SUBJECT CODE: PCME 211

TIITE OF THE COURSE: Thermal Engineering Lab

List of Experiments

1. Constructional details and operation of Babcock and Wilcox boiler.
2. Constructional details and operation of Lancashire boiler
3. Constructional details and operation of mounting and accessories of a boiler.
4. Constructional details and operation of locomotive boiler.
5. Constructional details and operation of 2-stroke petrol engine.
6. TO STUDY ABOUT 4 CYLINDER 4 STROKE ENGINE PARTS.
7. Constructional details and operation of 4-stroke petrol engine.
8. Constructional details and operation of 4-stroke diesel engine.
9. To find the performance of a diesel engine (BHP, thermal efficiency, fuel consumption, air consumption)

Experiment-1

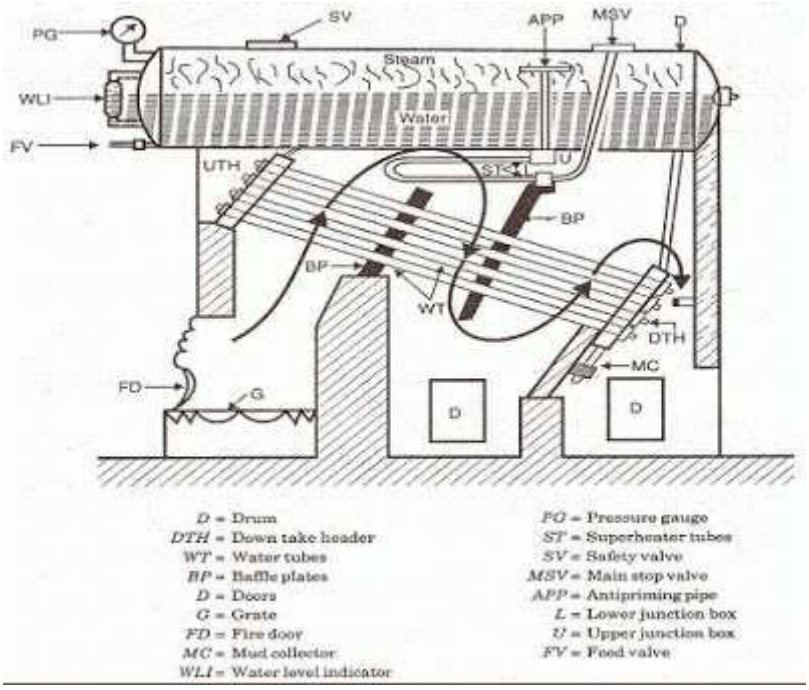
Experiment:- Constructional details and operation of Babcock and Wilcox boiler.

EQUIPMENT REQUIRED:- Model of Babcock and Wilcox Water Tube Boiler

THEORY

It is a water tube boiler used in steam power plants. In this, water is circulated inside the tubes and hot gases flow over the tubes.

Construction of Babcock and Wilcox Boiler



The Babcock and Wilcox Boiler consists of

1. Steam and water drum (boiler shell)
2. Water tubes
3. Uptake-header and down corner
4. Grate
5. Furnace
6. Baffles
7. Super heater
8. Mud box
9. Inspection door
10. Damper

Steam and water drum (boiler shell):

One half of the drum which is horizontal is filled up with water and steam remains on the other half. It is about 8 meters in length and 2 meter in diameter.

Water tubes:

Water tubes are placed between the drum and furnace in an inclined position (at an angle of 10 to 15

degree) to promote water circulation. These tubes are connected to the uptake-header and the down-comer as shown.

Uptake-header and down-corner (or downtake-header)
The drum is connected at one end to the uptake-header by short tubes and at the other end to the down-corner by long tubes.

Grate: Coal is fed to the grate through the fire door.

Furnace : Furnace is kept below the uptake-header.

Baffles: The fire-brick baffles, two in number, are provided to deflect the hot flue gases.

Superheater: The boiler is fitted with a superheater tube which is placed just under the drum and above the water tubes

Mud box: Mud box is provided at the bottom end of the down comer. The mud or sediments in the water are collected in the mud box and it is blown-off time to time by means of a blow –off cock.

Inspection doors: Inspection doors are provided for cleaning and inspection of the boiler.

Working Babcock and Wilcox Boiler:

Coal is fed to the grate through the fire door and is burnt.

Flow of flue gases:

The hot flue gases rise upward and pass across the left-side portion of the water tubes. The baffles deflect the flue gases and hence the flue gases travel in the zig-zag manner (i.e., the hot gases are deflected by the baffles to move in the upward direction, then downward and again in the upward direction) over the water tubes and along the superheater. The flue gases finally escape to atmosphere through chimney.

Water circulation:

That portion of water tubes which is just above the furnace is heated comparatively at a higher temperature than the rest of it. Water, its density being decreased, rises into the drum through the uptake-header. Here the steam and water are separated in the drum. Steam being lighter is collected in the upper part of the drum. The water from the drum comes down through the down –comer into the water tubes.

A continuous circulation of water from the drum to the water tubes and water tubes to the drum is thus maintained. The circulation of water is maintained by convective currents and is known as **"natural circulation**".

A damper is fitted as shown to regulate the flue gas outlet and hence the draught.

The boiler is fitted with necessary mountings. Pressure gauge and water level indicator are mounted on the boiler at its left end. Steam safety valve and stop valve are mounted on the top of the drum. Blow-off cock is provided for the periodical removed of mud and sediments collected in the mud box.

Salient features of Babcock and Wilcox Boiler:

1. Its overall efficiency is higher than a fire tube boiler.
2. The defective tubes can be replaced easily.
3. All the components are accessible for inspection even during the operation.
4. The draught loss is minimum compared with other boiler.
5. Steam generation capacity and operating pressure are high compared with other boilers.
6. The boiler rests over a steel structure independent of brick work so that the boiler may expand or contract freely.
7. The water tubes are kept inclined at an angle of 10 to 15 degree to promote water circulation.

Advantages and disadvantages of water tube boilers over fire tube boilers:

Advantages water tube boilers

1. Steam can be generated at very high pressures.
2. Heating surface is more in comparison with the space occupied, in the case of water tube boilers.
3. Steam can be raised more quickly than is possible with a fire tube boiler of large water capacity. Hence, it can be more easily used for variation of load.
4. The hot gases flow almost at right angles to the direction of water flow. Hence maximum amount of heat is transferred to water.
5. A good and rapid circulation of water can be made.
6. Bursting of one or two tubes does not affect the boiler very much with regard to its working. Hence water tube boilers are sometimes called as safety boilers.
7. The different parts of a water tube boiler can be separated. Hence it is easier to transport.
8. It is suitable for use in steam power plants (because of the various advantages listed above).

Disadvantages of water tube boilers

1. It is less suitable for impure and sedimentary water, as a small deposit of scale may cause the overheating and bursting of tubes. Hence, water treatment is very essential for water tube boilers.
2. Maintenance cost is high.
3. Failure in feed water supply even for a short period is liable to make the boiler overheated. Hence the water level must be watched very carefully during operation of a water tube boiler.

