SCHEME OF VALUATION

(Scoring Indicators)

Revision: 2015 Course Title: BASIC MECHANICAL ENGINEERING		Course Code: (15) 2021		
Qst. No.	**Scoring Indicator**	**Split up score**	**Sub Total**	**Tota**
	PART A			10
I (1)	The specific heat of a substance is the amount of heat required to change the temperature of unit mass of that substance by one degree. Its unit is kJ/kg.K.	1X2	2	
I (2)	Phosphor bronzes are copper-tin alloys containing 5 to 20% of tin, 0.1 to 1.5% of phosphorus and the rest copper.	1x2	2	
I (3)	A point on a phase diagram at which both the liquid and gas phases of a substance have the same density, and are therefore indistinguishable. At critical point the latent heat vanishes.	1x2	2	
I (4)	It indicates the deree to which the fresh charge is compressed in an I.C. engine. It is calculated as the ratio of the volume above the piston at BDC to the volume above the piston at TDC. If 'r' is the compression ratio, then; $r = \frac{V_S + V_C}{V_C}$ where, V_S - Swept volume, volume between TDC and BDC. V_C - Clearance volume, volume above TDC.	1x2	2	
I (5)	1) High initial cost. 2) Wind power is not consistent and steady. 3) Phenomenon such as tornadoes can destroy the whole plant. To avoid this costly designs and dontrols are required. 4) Wind power plants are established in remote areas requiring transmission to very long distances.	½x4	2	
	PART B			42
II (1)	The fatigue strength of a material is tested by applying a known alternating stress until the sample breaks. The fatigue strength or endurance limit of a material is the maximum alternating or reversible stress that can be applied for indefinitely large number of times without causing failure. Fatigue test is commonly conducted on a rotating beam fatigue testing machine as shown in figure. A highly polished specimen of circular cross-section is subjected to a bending moment by means of static load. As the specimen is rotated, all the points on the circumference of the specimen will alternately in tension and compression during each cycle. Thus each revolution of the specimen will constitute a complete		6	

cycle of stress reversal. A counter records the number of revolutions that the specimen withstands before it fractures. A number of specimens of the same material are tested under different stress levels (loads) and the number of cycles N, at which failure occurs is determined. The results are plotted in the form of S-N curve, fig (a) shows typical S-N curve for steel.

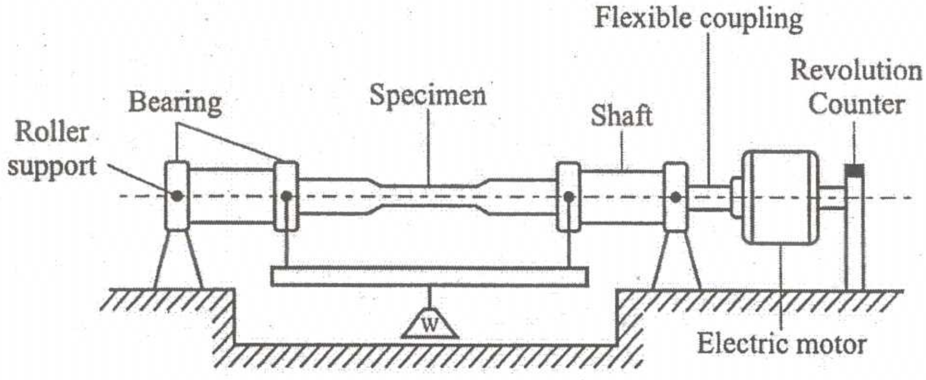
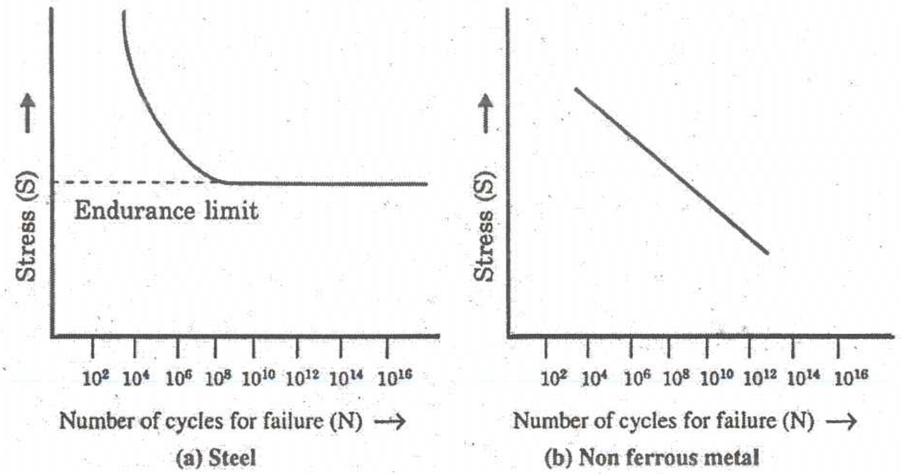


fig-3

Fatigue testing machine

It is found that the number revolutions (stress cycles) will go on increasing each time with the decrease in load (stress). After some tests a limit is reached, when the stress is not sufficient to break the test piece even after infinite number of revolutions. (It is shown by the horizontal portion of the S-N curve). This safe stress which does not cause the test piece to break is called endurance limit or fatigue limit. For ferrous metals, the fatigue limit is about 40 to 60% of the ultimate tensile stress.



3

Shapes of S–N curves

Commonly ferrous metals show a definite fatigue limit, while non ferrous metals do not, as shown in fig. (b). In such cases the fatigue limit is defined as the stress amplitude that produces failure in a given number of cycles, usually 10^7 cycles.

II (2)

Materials which are used in engineering applications are known as engineering materials. 6

Materials are classified in groups based on many criteria; for example, crystal structure (arrangement of atoms and bonds between them), or properties, or use. The main classes of present engineering materials are:

1) Metals and alloys
2) Ceramics 2
3) Polymers / organic compounds
4) Composites
5) Modern Materials

1) Metals & Alloys

Metals are electro positive elements which are characterized by thermal and electrical conductivity, lustre, strength, opaque to light, strong yet deformable under applied mechanical loads. All metals are crystalline solids.

An alloy is a substance that possess metallic properties, hold metallic bonds and is composed of two or more elements of which at least one is a metal. Brass Bronze, Duralumin, Solder, Monel metal, Stainless steels, etc. are examples of alloys.

Metals are again classified in to two groups. 2

(a) Ferrous metals:- All metallic materials having iron as their main constituent are known as ferrous metals, e.g., wrought iron, cast iron, steels, etc.

(b) Non- ferrous Metals:- Those metallic materials, which do not possess iron as their main constituent are known as Non- ferrous metals, e.g., Copper, Zinc, Tin, Brass, Bronze, etc.

2) Ceramics

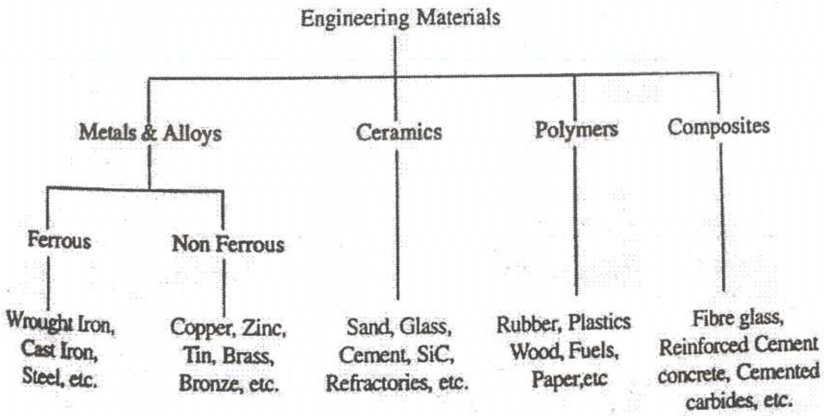
Ceramics are inorganic compounds made either of oxides, carbides, nitrides or silicates of materials. Ceramics are typically partly crystalline and partly amorphous. These materials are characterized by very high strength under compression, low ductility, usually insulators to electricity, brittleness, etc. eg: Sand, Glass, Cement, Silicon Carbide (SiC), Clay minerals, refractories, etc.

3) Polymers (Organic Compounds)

Polymers are organic compounds that are chemically based on carbon, hydrogen and other non-metallic elements. Polymers are amorphous, except for minority of thermoplastics. They are soft, light in weight, poor conductors of heat and electricity and having good corrosion resistance, good formability, etc. eg: Rubber, Leather, Plastics, Jute, Resins, Starch, etc.

4) Composites

Composites are multi-phase materials obtained by artificial combination of different materials to attain certain desired properties. An example is reinforced cement concrete (RCC), a structural composite obtained by combining cement, sand (fine aggregate), gravel (coarse aggregate) and thick steel fibres. Another example is a light weight brake disc obtained by embedding SiC particles in aluminium alloy matrix. Other composite materials are fibre glass, reinforced plastics, cemented carbides, etc. 2



Classification of Engineering Materials

5) Modern Materials

Modern materials are those which are used in emerging new technologies. They include: 1) Semi-Conductors such as silicon, germanium, etc, 2) Bio-Materials such as high molecular weight poly ethylene, high purity dense Al-oxide, etc., which are used as bio-compatible materials, 3) Smart / Intelligent materials such as piezo-electric materials, micro-electro-mechanical systems, etc, and 4) Nano-materials.

