**“Come to learn go to serve”**

**WEST COAST INSTITUTE OF MANAGEMENT & TECHNOLOGY**

**BANGLADESH**

**DEPARTMENT OF MECHANICAL ENGINEERING**

A PROJECT REPORT ON

**Diesel Engine Power Plant**

This project report is submitted to the Department of Mechanical Engineering, west coast institute of management & Technology, Bangladesh in partial fulfillment of the requirements for the award of the degree of Bachelor of Science in Mechanical Engineering.

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**ACKNOWLEDGEMENT**

At first, all the praise to almighty Allah, who has given authors the knowledge and capability of thinking to successfully complete the project work

It was expressed our sincerest gratitude to Md. Jahangir Alam, lectural, Department of Mechanical of Engineering of West Coast Institute of Management and Technology, Dhaka, for his sincere guidance, valuable suggestions and continuous encouragement for this project.

Again express our hearty thanks to Md.Kamal Faraji lectural and Head of the Department of Mechanical of Engineering, WCIMT- Dhaka for his kind permission and necessary arrangement of all the facilities for using the different workshops and material supply.

In conclusion, we are very much grateful to all staff members of Mechanical of Engineering Department for their helping and co-operation in all stages which led to the completion of our project work.

Date.

WCIMT, Dhaka.

**SYMBOLS AND ABBREVIATIONS**

TDC Top dead centre

BDC Bottom dead center

IVO Inlet valve opens

IVC Inlet valve closes

IGN Ignition

EVO Exit valve opens

EVC Exit valve closes

BP Brake power

BTDC Before top dead centre

BMEP Brake mean effective pressure

BSFC Brake specific fuel consumption

0C Degree centigrade

cc Cubic centimeter

CI Compression ignition

SI Spark ignition

**ABSTRACT**

This project explains about the power plant concept which is use the diesel engine as the prime mover. This power plant need to output electric energy

Generally it is used for heavy duty vehicles. It can also be used for power generation, pumping of water etc.

Maintenance of engine is an essential part which may be done in different engine maintenance shops. Our engine condition indicated that the engine was out of order, i.e. the engine was not in running condition. The main causes were fracturing piston pin and straight thread for the load balance.

We replaced those components for which the engine was failed to run. We manufactured the piston pin i.e. gudgeon pin and the straight thread for the engine and also cleaned piston, piston rings, cylinder block and other components. All the parts were cleaned properly and reassembled in proper position. Then the engine was performed for running and also for performance test. The maximum efficiency was found 32.52 % and the calculated maximum rated power was 2.89 kW at 920 rpm.

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**CAHAPTER – 1**

* 1. **INTRODUCTION**

**Diesel Engine Power Plant**

**1.1 Introduction**

Diesel engine power plant is suitable for small and medium outputs. It is used as central power station for smaller power supplies and as a standby plant to hydro-electric power plants and steam power plants.

The diesel power plants are commonly used where fuel prices or reliability of supply favors oil over coal, where water supply is limited, where loads are relatively small, and where electric line service is unavailable or is available at too high rates. Diesel power plants in common use have capacities up to about 5 MW.

Fig. 4.1 (a) shows various parts of an I.C. engine. The cylinder is the main body of the engine where in direct combustion of fuel takes place. The cylinder is stationary and the piston reciprocates inside it. The connecting rod transmits the force given by the piston to the crank, causing it to turn and thus convert the reciprocating motion of the piston into rotary motion of the crankshaft.

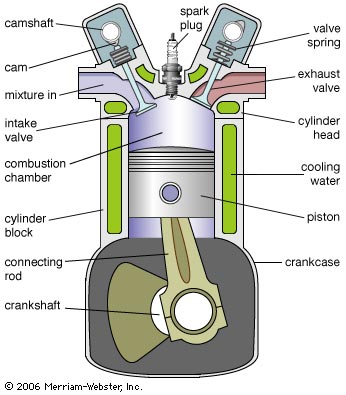
The valves may be provided

1. at the top or
2. On the side of the engine cylinder.

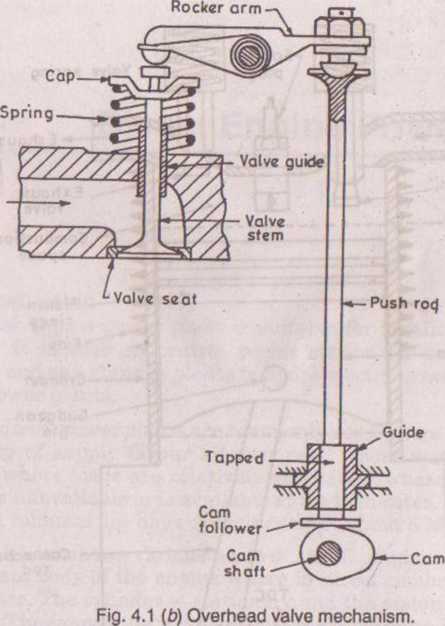
Fig. 4.1 (b) shows a typical overhead valve assembly.

The cam lifts the push rod through cam follower and the push rod actuates the rocker arm lever at one end. The other end of Urn rocker arm then gets depressed and that opens the valve. The valve returns to its seating by the spring after the cam has rotated. The valve stem moves in a valve guide acts as a bearing.

On a four stroke engine, the inlet and exhaust valves operate, once per cycle, i.e., in two revolutions of the crankshaft. Consequently, the cam shaft is driven by the crankshaft at exactly half its rotational speed.



**Fig. 4.1 (a)**

****

**Fig. 4.1 (b)**

**1.2 Classification of Internal Combustion (I.C.) Engines**

Internal combustion engines can be classified according to the following criteria:

**1. Method of Ignition.**

According to method of ignition: I.C. engines are of two types

(а) Spark ignition engines

(б) Compression ignition engines.

In spark ignition engines such as in petrol engines the air fuel mixture is compressed and ignited at the end of compression stroke by an electric spark. The compression ratio in such varies between 5to8. In compression ignition engines or diesel they are often called air admitted into the cylinder is compressed. The compression ratio being nearly 12 to 20. The temperature of air becomes very high due to compression. At or near to the end of Compression stroke fuel is injected through an injection nozzle into l lie hot air in the engine cylinder. Due to high temperature of air the fuel oil burns. The burning gases expand do work on the piston and hence on the load coupled to the engine. The gases are then exhausted from the cylinder and this cycle is repeated. In I.C. engine the charge of fuel and air in correct proportions should be supplied and combustion products should be exhausted from the cylinder when air expansion is complete in order that fresh charge may enter the cylinder.

Usually well designed compression ignition engines shows greater efficiency than spark ignition engines because of their higher compression ratios. Part load efficiency of compression ignition engine is higher.

**2. Cycle of Operation. According to cycle of operation I.C. engines are two types:**

* 1. Two-stroke cycle engine.
  2. Four-stroke cycle engine.