Experiment-2

Experiment:- Constructional details and operation of Lanchashire boiler

EQUIPMENT REQUIRED:- Model of Lanchashire boiler.

THEORY

It is a stationary, fire tube, internally fired boiler. The size is approximately from 7-9 meters in length and 2-3 meters in diameter.

Construction of Lancashire Boiler:

It consists of

1. Cylindrical shell
2. Furnace tubes, bottom flue and side flues
3. Grate
4. Fire bridge
5. Dampers

Cylindrical shell

It is placed in horizontal position over a brick work. It is partly filled up with water. The water level inside the shell is well above the furnace tubes.

Furnace tubes, bottom flue and side flues:

Two large internal furnace tubes (flue tubes) extend from one end to the other end of the shell. The flues are built-up of ordinary brick lined with fire bricks. One bottom flue and two side flues are formed by brick setting, as shown in the figure.

Grate

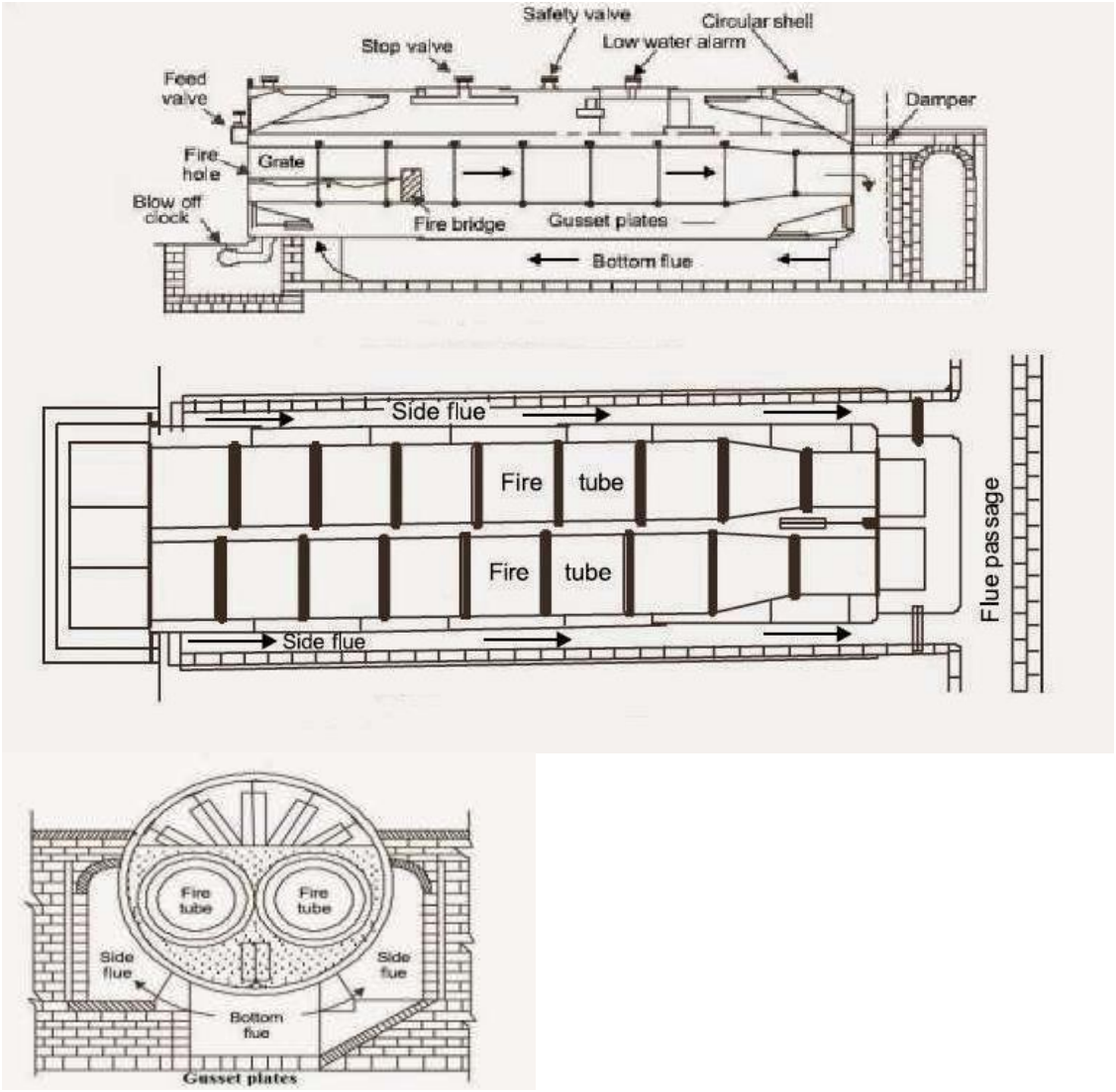
The grate is provided at the front end of the main flue tubes. Coal is fed to the grate through the fire hole.

Fire bridge:

A brickwork fire bridge is provided at the end of the grate to prevent the flow of coal and ash particles into the interior of the furnace (flue) tubes. Otherwise the coal and ash particles carried with gases form deposits on the interior of the tubes and prevent the heat transfer to the water.

Dampers:

Dampers is in the form of sliding doors are placed at the end of the side flues to control the flow of gases from side flues to the chimney flue.



Working of Lancashire boiler

Coal is fed to the grate through the fire hole and is burnt. The hot gases leaving the grate move along the furnace (flue) tubes upto the back end of the shell and then in the downward direction to the bottom flue. The bottom of the shell is thus first heated.

The hot gases, passing through the bottom flue, travel upto the front end of the boiler, where they divide into two streams and pass to the side flues. This makes the two sides of the boiler shell to become heated. Passing along the two side flues, the hot gases travel upto the back end of the boiler to the chimney flue. They are then discharged into the atmosphere through the chimney.

With the help of this arrangement of flow passages of hot gases, the bottom of the shell is first heated and then its sides. The heat is transferred to water through the surface of the two flue tubes (which remain in water) and bottom and sides of the shell.

The arrangement of flues increases the heating surface of the boiler to a large extent.

Dampers control the flow of hot gases and regulate the combustion rate as well as steam generation rate.

The boiler is fitted with necessary mountings. Pressure gauge and water level indicator provided at the front. Safety valve, steam stop valve, low water and high steam safety valve and man-hole are provided on the top of the shell.

High steam low water safety valve:

It is a combination of two valves. One is lever safety valve, which blows-off steam when the working pressure of steam exceeds. The second valve operates by blowing-off the steam when the water level falls below the normal level.

Blow-off clock:

It is situated beneath the front portion of the shell for the removal of mud and sediments. It is also used to empty the water in the boiler during inspection.

Fusible plug:

It is provided on the top of the main flues just above the grate. It prevents the overheating of the boiler tubes by extinguishing the fire when the water level falls below a particular level. A low water level alarm is mounted in the boiler to give a warning when the water level falls below the preset value.

Salient features of Lancashire Boiler

The arrangement of flues in this boiler increases the heating surface of shell to a large extent.
It is suitable where a large reserve of steam and hot water is needed.
Its maintenance is easy.
Superheated can be easily incorporated into the system at the end of the main flue tubes. Thus overall efficiency of the boiler can be increased.