II (3) — 6 marks (1x6)

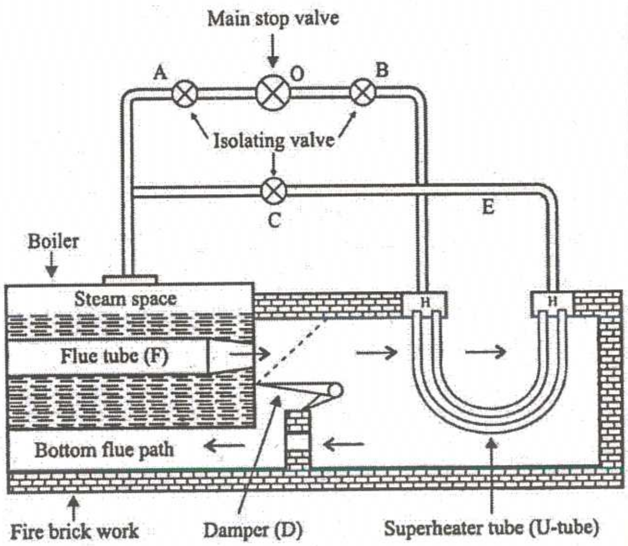
Sl. No.	Fire tube boiler	Water tube boiler
1.	Hot gases flow through the tubes which are surrounded with water.	Water circulates through the tubes and hot gases around them.
2.	Free circulation of water.	Forced circulation of water.
3.	Steam pressure is limited to 20-30 bar.	Works even at super critical pressures and temperatures (more than 221.2 bar and 374.15°C).
4.	Usually used for heating purpose only.	Used for power generation and heating purpose.
5.	Rate of steam production is less, limited to 9000 kg/hr.	Rate of steam production is high up to 500000 kg/hr.
6.	Overall efficiency up to 85%	Overall efficiency up to 92%.
7.	Construction is difficult.	Construction is simple. But includes more parts.
8.	Various parts are not accessible for cleaning, repairing and inspection.	Parts are more accessible.
9.	Chances of explosion is less.	Chances of explosion is more.
10.	Requires less skill for efficient working.	Requires more skill and careful attention.
11.	They are internally fired boilers.	They are externally fired boilers.

II (4) — 6 marks

A superheater is a device used to increase the temperature of saturated steam without raising its pressure. This is done by passing the steam through a small set of superheater tubes and hot gases over them. It is placed in the path of hot flue gases from the furnace, where the temperature of the gas is not less than 550°C.

Figure shows a Hairpin type or U-tube type superheater. It consists of two headers and a set of superheater tubes (U-tubes) made of steel. The headers are directly connected with steam space of the boiler through the pipe 'E'. Flow of hot flue gases over the superheater tubes (U-tubes) is controlled by using a damper 'D'. The superheater is put out of action by turning the damper upward to the vertical position and the flue gases coming out from the central flue tube (F) pass directly into the bottom flue without passing over the superheater tubes. (3)

When the steam from the steam space is required to be super heated, the valve 'A' is kept closed and the valve 'B' and 'C' are kept opened. After being superheated, the steam is passed through the isolating valve 'B' and the main stop valve 'O', to the steam engine/turbine. When steam directly from the boiler is required, the valves 'B' and 'C' are kept closed and the valve 'A' is kept opened.



Superheater

Fig-3

II (5)

Sl. No.	S.I. Engine	C.I. Engine
1.	Working based on Otto Cycle	Workig based on Diesel Cycle
2.	Spark plug is used	Fuel injector is used
3.	Fuel-air mixture is taken in, during suction stroke.	Only fresh air is taken in during suction stroke
4.	Fuel used is petrol or gasoline	Fuel used is diesel
5.	Light weight	Heavy weight
6.	Lower Compression ratio (6-10)	Higher compression ratio (16-20)
7.	High speed engine	Low speed engine
8.	Maximum efficiency is lower due to lower compression ratio	Maximum efficiency is higher due to high compression ratio
9.	Throttle controls the quantity of air-fuel mixture to regulate the load.	Quantity of fuel is regulated to control the load. Air quantity is not varied.
10.	Initial cost is lower and fuel cost is higher	Initial cost is high and fuel cost is lower

1x6

6

II (6)

I.C. Engines can be classified based on different criteria. Some of the most important classification is given below.

1. Based on application
   - Automobile Engine
   - Aircraft Engine
   - Locomotive Engine
   - Marine Engine
   - Stationary Engine
2. Based on the fuel used
   - Diesel engine
   - Petrol engine

Diesel Engine:- Uses diesel as fuel, fuel ignition takes place, without any spark, as a result of compression of the inlet air mixture and then injection of fuel. In other words self-ignition of fuel at high temperature and pressure takes place in diesel engine. Therefore Diesel Engines are also known as Compression Ignition (CI) Engines.

Petroleum-derived diesel is composed of about 75% saturated hydrocarbons (primarily paraffins including n, iso, and cyclo-paraffins), and 25% aromatic hydrocarbons (including naphthalenes and alkylbenzenes). The average chemical formula for common diesel fuel is $C_{12}H_{24}$, ranging approximately from $C_{10}H_{20}$ to $C_{15}H_{28}$.

Petrol Engine:- Uses petrol as fuel, fuel ignition is achieved by introducing an electric spark. Self-ignition is prevented in petrol engines as it will cause detonation or knocking. Therefore petrol engines are also known as Spark Ignition (SI) Engines.

Petrol is also known as gasoline. It consists of a homogeneous mixture of small, relatively lightweight hydrocarbons with between 4 and 12 carbon atoms per molecule (commonly referred to as C4–C12). It is a mixture of paraffins (alkanes), olefins (alkenes) and cycloalkanes (naphthenes).

3. Based on the type of ignition
   - Spark Ignition (SI) Engines
   - Compression Ignition (CI) Engines
4. Based on the type of Working Cycle
   - Otto Cycle Engine
   - Diesel Cycle Engine

1x6

6

- Duel Combustion Cycle Engine

5. Based on the Number of Strokes per Cycle
   - Two-Stroke Engine
   - Four-Stroke Engine

A two-stroke engine is a type of internal combustion engine which completes a cycle of operation with two strokes of the piston during only one crankshaft revolution. In a two-stroke engine, the end of the combustion stroke and the beginning of the compression stroke happen simultaneously, with the intake and exhaust (or scavenging) functions occurring at the same time.

A Four-stroke engine completes a cycle in four strokes of the piston or two revolutions of the crankshaft.

6. Based on the number of cylinders
   - Single Cylinder Engine
   - Multi cylinder Engine
     - Twin Cylinder Engine
     - Three Cylinder Engine
     - Four Cylinder Engine
     - Six Cylinder Engine
     - Eight Cylinder Engine
     - Twelve Cylinder Engine
     - Sixteen Cylinder Engine

7. Based on the Arrangement of Cylinders
   - In-Line Vertical Engine
   - V-Engine
   - W-Engine
   - Opposed Piston Engine
   - Radial Engines

8. Based on Cooling System
   - Air-Cooled Engines
   - Water-Cooled Engines

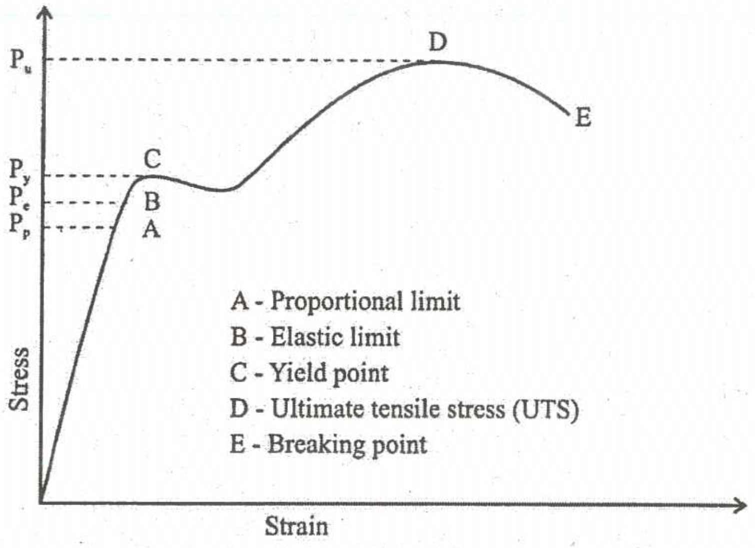
9. Based on the Valve Arrangement
   - L-Head or Flat Head Engine
   - T-Head Engine
   - I-Head Engine
   - F-Head Engine

L-Head Engine:- Both inlet and exhaust valves located on one side of the cylinder, a cross-section view would be an L-shape. This type of valve arrangement is, therefore, called a L-head or flat-head engine. The valves in this case are operated by a single camshaft.