The relative advantages and disadvantages of these engines are as follows:

The working or power stroke is completed in two revolu­tions of the crank shaft in four stroke cycle engine whereas in two-stroke cycle engine the working stroke is completed in one revolution. Thus the power obtained from a two- stroke engine should be twice that of power obtained from four-stroke engine but due to charge loss and power needed to drive scavenge compressor the actual power obtained from a two-stroke engine is 50 to 60% more than four-stroke engine. As one working stroke

1. Is completed for every revolution of crankshaft the turning moment on crankshaft is more uniform in case of two stroke engine and, therefore, a lighter flywheel serves the purpose.
2. Two-stroke engine is lighter in weight and requires less space than a four-stroke engine of the same power. This makes it suitable for marine engines,
3. In two-stroke engine the power needed to overcome-frictional resistance during suction and exhaust stroke is saved.
4. In a two-stroke engine there is more noise and wear.
5. The consumption of lubricating oil is greater in a two timid) engine due to large amount of heat generated.
6. Two-stroke engine is simple and its maintenance cost is low
7. Scavenging is better in four-stroke engine.
8. In two-stroke engine the exhaust port remains open for a very short time which results in incomplete scavenging and thus dilution of fresh change.
9. Construction of combustion chamber is better and simple in two-stroke engine.

**3. Number of Cylinders**. According to number of cylinders, they are classified as single cylinder and multi-cylinder engines.

Internal combustion engines may have more than one cylinder such as 4, 6, 8 etc. For any given engine the number of cylinders is fixed by the output desired, space available and balancing and torque considerations. With increase in number of cylinders the weight, cost, spam occupied and number of working parts of the engine increase. Tim size of an engine is designated by the cylinder diameter (bore) stated first followed by the length of stroke.

**4. Arrangement of Cylinders**. According to the arrangement of cylinders the I.C. engines may be classified as inline engines, V-engines, radial engines, horizontal engines etc. (Fig. 4.1).

**5. Speed.** According to speed I.C. engines may be classified as follows:

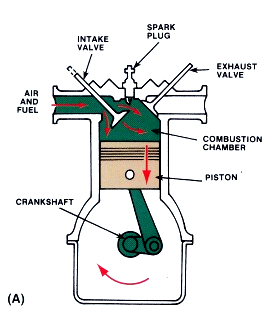
1. Low speed (up to 350 R.P.M.)
2. Medium speed (From 350 to 1000 R.P.M.)
3. High speed (Above 1000 R.P.M.)
4. **Method of cooling the cylinder**. According to the method of cooling the cylinder Ic engines are of two types:
5. Air cooled
6. Water cooled

**7. Purpose.** According to the purpose for which to be used they are classified as stationary, mobile and special.

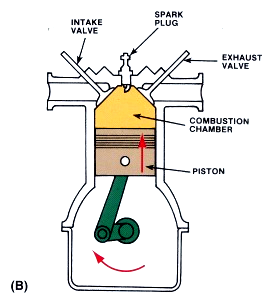
1.3 Four-stroke Diesel Engine

If four-stroke diesel engine the four operations are completed in two revolutions of crank shaft. The various operations are as follows:

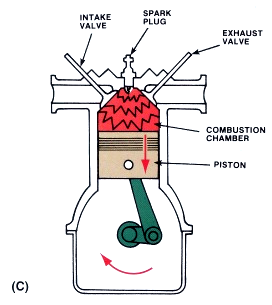
(i) Suction Stroke. In this stroke in let valve (I.V.) remains open [Fig. 4.2 (a)] and exhaust valve (E.V.) remains closed. The descend­ing piston draws in a fresh charge of air to fill the cylinder with it. The air taken in during suction stroke is nearly at atmospheric pressure. Line ab in the indicator diagram (Fig. 4.3) represents this stroke.



(ii) Compression Stroke. In this stroke I.V. and E.V. remain closed. Piston moves up and the air sucked in during suction stroke is compressed to high pressure and temperature (nearly 3.5 kg/cm2 and 600°C). This stroke is represented by the line be in indicator diagram.



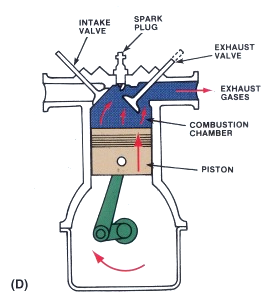
**Expansion Stroke.** During the stroke Fig. 4.2 (c), I.V. and K.V. remain closed. Injection of fuel through the fuel valve starts Just before the beginning of this stroke. Due to compression the temperature of air inside the cylinder becomes high enough to ignite l lt«r fuel as soon as it is injected. The fuel is admitted into the cylinder gradually in such a way that fuel bums at constant pressure. In Fig. 4.3, cd represents the fuel burning operation. The ignited mixture nl nir and fuel expands and forces the piston downward. Expansion stroke is represented by de in Fig. 4.3.



**Exhaust Stroke.** This stroke is represented by ea in Fig. 4.3. In this stroke E.V. remains open, Fig. 4.2 (d) and the rising piston forces the burnt gases out of cylinder.

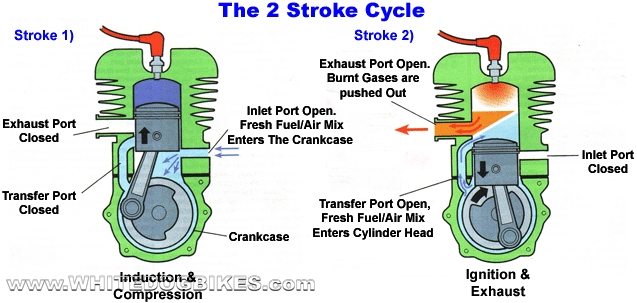
The exhaust of gases takes place at a pressure little above the atmospheric pressure because of restricted area of exhaust passages which do not allow the gases to move out of cylinder quickly. Fig. 4.4 Shows the valve timing diagram for a four-stroke diesel engine. The approximate crank positions are shown when I.V., E.V., and fuel valves open and close. I.D.C. represents (inner dead centre) and

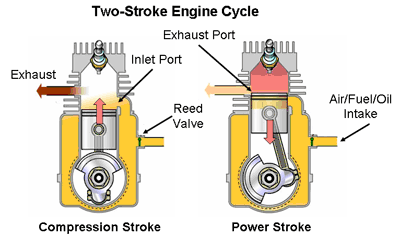
1. D.C. (outer dead centre), I.V.O. represents (Inlet valve opens) and
2. V.C. represents (Inlet valve closes). Similarly E.V.O. means ex­haust valve open and E.V.C. means exhaust valve closes F.V.O. represents fuel valve opens and F.V.C. represents fuel closes and F.V.O. represents fuel valve opens.