Experiment-3

Experiment:- Constructional details and operation of mounting and accessories of a boiler.

EQUIPMENT REQUIRED: - Model of Mounting & accessories in boiler.

THEORY: -

For efficient operation and maintenance of safety, the boiler equipped with two categories of components and elements.

First categories include the fittings which are primarily indicated for the safety of the boiler and for complete control the process of steam generation. These units are called mountings. The mounting from an integral part of the boiler and are mounted on the body of the boiler itself. The following mountings are usually installed on the boiler.

1. Two safety valve
2. Two water level indicators
3. Pressure gauge
4. Fusible plug
5. Steam stop valve
6. Feed check valve
7. Blow-of cock
8. Man and mud hole

Second categories include the components which are installed to increase the efficiency of the steam power plants and help in the power working of the boiler unit. These fitting are called boiler accessories. The following accessories are given below.

1. Air pre-heater
2. Economiser
3. Super heater
4. Feed pump and
5. Injector

FUNCTION, LOCATION AND WORKING OF MOUNTINGS AND ACCESSORIES.

A) SAFETY VALVE: The function of the safety valve is to permit the steam in the boiler to escape to atmosp0here when pressure in the steam space in the boiler. The safety valve operates in the principle that a valve is pressed against its seat through some agency such as sturt, screw or spring by external weight or force, when the steam force due to boiler pressure acting under the valve exceeds the external force, the valve gets lifted off its seat and some of the steam rushes out until normal pressure is restored again.

The commonly used safety valves are given below:

ii) Lever safety valve

iii) Spring loaded safety valve

iv) High steam-low water safety valve

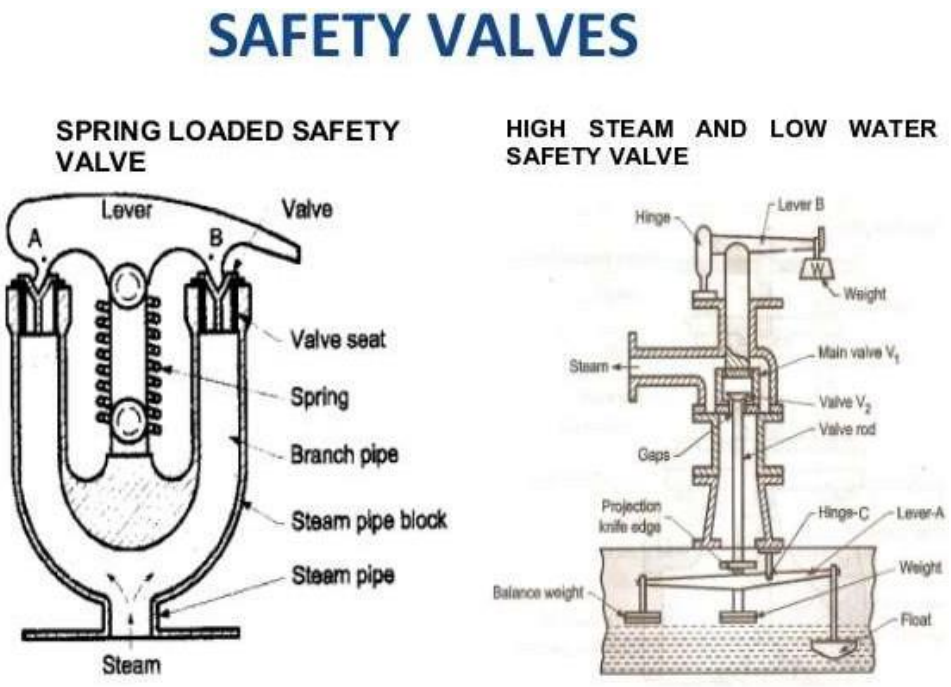


Figure of Safety valve

B) WATER LEVEL INDICATOR: The function of the water level indicator is to ascertain constantly and exactly the level of water in the boiler shell. It is fitted in the front of the boiler from where it is easily visible to the operator.

BOILER MOUNTINGS

1. WATER LEVEL INDICATOR

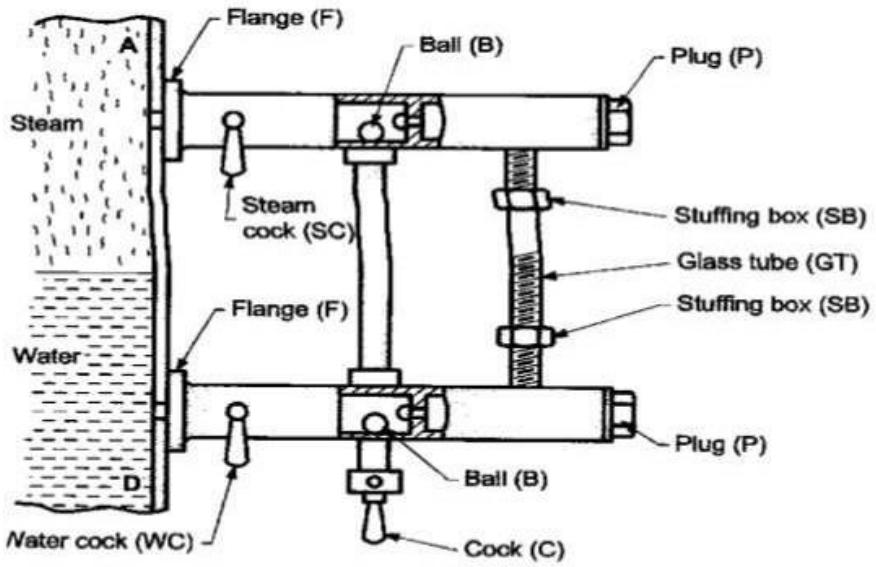


Figure of Water Level Indicator

The unit consists of a strong glass tube whose ends pass through stuffing boxes consists of heat resisting rubber packing to prevent leakage steam and water. The flanges are bolted to front end plate of the boiler, the upper flange being fitted to the steam space and the lower to water space in the boiler. There are two cocks namely steam cock and water cock which communicate the boiler shell spaces to the gauge glass tube. When the handle of the cocks are vertical, they are in operation and the water level in the tube corresponds to water level in the shell. A red mark on the glass tube indicates the safe water level.

C) FUSIBLE PLUG: The function of the fusible plug is to extinguish the fire in the event of the boiler shell failing below a certain specified limit. We know that when the water on heating transforms into steam, the level of water in the boiler falls down. If the water is not replenished and the steam generation continues then the parts, which have been uncovered by water uncovered by water may get overheated and subsequently are melted. To safeguard against this eventuality we use fusible plug.

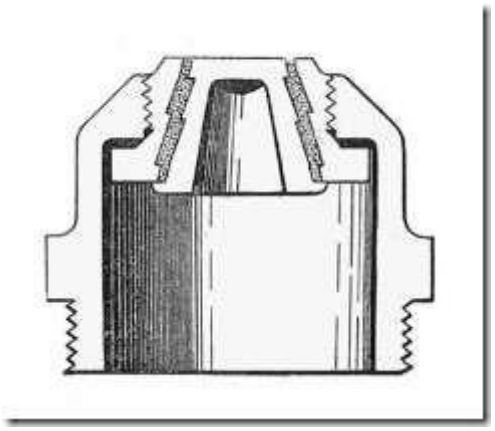


Figure of Fusible Plug

The fusible plug is inserted at the box crown or cover the combustion chamber at the lowest permissible water level.