T-Head Engine:- Inlet valve is located on one side of the engine and exhaust valve is located on the other side. The arrangement uses two camshafts for the operation of valves.

I-Head Engine:- Most current automobile engines have both valves in the cylinder head. This reduces the cost of the engine block and allows better engine breathing by providing a large inlet port on one side of the head and large exhaust port on the other side. The head is a large complex casting that provides openings for valve ports, coolant, valve actuating devices, and lubricant. The added cost and complexity of these type of cylinder head is offset by the reduced cost of the block and by the added performance produced by better engine breathing. This type of engine is called an I-head or overhead valve (OHV) engine.

F-Head Engine:- When one valve is in the head and the other valve is in the block, this is called a F-head engine. This arrangement employs one camshaft. This has many

	of the advantages and disadvantages of both L-head and I-head engines. The F-head engine has seen limited production.			
II (7)	<u>Advantages</u> 1) Heat released by fission reaction of 1 kg of Uranium would give energy equivalent of 4500 tonnes of high grade coal. Thus fuel consumption/demand is less. 2) It requires less space compared to hydroelectric and thermal power plants. 3) It produces valuable fissile materials. 4) The problems associated with envoronmental pollution, mine safety and fuel transportation etc., are less severe. 5) The unit cost of power generation by nuclear plant is comparable to or even lower than unit cost in coal fired power plants. 6) It can be located near the load centre, resulting in tremendous savings in transmission charges/losses. <u>Disadvantages</u> 1) Danger of nuclear radiation. 2) Radioactive waste disposal is a major problem. 3) It is used only as a base load plant. 4) It required more cooling water. 5) It is not a nenewable energy soucrce. 6) Requires high initial capital and skilled personal.	1x3 1x3	6	
III (a)	**PART C** The stress-strain diagram for mild steel which is a typical ductile material is shown in the figure. It is obtained by conducting tension test on a sample specimen of standard shape and size. It is a graphical representation of the behaviour of the specimen under tension. The strain is plotted along the x-axis and stress along the y-axis. The parameters which are used to describe the stress-strain diagram are proportional limit, elastic limit, yield point, ultimate strength, percentage elongation and percentage reduction in area.  Stress-strain diagram for mild steel (low carbon steel) in tensile test The initial portion of the diagram is a straight line up to point 'A'. Point 'A' represents proportional limit. It is the stress at which the stress-strain curve deviates from linearity. Up to this point the material perfectly obeys Hook's law.	fig-4	8	15

	The point 'B' indicates the elastic limit. It is the greatest stress that the metal can withstand without experiencing a permanent strain when the load is removed. The proportional and elastic limit indicates elasticity. Any structure or machine component must be designed so that its working stress do not exceed elastic, limit. Beyond point 'B' material shows plasticity. Up on further loading, it is found that at point 'C' the material elongates or yields without an increase in load. The stress corresponding to point 'C' is called yield point (yield strength). It is the minimum stress at which the specimen is deformed without an increase in load. After yield point, the load can be increased up to point 'D' with the corresponding elongation, The point 'D' represents Ultimate tensile strength of the material. It is the maximum stress, a material can with stand without fracture. The common measure of strength include yield strength & ultimate strength (UTS). In the diagram the portion DE is a down ward curve which indicates that a neck is formed with decrease in cross sectional area of the specimen. Now it requires lesser load to continue elongation till fracture takes place at 'E' (Breaking point).	1x4		
III (b)	The quality of cast iron not only depends up on the amount of carbon present in it, but also upon the conditions in which that carbon eixists. The various types of cast iron are as follows: 1) Gray Cast Iron, 2) White Cast Iron, 3) Chilled Cast Iron, 4) Malleable Cast Iron, 5) Nodular Cast Iron, and 6) Alloy Cast Iron **1) Gray Cast Iron**:- It is an ordinary commercial cast iron having the the composition, carbon - 2.5 to 3.8%, sulphur - 0.1%, silicon - 1 to 2.5%, phosphorus - 0.1 to 1%, manganese - 0.4 to 1%. In gray cast iron most of the carbon is present in the form of graphite flakes and its fractured surface has gray appearance in colour. Gray cast iron is obtained by slow cooling of molten iron, which contains relatively large quantities of carbon and silicon in it. Characteristics: (a) Lowest melting tempperature among ferrous alloys (b) High fluidity in molten condition (c) Low cost (d) Good machinability combined with hardness and rigidity (e) Good castability, weldability, and low shrinkage during solidification (f) High vibration damping capacity (g) The free graphite acts as a lubricant. Applications: Large machine tool bodies, automobile cylinders, pistons, pipes & pipe fittings, fly wheels, pulleys, agricultural implements, etc. **2) White Cast Iron**:- White cast iron has the following composition, carbon - 2 to 2.5%, sulphur - 0.18%, silicon - 0.85 to 1.2%, manganese - 0.1 to 0.4%, phosphorus - 0.1%. White cast iron contains carbon exclusively in the form of cementite. White cast iron is prepared by the rapid cooling of iron castings which contain low percentages of carbon and silicon, and high percentage of manganese. Characteristics: (a) It is very hard and brittle and its fractured surface has silvery white appearance. (b) It possess poor machinability and weldability (c) Possess good castability (d) It possess excellent abrasion and wear resistance Applications: Used for producing malleable iron castings, wrought iron and manufacturing those components parts which require a hard and abrasion resistant surface such as stamping shoes, dies, rollers for crushers etc.	2 2	7	

	3) Chilled Cast Iron:- It is a white cast iron produced by quick cooling of molten iron by using metal chills. Chilled cast iron has an outer layer of white cast iron, while the interior of the casting remains as gray cast iron. It posses high hardness and wear resistance at the surface while the core remains soft and tough. Applications: Chilled cast iron is used in the production of rolls for crushing grains, rail carriage wheels, plough shares, brake shoes, dies, etc.	2		
	4) Malleable Cast Iron:- Malleable cast iron is produced by annealing the white cast iron. The annealing process consists of heating the white cast iron slowly to 900-1000°C and keeping at this temperature for 25-60 hours and then slow cooling. There are two methods. (a) White heart process:- White cast irons are packed in an oxidising material. Some carbon is removed and the final structure of the casting consists of a white ferrite surface layer with graphite nodules or temper carbon. (b) Black heart process:- White cast iron castings are packed in an inert material such as ferrous silicate slag. During the process the iron carbide of white cast iron is decomposed to form nodular graphite or temper carbon. Its composition is carbon 2.3%, silicon 0.4 to 1.3%, manganese 0.4 to 0.6%, sulphur 0.15%, and phosphorus 0.2%.	1		
	5) Nodular Cast Iron:- Nodular cast iron is produced by small additions of magnesium to the gray cast iron melt. By doing so the graphite content is converted in to nodular or spheroidal form and is well dspersed throughout the material. It is also known as spheroidal cast iron or ductile cast iron. The composition of nodular cast iron is as follows: carbon - 3 to 3.5%, silicon - 1 to 3%, manganese - 0.3 to 0.8%, sulphur - 0.05%, phosphorus - 0.4%, and magnesium - 0.05 to 0.1%. **6) Alloy Cast Iron**:- The alloy cast iron is produced by adding certain alloying elements to the normal cast iron, for getting some desired properties. The advantages of alloy cast irons are the improvement in strength, hardness, corrosion resistance, wear resistance and response to heat treatment. The most common alloying elements which are added to the cast iron are nickel, chromium, molybdenum, vanadium and copper.			
				15
IV (a)	Cupola furnace is used for the manufacture of cast iron. The cupola is a refractory lined vertical steel cylinder having diameter up to 2 meters and height up to 12 meters and open at both top and bottom. The bottom can be closed by hinged drop doors made of cast iron and sand bed is formed (100 mm thick) above it before starting the operation. For starting a cupola, a coke fire is lit over the sand bed. When the fire is established, the furnace is charged with alternate layers of coke, pig iron and steel scrap, together with lime stone. An air blast is also introduced in to the furnace through tuyers. Now the burning is intensified, the metal in the cupola starts melting; which accumulates at the bottom of the furnace. The impurities in the form of slag floats over the top of the molten metal. After enough metal has been collected, the slag hole is opened and the slag is removed. Now the metal spout is opened and the molten cast iron is collected in ladles; and poured into moulds. Near the end of cupola operation, the charging is stopped, all the contents in the cupola are allowed to melt, then the air blast is shut off and the bottom drop doors are opened. The remains in the cupola are dropped in to the floor and quenched with water. The metal and coke are recovered from the same for use in the next operation. On the basis of combustion reactions the entire cupola may be divided in to different zones.	2	8	

(a) Crucible zone:- It is the space between the bottom of the tuyers and sand bed. The molten iron is collected here. This is also called well or hearth.

(b) Combustion (oxidising) zone:- It is situated above the top of tuyers. The actual combustion takes place in this zone. The oxidation of carbon, silicon and manganese are taking place in this zone.