* 1. Two-stroke Diesel Engine

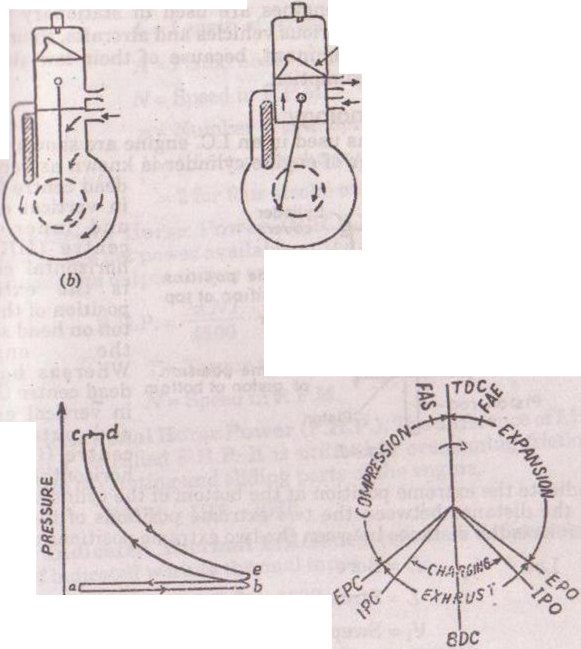
The various operations of a two-stroke diesel engine are shown I in Fig. 4.5. During the downward movement of piston (down stroke) The exhaust port is uncovered and the removal of burnt gases takes I place Fig. 4.5 (a). Further movement of the piston uncovers tin\* transfer port Fig. 4.5 (6). At this stage the crank case and cylinder space are in direct communication. The slightly compressed air in the crank case is transferred to the cylinder (at a pressure of about)0.05 kg/cm2 gauge) through the transfer port. While the transfer of change from the crank case to the cylinder is taking place the removal of products of combustion is also taking place simultaneously example the incoming charge in helping in the rejection of burnt gases, this is known as scavenging. As the piston moves upward (up stroke) the compression of air starts, Fig. 4.5 (c). Near the end of comparison stroke [Fig. 4.5 (d)] the fuel is injected and ignition of fuel is injected place due to heat of compressed air. Then due to expansion of products of combustion the piston moves downward. As inlet port is uncovered a fresh change of air gets entered in crank case.



****

Represents constant pressure combustion line, de represents expan­sion and exhaust and scavenging are indicated by eab.

Fig. 4.7 shows valve timing diagram for two-stroke diesel en­gine. TDC and BDC represent top dead centre and bottom dead centre respectively. IPO means inlet port opens and IPC means inlet port closes, EPO represent exhaust port opens and EPS represent’s j exhaust port closes. FAS mean fuel admission starts and FAI means fuel admission ends.

****

**1.5. Applications of internal combustion Engines**

Internal combustion engines are used in stationary plant, marine power plants, in various vehicles and aircrafts, their use in mobile units being predominant, because of their low size and weight and fuel low consumption.

1.6. I.C. Engine Terminology

The important terms used in an I.C. engine are shown in. The inside diameter of engine cylinder is known as bore top dead centre (TDC) in vertical engine and inner dead centre (IDC) In horizontal engine is the extreme position of the piston on head side of the engine. Whereas bottom dead centre (BDC) in vertical engine and outer dead centre (ODC) in horizontal engine indicate the extreme position at the bottom of the cylinder is the distance between the two extreme positions of piston Stroke is the distance between the two extreme pistons.

Let D = Bore

L = Stroke

V1 = Swept volume = {π/4) D x L.

Clearance volume is defined as the space above the piston at top dead centre.

V= Volume of cylinder = V1+Vc

1.7. Engine Performance

(i) IMEP. In order to determine the power developed by the engine the indicator diagram of engine should be available. From I he area of indicator diagram it is possible to find an average gas pressure which while acting on piston throughout one stroke would account for the network done. This pressure is called indicated mean effective pressure (I.M.E.P.).

(ii) IHP. The indicated horse power (I.H.P.) of the engine can be calculated as follows:

I.H.P. = Pm LAN, n

4500xk

Where Pm = I M.E.P. in kg/cm2

L = Length of stroke in meters

A = Piston areas in cm2

N =Speed in R.P.M.

n = Number of cylinders

k = 1 for two stroke engine

= 2 for four stroke engine.

(**iii)**Brake Horse Power (B.H.P.). Brake horse power is defined as the net power available at the crankshaft. It is found by measuring the output torque with a dynamometer.

B.H.P. = 2nNT

4500

T = Torque in kg.m

N = Speed in R.P.M.

Frictional Horse Power (F.H.P.). The difference of I.H.P. and B.H.P. is called F.H.P. It is utilized in overcoming frictional resistanceof rotating and sliding parts of the engine.

F.H.P. = IHP - BHP.

Indicated Thermal Efficiency (n I). It is defined as the »f indicated work to thermal input.

Ni=H.P. x 4500

W X Cu X J

Where W = Weight of fuel supplied in kg per minute.

Cu= Calorific value of fuel oil in kcal/kg.

J = Joules equivalent = 427.

(ui) Brake Thermal Efficiency (Overall Efficiency). It is defined as the ratio of brake output to thermal input.

η b = B.H.P. x 4500

W X Cu X J

(vii) Mechanical Efficiency (ηm). It is defined as the ratio of B.H.P to I.H.P. Therefore, ηm = B.H.P./I.H.P.

1.8. Heat Balance Sheet

Heat balance sheet is a useful method to watch the performance of the plant. Of all the heat supplied to an engine only part of it is converted into useful work, the remaining goes as waste. The distribution of the heat imparted to an engine is called as its heat balance. The heat balance of an engine depends on a number of factors among which load is primary importance. The heat balance of an internal combustion engine shows that the cooling water and exhaust gases carry away about 60-70% of heat produced during combustion of fuel. In order to draw the heat balance sheet of internal combustion engine, the engine is run at constant load and constant speed and the indicator diagram is drawn with the help of indicator. The following quantities are noted:

1. The quantity of fuel consumed during a given period.

2. Quantity of cooling water and its outlet and inlet temperatures.

3. Weight of exhaust gases.

4. Temperature of exhaust gases.

5. Temperature of flue gases supplied.

To calculate the heat in various items proceed as follows:

**Heat is Fuel Supplied**

Let W = Weight of fuel consumed per minute in kg.

Cv = Lower calorific value of fuel, kcal per kg.

Then heat in fuel supplied per minute = WCV kcal.

The energy supplied to I.C. engine in the form of fuel input is usually broken broken following items:

1. Heat energy absorbed in I.H.P.

The heat energy absorbed in indicated horse power I.H.P. found by the following expression:

Heat in I.H.P per minute = I.H.P. X 4500

J

1. Heat rejected to cooling in water

Let W1 = Weight of cooling water supplied per minute (kg)

Ti = Inlet temperature of cooling water in °C Ti = Output temperature of cooling water in °C Then heat rejected to cooling water = W\ (T% - Ti)

1. Heat carried away by exhaust gases

Let W2 = Weight of exhaust gases leaving per minute in kg.