D) PRESSURE GAUGE: Each boiler has to be provided with a pressure gauge, which record the pressure at which the steam is being generated in the boiler.

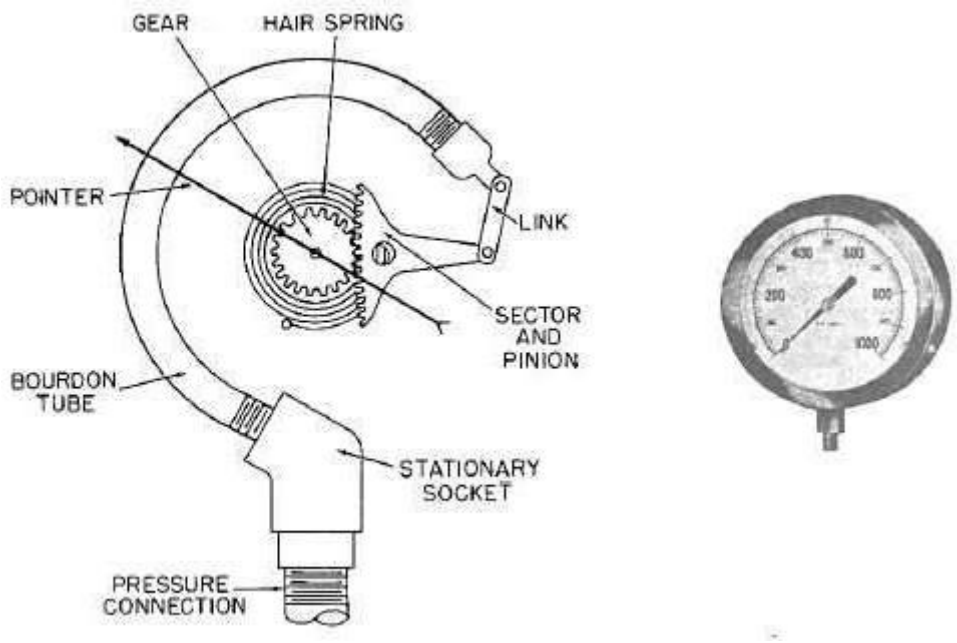


Figure of Pressure gauge

The gauge is usually mounted at the front top of the boiler shell or drum. The gauge should to be clearly visible to the attendant so that he can easily record the pressure reading.

E) BLOW OFF COCK: The blow of cock serves to drain out the water from the boiler periodically for any one of the following reasons:

1) To discharge mud, scale and other impurities which settle down at the bottom of the boiler?

2) To empty the boiler for internal cleaning and inspection.

3) To lower the water level rapidly if the level becomes too high.

The unit is fitted at the lowest portion of the boiler. It may be mounted directly to the boiler shell or through an boiler elbow pipe, which is fitted to the boiler shell.

F) FEED CHECK VALVE: The feed check valve has the following two functions to perform:

1. To allow the feed water to pass into the boiler.

2. To prevent the back flow of water from the boiler in the events of the failure of the feed pump.

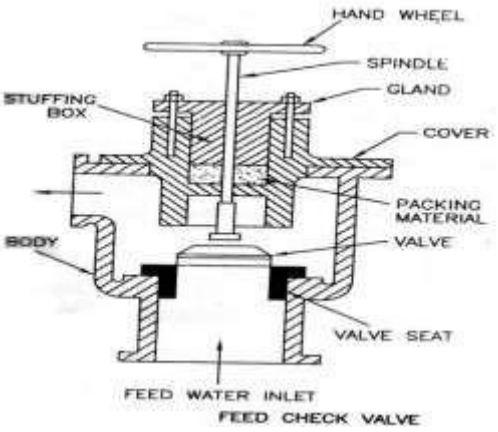


Figure of Feed check Valve

G) STOP VALVE: The function of the steam stop valve is to shut off or regulate the flow of steam from the boiler to the steam pipe or from the steam pipe to the engine. When used for the former purpose, it is called junction valve. Usually the junction valve means a regulating valve of larger size and a stop valve refers to a regulating valve of smaller size.

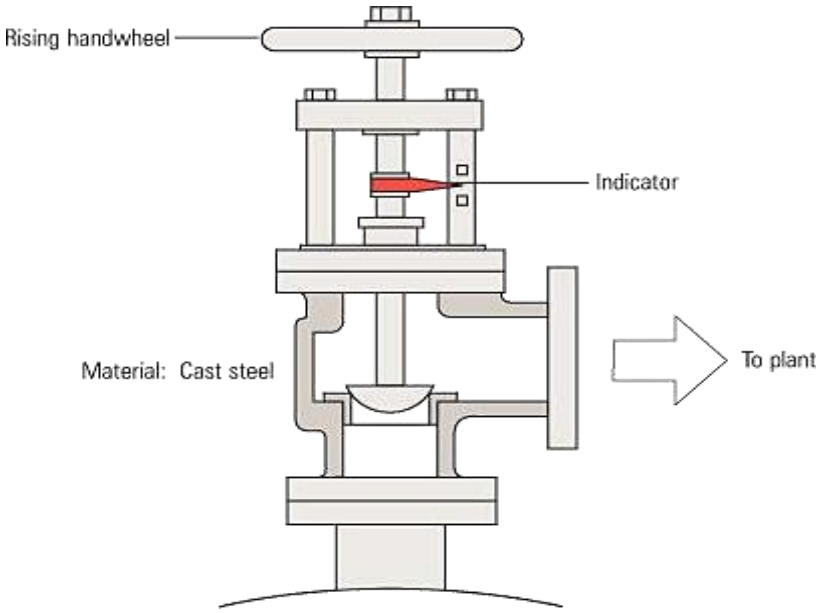
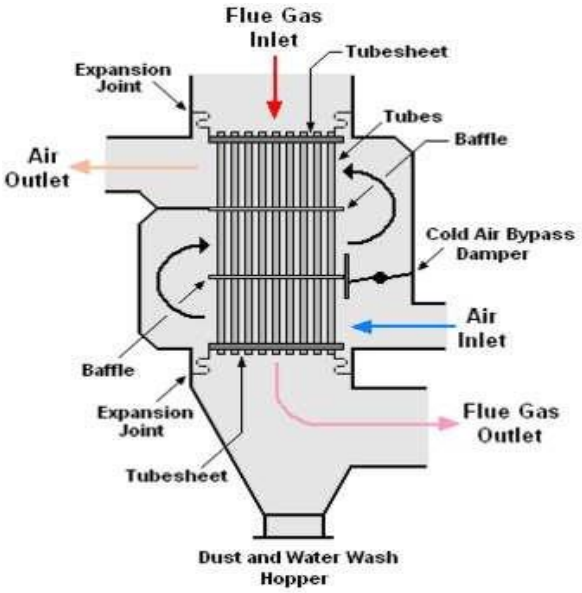


Figure of Stop valve

The junction valve is mounted on the highest part of the steam space of the boiler and is connected to the steam pipe, which carries the steam to the engine.