$C + O_2 \rightarrow CO_2 + heat$

$Si + O_2 \rightarrow SiO_2 + heat$

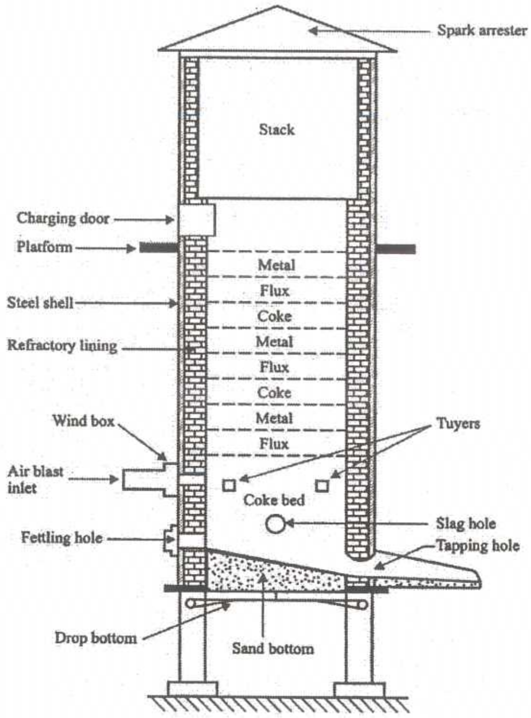
$2Mn + O_2 \rightarrow 2MnO + heat$

(c) Reducing zone:- It is located above the combustion zone. This zone, on account of the reducing atmosphere in it, protects the charge against oxidation and CO_2 is reduced to CO.

$CO_2 + C$ (of coke) $\rightarrow 2CO$ — heat

(d) Melting zone:- It is situated above the first layer of metal charge above coke bed. Highest temperature of about 1600°C is developed in this zone after complete combustion of the coke; and iron is melted here. A considerable carbon pick-up by the molten metal also occurs in this zone.

$3Fe + 2CO \rightarrow Fe_3C + CO_2$



Cupola furnace

fig-3

3

(e) Pre-heating zone (charging zone):- It extends from, just above the melting zone to the bottom level of the charging door. The charges are pre- heated in this zone due to upcoming hot gases.

(f) Stack zone:- The empty portion of cupola above the pre-heating zone, through which hot gases are released to the atmosphere is known as stack zone.

IV (b) Steel is basically an alloy of iron and carbon, with the carbon content varying up to 2 percent. The main difference between cast iron and steel is that, steel never contains graphite or free carbon in it. In steel, the major portion of the carbon, exists in cementite (iron carbide) and a small portion in ferrite. Besides carbon other elements present in steel are silicon, manganese, sulphur and phosphorus etc. 7

Steels may be classified, according to composition, in to two groups. 1

(a) Plain carbon steels (Unalloyed steels)

(b) Alloy steels

Plain Carbon Steels (unalloyed steels)

Steels which have its properties mainly due to carbon content are called plain carbon steels. In plain carbon stpels, the maximum content of the following elements does not exceed the limit.

Carbon - 1.5%, Silicon - 0.5%, Manganese - 1.0%, Sulphur - 0.03%, and Phosphorous - 0.04%.

Even though, the iron-carbon alloys up to 2% carbon content are classified as steel, for industrial applications iron-carbon alloys with carbon content only up to 1.5% are considered as steel. If the carbon content is increased above 1.5% there is a chance for the formation of graphite in its structure. When graphite is formed, it exhitbs the properties of cast iron. 3

	Classification of Plain Carbon Steel:- The plain carbon steels are usually classified on the basis of carbon content. They are: 1. Low carbon steels (0.08 - 0.3% carbon) 2. Medium carbon steels (0.3 - 0.6% carbon) 3. High carbon steels (0.60 - 1.5% carbon) Low carbon steels containing 0.08 to 0.15% carbon are known as dead mild steels. Because of low percentage of carbon, it possess high ductility, softness, machinability and weldability. They are used for chains, rivets, boiler plates, welded & solid drawn tubes, thin sheets and wires etc. Low carbon steels containing 0.15% to 0.3% carbon are known as mild steels. They possess more strength & hardness than dead mild steels. Plates and structural steel sections are usually made from mild steels. They are also used for beams, screws, railway axles etc. Medium carbon steels are stronger than mild steels, can be easily welded and forged. But their machinability and ductility are lesser than mild steels. Their mechanical properties can be further improved by proper heat treatment. They are used for shafts and axles, agricultural tools and implements, stronger nuts and bolts, locomotive tyres, drop forging hammers etc. Plain carbon steels which contain 0.6 to 1.5% carbon are generally known as high carbon steels. High carbon steels which contain more than 0.9% carbon are also called tool steels. The hardness and strength increases with the increase in carbon content up to 0.83%, there after hardness is continuously increasing while strength starts decreasing. Ductility & machinability decrease with increase in carbon content. By proper heat treatment their mechanical properties can be altered. They are used for making springs, wood working tools, metal cutting tools, ball bearings, files, dies and punches etc. **Alloy Steels** Steels in which elements other than carbon are added in sufficient amounts, to produce improvements in properties are known as alloy steels. The various alloying elements are nickel, chromium, molybdenum, tungsten, vanadium, manganese, silicon & cobalt. These elements may be used separately or in combination, to produce designed properties in steel. The reasons for alloying various elements in steel are: 1. To improve various mechanical properties like tensile strength, toughness, impact strength, ductility, hardness 2. To improve corrosion resistance 3. To improve electrical & magnetic properties 4. To improve hardenability 5. To improve weldability and machinability 6. To improve resistance to abrasion & wear 7. To retain physical properties at high temperature 8. To control grain size Classification of Alloy steels According to the purpose for which their properties are suitable, alloy steels can be classified in to: 1. Alloy structural steels:- Widely employed in engineering applications for parts that are subjected to both static &dynamic loads a. Low alloy steelsfup to 5% alloying elements) b. Medium alloy steels(5-10% alloying elements) c. High alloy steels (More than 10% alloying elements) 2. Alloy tool steels:- Employed in tool manufacture.	3		

3. <u>Alloy steels with special properties</u>:- (Special alloy steels) Steels for special purposes such as stainless steels, high speed steels, magnet steels, wear resisting steels etc., are called special alloy steels.

15

V (a) Cochran boiler is a vertical fire tube boiler. It consists of a cylindrical shell with its-crown having a hemispherical shape. The furnace is also hemispherical in shape. The grate is placed at the bottom of the furnace (A) and the ash pit is located below the grate. The fuel is introduced in to the furnace through a door (F) called fire door. The combustion of coal takes place on the grate and the flue gases pass through a short pipe (E) to the combustion chamber (B) which is provided with a fire brick lining. 8 2

From the combustion chamber, the flue gases pass through the horizontal flue tubes (fire tubes) to the smoke box (C). The smoke box door (G) enables the cleaning and inspection of the smoke box and flue tubes. From the smoke box, the flue gases escape to the atmosphere through the chimney (D).

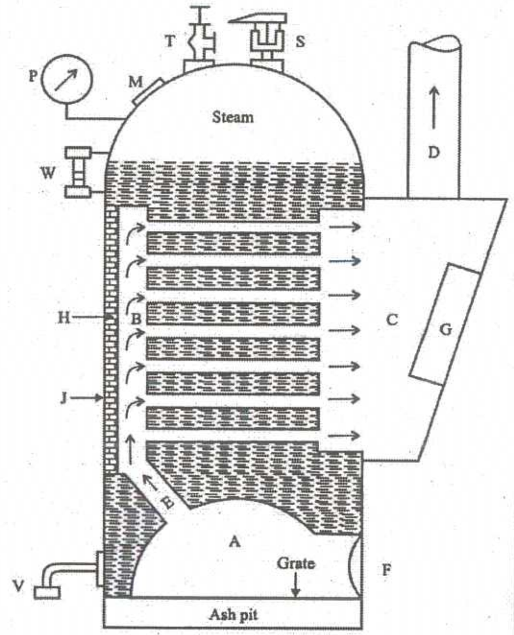


Fig. (4.3) Cochran Boiler

A - Furnace
B - CombustionChamber
C - Smoke box
D - Chimney
E - Short pipe
F - Fire door
G - Smoke box door
H - Fire brick lining
J - Boiler shell
M - Man hole
P - Pressure gauge
S - Safety valve
T - Steam stop valve
V - Blow-off cock
W - Water level indicato

fig-3

Due to the continuous flow of flue gases through the flue tubes, the water which surround them gets boiled and thus steam is produced. The steam thus generated is collected in the steam space within the boiler.

A manhole (M) near the crown of the shell is provided for cleaning. The blow-off cock (V) is opened when the boiler is to be emptied for cleaning, repair or inspection. It is also used to blow out the mud and sediments collected during the operation of the boiler.

