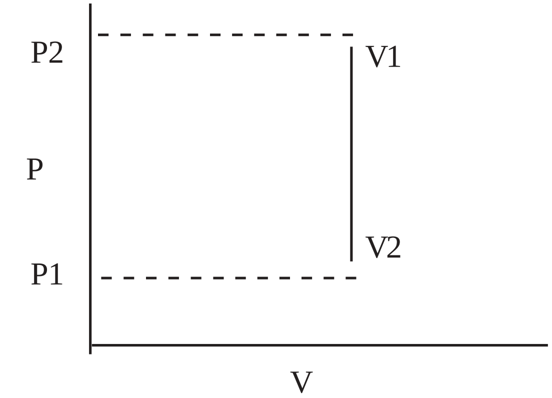
Workdone by the gas = 0,

The change in internal energy $= E_2 - E_1 = m\,Cv\,(T_2 - T_1)$

Where, m = mass of agass, Cv= The specific heat at constant volume process.

T_1= Initial temperature, T_2= Final temperature

Diagram



Heat transferred $Q = E + W = m\,Cv\,(T_2 - T_1)$
The above process is shown in figure a

CONSTANT PRESSURE PROCESS:

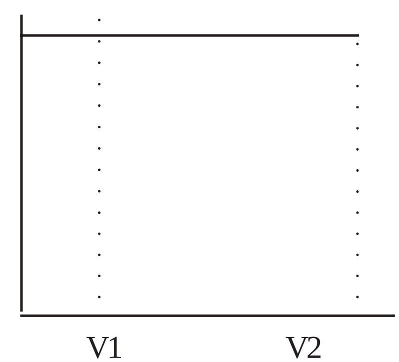
In this process the gas is heated at constant pressure pr cess. Its temperature and volume increases. Since there is change volume, heat supplied is utilized in increasing the internal energy ar doing some external work.

Work done 'W'= P dv
$= P\,(V_2 - V_1)$
Heat supplied at constant pressure process = $m\,Cp\,(T_2 - T_1)$

The change in internal energy $E_2 - E_1 = m\,Cv\,(T_2 - T_1)$

$Q = (E_2 - E_1) + W$

P1 = P2



CONSTANT TEMPERATURE PROCESS:

In this process, heat is supplied to a gas such that its temperature remains constant, such that its temperature remains constant. Such an expansion is Isothermal expansion. In this process the whole heat supplied to the gas will be used in doing external work.

Change in internal energy $E_2 - E_1 = 0$

According to the first law of thermodynamics

$Q = E + W$

$Q = W \; (E = 0)$

The above process is shown in figure a

Work done $W = P\,dv$

But for Isothermal process $PV = P_1V_1$ and $P = P_1V_1/V$

$W = P_1V_1 \; dv/V$

$= P_1V_1 \, Log \, V2/V_1$

ADIABATIC PROCESS:

In this, the working substance is neither receives nor gives out heat to its sorrounding during expansion or compression. In this, the working substance is thermally insulated from its sorrounding.
During the adiabatic process,

a. No heat leaves or enters in to the working substance

b. The change in internal energy is equal to workdone.

$Q = E + W$

$E = -W$

$W = 10000(P_2V_2 - P_1V_1)/1-\gamma$ Kgf-m

Negative sign indicated workdone on a gas for increase the intern
energy.
The above process is shown in figure a

POLYTROPIC PROCESS:

In this, gas may be heated in such way that the curve o
expansion follows law of $PV^n = C$

$W.D = 10000(P_2V_2 - P_1V_1)/n-1$ Kgf - m

SHORT ANSWER QUESTIONS:

1. Write the difference between constant volume and constant pressure process?

2. Differentiate the Isothermal process and isentropic process?

3. Derive an expression for workdone during the Isentropic process?

WORKED EXAMPLES:

1. Calculate the heat must be supplied to 2 Kg of gas t
rise its temperature from 80 C to 180 C at constant pressure proces
Find also external work done during heat supplied. Cp = 0.24, Cv=0.1

Solution:

Given data,

M= 2kg

T1= 80+273=353K

T2=180 +273= 453K

Cp= 0.24, Cv=0.17

We know ,

The heat supplied Q = m Cp(T2-T_1)

=2X0.24 (453-358) = 34 K cal.

Work done = Q-E = 48-34 = 14 kcal

CHAPTER - 5

FUELS AND COMBUSTION

INTRODUCTION:

A fuel is substance which liberated a large amount of heat when it is burned. The burning of fuel is known as combustion of fuel. The amount of heat liberated during combustion of one kg of fuel is known as calorific value of fuel.. Fuel mainly consists carbon and Hydrogen. So they are called as Hydrocarbon. The natural fuels such as coal, Oil, natural gas were laid down millions of years ago during the evolution of earth.

CLASSIFICATION OF FUELS:

Fuels are mainly classified in to

1.Natural fuels,

2.Artificial fuels/

Further, they are classified in to a. Solid fuel b. Liquid fuels c. Gaseous fuels.

1. NATURAL FUELS:

i. Solid fuels Eg. Wood, Peat, Lignite, Anthracite coal

ii. Liquid fuels Eg. Crude Oil

iii. Gaseous fuel, Eg. Natural gas

ARTIFICIAL FUELS:

i. Solid fuels Ex. Coke, wood, charcoal, briquette coal

ii. Liquid Fuels Ex. Petrol, Gasoline, Kerosene, Paraffin oil, Lubricating oil

iii. Gaseous fuel Ex. Coal gas, Producer gas water gas, Mond gas.

NATURAL SOLID FUELS:

Wood:

It is used as a domestic fuel .It becomes in to coal when it burnt in the absence of air. Th calorific value of fuel of wood is 1980 Kcal/Kg.

Peat:

It is the first stage of formation of coal. It has highly humidified substance. It produces smoke when it is burnt. Its average calorific value is 23000 KJ/Kg.

Lignite:

It is the next stage of peat. It contains 60 % carbon and 40 moisture. It is very brittle. It is formed into briquettes and can b stored. Its average calorific value is 25000 Kj/kg.

Bituminous coal:

It is next stage of lignite in coal formation. It contains 4 to 6% of moisture and 75 to 90% of carbon. It burns with long smokey yellow flame. Its calorific value is 36000kj/kg..

Artificial Solid fuel:

It is made by burning with limited supply of air at about 28^{o}C. It is used in metallurgical process.

Coke: It is made by remove its volatile matter in bituminous coal. It contains 85 to 90 % of carbon. Its calorific value is 32760 Kj/kg.

Briquette coal: It consists of finely grounded coal mixed with a suitable binder and pressed together in briquittes

Pulverised coal: It is formed by powdering low grade with high ash content The coal is dried crushed in to a fine powder. This is used in cements industry.

LIQUID FUELS:

Natural Petroleum or Crude Oil:

It is available at about 5000 m from the surface of the earth. It is dark brown thick oil and consists of comlex mixtures of hydrocarbons.

Petrol or Gasolene:

It is obtained by distillation of crude oil from 65 C to 220 C. It is the lightest and most volatile liquid fuel. It is used in S.I engines. Its calorific value of fuel is 45000 Kj.

Kerosene or paraffin oil:

It is obtained by distillation of crude oil from 160 C 250C. It is heavier and less volatile than petrol. It is used lighting a heating fuel.

Heavy fuel oils:

It is obtained by distillation of crude oil at about 200 to 360C. These are used in diesel engines and marine engines. The are also used oil fired Boilers.

Tar: It is by product from the manufacture of coal gas.

Benzene:

It is a good alternative to petrol and less liable to det nation than standard petrol.

Alcohol:

It is formed by fermentation of vegetable matter. Its cal rific value is 26880 kj/kg. But its cost is high.

GASEOUS FUELS:

Natural gas:

It is available from oil wells. Natural gas consists Mar gas or Methane along with Hydrogen and slight quantities of other H drocarbons. Its calorific value is 35700 Kj/cub.m.

ARTIFICIAL GASEOUS FUELS:

Coal gas or Town gas: It is obtained by carbonizing the coal retorts at high temperature in the absense of air. It consists Hydroge Carbon monoxide, Carbon dioxide, methane and Nitrogen. Its calori value 21000 to 25200 Kj/cub.m

Producer gas:

It is obtained by partial burning of coal, coke in a mixed air steam blast. It is used in power generation plant and glass melting furnaces.

Water gas:

It is obtained by raising the coke to red hotness and passing the steam over it. It consists hydrogen and carbon monoxide. It is used as suplement of town gas. Its calorific value is 11550 to 21000Kj/kg.

Coke-Oven gas:

It is a by-product from coke oven . Its calorific value is 14700Kj/cub.m to 18900kj/cub.m

Blast Furnace gas:

It is by product from blast furnace. Its calorific value is 3800 KJ/cub.m. It is used in metallurgical industries.

Mond gas:

It is obtained by passing air or steam over waste coal at 650C. It is used in gas engines. Its calorific value is 9800 KJ/cub.m

Calorific Value:

The calorific value of fuel is defined as the amount of heat generated by complete combustion of one Kg of fuel for solid and liquid fuels it is measured in KJ/Kg or Kcal/Kg where as for gaseous fuel it is expressed in KJ/m3 or kcal/m^3 at a temperature of 15 ^{o} C and pressure of 760 mm of Hg.

a) Higher calorific value of fuel(H.C.V) or Gross calorific value of fuel :

It is the amount of heat liberated by complete combustion of unit mass or unit volume of fuel including the heat of products of combustion which is recovered by cooled down to atmospheric temperature i.e., 15 ^{o}C.

b) Lower calorific value of fuel: (L.C.V)

It is the amount of heat generated by complete combustion of unit mass or unit value of fuel where the products of combustion

are cooled to 100 ^{o}C without condensation of steam.

Merits of Liquid fuels: compared with solid fuels.