H) MAN HOLES: These are door to allow men to enter inside the boiler for the inspection and repair

I) AIR PREHEATER: Air heater or air pre-heater is waste heat recovery device in which the air on its way to the furnace is raised in temperature by utilizing the heat of the exhaust gases. Air pre-



heater are classified into the following two categories.

Figure of Air preheater

· Recuperative Air heater

· Regenerative Air heater

J) ECONOMISER: The economizer is a device, which serves to recover some of the heat being carried by exhaust flue gases. The heat thus recovered is utilized in raised temperature in feed water being supplied to the boiler. If the water is raised and thus there is a saving in the consumption of fuel.

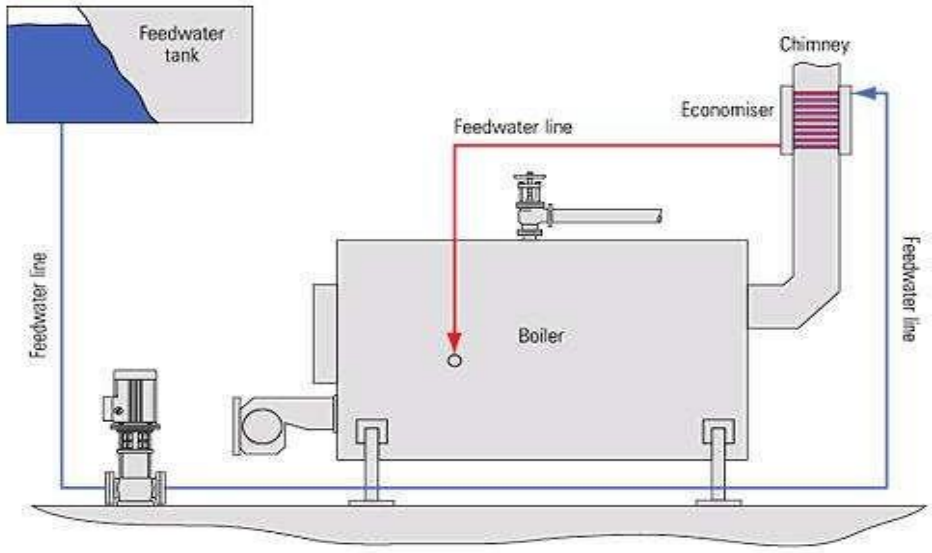


Figure of economizer

The economizer unit is installed in the path of the flue gases between the boiler and the chimney.

K) STEAM SUPER HEATER: The steam generated by a simple boiler in generally wet or at the most dry saturated. Steam super heater is a surface heat exchanger in which the wet steam is first dried at the same temperature and pressure and then raised to temperature above the saturation

temperature at constant pressure. Heat of flue gasses utilized in super heating the steam and as the super heater is placed in the path of the flue gasses,

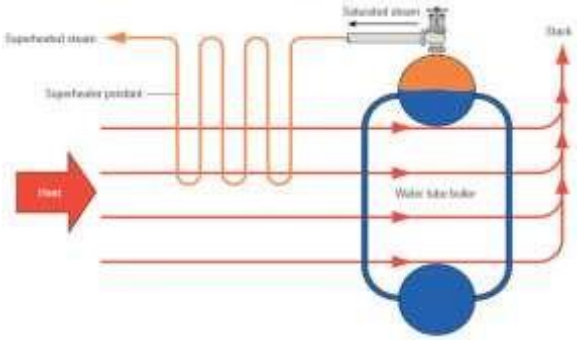


Figure of Super heater

Since superheating result in the increased efficiency and economy of the steam plant.

L) FEED WATER EQUIPMENT: The pressure inside a steaming boiler is high and so the feed water has to be raised in pressure before its entry can be affected in the boiler. Feed pump is a device which raised the pressure of water and forces it into the boiler.

Experiment-4

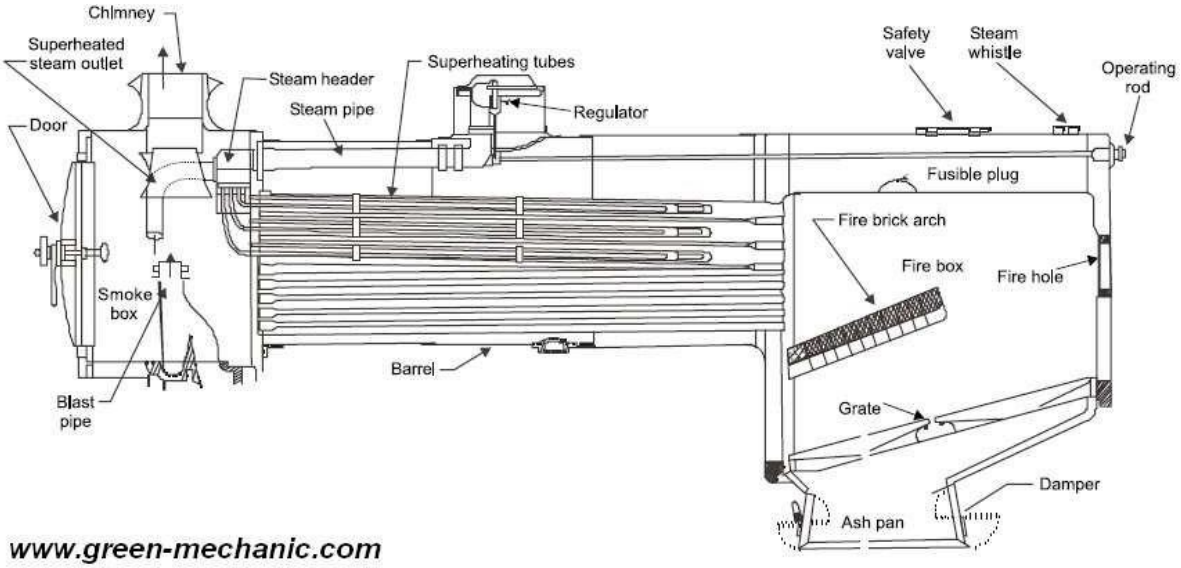
AIM: -. Constructional details and operation of locomotive boiler.

EQUIPMENT REQUIRED: - Model of locomotive boiler boiler.

THEORY: -

Parts of locomotive boilers

- Grate
- Damper
- Ash pit
- Fire box
- Fire hole
- Fire brick arch
- Fusible plug
- Operating rod
- Steam whistle
- Safety valve
- Regulator
- Barrel
- Super heating tube
- Steam pipe
- Steam header
- Smoke box
- Blast pipe
- Super heated steam out let
- Chimney
- Door



Working of locomotive boiler

Fuel is place on the grate where it is burned to produce the hot gases. Fire hole is used to feed the fuel. Hot gases which are produce as a result of fuel burning are diverted into fire tube with the help of fire brick arch.