Various mountings such as pressure gauge (P), steam stop valve (T), safety valve (S) and water level indicator (W) are also shown in fig. which will be explained separately. 3

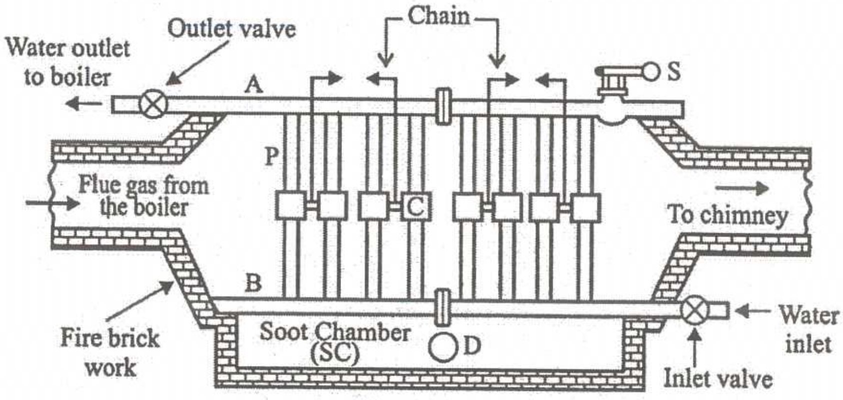
Cochran boiler is made in sizes up to 2.75 meter diameter and 5.6 metre height. It is made in different capacities with production of steam ranging from 150 to 3000 kg/hour and working pressure up to 20 bar. Fire tubes (flue tubes) are generally 6.25 cm in external diameter and 165 to 170 in number.

Advantages of Cochran boiler

1) It is very compact and requires minimum floor area.
2) Any type of fuel can be used with this boiler.
3) It is well suited for small capacity requirements.
4) It gives about 75% thermal efficiency with coal firing and 85% with oil firing.
5) This boiler is particularly suitable for its portability.

V (b)

Economiser is a device used to heat feed water by tuilising the heat in the exhaust flue gases, before leaving through chimney. It is fitted between the boiler and the chimney. A commonly used economiser known as Green's Economiser is shown in the figure. 7



Economiser

fig-3

It consists of two horizontal pipes 'A' and 'B' which are connected to each other by means of a number of vertical pipes (P). The feed water is pumped into the Economiser through the bottom pipe 'B' and the hot water leaves the economiser to the boiler through the top pipe 'A'.

The water while flowing through the vertical pipes, gets heated by the incoming waste flue gases from the boiler furnace. A set of scrapers (C) are fitted over the vertical pipes. The soot deposited on the pipe surface is removed by moving the scrapers up and down continuously with the help of chain and gear arrangement. The soot thus removed is collected in the soot chamber 'SC' and is taken away through the door 'D' periodically. A safety valve 'S' is fitted to the pipe 'A' to secure the pipe from excessive pressure of the flowing water. 4

VI (a)

Important parts of a steam engine are: 8 15

1. Frame:- Heavy cast iron part which supports all the stationary and moving parts, and keeps them in proper relative positions. It rests upon foundations.

2. Cylinder:- It is a steam tight cylindrical vessel bolted to the frame; in which the piston reciprocates. One end of the cylinder is closed by means of a separate cover and is known as cover end of the cylinder. The other end known as the crank end carries the stuffing boxes through which the piston rod and valve rod passes.

3. Steam chest:- It is a closed chamber which supplies steam to the cylinder with the movement of D - slide valve. Two steam ports are provided for admitting the steam to the cylinder and an exhaust port for returning the exhaust steam. These ports are opened and closed at proper time by the slide valve. Steam chest is made of cast iron.

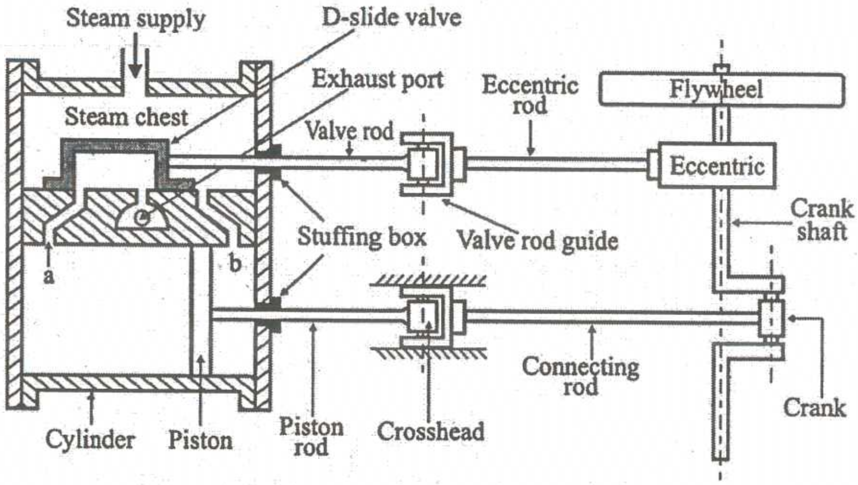
4. Stuffing box:- They are fitted on the crank end of the cylinder block. The main function of the stuffing box is to prevent the leakage of steam and at the same time allowing the piston rod and eccentric rod a free movement. 2

5. Piston:- It is a cylindrical disc moving to and fro in the cylinder under the action of steam pressure. Its function is to convert the heat energy of steam into mechanical work. It is made of cast iron. Piston rings make the piston, steam tight in the cylinder and there by prevent the leakage of steam past the piston. Piston rod is circular in cross section and is made of high grade steel; which connects the piston to the cross head.

6. Crosshead:- It is a link between the piston rod and the connecting rod. It guides the movement of the piston rod and prevents it from bending. It is made of cast iron.

7. Connecting rod:- The connecting rod is a link between the cross head and crank. It helps in converting the reciprocating motion of the piston to the rotary motion of the

crank. The end of connecting rod which is connected to the cross head is known as small end, and the end connected to the crank is known as big end. Connecting rod is made of forged steel.



Single Cylinder Double Acting Steam Engine fig-4

<u>8. Crank</u>:- Crank is formed on the crankshaft of the engine. Its function is convert the reciprocating motion of the piston rod and crosshead in to the rotary motion of the crankshaft of the engine. It is forged along with the crankshaft.

<u>9. Crankshaft</u>:- It is the main shaft of the steam engine and carries on it the crank, flywheel and eccentric. It is supported on the main bearings of the engine and is made of forged steel.

<u>10. D-slide valve</u>:- D-slide valve is situated in the steam chest and its function is to admit the steam to the cylinder, and exhaust the steam from the cylinder at the proper time. The valve gets to and fro motion from the eccentric, fitted to the crankshaft. It is made of cast iron.

<u>11. Eccentric</u>:- The main function of the eccentric is to convert the rotary motion of the crankshaft into the reciprocating motion of the D-slide valve. An eccentric rod connects the valve rod and eccentric. Eccentric is usually made of cast iron, whereas valve rod and eccentric rod are made of forged steel. 2

<u>12. Flywheel</u>:- The flywheel is a heavy cast iron wheel mounted the crankshaft to prevent the fluctuation of engine speed. The flywheel stores energy when excess of energy is being transmitted by the engine and give this energy back when the power exerted by the engine is minimum, thus keeping the crankshaft turning at a constant speed.

Governor (Not shown in figure):- The function of the governor is to maintain the speed of the engine constant irrespective to the load on the engine. This is achieved either by controlling the quantity or pressure of the steam supplied to the engine.

<u>Working of steam engine</u>

The high pressure superheated steam from the boiler is supplied to the steam chest. This steam is first admitted to the cover end (left hand side) of the cylinder when the steam admission port (a) is uncovered by the D-slide valve, while the steam is exhausted through the steam port (b) at the crank end and exhaust port (which has done work on the right side of the piston). Now, the steam admitted on the cover end, exerts pressure on the surface of the piston and pushes it to the crank end (right hand side) of the cylinder.

At the end of this stroke, fresh steam from the steam chest is again admitted by the D-slide valve to the crank end of the cylinder (when steam admission port ‘b’ is opened) while the exhaust steam on the cover end is exhausted through the steam port ‘a’ and exhaust port. Now the steam at the crank end pushes the piston back to its original position ie; towards left hand side/cover end of the cylinder.

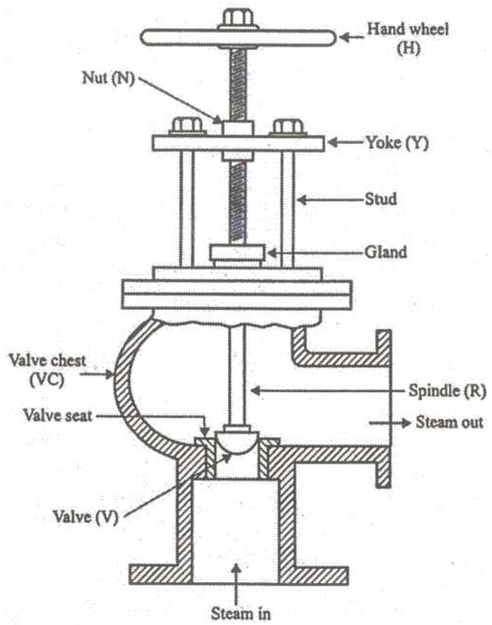
The D-Slide valve gets to and fro motion from the eccentric fitted to the crankshaft.