1. Liquid fuels have higher calorific value then that of solid fuel
2. It is better control of consumption
3. It is having better cleanliness
4. Better economy in handling
5. It requires less storage capacity
6. There is no deterioration is storage

Demerits:

1. Its cost is high
2. Risk of fire is more
3. It requires costly containers

Merits and Demerits of Gaseous fuel

1. The handling of gaseous fuels is better
2. The temperature of furnace is easily controlled
3. They can be used directly in Diesel engines.
4. They produce no smoke or ash
5. They are free from impurities like sulfur

Demerits:

1. There are more chances of Fire Hazards as they are readily in flammable
2. They require large storage capacity

Requirements of Good fuel:

1. It should have higher calorific value
2. It should have low ignition point
3. It should burn freely with high efficiency
4. It should not produce no harmful gas
5. It should produce least quantity of smoke and gases
6. It should be economical to storage and transportation.

Chapter 6

Air Standard Cycles

Introduction:

A thermodynamic cycle is occurred when the working fluid of a system under goes a number of operations or processes which takes place in a certain order and ultimately return the fluid to initial conditions when these operations of cycles are plotted on P-V diagram, they from a closed figure the net work done by working fluid is given by area under curve.

Different engines work on different cycles, while performing the cycle of operations the engine takes certain amount of heat. A part of this heat taken in by the engine is converted in to useful work while the remainder is rejected during the completed of the cycle.

Work done on piston equals to area under P-V diagram, which is equal to difference between the heat supplied and rejected.

Thermal efficiency = Wok done/ heat supplied
= (heat supplied – heat rejected)/ heat supplied

In actual practice of thermodynamics, an Internal combustion engine does not under go a cycle change as the air and fuel taken in the beginning of the cycle and can not received at the end of the cycle. Instead it is changed in to products of combustion all though the engine completes the cycle of operations for the sake of simplicity and find out the efficiency working on particular cycle. Air is assumed to be the work substance inside the engine cylinder which observer and rejects the certain amount of heat by bringing the hot body and cold body in contact with air in engine cylinder.

These cycles are known as air standard cycles and efficiency thus obtained is known as air standard efficiency

Assumptions of Air standard cycles

1. The working substance is pure dry air is assumed to be perfect g
   i.e., It obey the gas laws.
2. The specify heat remains constant at all temperature
3. Heat is supplied by bringing the hot body is contact with cylinder appropriate points during the process. Similarly heat is rejected bringing cold body is contact with cylinder at the points apart fro intentional changes in heat.
4. All the compression and expansion processes are adiabattically a they takes place without any internal function.
5. The cycle is considered to close one there is no suction and exhau strokes, same air is used again and again to repeat the cycle .
6. No chemical reaction takes place inside the engine of cylinder.

Carnot cycle:

Carnot cycle was devised by Sadi carnot. It has highe possible efficiency and consists of two isothermal processes and tw adiabatic processes. Assume air is the working fluid and enclosed in cylinder. Inside which slides a frictionless piston. In this heat is su plied at temperature T_1 and is allowed to expand Isothermally this for the piston is the cylinder, these doing some useful work

At point '2' the source of heat is removed and the system is allowed to expand further to get cooled to a temperature T2 is the adiabatic process, these doing necessary useful work.

At point 3, a cold body of temperature T2 is applied and heat is rejected to the sold body. The movement of the piston reverses, thus compressing the system in so thermal process.

At point 4 , the cold body is then removed and the system is compressed a diabolically to the point. Which is shown is fig(a) on P-V diagram.

During, the entire cycle, the heat is supplied during 1-2 and heat is rejected during 3-4. There is no heat exchange during two adiabatic processes.

Fig. 1

Let P_1, V_1, and T_1 are the initial pressure volume and temperature respectively at point 1 in P-V diagram.

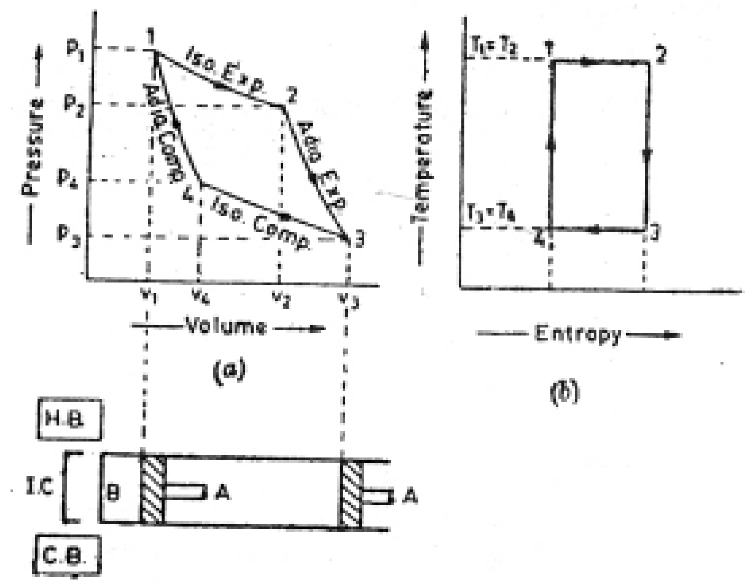
P_2, V_2 and T_2 are the pressure, volume and temperature respectively at point 3.

Let I so thermal expansion ratio = $V_2 / V_1 = r$
during the process 1 – 2
And , I so thermal compression ratio = $V_3 / V_4 = r$
during the process 3 – 4
Let the cylinder contain one kg of air

: : Heat supplied in process 1 –2 = $P_{1V1} \log r = RT_1 \log r$
Heat rejected in process 3- 4 = $P_2 V_2 \log r$
$= r T_2 \log r$
we know,
: : Workdone = Heat supplied – heat rejected
$= RT_1 \log r - R T_2 \log r$

Efficiency of otto cycle = W.D/HS
: : Efficiency of otto cycle = H . S – H . R/H.S
$= (RT_1 \log r - R T_2 \log r)/ RT_1$ log

$\therefore \eta = T1 – T2/ T_1$



OTTO CYCLE:

Otto cycle was devised by Dr A.N.O T T O It is als called as constant volume cycle. It consists of Two revers role adi batic processes and two constant volume prieasses. Heat is supplie during the process 2- 3 at constant volume processes and heat is r jected at const. Volume during the process 4 –1. The processes 3 - and 1 – 2, there is no heat is supplied. let the expansion ratio or con pression ratio is equal to r i.e.,

$V_1 / V_2 = V_4 / V_{3 = r}$

Let one kg of air is in the cylinder

Heat supplied during the process 2-3 = $Cv(T_3-T_2)$

Heat rejected during the process4-1 $=Cv(T_4 - T_1)$

Air standard efficiency = Work done/Heat supplied

= Heat supplied – Heat rejected/Heat supplied

$= Cv(T_3-T_2) - Cv(T_4 - T_1)/ Cv(T_3-T_2)$

$=1- (T_4 - T_1)/ (T_3-T_2)$

since the process 1-2 is adiabatic compression

$$T_2/T_1 = (V_1/V_2)\gamma^1 = r\gamma^{1,}$$

$$T_2 = T_1 r\gamma^1$$

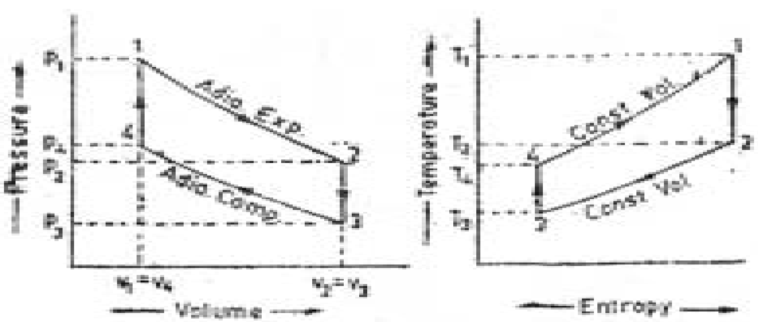
Similarly 3-4 Adiabatic expansion process $T_3 = T_4 r\gamma^{1,}$

Also $r = V_1/V_2 = V_4/V_3$

Substituting the above values

$$\eta = 1- (T_4 - T_1)/(T_4 r\gamma^1 \_ T_1 r\gamma^1)$$

$$= 1-1/r\gamma^1$$



(a) p-v diagram (b) T-s diagram

Diesel Cycle:

It was devised by rydholpro diesel in this cycle heat i supplied at constant pressure process. It consists of the following op erations

4 –1 heat addition at constant pressure process

1 –2 adiabatic expansion

2- 3 constant volume process

3 –4 Adiabatic compression process

Let P3, V3 and T3 be the prossure, volume and temperature o air in the cylinder in its ally at Point 3. The fistam compresses the ai adiabafically and the conditions of air at 4 is P4, V4 and T4. A ho body is then borceght is contact with the cylinder such that heat is sup plied at constant processure process due to this, the volume is crease to V1 and then heat is discontinued. It is represented by ‘I’. The air i now then expands adiabatically to the conditions P2, V2 and T2 at poir

2. Now cold body is brought to the end of the cylinder such that th pressure drops at constant volume till the temperature and pressure T and P3 are reached. Thus the air finally returns to intial conditions o air heat cersider one Kg of air

: : Heat supplied = Cp (T1 – T4)

Heat rejected = Cv (T2 – T3)

Workdone = heat supplied – heat rejected

= Cp (T1 – T4) – Cv (T2 – T3)

Efficiency = Workdone / Heat supplied

= CP (T1 – T4) – Cv (T2 – T3) / Cp (T1 – T4)

= 1 – Cv (T2 – T3) / Cp (T1 – T4)

= 1 – 1r (T2 – T3) / (T1 – T4) (Cp = r) / Cv

For onc Kg mass of air

Air standard efficiency = heat supplied – heat rejected / heat supplied

$= C_p (T_3 - T_2) - C_v (T_4 - T_1) / C_p (T_3 - T_2)$

$= 1 - C_v (T_4 - T_1) / C_p (T_3 - T_2)$

$= 1 - 1 / \gamma * \{(T_4 - T_1) / (T_3 - T_2)\}$

Let r be the compression ratio $= V_1/V_2$

Expansion ratio $r_e = V_4/ V_3$

ρ= Cut-off ratio $= V_3/ V_2 = V_3/ V_4 * V_4 / V_2$

$= V_3/ V_4 * V_1/V_2$

$= r / r_e$

cut-off ratio = compression ratio/ expansion ratio

connsidering adiabatic compression(1-2)