Steam produce is collected is the steam drum place at the top of the shell. As shown the wet steam goes through inlet headers of super heater and after passing through tubes, it returns to the outlet header of super heater and is taken out for steam engine. For the cleaning and maintenance of the complete boiler a door is provided at the side of the smoke box. Chimney is completely eliminated in locomotive boilers because they are always in motion

Application of locomotive boilers

Locomotive boilers are used to give power in following machinery

- Steam railway engine
- Marine steam engine

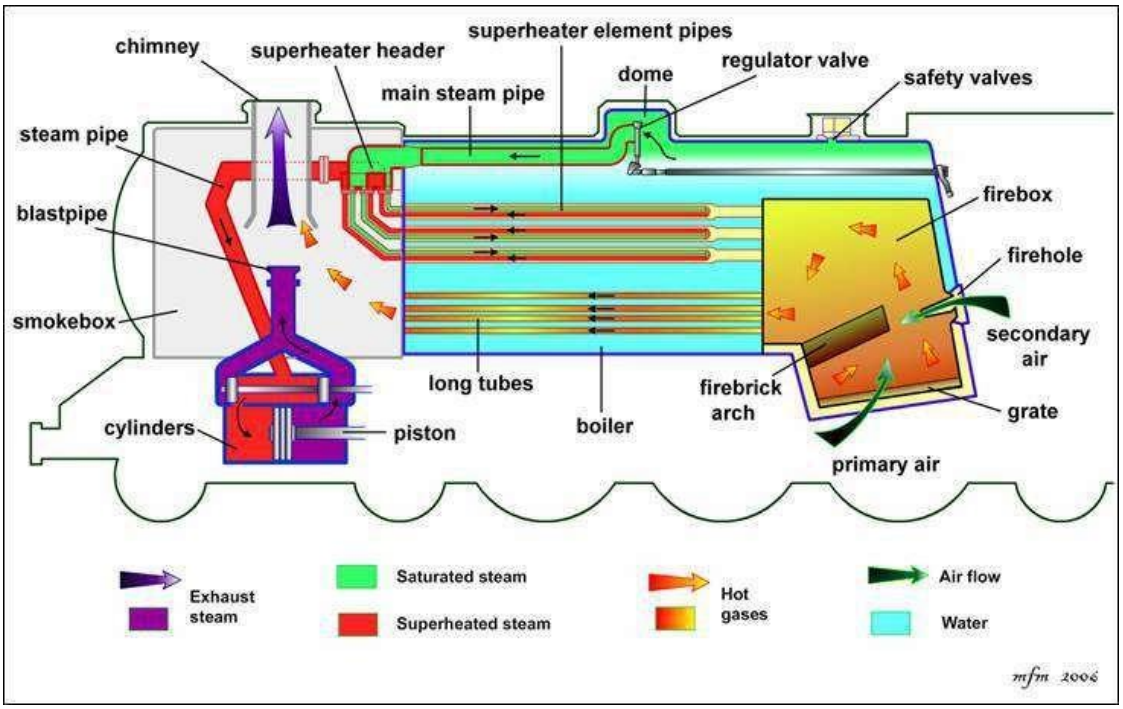
These boilers were invented for getting steam to run a steam engine used in locomotives.

OR

In this section, we will take a look at the working principles of the steam engine used in locomotives. Basically, solid fuel such as coal is burned to heat up water. When it gets hot enough, water will condense into steam. The pressure of the steam pushes the pistons which consequently move the gears and the wheels, thus moving the locomotive.

The Flow of the Steam and Gases

Solid fuel is burned on the grate inside the firebox. The primary air is admitted below the grate and is drawn to the firebed while the secondary air is admitted through the firehole door. The firebrick arch lengthens the path of the hot gases from the burning of the fuel to ensure complete combustion. The hot gases are then drawn through long tubes in the boiler to the smokebox and out of the locomotive from the chimney.



The heat from the firebox heats up the water in the boiler. Water is also heated by the heat from the hot gases going through the long tubes. As water becomes hotter, it turns into saturated steam which collects above the water. The regulator valve, which controls the passage of the steam to the

cylinders, is situated in the dome. There are also safety valves on top of the boiler to release steam if the pressure tends to rise to a dangerous level.

The saturated steam flows through the main steam pipe to the superheater header. It then travels through superheater element pipes in the boiler where it is heated up. After coming out of these pipes through the superheater header, it will have become superheated steam. The extremely hot steam then flows through steam pipes to the cylinders where its pressure moves the pistons which move the wheels of the locomotive.

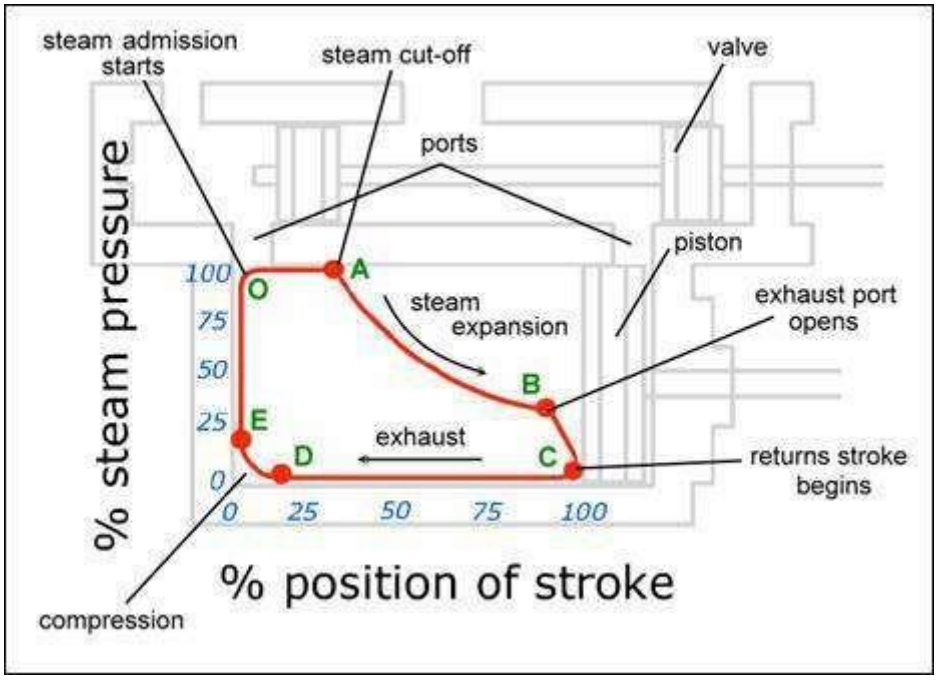
In the smokebox, exhaust steam passes through the blastpipe to the chimney at high speed due to the confined vent of the blastpipe. This creates a partial vacuum in the smokebox which provides the draw of the air to the firebox and ensures that the hot gases are drawn out of the firebox via the tubes in the boiler.