Thus, two working strokes are completed and the crankshaft turns by one revolution, ie; the engine is double acting. The operations are repeated.

VI (b) 7

The function of a steam stop valve is to control the flow of steam from the boiler to the main steam pipe and to shut off the steam completely when required. It is fitted to the highest part of the boiler shell.

A commonly used steam stop valve is shown in figure.



Steam stop valve

fig-3

The main body is made of cast iron or cast steel. The valve, valve seat and the nut through which the valve spindle works, are made of brass for smooth working.

The valve (V) is carried at the end of a vertical spindle (R) whose upper part is threaded and is fitted with a hand wheel (H) at the top. 4

The spindle is passed through a gland (to prevent the leakage of steam) and a nut (N) provided in the yoke (Y).

By rotating the handle wheel, the valve may move up or down and it may close or open the passage fully or partially for the flow of steam.

VII (a) 8 15

Diesel engines are also called compression ignition engines or C.I engines. Diesel engines work on diesel cycle. Diesel cycle is a constant pressure combustion cycle.

The atmospheric air is entered into the cylinder during suction stroke. The air is compressed by the upward movement of the piston and the temperature and pressure of air increases. The temperature of the air will be above the ignition temperature of the fuel. A definite amount of fuel is sprayed by the injector into the cylinder and is automatically ignited. During this combustion, the pressure and temperature of the gas increases rapidly and it pushes the piston downwards and expansion stroke takes place. This expansion stroke is also called power stroke as the power is obtained during this expansion. The burnt gases escape from the cylinder through exhaust valve or exhaust port.

<u>Working Principle of Four Stroke Diesel Engine</u>

In a four stroke diesel engine, one power stroke is obtained by two complete revolution of the crank shaft. The entire process of a diesel engine cycle is completed by 4 strokes, as explained below.

<u>i) Suction stroke</u>

During this stroke, the piston moves downwards and the inlet valve is opened. The air is sucked into the cylinder though the inlet valve. This is represented by 5-1 in the pV diagram. Exhaust valve remains closed during this stroke. 4

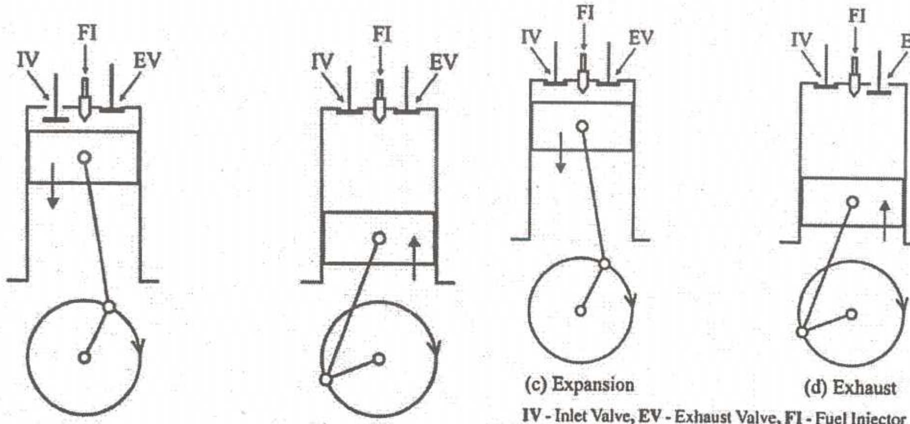
<u>ii) Compression stroke</u>

During this stroke, the piston moves upward. Both the inlet valve and exhaust valve remains closed during this process. The air present inside the cylinder is compressed by the upward movement of the piston. This is represented by 1-2 in the pV diagram. The temperature and pressure of the air increases rapidly during this process.

iii) Expansion stroke or power stroke

At the end of compression stroke, the temperature of air inside the cylinder is such that it exceeds the ignition temperature of the fuel. At this stage, fuel is sprayed into the cylinder by the fuel injector and the fuel starts burning.

This combustion is a constant pressure process and is represented by 2-3 in pV diagram.



(a) Suction (b) Compression (c) Expansion (d) Exhaust

IV - Inlet Valve, EV - Exhaust Valve, FI - Fuel Injector

Working of four stroke diesel engine

fig-2

The pressure of the gas increases instantaneously and the gas starts expanding by moving the piston downwards. Hence work is done on the piston. This stroke is also known as power stroke because the power is obtained during this stroke. The inlet valve and the exhaust valve remain closed during this stroke. This is represent by 3-4 in pV diagram.

iv) Exhaust stroke

At the end of expansion stroke, the exhaust valve opens instantaneously and inlet valve remains closed. The piston starts moving upwards and the gas escapes the cylinder through the exhaust valve. This is represented by 1-5 in pV diagram. By completing this stroke, one cycle has finished and the process continues

At the end of expansion stroke, the exhaust valve opens and the burnt gas escapes through exhaust valve. This takes place even before the piston moves upward and is a constant volume process. This is represented by 4-1 in the pV diagram.

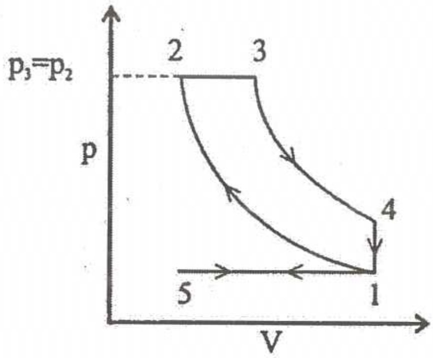


fig-2

7

VII (b) The figure shows the cross section of a simple spark ignition engine, which is a reciprocating IC engine.

The main parts of IC engines are:

i) Cylinder ii) Piston iii) Piston ring
iv) Gudgeon pin v) Connecting rod vi) Crank shaft and crank pin
vii) Fly wheel viii) Valves and cam mechanism

Cylinder:- Cylinders are made of cast iron or aluminium alloys. Its function is to provide enough space for the movement of the piston, and guide the piston through a specific path. The combustion of fuel takes place inside the cylinder. The cylinder must be capable of withstanding high temperature. Water jackets are provided outside the surface of the cylinder for achieving cooling action, so that over heating of the cylinder 4 is prevented. The top end of the cylinder is covered by cylinder head. The spark plug, inlet valve and exhaust valve are fitted on the cylinder head.

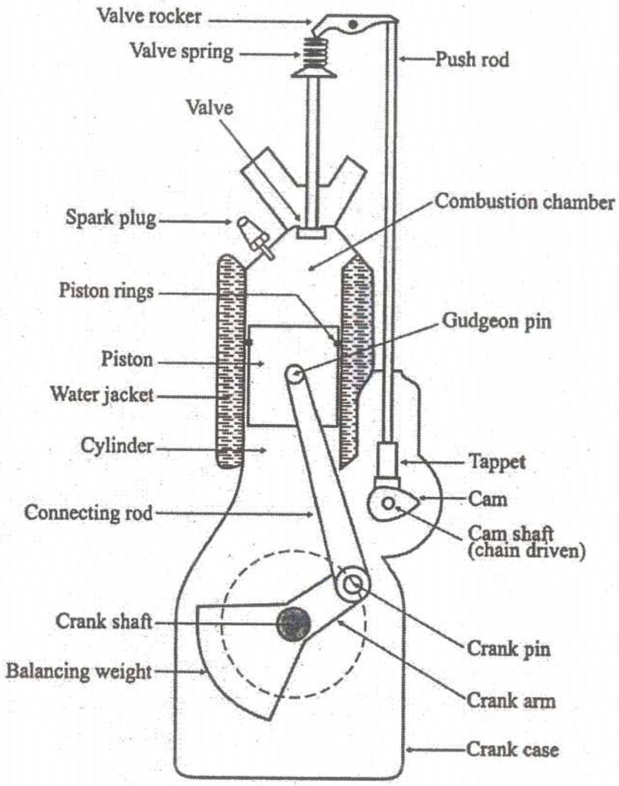
Piston:- It is the reciprocating part of an IC engine. It is usually made of cast iron or aluminium alloy. The piston moves inside the cylinder. The heat energy produced by the combustion of fuel inside the cylinder is converted into mechanical energy with the help of piston.

Piston rings:- Piston rings are fitted into the circumferential grooves of the piston. The main function of piston rings are (i) It minimise the gap between the inner surface of the cylinder and the piston (ii) It prevents the wear and tear of the piston, (iii) It prevents the leakage of gas past the piston, and (iv) Helps in correct lubrication of piston and cylinder.

Gudgeon pin:- Connects the connecting rod with the piston.

Connecting rod:- It is usually made of steel. It connects the piston and the crank shaft via crank arm.

Crank shaft and crank pin:- The crank shaft converts reciprocating motion of the piston into rotational motion. The connecting rod is connected to, the crank arm with the help of crank pin.