(Sum of weight of air and fuel supplied)

T3 = Temperature of flue gases supplied per minute °C.

Ti = Temperature °C of exhaust gases.

Kp = Mean specific heat at constant pressure of exhaust gases

The heat carried away by exhaust gases

= W2xKpx (T*4*, - T*3*) kg cal.

(d) Heat unaccounted for (Heat lost due to friction, radiation etc.)

The heat balance sheet is drawn as follows :

|  |  |  |
| --- | --- | --- |
| Item | Head units kcal | Per cent |
| Heat is fuel supplied |  |  |
| Heat absorbed by I.H.P |  |  |
| Heat rejected to cooling water  water. |  |  |
| Heat carried away by exhaust gases. |  |  |
| heat unaccounted for (by difference) |  |  |
| Total |  |  |

A typical heat balance sheet at full load for Diesel cycle (compression ignition) is as follows

1. Useful work = 30%
2. Heat rejected to cooling water = 30
3. Heat carried away by exhaust gases = 26%
4. Heat unaccounted (Heat lost due to friction, radiation etc.) = 10%.

1.9. Diesel Engine Power Plant Auxiliaries

Auxiliary equipment consists of the following systems:

**Fuel supply system**. It consists of fuel tank for the storage of fuel, fuel filters and pumps to transfer and inject the fuel. The fuel ml may be supplied at the plant site by trucks, rail, road, tank, cars etc.

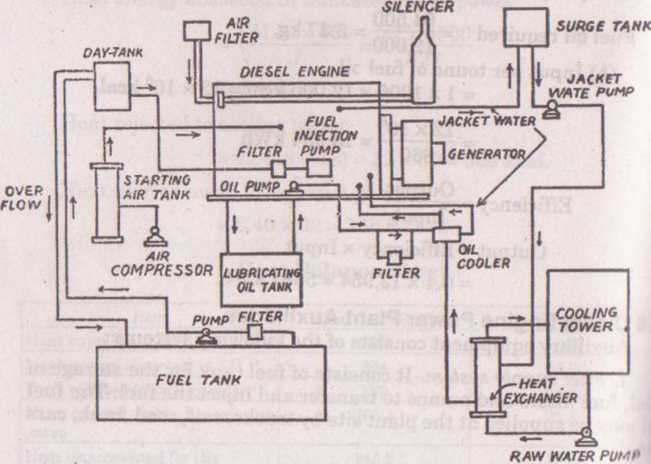
**Air intake and exhaust system.** It consists of pipes for the y of air and exhaust of the gases. Filters are provided to remove dust etc. from the incoming air. In the exhaust system silencer is provided to reduce the noise.

Filters may be of dry type (made up of cloth, felt, glass, wool etc.) It oil bath type. In oil bath type of filters the air is swept over or through a bath of oil in order that the particles of dust get coated, of the air intake systems are as follows:

1. To clean the air intake supply.
2. To silence the intake air.
3. To supply air for super charging.

The Intake system must cause a minimum pressure loss to avoid reducing engine capacity and raising the specific fuel consumption. Filters must be cleaned periodically to prevent pressure loss from clogging. Silencers must be used on some systems to reduce high velocity air noises.

1. **Cooling system.** This system provides a proper amount of water circulation all around the engines to keep the temperature at reasonable level. Pumps are used to discharge the water inside and the hot water leaving the jacket is cooled in cooling ponds or other devices and is recalculated again.
2. **Lubricating system**. Lubrication is essential to reduce friction and wear of the rubbing parts. It includes lubricating oil tank, pumps, filters and lubricating oil cooler.



**Fig.4.9 (a)**

1. **Starting system.** For the initial starting of engine the various devices used is compressed air, battery, electric motor or self starter. Fig. 4.9 (a) shows the auxiliary equipment of diesel engine power plant.

1.01.Internal Combustion Engine Cooling Methods

Due to combustion of fuel in the engine cylinder the temperature of burning gases is too high (nearly 1500° to 2000°C). This temperature may cause the distortion of some of the engine parts such cylinder head and walls, piston and exhaust valves and may be the lubricating oil. Thus a cooling arrangement is essential to carry it away some of the heat from the cylinder to avoid the overheating. A well designed cooling system should provide adequate cooling but not excessive cooling. A cooling system should:

1. Absorb and dissipate the excess heat from the engine in order at prevent damage to the engine.
2. Maintain sufficient high operating temperature so that smooth and efficient operation of the engine takes place.

It is observed that about 25 to 30% of the heat supplied is absorbed by the cooling medium. Fig. 4.9 (b) indicates a typical heat distribution for a reciprocating internal combustion engine.

Heating supplied (100%)

The following points should be noted to achieve good cooling of diesel engine.

1. Adequate quantity of water should continuously flow throughout the operation of the engine.
2. The cooling water should not be corrosive to metals.
3. The cooling water used for cylinder jackets should be free from scale forming impurities.
4. The temperature rise of cooling water should not be more than 11°C and the temperature of water leaving the engine should be limited to 60°C.

**1.11. Cooling methods**

There are two methods of cooling the I.C. Engines.

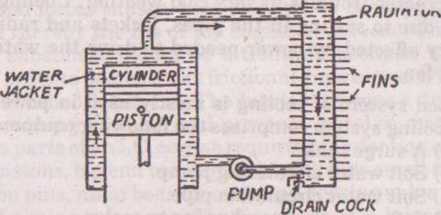
1. Air cooling
2. Water cooling.

**Air Cooling**. It is a direct method of cooling. In air cooled engine fins are cast on the cylinder head and cylinder barrel to increase its exposed surface of contact with air. Air passes over fins and carried away heat, with it. Air for cooling the fins may be lined from a blower or fan driven by the engine. Air moment relative to engine may be used to cool the engine as in case of motor cycle’s engine. About 13 to 15% of heat is lost by this method. Fig. 4.10 own air cooling system. Simplicity and lightness are the ad shows not as effective as water cooling. The rate of cooling depends upon the velocity, quantity and temperature of cooling air and size of surface being cooled.

Fig. 4.10 (a) shows position of valves, Fins and head in air cooling system. This system is used in motor cycles, scooters and aero plans.

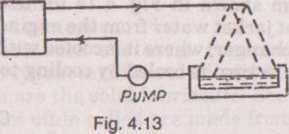
Fig. 4.10 (a) Air cooling system

**Water Cooling.** It is the indirect method of cooling the engine The various cooling systems used are shown in Figs. 4.11 and 4.12 Water after circulating in water jackets (passages around the cylinder, combustion chamber valves etc.) goes as waste [Fig. 4.111 or in recirculation method of cooling [Fig. 4.12] water is continuously circulated through water jackets. Water takes up the heat and leaves for radiator where it is cooled for recirculation.