$T_2/T_1 = (V_1/V_2)^{\gamma - 1} = r^{\gamma - 1}$

$T_1 = T_2 /(r^{\gamma} - 1)$

Consider constant pressure process(2-3)

$T_3/T_2 = V_3/V_2 = \rho.$

$T_3 = T_2 \rho = T_1 * r^{\gamma - 1} * \rho$

Consider adiabatic expansion (3-4)

$T_3/ T_4 = (V_4 / V_3)^{\gamma - 1} = r_e^{\gamma - 1} = (r/\rho)^{\gamma - 1}$

$T_4 = (T_3 * \rho^{\gamma - 1})/r^{\gamma - 1}$

Substituting the value of T_3

$T_4 = T_1 * \rho^{\gamma}$

Substituting the proper value from above equations

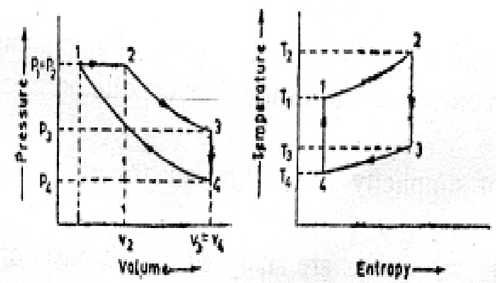
Air standard efficiency of diesel cycle =

$= 1 - 1/\gamma\{[T_1 * \rho^{\gamma} - T_1] / [T_1 * r^{\gamma - 1} * \rho - T_1 * r^{\gamma - 1}]\}$

$= 1 - 1/ r^{\gamma - 1}\{(\rho^{\gamma} - 1)/ \gamma(\rho - 1)\}$

Diesel -Cycle

Diesel cycle consists of a Constant pressure, a Constant volume and two adiabatic processes. Heat is supplied during Constant pressure process 2-3 and is rejected during the Constant volume process 4-1. During the adiabatic process 3-4 and 1-2, no heat is applied.



Summary

A thermodynamic cycle consists of series of operations, which takes place in certain order and rerurns to initial conditions.

For the sake of simplicity and to find out the efficiency of the engine working on

Particular cycle, the cycles are analyzed on the basis of air as working medium

Efficiency of cycle is given by (Heat cupplied - Heat rejected) / Hear supplied

The efficiency of Carnot cycle is given by 1 - (T3 / T1)

The air standard efficiency of otto cycle

The air standard efficiency of diesel cycle

Short Answer Questions

1. What is thermodynamic cycle?

2. What is efficiency of air standard cycle?

3. What are the processes contained by the Carnot - cycle?

4. In otto-cycle what are the processes performed to complete the cycle.

5. Whatt is diesel cycle?

Essay Type Questions

1. What are the assumptions of air standard cycle?

2. Derive the air standard cycle effeciency of carnot cycle?

3. Derive the air standard cycle effeciency of otto cycle?

4. Derive the air standard cycle effeciency of Auto Cycle?

CHAPTER-7

I.C. Engines

Introduction to I.C. Engines

Engine is a device, which converts the heat energy into mechanical energy. Heat energy is obtained form the combustion of fuel. Engine is classified on the basis of combustion as

1. external combustion engine
2. internal combustion engine

1. External combustion engine

The combustion of fuel takes place outside the engine cylinder.
Eg: steam engine

2. Internal combustion engine

The combustion of fuel takes place inside the engine cylinder.

Classification of I.C Engines

The internal combustion engines may be classified as according to

1. Fuel used

(a) Diesel engines or Heavier fuel engines.
(b) Petrol engines
(c) Gas engines

(C) Bl-fuel engines

2. Working cycle

(a) Otto cycle engines
(b) Diesel cycle engines
(c) Dual combustion cycle engines.

3. Number of strokes per cycle

(a) Two stroke engines
(b) Four stroke engines

4. Method of ignition

(a) Spark ignition engine
(b) Compression ignition engines

5. Cooling system

(a) Air cooling system
(b) Water cooling system

6. Number of cylinders

(a) Singel cylinder engine
(b) Multi cylinder engine

7. Cylinder arrangement

(a) Horizotal
(b) Vertical
(c) V-type
(d) Radial
(e) Opposed piston

(f) In-line

8. Speed

(a) Low speed engines
(b) Medium speed engines
(c) High speed engines.

11.3 Application of IC Engines

1. Stationary
2. Automotive
3. Aircraft
4. Marine
5. Locomotive engines-

Engine Nomenclature

Bore

The inside diameter of an engine cylinder is known as bore.

Stroke

It is the distance traveled by a piston from of its dead center positions to the other dead positions.

Dead center

These are corresponding positions occupied by the piston at the end of the stroke.
For vertical engines these positions are known as top dead centers and bottom dead center.

Top dead center

The top most position of the piston towards the cover end of t engine cylinder of vertical engine.

Bottom dead center

The lowest position of the piston towards crank end of the cyli der of vertical engine.

Crank radius

The distance between the center of main shaft and center of crank pin.

Stroke volume

The volume swept by the piston when It moves betwe two extreme positions is known as stroke volume or swept volume a is denoted by:

v.s. = piston area* stroke length

= (II /4) D*D*L

wher "D" = dia of the piston i.e. bore

"L" = stroke length

Clearance volume

The volume occupied by the working substances between t piston and cylinder head is clearance volume and is denoted by. Vc

Total cylinder volume

The volume occupied by the working substance when the pistonis in the lowest position of engine cylinder B.D.C.or O.D.C. is known as total cylinder volume.

Total cylinder volume = Swept volume +clearance Volume

Compression ratio

It is the ratio of total cylinder volume to the clearance volume

Engine Basic Operations.

The following sequence of operation is required to take place in away IC engine to complete the cycle.

1. Suction stroke

In the suction stroke the inlet valve is open, the exhaust value is closed. When the piston moves from T.D.C TO B.D.C in vertical engine or the piston moves from inward dead center to outer dead center in horizontal, a partial vacuum is developed inside the cylinder. Then the higher pressure of the outsid4e atmosphere forces the mixture of the fuel vapour or gas and air in correct proportion in case of gas or petrol engines, pure air is in case of diesel engines must be supply to engine cylinder engine.

2. Compression stroke

In this stroke both inlet d exhaust valves are closed. The piston moves from B.D.C. TO T.D.C the mixture of gas fuel vapour and air in case of petrol engine or pure air in case of diesel engine is compressed in the engine cylinder during the stroke.

The compression heat vaporizes mixture of fuel and, is burn by an electric spark initiated by spark plug. In case of diesel engine t diesel is pumped at high pressure into highly compressed hot air at t end of compression stroke, which follow the combustion of diesel tak place.

3. Power stroke

In this stroke both valves remains closed. The resulting pressu rise is due to combustion of fuel and the expansion combustion produc drives the piston and rotates the crankshaft.

4. Exhaust Stroke

In this stroke exhaust valve is opened, and inlet valve is close Piston moves from B.D.C. TO T.D.C When the expansion of combusti products is complete, the burnt out gases must be cleared or remov from the engine cylinder to give scope to for fresh mixture of fuel in ca of petrol engine and in case of petrol engine and in case of diesel engin

Four Stroke Diesel Engine

Four – stroke cycle diesel engine completes by the four strok of the piston or two revolutions of crankshaft (flywheel)

Suction stroke

a) Piston moves from B.D.C to T.D.C. inlet valve opens, partial vaccum be created inside the cylinder.
b) Fresh filtered air is admitted through inlet valve. Exhaust valve r mains closed

Compression stroke

a) Piston moves from B.D.C to T.D.C. both inlet and exhaust valves are closed.
b) Air is lightly compressed in the combustion chamber its pressure and temp increases.
c) At the end of compression fuel is injected into the combustion chamber by fuel injector system.

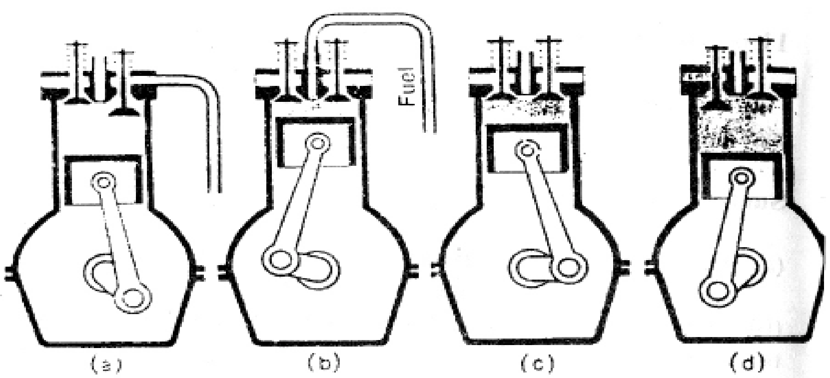
Power stroke

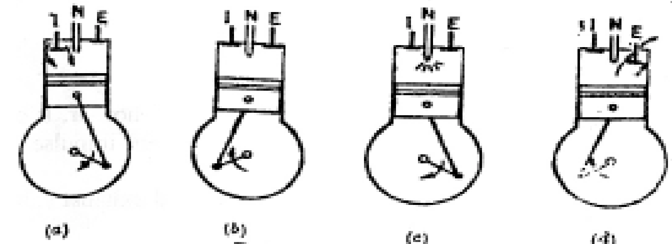
a) the injected fuel comes in contact with compressed hot air, it catches fire. These gases expand rapidly and provide power impulse to the position.
b) Piston moves from TDP.to B.D.C, both inlet and exhaust valves are closed.

(Events going on in a four stroke diesel engine)

Exhaust stroke

(a) Piston moves from B.D.C to T.D.C, inlet valve closes and exhaust valve opens.
(b) Exhaust gases are expelled out of the cylinder. n each stroke the crankshaft completes 180 degrees and so 180* 4strokes =720degrees





Four stroke cycle diesel engine

Four- Stroke Petrol Engine

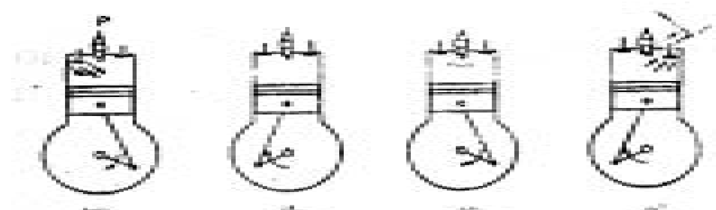
In four- stroke cycle petrol engine completes by four strokes of the pist (Suction, compression and power stroke, exhaust stroke) or in two rev lutions of crankshaft (flywheel).