VARIOUS PARTS OF AN I.C. ENGINE

fig-3

Fly wheel:- Crank shaft is connected to the flywheel of high mass. Flywheel is a rotating device used to maintain uniform speed of the engine. Since the power stroke is intermediate in an engine, flywheel helps to smoothen the variation in the torque.

Valves and Cam mechanism:- The valves controls the intake of air and fuel mixtures (in case of SI engines) and exhaust of the combustion gases in a cylinder. The valves are operated by cam mechanism. Push rod and rocker arm are used for opening the valves which automatically closes with the help of valve spring.

VIII 15

(a) Petrol engine or Spark Ignition Engine works on otto cycle. This cycle is also called constant volume cycle. 8

The main difference between the diesel engine and the petrol engine is that the fuel injector is replaced by a spark plug and the intake air is replaced by air-fuel mixture. Carburetor is used for producing air-fuel mixture.

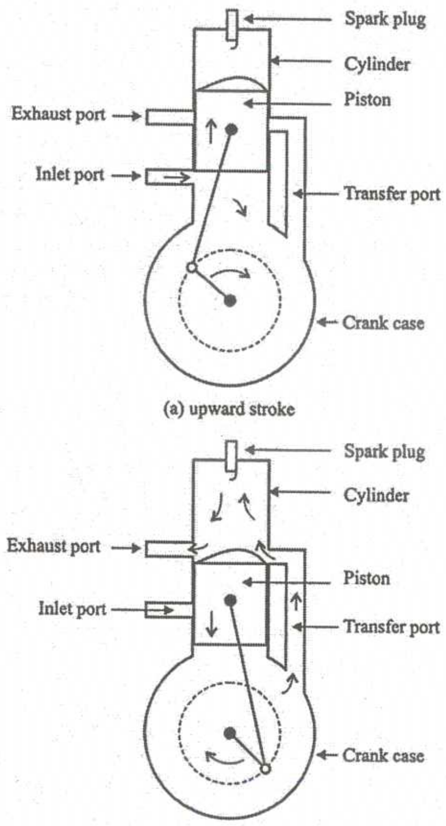
The air-fuel mixture enters the cylinder during the suction stroke. This mixture is compressed during the compression stroke. At the end of compression stroke, the spark plug is activated and spark is produced. The air-fuel mixture starts burning and the pressure and temperature of gas increases. The burnt gases pushes the piston downwards and thus work is done on the piston. Piston starts moving downwards and the expansion stroke takes place. During exhaust stroke, burnt gases escape from the cylinder through exhaust valve or exhaust port. 1

WORKING PRINCIPLE OF TWO STROKE PETROL ENGINE

In two stroke petrol engine one power stroke is obtained by one complete revolution of the crank shaft. Working of a simple two stroke petrol engine employing crank compression is shown in figure. The valves are replaced by ports in case of two stroke petrol engine.

As the piston moves upwards, it uncovers the inlet port and the air-fuel mixture enters the crankcase. At the same time the air-fuel mixture present inside the cylinder is compressed. At the end of compression, spark plug is activated and spark is produced in the cylinder. The air-fuel mixture is ignited and combustion takes place. The burnt gas starts expanding and pushes the piston downward. Thus power stroke takes place. During this expansion process, the piston covers the inlet port and uncovers the exhaust port. The burnt gas escapes through the exhaust port. Then the transfer port is uncovered and the compressed air-fuel mixture from the crank case flows into the cylinder.

Air-fuel mixture is initially compressed in the crank case by the downward movement of the piston. This fresh air-fuel mixture entering the cylinder helps to remove the burnt gases present in the upper part of the cylinder. This phenomenon is known as scavenging.



(a) upward stroke

(b) downward stroke

Working of two stroke petrol engine

fig-3

4

VIII (b)

7

Sl. No.	Four Stroke Engine	Two Stroke Engine
1.	One power stroke is obtained in every two revolutions of the crank shaft. Thus crank torque is non-uniform.	One power stroke is obtained in every revolution of the crank shaft. Thus the crank torque is more uniform.
2.	Heavy fly wheel is required due to non-uniform torque.	Lighter fly wheel is used.
3.	Valves are present.	Ports are present instead of valves.
4.	More efficient, because burnt gases are almost completely removed during exhaust stroke.	Less efficient because some amount of burnt gases are always present in the cylinger and it mixes with fresh charge.
5.	Heavy weight and design is more complicated.	Light weight and simple design.
6.	For the same size, four stroke engine develops about one half of the power developed by two stroke engine.	For the same size, two stroke engine develops almost twice the power developed by a four stroke engine.
7.	Thermal efficiency is higher.	Thermal efficiency is lower.
8.	Rate of wear and tear is lesser.	Rate of wear and tear is more.
9.	Engine will run in one direction only.	Engine will run in both directions due to lack of valves.

1x7

10.	Used in cars, buses, aeroplanes, power generators, tractors, etc., where efficiency is important.	Used in lawn movers, scooters, motor cycels, hand sprayers, mopeds, etc., where low cost, compactness and light weight are important.
11.	Degree of pollution is much lower.	Degree of pollution is higher.
12.	Commercially manufactured at present.	Commercial manufacturing is restricted or baned in many countries.

IX (a) 8 15

Water collected at an elevated position in the earth's surface possesses potential energy. As the water falls through a certain height, its potential energy is converted into kinetic energy and this kinetic energy is converted to mechanical energy while the water is flowing through hydraulic turbine. This mechanical energy is utilised to run an electric generator which is coupled to the turbine shaft. The power developed in this manner is given as: 2

Power = WQHη Watts

where W = Specific weight of water, N/m^3

Q = Rate of water flow, m^3/Sec

H = Height of fall or head, m

η = Overall efficiency of plant

A schematic diagram of a hydro electric power plant is shown in figure.

Essential elements of a hydro electric power plant

Following are the essential elements of a hydro electric power plant.

1. Catchment area, 2. Reservoir, 3. Dam, 4. Penstock pipes (conduits), 5. Surge tank, 6. Draft tube, 7. Tail race, 8. Power house, 9. Power transmission system, and 10. Spill ways.

1. Catchment area

Catchment area is the whole area behind the dam, from where the water is collected in a river across which the dam has been constructed.

2. Reservoir

The main purpose of the reservoir is to store water during rainy season and supply the same during dry season.

3. Dam

Dam is a construction across the river to develop a reservoir of the desired capacity to store water and builds up a head for power generation.

4. Penstocks (Conduits)

They are passages or pipes through which water is conveyed to the turbine. 3

5. Surge tank

The surge tank is a small reservoir in which water level rises or falls to reduce the pressure variations in a penstock. It is used to avoid the effect of water hammer in the penstock.

6. Draft tube

It is a diverging passage connecting the turbine outlet with the tail race.

7. Tail race (outlet water way)

It is a passage for discharging the water leaving the turbine, into the river/canal.

8. Power house

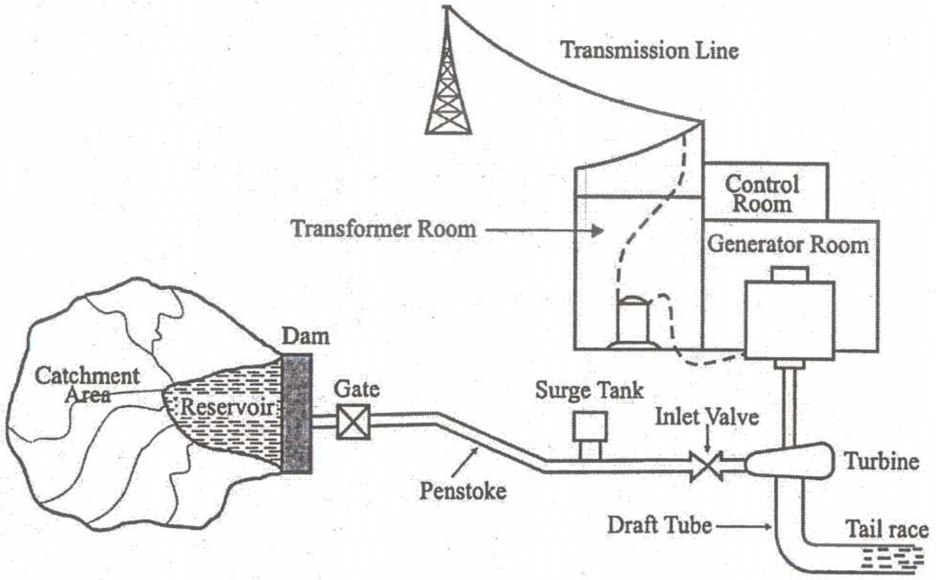
The power house is a building in which turbines, generators and controlling equipment are housed, and electric power is generated.

9. Power transmission systems

It consists of step-up transformers, switch gear mechanisms, outgoing connections etc.

10. Spill ways

It is used to discharge the water during flood period without passing through the power house.