Valve and Piston Working

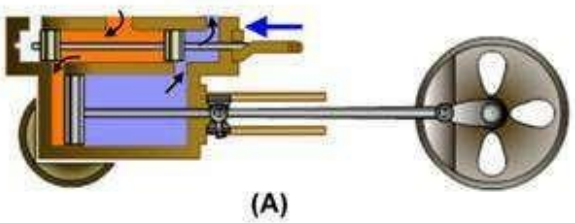
In a steam engine, the movement of the valve ensures that steam is admitted to and exhausted from the cylinder at the right moment. For a typical cylinder that has two ports, the function of the valve is to admit superheated steam at one end while allowing used or exhaust steam to escape at the other. As a result of covering and uncovering these ports in sequence, the piston is pushed forward and backward by the high pressure steam from the boiler. To regulate the movement of the valve, a mechanical valve gear system is used and this is discussed further in the following subsections.

To know how the valve affects the speed of the locomotive, we have to understand a few terms which are common among steam locomotives operators and enthusiasts. Lap refers to the amount of overlap between the valve and the port. In slow moving locomotives, the long lap on the exhaust port gives time for the steam trapped in the cylinder to expand fully to push the piston. On the other hand, on higher speed locomotives the exhaust port is made to open early (short lap) when the valve is in mid-position thus allowing the steam to escape faster. Furthermore, higher speed locomotives also have long lead which means that the admission port is already open when the piston is at the end of its movement so there is a sufficient steam pressure that will immediately pushes the piston back to begin its next movement.

Cut-off denotes the position of the piston, at the moment the valve is closing the admission port. When the engine is working hard and slowly, long cut-off admits steam for most of the stroke of the piston. On fast running locomotives this will cause back pressure to the boiler. To avoid unnecessary back pressure, cut-off is reduced so that steam is admitted for only 20% of the piston stroke and the remainder of the stroke is due to the expansion of the high pressure steam.

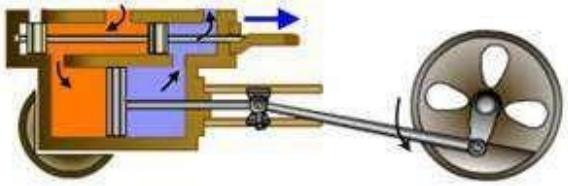


The indicator diagram such as the one above was used by steam locomotive engineers during the steam era to estimate the locomotive's efficiency in converting the steam's energy into useful power at various speeds and cut-offs. The horizontal line OA shows the pressure as the steam enters the cylinder. At cut-off, the pressure drops as the steam expands and does work to push against the piston. After the exhaust port opens, the line reverses (CD) to indicate the start of the return stroke of the piston. It shows the low pressure as the steam is exhausted. The line DE at the end of the return stroke registers a pressure rise due to the compression of the remaining steam after the exhaust port has closed. As fresh steam is admitted into the cylinder, the pressure rises back to point O and the cycle repeats.



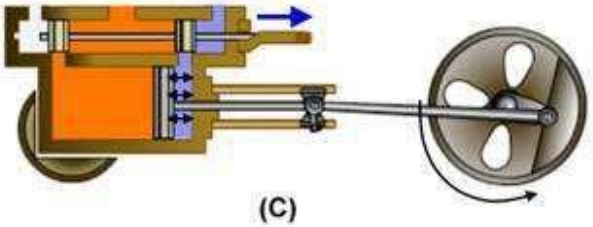
(A)

(A)
The opening of the front port allows superheated steam from the boiler to enter the cylinder and push the piston back. As the piston moves backwards, used steam from the previous stroke is exhausted through the back port.



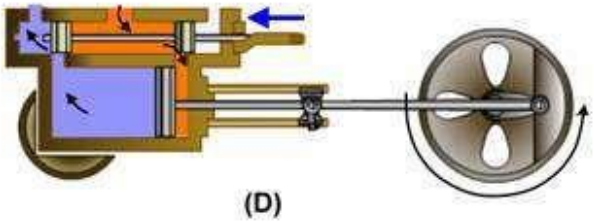
(B)

(B)
The valve starts to move backwards while the steam in the cylinder continues to expand and pushes the piston back.



(C)

(C)
The front port opens to exhaust steam and at the same time the back port closes. This creates some back pressure before the next stroke is made.



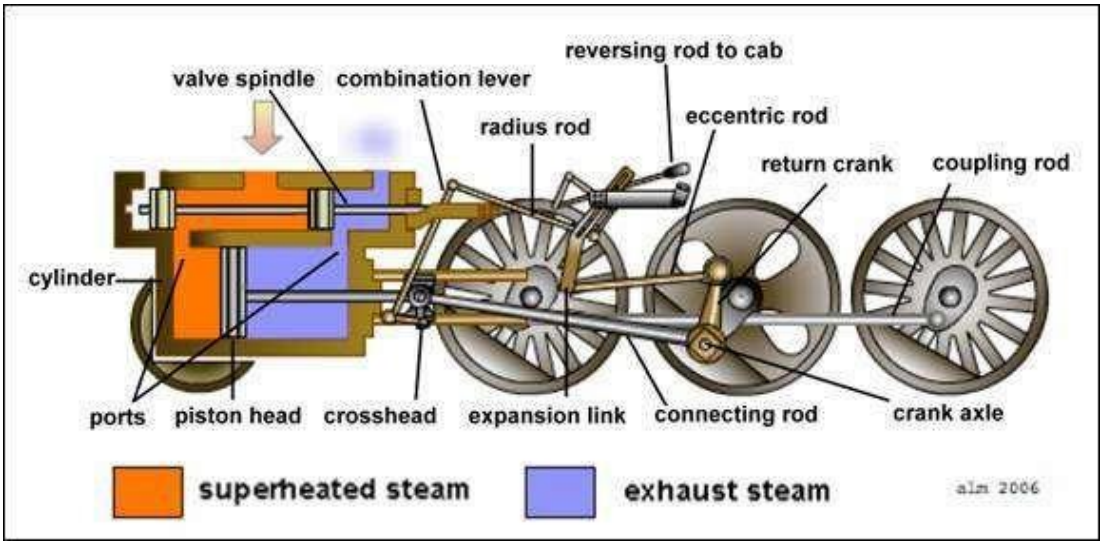
(D)

(D)
The back port opens to allow fresh steam into the cylinder which then pushes the piston forward. A new sweep begins again and the process repeats.

superheated steam

exhaust steam

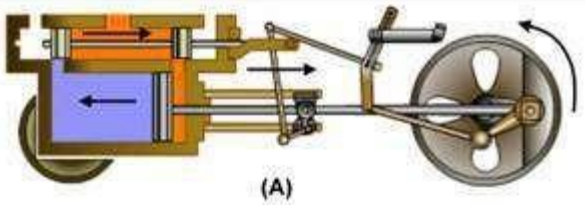
The Walschaert System



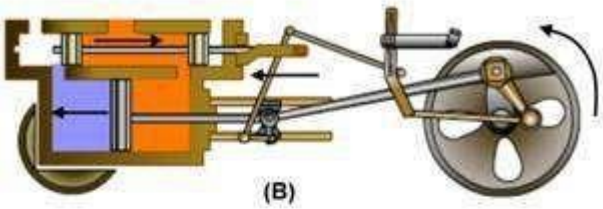
The locomotive valve gear enables the driver to choose the cut-off of the steam admission and to reverse the locomotives. One of the most common valve gear systems found on UK built locomotives is the Walschaert system, which was first patented in 1844 by Egide Walschaerts, a Belgian engineer. It first appeared on a British railway in 1878. It did not become popular in Britain until the twentieth century but it is now generally regarded as the best valve gear design due to the easy maintenance.