Suction stroke

(a) Piston moves from T.D.C to B.D.C inlet valve opens partial vacu is created inside the cylinder.
(b) Fresh change (fuel + air) is admitted into the engine cylinder.

Compression stroke

(a) Piston moves from T.D.C to B.D.C, both inlet and exhaust val closed.
(b) Charge is compressed inside the cylinder its pressure and tempe ture increases.
(c) At the end of compression a spark is initiated by the spark pl which ignites in the charge



Four-stroke cycle petrol engine

Power stroke

(a) Both valves remains closed

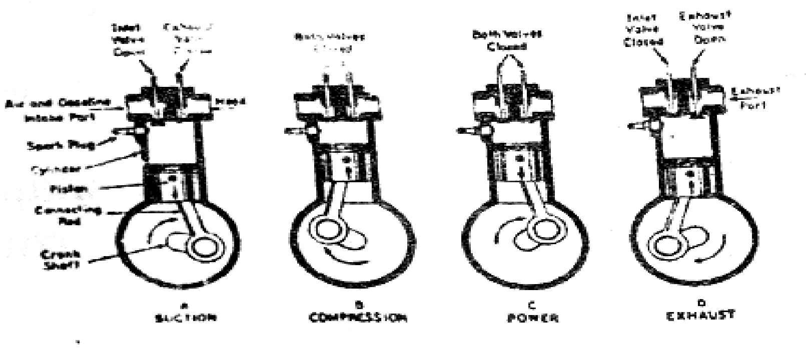
(b) The burning gases expand and push the piston — B.D.C as the power is developed. Heat energy in the burning gases to conerted into mechanical energy

Exhaust stroke

(a) Piston moves from B.D.C to T.D.C. exhaust ….. closed.

(b) Burnt gases are expelled out of the cylinder. in

(c) Each stroke crankshaft completes 180degrees. So 180degree X



Two –stroke Diesel Engine

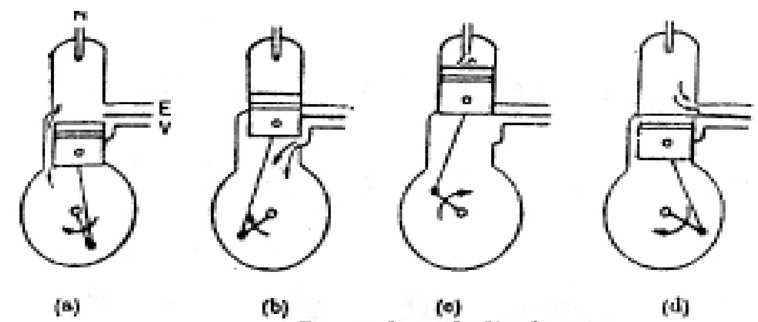
The two-stroke diesel engine differs slightly from that of two-stroke petrol engine. Two-stroke diesel engine requires a supply of air to blow out exhaust gases and to fill the cylinder with clean air. Air is usually supplied by a blower or air compressor, which is driven by the engine.

Upward stroke

(a) Piston moves upward from B.D.C to T.D.C covering both the intake and exhaust ports. A partial vaccum is created in created in crank-case, the inlet port is uncovered by piston and the fresh air is sucked into crankcase.

(b) The upward stroke of piston causes compression of previously ava able air inside the engine cylinder takes place simultaneously. Fu is injected into the combustion chamber by means of fuel injecti system.

(c) The descending piston uncovers the transfer port soon after the e haust port. Air under pressure from crankcase enters into the cyl der and helps in expelling out the burnt gases, the shape of the pist head helps in scavenging (complete removing of burnt gases fro engine cylinder) the burnt gases from the engine cylinder. Crank shaft completes 180degrees (1/2 cycle) 180 +180 =360 (one co plete cycle).



Two-stroke cycle diesel engine.

Two –stroke Petrol Engine

The two-stroke petrol engine working consists of upward stroke:

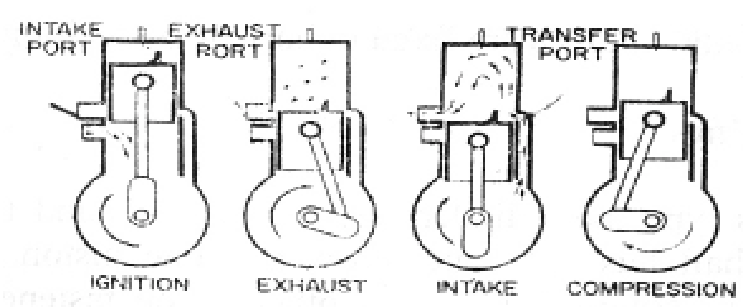
(a) Piston moves upward from B.D.C to T.D.C covering both the tran fer and exhaust ports. A partial vaccum is crated in crankcase, t inlet port is uncovered by piston and the mixture of air and fuel vapo from the carburettor is sucked into the crankcase

(b) The upward stroke of piston causes compression of previously ava able charge (air +fuel vapour) inside the engine cylinder takes pla simultaneously. Thus during upward stroke suction and compressi of charge (air +fuel) take place. At the end of compression strol the charge is ignited by high –voltage electric spark initiated by spa plug.

Downward stroke

(a) After ignition of charge, combustion of charge takes place. The burning gases expand rapidly and force's the piston downward on its power stroke. Inlet port is closed by piston and compresses the charge drawn in the crankcase.

(b) Piston moves downward towards the end of power stroke. The exhaust port is uncovered and the used gases pass out of the cylinder.



(c) The descending piston uncovers the transfer port soon after the exhaust port. Air under pressure from crankcase enters into the cylinder and helps in expelling out the burnt gases, the shape of the piston head helps in scavenging (complete removing of burnt gases from engine cylinder) the burnt gases from the engine cylinder. Crank – shaft completes 180degrees (1/2 cycle) 180+180 =360 (one complete cycle.

After completing the power stroke, the piston moves upwards and the cycle is repeated.

11.9 Cylinder Arrangements in Multi Cylinder Engines

1. In-line engine

Engine cylinders are arranged in line in same plane

2.V-type

In this arrangement on the common crank case cylinder blocks are a ranged fixed at any angle to each other, mostly in the shape of "V". this case two connecting rod big ends are fixed to one big end journal crank sheet. The main advantage of such an arrangement is that su engines require less space area.(In length size)

3.Opposed-type

In this arrangement 2 cylinders are fixed in same plane opposite to ea other

4. Horizontal –type

Horizontal engines are fixed in horizontal position.

5. Radial engines

In this type the cylinders are arranged around the crank –shaft. The cra –shaft has only one throw and one position is connected to master ro The connecting rods of other piston fastened to master rod. For pow to flow to master rod and then to crank shaft. This is used in air-craf

Difference Between 2-Stroke and 4-Stroke and Petrol and Diesel Engines

Two stroke

1. Crank-shaft completes one revolution for one power stroke.
2. Contains ports
3. Usually air cooled engines
4. More torque due to more even power impulse.

5. More power is produced for the same engine size.
6. Initial cost is less.
7. Useful gases escape out with exhaust gases.
8. Light in weight.
9. Mostly single cylinders.
10. Rate of wear and tear is more.
11. Volumetric efficiency is less due lesser time for induction.
12. Lighter flywheel is used.

Four Stroke Engine

1. Crank-shaft completes two revolutions of one power stroke.
2. Contains valves and valve operating mechanisms.
3. Mostly water-cooled engines.
4. Turning moment is not so uniform.
5. Comparatively less power is produced.
6. Initial cost is more.
7. Loss of useful gases is very less.
8. Heavier in weight.
9. Mostly multi-cylinder engines.

10. Wear and tear rate is less ; due to fuel fledged lubrication system
11. Volumetric efficiency is more due more for induction.
12. Heavier flywheel is needed to keep the engine running uniform sp

Petrol Engine

1. S.I engine ignition is by means of spark produced by the spark plu
2. It works on otto cycle or Constant volume cycle.
3. Mixture of petrol and air is induced during suction stroke.
4. Carburattor are used to supply the charge.
5. Quality of mixture is controlled.
6. Petrol is as fuel.
7. Compression ratio varies from 6:1 to 9:1.
8. Temperature of compressed fuel mixture is 60 to 80 degrees.
9. Lighting in construction.
10. Occupies less space.
    1. High speed engine.
    2. Produced less torque.

Diesel Engine

1. In C.I engine ignition takes place due to heat produced high compression of air.
2. It works on diesel or Constant pressure cycle.
3. Only air is drawn Inn during suction stroke.
4. Fuel injector injects fuel oil spraying into compressed air.
5. Quantity of injected fuel is controlled.
6. Diesel is used as fuel.
7. Comparative ratio is high and varies from 12:1 to 22:1.
8. Temperature of compression in air is 500 degrees.
9. Heavy in construction.
10. Occupies more space.
11. Comparatively low speed.
12. Torque characteristic are better.

Summary

The internal combustion engine, in which combustion of fuel takes place in-side the Engine cylinder.

Internal combustion engines are classified on basis of

1. Fuel used.
2 .Cycle of operation
3. Number of working strokes.
4. Types of cooling
5. Type of ignition
6. Method of fuel injection
7. Arrangement of cylinders
8. Speed of the engine.
9. Applications.

Short Answer Questions

1. What is an engine?

2. Write the classfication of Engines?

3. What are the cycle of operation?

Eassay Questions

1. Write the classification of I.C. Engines?

2. Write differences between two - stroke and four stroke engines

3. Compare petrol and diesel engines

4. Describe two - stroke petrol engine with a neat sketch

5. Describe two-stroke diesel engine with a neat sketch

6. Write about the four - stroke petrol engine with neat sketch

7. Write about the four-stroke diesel engine with neat sketch?

CHAPTER - 8
PUMPS

Introduction

In general the machines are classified into TWO types. These are a) power producing machines and b) power using machines. Power producing machines convert the energy possessed by the liquid into mechanical energy and then into electrical energy viz., turbines. Power using machines uses the mechanical energy of a machine and converts the same into fluid energy viz. Pumps.