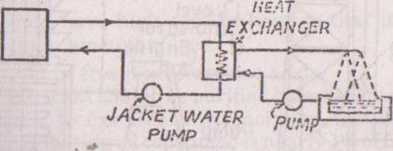


In stationary diesel engine plants the water cooling systems are as follows:

1. Open or Single Circuit System.In this system [Fig. 4.13*)* pump draws the water from cooling pond and forces it into the main engine jackets. Water after circulating through the engine return to the cooling pond.



(ii) Closed or Double Circuit System. In this system [Fig. 4.14] raw water is made to flow through the heat exchanger when it takes up the heat of jacket water and returns back to the cooling pond.



heat lost by water cooling is about 25 to 35%. The amount of heat lost is called jacket loss. The rate of flow of water should be so adjusted that the outlet temperature of cooling water does not exceed 60’c and rise in temperature of cooling water is limited to 11’c the water used for cooling purposes should be free from impurities. Water cooling methods permit uniform cooling. Water cooling creates troubles in very cold weather. Cooling efficiency is reduced due to scaling in the pipes, jackets and radiator. Engine efficiency affected by power needed to drive the water pump and radiator fan.

Closed system of cooling is mostly used in power stations. A closed cooling system comprises the following equipment.

1. A surge tank.
2. Soft water circulating pump.
3. Soft water circulation pipe.
4. Soft water heat exchanger or cooler.
5. Raw water softening plant.
6. Raw water circulation pump.
7. Raw water circulation pipe.
8. Raw water cooling arrangement such as cooling tower.
9. Thermometer for measuring inlet and outlet temperatures.
10. Temperature regulator to control the Excessive jacket temperature.
11. Safety device to control the excessive jacket temperature.

This system shown in use soft water for jack cooling. The hot jacket water from the engine is passed through cooler (heat exchanger) where it is cooled with the help of raw water. The raw water in turn is cooled by cooling towers.

**1.02. lubrication**

Frictional forces causes wear and tear of rubbing parts of the engine and thereby the life of the engine is reduced. This requires that some substance should be introduced between the rubbing surfaces in order to decrease the frictional force between them. Such substance is called lubricant. The lubricant forms a thin film be­tween the rubbing surfaces and prevents metal to metal contact. The various parts of an I.C. engine requiring lubrication are cylinder walls and pistons, big end bearing and crank pins small end bearing and gudgeon pins, main bearing cams and bearing valve tappet and guides and timing gears etc. The functions of a lubricant are as follows:

1. It reduces wear and tear of various moving parts by minimizing the force of friction and ensures smooth run­ning of parts.
2. It helps the piston ring to seal the gases in the cylinder.
3. It removes the heat generated due to friction and keeps the parts cool.

The various lubricants used in engines are of three types:

(i) Liquid Lubricants.

(ii) Solid Lubricants.

(iii) Semi-solid Lubricants.

Liquid oils lubricants are most commonly used. Liquid lubricants are of two types: (a) Mineral Oils (b) Fatty oils. Graphite, while lead and mica are the solid lubricants. Semi solid lubricants or greases as they are often called are made from mineral oils and fatty oils.

A Rood lubricant should possess the following properties:

It should not change its state with change in temperature.

It should maintain continuous films between the rub­bing surfaces.

It should have high specific heat so that it can remove maximum amount of heat.

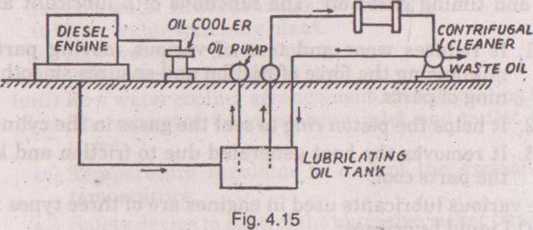
It should be free from corrosive acids.

The lubricant should be purified before it enters the engine. It should be free from dust, moisture, metallic chips, etc. The lubricating oil consumed is nearly 1% of fuel consumption. The lubricating oil gets heated because of friction of moving parts and should be cooled before recirculation. The cooling water used in the engine may be used for cooling the lubricant. Nearly 2.5% of heat of fuel is dissipated as heat which is removed by the Lubrication oil.

Lubricating oil is purified by following four methods :

1. Settling,
2. Centrifuging,
3. Filtering,
4. Chemical reclaiming. The centrifuging widely used gives excellent purification when properly done.

Fig. 4.15 shows the lubricating oil external circuit.



1. Engine Starting Methods

Spark ignition engines (Petrol engines) are used mainly in smaller size where compression ratio to be our come in cranking is only 5 to 7. Hand and electric motor (6 - 12 V, d - C) cranking are practical. Diesel engines are difficult to be started by hand cranking because of high compression required and therefore mechanical cranking system is used.

The various methods used for the starting of diesel engine are as follows:

Compressed Air System. Compressed air system is used to start large diesel engines. In this system compressed air at a pressure of about 20 kg per sq. cm is supplied from an air bottle I" the engine an inlet valve through the distributor or through inlet manifold. In a multi-cylinder engine compressed air er.ers mm cylinder and forces down the piston to turn the engine shall meanwhile the suction stroke of some other cylinder takes place .mi the compressed air again pushes the piston of this cylinder .mil causes the engine crank shaft assembly to rotate. Gradually the engine gains momentum and by supplying fuel the engine will Mart running.

Electric Starting.Electric starting arrangement consists of an electric motor which a drives pinion which engages a toothed 11 on engine flywheel. Electric power supply for the motor is made available by a small electric generator driven from the engine in case of small plants a storage battery of 12 to 36 volts is used to supply power to the electric motor.

The electric motor disengages ' automatically after the engine has started. The advantages of electric starting are its simplicity and effectiveness.

Starting by an Auxiliary Engine. In this method a small petrol engine is connected to the main engine through clutch and gear arrangements. Firstly, the clutch is disengaged and petrol engine is started by hand. Then clutch is gradually engaged and the main engine is cranked for starting. Automatic disengagement of clutch takes place after the main engine has started.

1. Starting Procedure

Actual process of starting the engine differs from engine to engine. Some common steps for starting the engine are as follows:

1. Before starting the engine it is desirable to check fuel system, lubricating system and cooling water supply.
2. Depending upon the method of starting a check for the same is essential. If air starting is used the pressure of air should be checked and also the air system should be checked for possible leakage. The storage battery should be checked if electric motor is used for starting.
3. There should be no load on the engine.
4. Crank the engine and run it at slow speed for a few minutes and again check the working of various systems such as fuel, lubricating oil system etc.

The speed of the engine should be gradually increased till it synchronizes with the bus bars. Then connect the generator to the bus and finally increase the engine speed so that it takes up desired load.

4.12.1 Stopping the Engine

The engine should not be stopped abruptly. Top stop the engine the speed should be decreased gradually until no power is delivered by the alternator. Then the engine is disconnected from the bus bars and is allowed to run idle for some time.