Schematic diagram of a hydro electric power plant

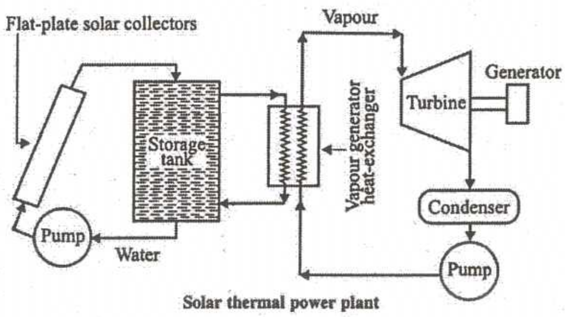
fig-3

Working of a hydro electric power plant

Water available from the catchment area is collected in the reservoir behind the dam. The power house is located at a lower level, so that maximum possible head is available for the supply water. The power house provided with water turbines are coupled to electric generators for the production of electricity. Water from the reservoir is supplied to the turbines through penstock. Gates and valves control the rate of water flow entering the turbine. A storage reservoir known as surge tank is fitted to the penstock at a point near to the turbine. It is provided to avoid the effect of water hammer in the penstock. The turbines convert the kinetic energy of flowing water into mechanical energy. The mechanical energy developed by the turbine is utilised for running the electric generator. The water after doing work on the turbine passes through the draft tube to the tail race. Transformers and transmission lines are provided for the efficient distribution of electric power generated.

IX (b) — 7

A low temperature solar thermal power generation unit is shown in figure. It uses flat plate collectors so that maximum temperature of working cycle is limited to 100°C. Refrigerants like ammonia, freons etc. which evaporates at low temperature is used as the working fluid to run the turbine.



Solar thermal power plant

fig-3

Different parts of a solar thermal power plant are:

i) Flat plate collector ii) Heat exchanger (vapour generator) iii) Turbine

iv) Generator v) Pump vi) Condenser

The solar radiation is trapped using the flat plate solar collector and the hot water generated is stored in a well insulated container. The hot water from the container is passed through the heat exchanger and the working fluid is vapourised. This vapour runs the turbine, which is coupled to the generator and electricity is produced. The exhaust vapour is condensed back to liquid in a condenser and is pumped to the heat exchanger for the next cycle. 4

Parabolic solar collectors which can easily generates temperatures up to 300°C can be employed for solar thermal power plants; where the working fluid is water instead of refrigerant. Such plants are termed as high temperature solar thermal power plants.

15

8

X (a) Diesel power plants in the range of 2 to 50 MW capacity will provide the most economic means of generating electricity on small scale, particularly where there is no convenient site for micro hydroelectric plants and cheap fuels are not available for thermal plants.

It basically uses a stationary heavy duty diesel engine that drives a generator.

Working of Diesel Power Plant

The working of a diesel engine power plant can be explained with the help of the following figure. 2

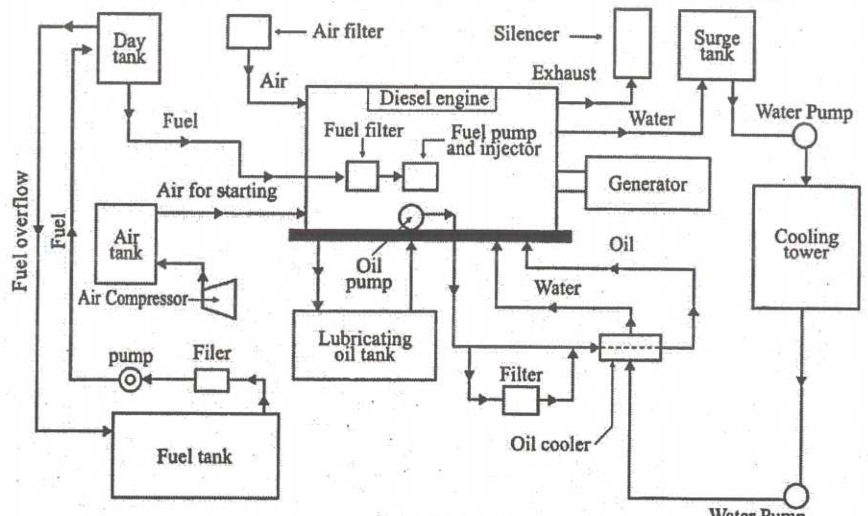
The plant comprises the following elements:

1. Diesel engine

It is the prime mover of the plant and is directly coupled to generator.

2. Air intake system

Air intake system includes air filter, ducts and super charger/turbo charger if fitted. Super chargers or turbo chargers are compressors used for supplying intake air at a pressure about 0.2 to 1.4 bar more than atmospheric pressure. [Supercharging refers to the use of compressors that are mechanically driven from the engine crankshaft, while turbo charging refers to compressors driven by a gas turbine, which produces mechanical energy from the engine exhaust stream]



Diesel power plant

fig-3

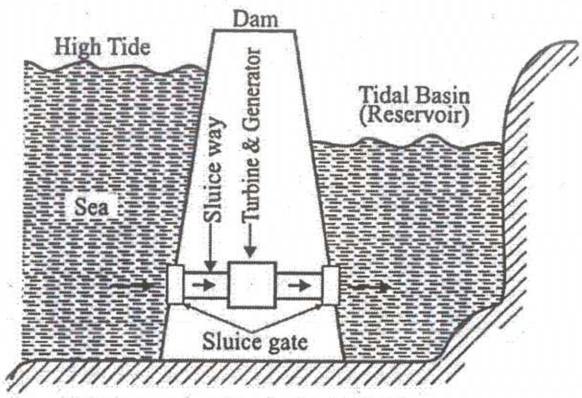
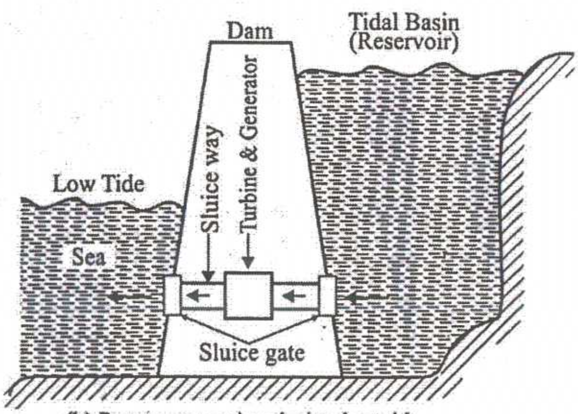
3. Exhaust system

The exhaust gases from the cylinders are collected in the exhaust manifold and are exhausted to atmosphere well above the ground level. A silencer is also fitted to the exhaust pipe to reduce the exhaust noise.

4. Fuel system

Fuel system includes bulk storage fuel tank, daily consumption fuel tank, pipe lines with fuel pump and filters, and fuel injection system. This system ensures the distribution of fuel to the cylinders at the correct time and proper amount.

5. Cooling system

	Engine cylinders are surrounded with water jackets through which cold water is circulated. Water (Coolant) pumps, radiators or cooling towers are provided to cool the warm jacket water and to recirculate it through the jackets. Thermostatic controls are provided to maintain the circulating water temperature around 80°C. 6. Lubrication system The system consists of oil filter, oil pump, oil cooler, pipings etc. Efficient lubrication system is necessary to reduce friction, wear and tear of bearings and other moving parts of the engine. Lubricating oil helps in heat dissipation, clears the surfaces and provide sealing action between cylinder and piston. 7. Engine starting system Due to high compression ratio, diesel engines are difficult to start by hand cranking. Common methods used for starting the engine are a) Compressed air starting system Air above 20 bar pressure, supplied from an air tank is admitted to cylinders to start the reciprocating movement of the piston, thus rotate the engine. b) Electric motor starting c) An auxiliary engine starting Small petrol engines are used for this purpose.	3		
X (b)	Tides can be defined as the periodic rise and fall of water in the sea. A vast amount of renewable energy is available from the ocean by means of tides. The tidal energy can be extracted by utilising the kinetic energy possessed by the moving water from a higher elevation to a lower elevation. Tides can be mainly classified as high tide and low tide based on the height of the sea water above and below the mean sea level. Water level above the mean sea level is high tide and below the mean sea level is low tide. Tides are occurring as a result of gravitational attraction of moon on sea water. Working of Tidal Power Plant A simple tidal power plant is shown in the figure. It mainly consist of: 1) Dam It act as a wall to form a reservoir or basin. 2) Power House It includes generator, turbine and control devices. 3) Sluice way It is gate controlled and is used to adjust the rate of flow of water from the sea to the basin during high tide and from the basin to the sea during low tide. A reversible hydraulic turbine coupled to a generator is used in this type of power plant. During the high tide, the water flows from the sea to  (a) Power generation during high tide  (b) Power generation during low tide	2 fig-3 2	7	

	the basin through the sluice way and drives the turbine. The turbine is coupled to the generator and electricity is produced. During the low tide, the water flows back from the basin to the sea, through the sluice way and again drives the turbine. Thus electricity is produced while water flows in both directions (Filling and emptying of the basin).			