As stated above Pumps are, power using machines and whenever fitted in a pipeline, causes an increase in the energy of the fluid in that pipeline.

Definition

Pump is defined as "a mechanical device, which converts the mechanical energy, supplied to it into the hydraulic energy of the fluid flowing through it".

Functions of Pump

Following are the functions of a pump.

i) it converts the mechanical energy supplied to it into hydraulic energy of the fluid flowing through it.
ii) It increases the kinetic energy and pressure energy of the flowing liquid through it.
iii) It converts the kinetic energy of the fluid into pressure energy before the fluid enters into the delivery pipe.
iv) It lifts the liquid from lower level to higher level.

Classification of Pumps

On the basis of action involved in the working of Pumps, pumps are classified into 3 categories. These are

i) Dynamic pumps.
ii) Displacement pumps and

iii) Special pumps.

Dynamic Pumps

The pumps in which the energy is continuously added to the pump, to crease the velocities of fluid and to discharge the same to higher levels called ad dynamic pumps.

Ex: Centrifugal pumps.

The Pumps are again classified into sub groups as shown in the Flg 1.1

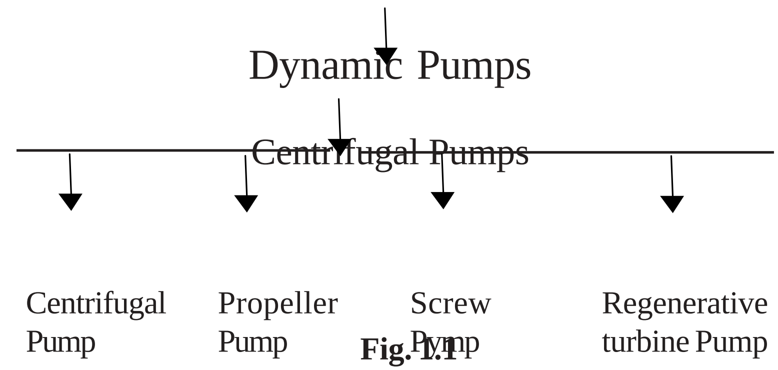


Fig. 1.1

i) Centrifugal Pumps

In these pumps the pressure head is developed by the centrifug effect in the impeller of the pumps.

ii) Propeller Pumps

In these pumps the pressure head, is developed by the propelling or lifti action of the vanes of the impeller.

iii) Screw Pumps

In these Pumps the screws fitted in a casing develop the pressure head rotating around themselves.

iv) Regenerative turbine Pump

In these pumps the pressure head, is developed by the rever turbine action of the vanes of the impeller.

Displacement pumps

These are the pumps in which the energy is periodically added to one or more movable parts of the pumps to physically displace the fluid in contact with these movable parts to higher levels.

Ex: Reciprocating pumps, Rotary pumps.

These pumps are classified into sub groups as shown in the

i) Reciprocating Pumps

In these pumps the movement of piston or plunger in a cylinder physically displaces the liquid. If the cylinder is provided with a piston it is called as 'Piston' Pumps and is called as 'Plunger' pumps if it is provided with a plunger.

ii) Single acting Pumps

In these pumps the liquid is sucked and discharged from one side (face of the piston side) of the piston.

iii) Double acting Pumps

In these pumps the liquid is sucked and discharged from both the sides (face of the piston and rod sides) of the piston.

Displacement Pumps

Reciprocating Pumps   Rotary Pumps

Piston   Plunger   Gear   Vane   Cam and piston   lobe

Single Acting Pump   Double Acting Pump   Differential Pump

Fig. 1.2

iv) Rotary Pumps

These Pumps displaces the liquid physically by means of rota ing action of the components (gears or vanes or cams etc.,) provided i a casing.

v) Gear Pump

These pumps are provided with two intermeshing gears in a clos fitting casing. Each gear teeth acts like plunger of a reciprocating pump During rotation, each pair of teeth intermesh on the suction side ar provides suction effect. The liquid under pressure is carried to the othe side and gets displaced.

vi) Vane Pumps

These Pumps consists a circular rotor with slots mounted ec centrically in a circular casing. Each rotor slot carries a rigid vane th forces the liquid to slide in a radial direction

vii) Lobe Pumps

These pumps are provided with a pair of rotors which, rota with continuous contrary motion within a pumping chamber. A pair c timing gears is housed in a casing to facilitate the rotation of rotor Thus these rotors pump liquid with changing volumes.

Special Pumps

These are the pumps which, use either centrifugal action or re ciprocating action and consists some special arrangement to discharg the fluid.

The following are a few varieties of special Pumps and are a shown in the

Construction of Centrifugal Pump

in this simplest form it consists the following components as shown

in the **Fig 2.1.**

I) Impeller
II) Shaft
III) Casing
IV) Suction pipe
V) Delivery pipe and
VI) Prime mover

i) Impeller

The rotating part of the pump is called as impeller. The impeller is always subjected to wearing force because its function is to force the liquid into a rotating motion.

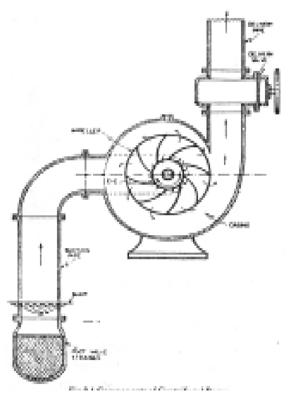


Fig 2.1 Components of Centrifugal Pumps

The impeller is fitted with a series of curved vanes and is mounted on a hub. At the eye of the impeller a wearing ring is fitted so as to prevent the exposure of impeller material at the eye, to the wearing forces. The impellers are selected according to the requirement of pumping and are of following types.

a) Shrouded or enclosed impeller
b) Semi enclosed impeller
c) Open impeller
d) Single suction impeller and
e) Double suction impeller.

a) Shrouded impellers

The vanes of these impellers are surrounded with shrouds shown in the Fig 2.2. These shrouds or plates are called as 'crow plate and 'base' plate. These impellers are suitable for pumping pu liquids against higher heads.

b) Semi enclosed impellers

The vanes of these impellers are provided only with 'base' pla i.e.only on one side as shown in the Fig 2.3. These impellers a used for pumping liquids containing debris up to some extent.

c) Open impellers

The vanes of these impellers are neither provided with 'bas plate nor 'crown' plate. The vanes are fixed to shaft by means of a w plate as shown in the Fig 2.4. these are used for pumping liquids havi large quantify of suspended matter.

d) Single suction impeller

In these impellers the liquid enters into the impeller eye on from 'one' side. As the impeller experiences unbalanced thrust, a ba ancing disc is fitted to the opposite side of the shaft.

e) Double suction impeller

In these impellers the liquid enters from either side of the impe ler . as there is natural balance necessity of a balancing disc is not arise

The impellers are made of following materials

- Low carbon steels coated with stainless steel
- Stainless steel
- Aluminum, Bronze and zinc alloys
- Blades with cast stainless steel sheets.

ii) Shaft

This hub or shaft consists a key at its one end and flexible coupling with pin and rubber bushing, at the other end. The impeller is fitted on the key of the shaft. At the other end the shaft is coupled with flexible coupling to another shaft of a prime mover. A portion of the shaft is extended into the stuffing box to prevent air leakage on the suction side and leakage of water on the delivery side when the pump is working. The portion of the shaft which, situates inside the stuffing blx is protected from corrosion and abrasive action by means of providing removable shaft sleeves made up of gunmetal. The Glands in the stuffing box are made of hard bronze. The shaft is also supported on ball bearings at both the ends so as to provide perfect balance during the rotation of the impeller. Grease cups are provided at the bearings to have good amount of lubrication. The shaft is made of high tensile steel.

iii) Casing

It is provided for housing the impeller and to support the bearing that carries the impeller shaft. The casing is either a vertical split type or a horizontal split type as shown in the Fig 2.5.

Two openings are provided in the casing for connecting suction and delivery pipes. It is provided with a stuffing box to prevent leakage from the gap between the pump casing and shaft. It is provided with a gasket as its split to prevent the leakage losses. It consists an arrangement for priming and an air cock to allow the escape of entrapped air in the casing suction pipe. The entire casing is fixed to a base plate made of cast iron ore welded steel. Sometimes Dowel locating pins are driven through the pump and motor into this base plate to ensure correct assembly and alignment.

On the basis of requirement any one of the following varieties of casin are provided.

a) Diffused casing
b) Volute casing and
c) Whirlpool or vortex casing

a) Diffused casing

In this, a diffuser ring having guide vanes surrounds the impell as shown in the liquid enters without shock. These are suitable for i stallations in deep wells and mines.

b) Volute casing

In this a spiral casing with gradual increase in area of cros section surrounds the impeller as shown in the Fig 2.7.

Due to the increased area at the outlet of the pump casing t velocity of the liquid reduces and thus the pressure energy of the liqu rises. In this the loss of kinetic energy is more and is due to the formati of eddies in the casing.

c) Whirlpool casing

It is a combination of vortex or whirlpool chamber and volu casing. In this a whirlpool chamber is provided in between the volu casing and the impeller as shown in the Fig2.8. Due to the vorex cha ber the loss of kinetic energy due to the formation of eddies reduces. the efficiency of the pump increases.

iv) Suction pipe

It is a pipe whose upper end is connected to the flange of t casing and lower end is submerged in the sump. The lower end of t pipe is fitted with a foot valve and a strainer.

v) Delivery pipe

It is a pipe whose lower end is connected to the flange of the casing and upper end is extended up to the reservoir. It is also provided with a delivery valve nearer to the casing to regulate the flow of liquid.

vii) Prime mover

It is used to rotate the impeller. Its shaft is connected to the shaft of the impeller by flexible coupling. This prime mover may be fitted to the base plate on which the pump casing is fitted or to another plate. In general an electric motor is provided for the purpose.