4.13 Starting Aids

Starting aids may be used during cold weather to obtain quicker starting of the engine. Ethyl ether is mostly used as such aid. Glow plugs another starting aid. Glow plug forms a local hot spot thus imitating the combustion of fuel even if the compression temperature of air in sufficient

1. Warning up of Diesel Engine

The diesel engine should be allowed to warm up for four to five minutes after the engine has started. During this time the following points should be checked.

1. To check whether the firing is correct in all cylinders
2. To check the operation of fuel pump
3. To check the cooling water system, circulating water pump etc.
4. To check the lubrication system
5. To check the color of exhaust gases etc. to know whether the combustion is proper.

After these checks the engine should be put on load. Then the speed of engine should be gradually increased in order to synchronies the incoming generator with the station bus bars.

1. I.C. Engine Fuel

The internal combustion engines use both oil and gas fuels, the former being predominant. The oils used are specified according to the following properties:

1. Cetane number
2. Viscosity
3. Volatility
4. Pour point
5. Flash and fire point
6. Heating value
7. Distillation test.
8. Aniline point
9. Conradson Carbon
10. Ash

Cetane number indicates the ease with which fuel ignites when injected whereas viscosity is significant in oil-handling, volatility is an index of ease with which the combustible fuel air mixture can be prepared and pour point indicates the temperature at which oil flows. Fire hazards of an oil depend on flash and the fire point Heating value measures the thermal energy in fuel and the distil­lation test is carried out to indicate whether oil contains any heavy ends of the refining process which generally burn poorly. Aniline point of oil fuel is used in calculating the diesel index which measures ignition quality. Conradson carbon indicates fire extent of components in oil with a tendency to form carbon deposits and ash indicates the components of oil believed to cause cylinder went

1. Fuel Supply

The fuels used in I.C. engines are in liquid form. They hip preferred because of their high calorific value and case of storage and handling. The storage of oil fuel is simpler than the solid I n. I the amount of fuel to be stored depends upon the service hour’s unit vary for different installations. Bulk storage and engine day I hold the engine fuel. The fuel delivered to the power plant is received in storage tanks. Pumps draw the oil from storage tanks and supply it is the smaller day tanks from where the oil is supplied to the engine as shown in fig

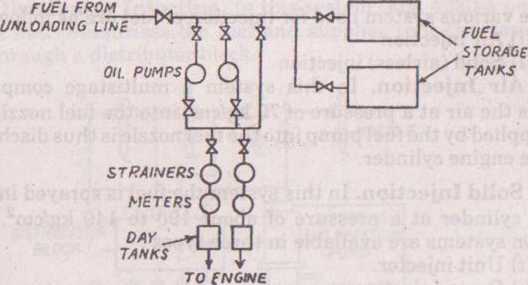
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fig4.16

The fuel oil used should be free from impurities. Efforts should he made to prevent contamination of the fuel. An important step is to reduce the number of times the fuel is handled. Greater amount of impurities settle down in the storage tank and remaining im­purities are removed by passing the oil through filters. Storage tank may be located above the ground or underground. But underground storage tanks are preferred. Fig. 4.17 shows an underground storage tank. It is provided with coils, heated by steam or hot water to reduce for viscosity and to lower the pumping cost. Main hole is provided fin internal access and repair. Vent pipe is provided to allow the tank to breathe as it is filled or emptied. Level indicator measures the quantity of oil in the tank, and an overflow line is provided to control the quantity of oil.

4.16 Diesel Engine Fuel Injection System

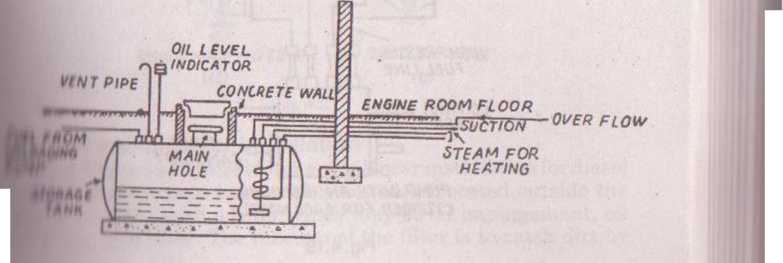


Fig. 4.17

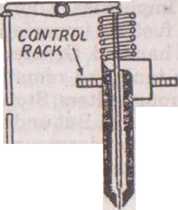
The fuel injection system should be such that adequate quantity of fuel oil is measured by it, atomised, injected and mixed with the fuel oil because even the smallest particles of dirt can completely damage the fuel injection system.

The various systems used for injection of fuel are as follows:

1. Air injection
2. Solid (airless) injection

Air Injection, In this system a multistage compressor delivers the air at a pressure of 70 kg/cm2 into the fuel nozzle. The fuel supplied by the fuel pump into the fuel nozzle is thus discharged into the engine cylinder.

Solid Injection. In this system the fuel is sprayed into the engine cylinder at a pressure of about 100 to 140 kg/cm2. Solid injection systems are available in three types:

1. Unit injector.

(ii) Pump injection. rocker arms

PUSH

ROD

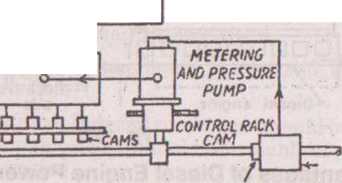
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PLUMGtR

Fig. 4.18

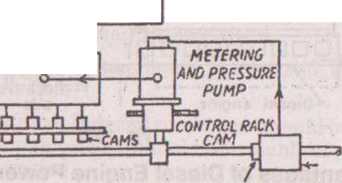
(ii) Distributor injection.

Unit Injector. In this sys­tem a pump plunger is actuated by a cam through a push rod and rock­er arm mechanism. The plunger moving in a barrel raises the pres­sure of fuel oil meters the quantity of fuel and controls the injection timing. There is a oring loaded delivery value in the nozzle. This valve is actuated by the change in fuel oil pressure (Fig. 4.18).



Pump Injection. In this system individual pump is provided for each nozzle. The pump measures the fuel charge and controls the injection timing

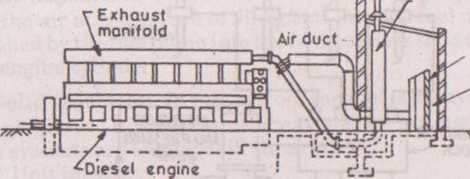
Distributor Injection. In this system (Fig. 4.20) a pump measures and pressurizes the fuel and supplies to it the various nozzles through a distributor block.



4 17 Fuel Injection Nozzle

Fuel injection takes place through very fine holes in the nozzle body. There are several types of fuel injection nozzles. Two common types are fuels injection nozzle and pintle nozzle In multihole nozzle each spray orifice produce a dense and compact spray. In pintle nozzle, fuel 4.18 **filter and silencer installation**

fig. 4.22 shows a typical filter and silencer installation for diesel the air system begins with an intake located outside the building provided with a filter which may be oil impingement, oil path thy type filter. The function of the filter is to catch dirt by causing it to cling to the surface of filter material. A silencer is provided between the engine and intake.



1. Advantages of Diesel Engine Power Plant

The various advantages of the diesel engine power plants arc follow:

1. Plant layout is simple.
2. In this plant handling of fuel is easier. Small storage space for fuel is required, there is no refuse to be disposed oft and oil needed can be easily transported.
3. It can be located near load centre.
4. A diesel engine extracts more useful work from each heat unit than other types or I.C. engines. Therefore, it In­comes an attractive prime mover wherever first cost in written off and operating cost is important.
5. The plant can be quickly started and can pick up load in very short time.
6. There are no standby losses.
7. It does not require large amount of water for cooling
8. The plant is smaller in size than steam power plant for the same capacity.
9. The operation of the plant is easy and less labour is needed to operate the plant.
10. Compared to steam power plant using steam turbine, the life of diesel power plant is longer.

Diesel engines operate at higher thermal efficiency Mi compared to steam power plants.

**Disadvantages**

1. The plant does not work satisfactorily under overload conditions for longer times.
2. Lubrication cost is high.
3. The capacity of plant is limited.
4. The capacity of plant is limited.
   1. Site Selection

While selection the site for diesel engine power plant the fallow­ing factors should be considered:

1. Distance from load centre. The plant should be located near the load centre. This will minimize the cost of transmission lines, the maintenance and power losses through them.
2. Availability of water. Water should be available in sufficient quantity at the site selected.
3. Foundation condition. Sub-soil conditions should be such that Inundation at a reasonable depth should be capable of providing a strong support to the engine.
4. Fuel transportation. The site selected should be near to the source of fuel supply so that transportation charges are low.
5. Access to site. The site selected should have road and rail transportation facilities.

The site selected should be away from the town so that the smoke and other gases coming out of the chimneys do not effect the Inhabitants.

4.21 Layout

Layout of diesel engine power plant is generally the various units are installed with parallel centre linessome space is left for future expansion. Sufficient space should be provided around the various units for dismantling and repairing the engine. The engine room should be provided with adequate ventila­tion. Fuel oil storage tanks may be located outside the main build­ings.

1. Applications of Diesel Engine Plants
2. They are quite suitable for mobile power generation and are widely used in transportation systems consisting of rail road’s, ships, automobiles and aero planes.
3. They can be used for electrical power generation in capacities from 100 to 5000 H.P.
4. They can be used as standby power plants.
5. They can be used as peak load plants for some other types of power plants.
6. Industrial concerns where power requirement are small say of the order of 500 kW, diesel power plants become more economical due to their higher overall efficiency.

Diesel power plant is quite suitable at places where

1. Fuel prices or reliability of fuel supply favour oil over coal,
2. Water supply is limited.
3. Loads are relatively small.
4. Power from other power plants such as steam, hydro power plants etc. is not available or is available at too high rates.
5. Cost of Diesel Power Plant

Cost of any power plant changes rapidly when there are inflationary tends in the nation’s currency and cost becomes out-of-date far more rapidly than technical information. A diesel engine power plant may cost about Rs. 1500 to Rs. 2000/kW of capacity. The major part of the cost in diesel engine power plant is that of engine generator set. Approximate sub-division of investment cost lm various items may be as follows:

1. Testing Diesel Power Plant Performance

The performance of the engine is dependent on engine ' compression ratio, weight of inducted air and friction losses. The newly purchased equipment is tested for various standards set up by the Indian Standards Institution and other such institutions. Tests such as checking of preliminary calibrations, accuracy of tolerances methods, specific thermal performance, and accuracy of speed control, governor characteristics and cyclic irregularity are conducted to know whether the equipment supplied is up to the standards specified. Careful supervision of the equipment used for recording temperature, pressure and electrical data are essential. The temperature inside the engine should not be allowed to exceed safe limits as diesel engine is an all metal machine and there is no refractory protection. Incorrect working of pressure gauges, ther­mometers and automatic warning signals is very harmful. For testing the cycle of the engine mechanical indicators are used for low speed and for higher speed electronic indicators are used, electronic indicators given pressure time data which can be converted into pressure volume (p.v.) data by graphical devices and then mean effective pressure, power, valve action etc., can be determined.

The important items can be measured for predicting the performance and making energy balance. They are as follows:

1. Rate of fuel consumption
2. I.H.P. (iii) B.H.P.

(iv) Quantity of cooling water and its rise in temperature (v) Quantity of air (vi) Atmospheric temperature

(vii) Temperature of exhaust gas: (viii) Or sat analysis.

To calculate air consumed by the engine the volumetric efficiency calculated. To watch the performance of the plant heat balance is drawn and for this flow of fuel, coolant, exhaust gases, temperature of these flows, quantity of fuel and air recorded. B.H.P. ft In engine connected to the generator is calculated by finding the output of the generator (measurable by electrical instruments) and efficiency of the generator. The heat lost due to friction, radiation Bill be found from the heat balance sheet

The typical performance of a diesel engine. The variation of mechanical efficiency (r|m), brake thermal efficiency (r\b) and specific fuel consumption (S) with B.H.P. is indicated in the figure.

1. Log Sheet

It is the official record of instrument reading and operating details entered up by the plant operator.

1. Advantages of I.C. Engine over Steam Engine

Both I.C. engine and steam engine are basically heat engines but in I.C. engine the combustion of fuel takes place inside the engine cylinder whereas the combustion of fuel in steam engine takes place outside the cylinder. In I.C. engine the pressure and temperature inside the cylinder is very high and therefore, construc­tion material with better resistance are required. The various ad vantages of I.C. engine over steam engine are as follows:

1. I.C. engine has higher efficiency ranging from 35 to 40% whereas the efficiency of steam engine lies between 15 to 20%.
2. I.C. engine has low weight to power ratio due to its compact design.
3. I.C. engines are usually single acting and hence there is no necessity of stuffing box glands for piston rod.
4. To start a steam engine firstly the boiler is to be fired nail steam to be raised whereas I.C. engine can be quickly started.
   1. Plant Maintenance

Diesel engine power plant maintenance depends on factors. Careful supervision of the equipment used for recording temperature pressure and electrical data are essential the temperature inside the engine should not be allowed to exceed the safe limits as diesel engine is an all metal machine and there is no refractory protection. The temperature, flow and quality of fuel oil should be checked from time to time. The fuel oil must be cleaned from dirt and other impurities by means of filters. Filters may have fiber element, or cloth or fiber or a combination of cloth and fiber. When filter element becomes choke it should be replaced by a new one. Dirt in fuel oil ruins the fine lap of fuel injection pumps plugs the injection nozzle orifice. Occasionally, all the fuel be drained and the fuel tank cleaned thoroughly. The temperature and flow of coolant, lubricating oil and exhaust gases should be checked at regular interval.