Operation of pump

For starting and operating a centrifugal pump the under mentioned sequence should be followed to ensure better life to the pump.

i) Initially, the cooling system and its reservoirs should be checked.
ii) Check for proper coolant flow.
iii) Open the suction valve and close all the drains in the casing and in piping.
iv) Prime the pump and ensure that there is sufficient liquid in the reservoir to feed the pump if necessary.
v) Start the mother and bring it into proper speed. When the rated speed is reached, open the discharge valve slowly.
vi) Check up the leakage in all the piping and in stuffing boxes.
vii) Check the pump suction, discharge and temperature.

In case the pump shows any sign of trouble such as over heating of bearings, more vibration or noise then stop the pump at once and find out the cause and then take the corrective action.

Priming

The suction pipes, pump casing and some part of the d charge pipe must be filled with full of liquid all the times. Driving c air from the casing and suction pipe is known as priming. On initial sta or after a long shut down air which, is trapped in the casing should expelled from the casing. This is to be dome by allowing the liquid flo into the casing to push the air and allowing the air from the air- co situated on the top of casing

The priming of pumps can be done, by using any one the three methods. These are

a) Manual priming
b) Priming by vacuum
c) Self-priming.

a) Manual priming

In this method the liquid is poured into the casing through a fu nel provided on the top of casing. Sometimes the casing is co nected with a main as shown in the Fig so as to use the liquid the main for priming purpose.

b) Priming by vacuum

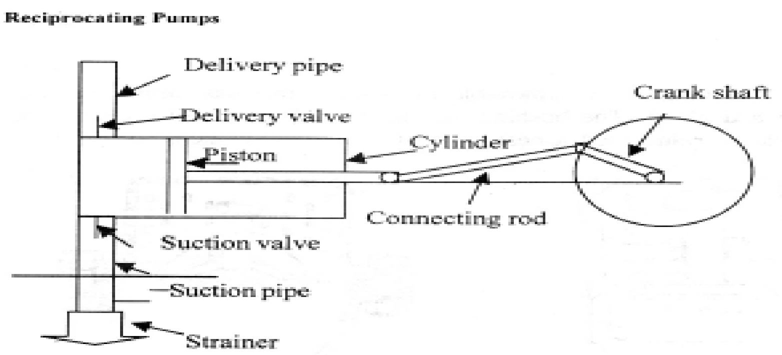
In this method the air from the suction pipe and pump is, suck by using rotary compressors. When air is sucked from the pur and suction pipe then atmospheric pressure in the sump forc the water into the suction pipe.

c) Self priming

In this method the pump is primed automatically. Each manufa

Working of Reciprocating Pump

As shown in the Fig 4.2, the piston is connected to a crank by means of a connecting rod. As the crank is rotated at uniform speed by a driving engine or motor, the piston moves to and fro in the cylinder.



Initially the piston is at its extreme left position as shown in the Fig 4.6a. When the crank rotates from q = 0 to q = 180, the piston moves from its left position to towards its extreme right position. During this backward movement of the piston a partial vacuum is created in the cylinder. The atmospheric pressure acting on the liquid surface in the well or sump forces the liquid to fill up the suction pipe and the cylinder by by opening the suction valve. Thus the air in the suction pipe and cylinder is first replaced with liquid. This is known as 'priming' of the pump since during this operation the liquid is sucked from sump, it is known as suction stroke. At the end of suction stroke the crank is at its extreme right position i.e.
At q = 180 and the cylinder is full of liquid as shown in the Fig 4.6b.

When the crank rotates from q = 180 to q = 360 the piston moves from its extreme right position to its left position. Due to this forward movement of the piston the pressure of the liquid rises above atmospheric and the suction valve is get closed as it is a one – way valve. Since the liquid is at high pressure it opens the delivery valve and moves through the delivery pipe into the reservoir. This operation of the pump is called as 'delivery' stroke as the liquid is delivered into the reservoir.

At the end of this delivery stroke the piston is at its extreme le position and the crank is at q = 0 or q = 360 as shown in the Fig 4.6

After the crank completes one full revolution, both the suctio and delivery valves are in closed position. The same cycle is repeate as the crank rotates.

Single acting pump

In a single acting pump the liquid is in contact with only side the piston. Thus a single acting pump has one suction pipe and one d livery pipe as shown in the Fig 4.7.

In this pump for one complete revolution of crank there exis only two strokes. These are suction and delivery strokes. The pum delivers the liquid only during the delivery stroke.

Double acting pump

In a double acting pump the lipuid is in contact with both th sides of the piston. Thus a double acting pump has two suction pip and two delivery pipes with appropriate valves as shown in the

In this pump for one complete revolution of crank there exists fo strokes. These are two suction and two delivery strokes. The pum delivers the liquid during each stroke. I.e. during each stroke suctio takes place on one side of the piston and the delivery of the fluid tak place on the other side.

Discharge calculations

The discharge calculation for single acting and double acting reciprocating pumps is as follows.

a) Single acting pump

As explained in 4.4 a single acting pump has only on suction stroke and one delivery stroke for one complete revolution of the crank.

Let

A = Cross-sectional area of the piston in sq.meters
L = Length of the piston stroke in meters
N = Speed of the crank in r.p.m
R = radius of the crank

Then
Number of delivery strokes = (N/60) per second

Theoretical volume of liquid pumped per stroke

Qth per stroke = (Cross- sectional area of the piston* length of the stroke)
Qth per stroke = (A*L)
Qth = (A*L*N)/ (60) m3 / sec …eq (4.1)
Since L=2r
Qth = (2*A*r*N) /(60) m3/sec …eq (4.2)

If the Qth is required in litres per second then the discharge quantity should be multiplied with 1000 because 1m3 = 1000 liters.

b) Double acting pump

As explained in art 4.5a double acting pump has two delivery strokes for one complete revolution of the crank.

Let
A = Cross – sectional area of the piston in sq. meters
A = Cross – sectional area of the piston in sq. meters
L = Length of the piston stroke in meters
N = Speed of the crank in r.p.m
R = radius of the crank

Theoretical volume of liquid pumped per stroke
Qth Per stroke = discharge from cover side
+ discharge from crank side
Qth per stroke = ((A*L) + (A-a)*L)

Qth = (A*L) + ((A-a)*L)/ (60)

Qth = ((2A-a)*L) /60 m3/ sec …eq (4.3)

Since L = 2r

Qth = (2A-a)*2r*N) /(60) m3/sec …eq (4.4)

If the Qth is required in liters per second then the discharge quant should be multiplied with 1000 because 1m3 + 1000 liters.

1. Coefficient of discharge (C_d)

It is the ratio of actual volume of liquid discharged to the volur swept by the piston.

$$\text{Coefficient of discharge} = \frac{\text{Actual discharge}}{\text{Theoretical discharge}}$$

Cd = Q act / Qth …eq (4.6)

2. Slip (S)

it is the difference between the theoretical discharge and actu discharge.

S = Qact / Qth … eq (4.7)

Ex: 1

In a single acting reciprocating pump the cylinder is 15cm and stroke length is 23cm. Calculate the theoretical discharge if the pump is running at 40.p.m.

Solution

Given data: 1. Cylinder dia = 15cm

2. stroke length = 23cm

3. pump speed = 40r.p.m

Required date : Qth

From eqn (4.1)Qth = (A*L*N) / (60) m3/sec

Qth (O*0.15*0.23*40) /(60)

Qth = 0.003m3/sec Ans

Qth = 0.163 m3 / min Ans

Qth = 163 lpm Ans.

Ex: 2

In a Double acting reciprocating pump the cylinder diameter is 30cm and piston rod diameter is 5 cm. The stroke length is 36cm. Calculate the theoretical discharge if the pump is running at 50r.p.m.

Solution

Given data : 1. Cylinfrt fis = 30 cm

2. piston rod dia = 5cm

3. stroke length = 36 cm

4. pump speed = 50 r.p.m

Required data Qth

From eqn (4.3) Qth = ((2A-a)*L)60m3/sec

A = II* 0.30*0.30: a = II* 0.05*0.05

A = 0.07069 sqm: a = 1.9635* 10-3 sqm

Qth = (2*0.0706’9 – 1.9635*10-3) 0.36*50/(60)

Qth = 0.0418 m3/sec Ans

Qth = 41.8lps Ans

Ex:3

In a single acting reciprocating pump the cylinder diameter is 15cm a stroke length is 30cm. Calculate the theoretical discharge if the pump running at 40r.p.m. also calculate the actual discharge and slip if the c efficient of discharge is 0.94.

Solution

Given data: 1. Cylinder dia = 15cm

2. stroke length = 30cm

3. pump speed = 40 r.p.m

Required data : Qth

From eqn (4.1) Qth = (A*L*N) / (60)m3 / sec

Qth = (II .150.15*0.30*40) / (60)

Qth = 0.004 m3 / sec Ans

Qth 0.212 m3 /min.

Qth = 212 lpm Ans.

ii) From the eqn 4.6 Cd = Qact / Qth

Qact = Cd * Qth

Qact = 0.94 *212

Qact = 0.94*212

Qact = 199.28 lpm Ans

iii) from the eqn 4.7s = Qact – Qth

S = 199.28 – 212

S 12.72 lpm Ans

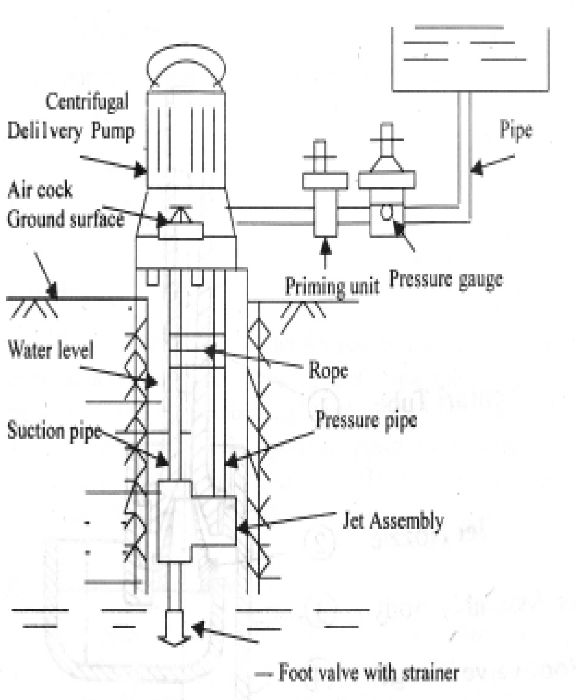
Jet pump Applications

The Jet pump is used for the following applications.

i) For lifting more fluid from greater depths
ii) For water supply to nurseries, foresteries and to domestic purposes.
iii) For water supply to small irrigation works, gardening.