* 1. Specific Fuel Consumption

One of the most important parameters used for the comparison of engines and one which is based on power produced or delivered t» the specific fuel consumption. It is defined as the ratio of amount of fuel (kg) used by the engine per hour to the horse power produced or delivered by the engine, when specific fuel consumption is based on I.H.P. produced it is called indicated specific fuel consumption and if specific fuel consumption is based in B.H.P. delivered it is called brake specific fuel consumption.

4. 29. Comparison of a Diesel Engine and Petrol Engine

Diesel engines are quite efficient at part loads as compared to petrol engines and work efficiently in greater range.

1. A diesel engine is superior than a petrol engine because of the following factors:
2. The compression ratio is higher than a petrol engine and this increases the efficiency of the engine. The variation of air standard efficiency (η) with ratio of compression(r) is shown in.
3. In diesel engine, the combustion takes 1 place approximately at constant pres­sure rather than at constant volume as in a petrol engine.
4. No electric spark is required.
5. As diesel is cheaper than petrol, therefore, the power cost in diesel engine is low.

4.30. Supercharging

The I.H.P. produced by an I.C. engine is almost directly proportional to the air consumed by the engine. Increasing the air consumption on permits the greater quantities of fuel to be added and result in greater power produced by the engine. It is, therefore, desirable that the engine should take in the greatest possible mass of air. The supply of air is pumped into the cylinder at a pressure fail Hum the atmospheric pressure and is called supercharging. When greater quantity of air is supplied to an internal combustion engine it would be able to develop more power for the same size and conversely a small size engine fed with extra air would produce the same us a larger engine supplied with its normal air feed is used to increase rated power output capacity of a to make the rating equal at high altitudes corresponding the un supercharged sea level rating.

Supercharging is done by installing a super charger between engine and air inlet through air cleaner super charger is merely a compressor which provides a denser charge to the engine thereby enabling the consumption of a greater mass of charge with the same total piston displacement. Power required to drive the super charger is taken from the engine and thereby removes from over all engine output some of the gain in power obtained through supercharging.

There are two types of compressors that may be used as super chargers. They are as follows:

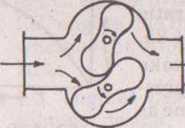
1. Positive displacement type super chargers.
2. Centrifugal type super chargers.

Positive displacement type super chargers are further of three types as follows:

1. Rotary type.
2. Screw type
3. Piston and cylinder type.

Air out

In rotary type super chargers the air is compressed by a meshing; gear arrangement called Roots blower as shown in Fig. 4.26 or by a



Air in

Fig.4.26

Rotating vane element the air is taken Inn intake and discharged at outlet end. It screw type supercharge the air is trapped between inter meshing helical shaped gears and forced out axially. In piston and cylinder type supercharger the piston compresses the air in a cylinder whereas a centrifugal type super-charger has an impeller running in housing at a high centrifugal supercharger is commonly by used in reciprocating| power plants for aircraft.

1. Advantages of Supercharging

Due to a number of advantages of supercharging the modern diesel engines used in diesel plants are generally supercharged the various advantages of supercharging are as follows:

1. For given output engine size is reduced.
2. Engine output can be increased by about 30 to 50%
3. The specific fuel consumption of a super charged engine is less than natural aspirated engine. This is due to the fact that combustion is supercharged engine is better due to better mixing of fuel and air.
4. Supercharged engine has higher mechanical efficiency.
5. Supercharging reduces the possibility of knocking in diesel engine.
6. Factors Affecting Engine Performance

Diesel engine can extract more work out of each heat with unit than other engines.

Various factors which affect performance of a diesel engine are as follows:

1. Amount of fuel burnt per minute.
2. Brake means effective pressure.
3. Fuel injection system: An efficient fuel injection system is needed. The required quantity of fuel should be measured out, injected, atomized and mixed with combustion-air.
4. Combustion process.
5. Fuel-air ratio.
6. Type of engine such as two stroke or four stroke engine. Two Stroke engines are generally used in diesel power plants.
7. Cooling method.
8. Size of cylinder.

**4.33 Combustion Phenomenon in C.I. Engines**

InC.I. engines the intake is air alone and the fuel is injected at pressure in the form of fine droplets near the end of compression.The normal compression ratios are in the range of 14 to 17. The air fuel ratio used in C.I. engines lay between 18 and 25 as against 14 in S.I (spark ignition) engines. Therefore C.I. engines are bigger and heavier for the same power output than S.I. engine.

In C.I. engine combustion occurs by the high temperature produced by the compression of air i.e. it is an auto ignition. Each droplet of fuel as it enters the highly heated air of engine cylinder is quickly surrounded by an envelope of its own vapour and this turn and an appreciable internal is inflamed at the surface of envelope.

4.36 Comparison of Gas Turbine with Reciprocating I.C. Engine

Gasturbines and reciprocating I.C. engines are used for former generation.

Advantages of gas turbines over I.C engines are as follows:

Gas turbine has lesser number of parts.

Mechanical losses in gas turbines are less because in gas turbine the single rotating unit consists of a compressor and a turbine together with a few main bearings com­pared to complicated reciprocating mechanism with its valve gear arrangement which is the prime sources of losses due to friction. Further oil and fuel supply pumps are not used thus reducing mechanical losses.

1. The life of gas turbine is longer than I.C. engine.
2. It is easier to carry out heat transfer process.
3. Gas turbine has large power to weight ratio.
4. This reduces cost of gas turbine.
5. This makes it more suitable prime mover in mobile power units particularly in air craft’s.
6. Gas turbine is simple in construction.

The reduces cost gas turbine. This makes it more suitable prime mover in mobile power units particularly in air craft’s.

1. gas turbine is reliable in operation because balancing of rotating masses both static and dynamic, can be very accurately done and unlike reciprocating engines the tensional vibration effects due to combustion load changes and inertia effects are absent due to the steady flow nature that renders continuous effect on the rotor blades of com presser and turbine.

Further the absence of valve and valve gears is another reason for quiet running of gas turbines.

1. In gas turbine the parts that are to be lubricated are few in numbers.
2. Maintenance is easier.

**CHAPTER 5**

**RESULTS & DISCUSSION**

**5.1 RESULT**

The engine was running nicely after replacing the PISTON PIN and the STRAIGHT THREAD for the load balance

**5.2 DISCUSSION**

**CAHAPTER – 6**

**CONCLUSION**

**6.1 CONCLUSION**

The engine is now in running condition though some little defects are available**.** It was tried our best to improve the engine condition hence highest possible maintenance performed using lowest cost and number of parts changes were reduced. The rate of fuel consumption would be reduced if the piston and piston rings were changed because there have some erosion occurred in the top of the piston head. It would also increases the efficiency of the engine. The engine may be used in required purposes as it is ok.