As compressor it is used for

i) For removal of rubber deposits from aircraft runways.
ii) For removal of scales from steel structures.
iii) For testing pressurized pipe - lines
iv) For concrete fillings in under water works.
v) For cleaning heat exchangers, boilers, boiler tubes and evaporators.
vi) For cleaning ferrous and non-ferrous castings.
vii) For cleaning vessels in food precessing plants.
viii) for kiln cleaning and removal of blockage.



Working of jet pumps

The pumping of fluid in the jet pumps consist three stages. These are

i) priming
ii) pressure regulating and
iii) pumping

i) Priming

When the pump is started for the very first time. It is to be prime using water. i.e. the water is to be poured through the 'T' joint keepi the air cock in open condition until there is free flow of water from t air cock. Then the air cock is gradually closed while pouring the wat if there is any fall in water level in the 'T' fitting after closing the a cock then the piping system should be checked for leakage.

ii) Pressure regulation

In jet pumps the maximum flow occurs only at particular opera ing pressure. So to get the maximum flow, the pressure valve is to adjusted by loosening it, until maximum flow is maintained. Too mu loosening of the screw will sometimes lower the pressure of the jet.

iii) Pumping

As and when the motor of the pump is started, initially the wat is entered into the suction pipe because of the centrifugal action of t pump. When the water enters into the delivery pipe. Then a part of it allowed into the pressure pipe through the hose. Then by adjusting t pressure valve, the pressure of the water in the pressure pipe is raised the required extent. This water which id under pressure is allowed pass through the nozzle of the jet assembly. The high velocity jet from t nozzle creates a low pressure at it tip and causes pull of more water fro the suction pipe. The water then passes through the venturi tube at hig velocity along with the jet stream. When it passes upward in the enlarg part of the venturi the velocity of the stream decreases and the pressu increases. This raised pressure forces the water up to the suction limit the pump.

Applications

These pumps can be used

1. For Drinking water supply installations in cities and in rural areas.
2. For Service water supply installations in industries.
3. To supply more water for irrigation works from deep wells.
4. To lower the ground water level in building sites.
5. To use in deep well operations.
6. To lower the ground water level in mines.
7. To use at places where the surface installations can expose to floods, fire and to harmful chemicals.
8. To use at places where there exists frequent changes in ground water level.
9. To use in booster pump installations. i.e. at places where it is needed to draw water from a main at a low pressure and deliver the same to an elevated tank or to another main where a higher pressure is desired.

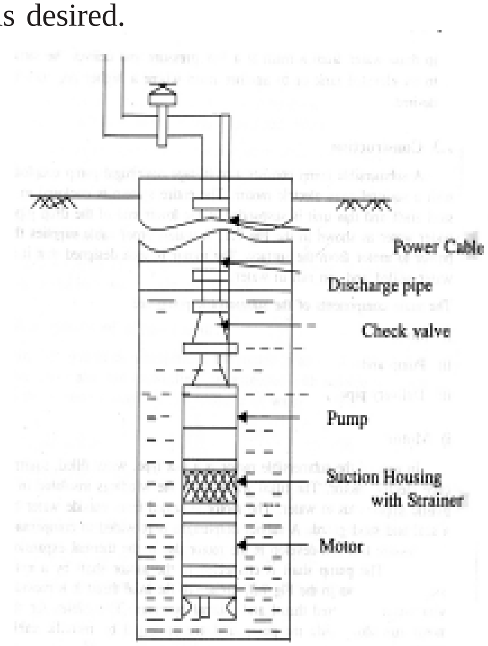


Fig 7.2 Line diagram of Submersible pump

Working of the pump

The pumping of the water inn submersible pumps is same as i centrifugal pumps. The only difference is, in submersible pumps ther is no suction pipe and hence the need of priming for every pumping i not necessary.

The pumping in submersible pumps consist the following operations.

i) Priming before installation

The motor must be filled with clean non-acid water (not di tilled water) and free of sand for the purpose of priming before a su mersible pump is installed.

ii) Pumping

The pump must be started by slightly opening the gate-valv Then the discharged water must be checked for the sand content, as e cessive sand in the water is harmful to the pump. If there is an appr ciable amount of sand found to be present, then the pump must run wi partly opened gate-valve, until the sand contents are reduced to accep able quantity. Then the valve can be opened gradually to pump the wat as per the capacity of the pump.

CHPATER - 9

Sprinkler irrigation

It is a method of 'Surface irrigation' system. In this method wa-ter is [illegible] umps,

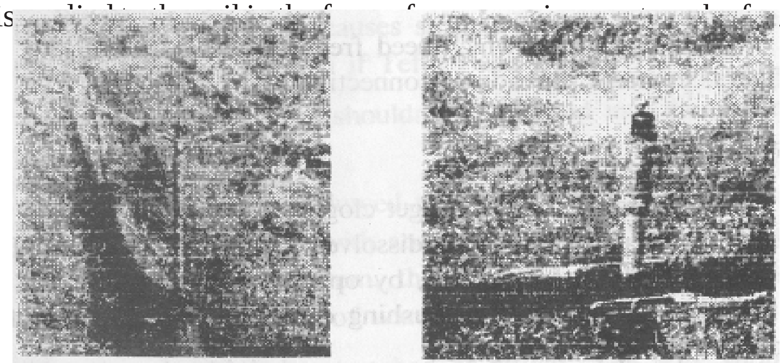


Fig 3.6 Sprinkler irrigation System

pipes and sprinklers. In this method water is forced under pressure through a small circular hole or nozzle. The water came out from the nozzle breaks up into small drops as it travels through the air and falls to the land in the form of a spray, somewhat resembling the rain fall. In general the rate of spray is kept less than the infiltration rate of the soil. The sprinkler systems used in this method can be either permanent installations or semi portable or purely portable systems.

Components of sprinkler system

Main components of this system are is follows.

i) Head assembly comprising

a) sand filter

b) screen filter

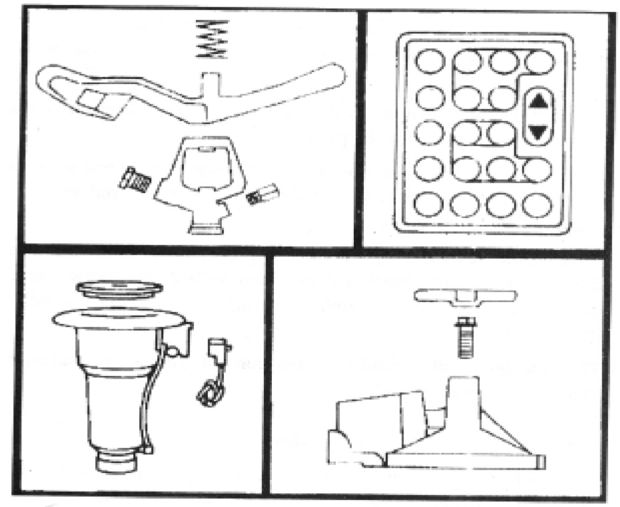
ii) Main and Sub main pipes

iii) Riser pipes

iv) Sprinkler heads

v) Values and fittings and

vi) Pump set.



Installation, Working of Sprinkler irrigation System

The installation and working of the system can be discussed u der two separate headings as mentioned below.

Installation of Sprinkler system

The installation of this system involves laying of head assemb Mains, Sub mains, Sub mains and sprinkler heads on the ground in t following sequence.

i) The Delivery pipe of the pump set is first connected to a Stora tank, from where the water is to be distributed.

ii) The head assembly is then connected to the storage tank

iii) The mains are connected to this 'Head assembly' and are buri in the ground at equal distances in the area where the irrigation to be practiced.

iv) The sub mains are joined to the mains in a lateral direction a are laid parallel to the rows of plants.

v) The riser pipes, which are usually 80cm high, are joined to t submains. In general the height of the riser pipes is fixed as p the height of the crop in the farm.

vi) Finally the revolving sprinkler heads are mounted on the risers. Sometimes the sub mains are provided with perforation and are directly fitted with jets, through which the water jets out and falls on the ground.

vii) Thus the laying of sprinkler system consists joining the mains, sub mains, risers and sprinklers.

Working of sprinkler system

The pump, which is in general a Centrifugal Pump, lifts the water from the well and supplies the same to Mains. Then this water is allowed to pass through the Sand filter and Screen filters in an ‘Head assembly’ to remove the suspended particles from the water, otherwise these particles clog the nozzles. The water from the ‘head assembly’ starts flowing through the mains, sub mains, risers and then enters into the sprinklers with high velocity.

The spray pattern of the sprinklers (full, center, left or right) can be adjusted using a knob fitted at he bottom of sprinklers. As and when the water jet enters into the sprinkler it strikes the sprinkler arm at one side and causes the movement of the sprinkler to that side. Then the next phase of water jet strikes the other end of the sprinkler arm and again causes the movement of the sprinkler to that side. Thus the sprinkler rotates in a horizontal direction by using the high velocity of water jet and produces a circular wetting pattern.

In some installations nozzles are fitted directly to the perforations on the sub mains instead of fitting the rotating sprinklers heads to the risers on these sub mains. The water is allowed to jet out from these nozzles and is sprayed on the land like an umbrella on the ground.

Troubles in Sprinkler system components

i) The abrasive action of silt in the water causes excessive wear on pump impellers, sprinkler nozzles and in bearings.

ii) The debris entered into the nozzle chokes the nozzle and causes the reduced efficiency of the system.

Drip Irrigation:

It is a most important method in the sub irrigation system. It
also called as Trickle irrigation system.

The Drip Irrigation system is a net work of pipes and tubes whic
forms a delivery system to feed exact amount of water to each plant d
rectly to its root zone, drop by drop. The water drips from the nozzles
a very slow rate and keeps the soil moist in a bulb shape under the plar

This method ensures optimization of crop yield without subjec
ing the plant to stress and strain. Times and intervals for watering diff
according to the type of plant. The most important factor to remember
the depth of the root zone and soil composition. The deeper the roots ar
the finer the soil the longer the watering time must be, but frequency
watering will be reduced. A finer soil such as clay cannot absorb wat
very quickly but will hold the moisture for a longer period of lime. Sha
low root zones and sandy soil types will require frequent watering of
shorter duration. The Plant and soil moisture conditions are to be ob
served to adjust watering times and intervals to maximize plant grow
and minimize water use. In a system with mixed plantings, some com
promises may have to be made between plants that require occasion
deep watering and those that prefer frequent shallow watering. This ca
be partly accomplished by using emitters of higher output on the dee
rooted plants. If this is not practical because of other factors, a compro
mise can be reached by doing shallow watering on a frequent basis a
well as occasional deep watering. The first irrigation cycle should be
much longer one than normal. Because we have to completely establis
the wet zone in each plant’s root zone. This cycle should be from 1 ho
up to possible 6 hours, depending on the plant material that is to be don
watering and the types of soil systems. To do this we have to inspect th
emitters, flush the lines by opening the end cap, and clean the filte
Depending on water quality, the frequency of filter cleaning may var

The development of drip irrigation products has led to successful and trouble-free systems for both the commercial grower and the home-owner. The design of the system using filtration and quality emission components will make maintenance a simple yearly task. Visual inspection of the system is the best way to observe performance and can be done in minutes while gardening. It should be noted that plants requiring different irrigation frequencies should be placed on separate control values.

Components of Drip irrigation system

Main components of this system are as follows.

i) Head assembly comprising

- a) Back flow prevention device
- b) Fertilizer dispenser
- c) Y filter
- d) Ventury meter
- e) Ventury by-pass assmbly

ii) Main and Sub main pipes

iii) Lateral pipes

iv) Drip nozzles

v) Valves and fittings and

vi) Pump set.

i) Head or Valve Assembly

The components that are to be installed into all drip irrigation systems are

a) A back flow prevention device such as a pressure vacuum breaker,

an anti-siphon, or an atmospheric vacuum breaker is recommende for all watering systems that are connected to a drinking water su ply. This eliminates the possibility of irrigation water backing – u into the drinking or potable water system.

b) A fertilizer dispenser which, allows for the application of liquid any dry, totally water soluble fertilizer.

c) A filter to screen out small particles matter from the water and pr tects the small openings or orifices of emitters, micro-sprays, et from clogging. It contains a fine mesh screen or Cartridge that ca be rinsed and reused.

d) A pressure regulator which reduces the higher pressures found home plumbing systems, usually 45 – 100 PSI, down to 10 to 25 N depending on the drip irrigation system being installed. The low pressure greatly reduces the possibility of leaks and blowouts. Th pressure regulator is placed on last so that the pressure going out the lines is at the desired level.

e) A venturi meter to measure the flow rate.

ii) Main pipes, Lateral pipes

The poly tubing is connected to the pressure regulator. For th parts we have to provide in future adopters should be installed in th piping.

iii) Drip Emitters

Selection, spacing, and coverage of drippers are very importa as the drippers are heart of the system. The various available drippe in the market are as follows.

a) Pressure compensating drippers

These are the most advanced drippers and are available in flow rates of 1, 2 and 4 gph. They allow long runs with equal flow from each dripper at any pressure between 10 and 55 psi. They are self-cleaning and utilize a silicone diaphragm which moves up and down as pressure fluctuates to control the flow. They are designed for long life under the harshest conditions and are ideal to use in any design.

b) Button drippers

These drippers allow water to move rapidly in irregular random motions. These drippers regulate water flow by dissipating energy in friction against the walls of the water passage. Button drippers are available in flow rattes of 5, 1 and 2 gph and working at 25 psi and also have extra large water passages to prevent clogging.

c) Flag drippers

These drippers use the same concepr as button drippers, but may be opened to clean. They are available in flow rates of 1 and 2 gph at 25 psi. and they have barb inlet and outlet for easy installation

a) Adjustable drippers on spike

These allow the option of changing the flow for each individual plant. Twisting the dial on the dripper towards the or away the signs will allow to adjust the flow between 1 gph and 10 gph. These are available with ¼ barb or 5 spike.

3.3 Installation, Working of Drip irrigation System

The installation and working of the system can be discussed under two separate headings as mentioned below.

Installation of Drip system

The installation of this system involves laying of head assembl Mains, Sub mains, Laterals and drip nozzles on the ground. If the syste needs more supply then the system is to be divided into as many ind vidual systems as necessary. In doing this we have to consider certa plants with differing watering requirements. For the future extensio provisions should be made in the system.

The installation should be started from the water source to t laterals in the following sequence.

i) The Delivery pipe of the should be started from the water sour to the laterals in the following sequence.
ii) The head assembly is then connected to the storage tank.
iii) The mains are connected to this 'Head assembly' and are buri in the ground at equal distances in the area where the irrigation to be practiced.
iv) The sub mains are joined to the mains in a lateral direction a are laid parallel to the rows of plants.
v) The lateral pipes, which are usually 50cm long, are joined to t sub mains. In general one lateral is provided for one plant.
vi) The drip nozzles with regulators are fitted to the laterals exact at the location of the plant. The end of the lateral is provid with a 'stop' to prevent the wastage of water.
vii) Thus the laying of drip system consists joining the mains, s mains and laterals.

Precautions during alignment

The precautions to be taken during the alignment of the drip sy tem are as follows:

i) For pipe thread connections the male threads should be wrapp with two to three wraps of Teflon tape before making the co nection.

ii) The correct direction of flow on valves and other components should be checked before making the final connections. Usually all pipe Threaded components will have an arrow' on them that points in the direction of the water flow.

iii) Over tightening of the plastic fittings by using a wrench or pliers should't be done as it causes stripping of threads. In general hand tightening will be enough if Teflon tape is used.

iv) The dirt out of the lines shouldn't be allowed into the system during installing the system.

v) The tubing should be allowed to "relax" or sit in the sun. This will make it easier to work with and assemble. If it's cold outside when we're installing the system, then the end of the tubing should be dipped into a container of warm water.

vi) The pipe shouldn't be stretched or pulled. The hose should be allowed to "snake" along the ground. This will allow for expansion and contraction due to weather conditions.

vii) When punching a hole for an emitter, spry, or connector, the punch should be made perpendicular to the tubing while supporting the backside of the tubing with the other hand.

viii) All the tubing lines should be flushed before closing so as to remove any debris that may have gotten into the system during istallation.

Working of Drip system

The pump which is in general a Centrifugal Pump, lifts the water from the well and stores it in an elevated storage tank. The tank level from the ground is dependent on the area of the land to be irrigated. The water from the storage tank is released as and when required and passed through a fertilizer tank, so as to mix the fertilizer directly to the water. Then this water is allowed to pass through the Sand filter and Screen filters in an 'Head assembly' to remove the suspended particles form the water, otherwise these particles clog the drip nozzles. The water from the 'head assembly' starts flowing through the

mains, sub mains, lateral and drip adjusting the regulators fitted to t
nozzles. The process of dripping is allowed to continue for a period
7 to 8 hours every day.

The excess water flowing through the mains is again collected
the other end of the farm and disposed off in a suitable way.

3.4 Troubles in drip system components.

The components, which need frequent observation in this syste
are filters, emitters, threads at connections and poly tubes.

i) Filters

The filters are frequently get clogged as these are used to pr
vent the entry of silt particles and un dissolved particles of fertilizer.
clean these filters the lines are flushed, by opening the end cap of t
tubing. The frequency of cleaning by flushing depends on the quality
water and on the quality of fertilizer.

ii) Emitters

The emitters are get clogged due to the presence of the silt pa
ticles of the water. The efficiency of the emitters reduced to a large e
tent due to this clogging. So the clogged emitters are to be preferab
replaced with new one. If we want to remove completely the emitte
then we have fix goof plugs in the place of emitters, so as to avoid leak

iii) Threads at connections

Forcing a hose thread fitting into a pipe thread fitting results
stripped threads and these threads causes leaks. These leaks can
avoided by wrapping the male threads for 2-3 times with a Teflon tap
If the damage is of serious nature then that damaged part of the pi

should be removed and a new piece is to be installed at that place.

iv) Poly tubes

The efficiency of the system decreases drastically if there exists any break in the lines. If there exist any break in the line, then the damaged section should be removed and a new piece is to be installed using couplings. Before making connection to the system, this newly installed pipe should be flushed to remove any particles that may exists in it.

Summary

1. The drip irrigation is a veriety of sub irrigation system. It consist a net work of pipes and drippers and is used to feed exact amount of water to each plant directly to its root zone.
2. The main components of drip system are a) head assembly, b) polypipes and c) drippers.
3. The main disadvantage of this drip system is 'blocking of drippers due to the presence of silt'. So it is not preferable if the water consists soil particles.
4. The sprinkler irrigation is a variety of surface irrigation system. It consist a net work of pipes and sprinklers and is used to feed the crop by applying the water in the from of a natural rain.
5. The main components of sprinkler system are a) head assembly, b) poly pipes and c) sprinklers.
6. The main disadvantage of this sprinkler system is, it is not useful for crops which require large quantity of stagnated water such as paddy crop. It is not preferable if the water consists soil particles.

Short Answer Question

1. Mention the components of drip irrigation system
2. Mention any three types of drippers.
3. Mention the reason for fitting of 'Y' filter in the head assembly
4. Mention the troubles in drip system.
5. Mention any three types of sprinklers
6. Mention the troubles in sprinkler system

Descriptive Answer Questions

1. Explain in detail about the components of drip system.
2. Explain in detail about the installation of drip system.
3. Explain in detail about the working of drip system
4. Explain in detail about the precautions to be taken during the insta lation of drip system.
5. Explain in detail about the components of sprinkler system
6. Explain in detail about the installation and working of sprikler sy tem.