In this system, the fore-and-aft movement of the valve spindle depends on the combined movement of the combination lever and the expansion link. The combination lever motion is worked by the crosshead at the end of the piston rod. It is connected to the expansion link by the radius rod. The expansion link movement is obtained from its connection to the eccentric road. The other end of the eccentric road that is attached to the crank axle caused the pendulum-like motion of the expansion link.

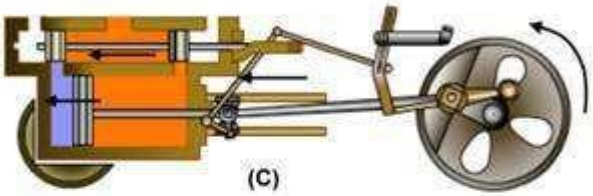
By adjusting the position of the radius rod in the expansion link, we can adjust the length of travel of the valve spindle. This can be done by lifting or lowering the reversing rod from the cab. To obtain the maximum valve travel (longest cut-off and maximum steam admission), the radius rod is positioned furthest from the centre of the expansion link. On the other hand, moving the radius rod up and down from one half of the expansion link reverses the movement of the locomotive.



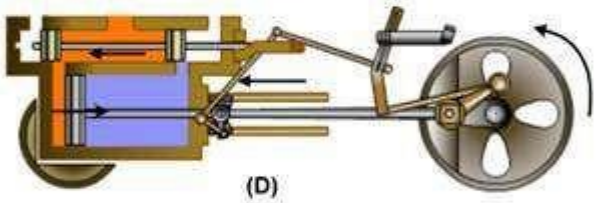
(A)
The valve spindle is drawn back as the expansion link pulls the radius rod. This starts to open the admission and the exhaust ports.



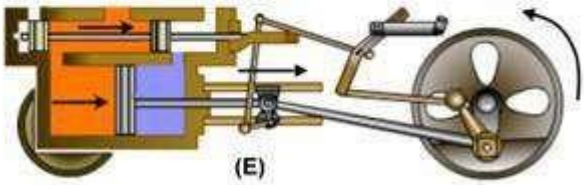
(B)
The radius rod continues to pull the valve spindle backwards. However its movement is moderated by the forward-moving combination lever.



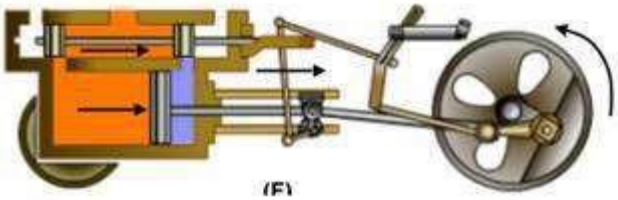
(C)
The combination lever forces the valve to cut steam admission off.



(D)
The radius rod moves the valve spindle further forward to begin steam admission at the front port thus initiating the rear stroke of the piston.



(E)
The rear moving combination lever, moderated by advancing radius rod draws back the valve spindle.



(F)
The combination lever continues to pull back the valve spindle to start uncovering the front port for exhaust.

Experiment-5

AIM: -. Constructional details and operation of 2-stroke petrol engine.

EQUIPMENT REQUIRED: - Model of two-stroke petrol engine.

THEORY: -

The two stroke engine was developed by Sir Duglad Clerk in 1881 and further improved by Joseph Day in 1891. The cycle of operations Viz. suction, compression, expansion and exhaust can be completed in two strokes of the piston or one revolution of the crankshaft (Two strokes are overlapping with each other.)

Construction: - The main engine components are: -

1. Piston with a deflector
2. Cylinder block with three ports – Intake, Transfer and exhaust ports.
3. Crank case
4. Connecting rod
5. Crank wheel and flywheel
6. A carburetor
7. Intake and Exhaust manifolds

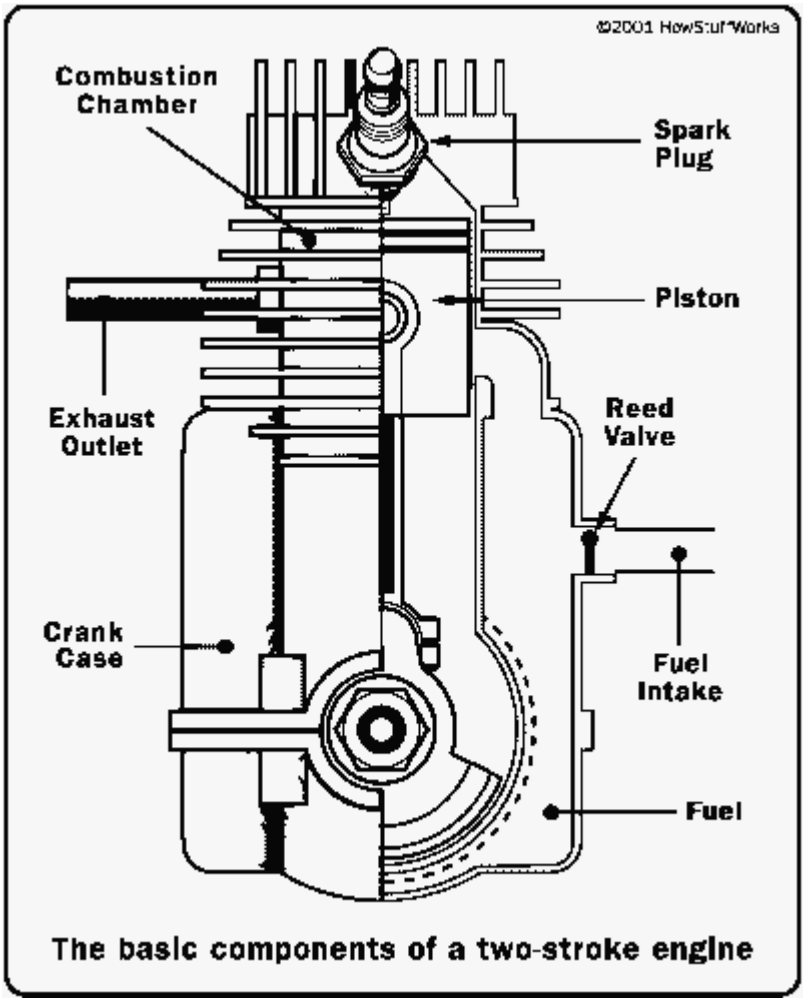
Working Principle of two stroke petrol engine

The working principle of a two-stroke petrol engine is discussed below: -

First stroke:

To start with let us assume the piston to be at its bottom dead center position (BDC). The arrangement of ports is such that (Connected to crankcase) the piston performs two jobs simultaneously

As the piston stats rising from its dead center position, it closes the transfer port. The charge (Mixture of air and petrol), which is slightly compressed. At the same time with the upward movement of the piston, vacuum is created in the crank case (which is gas tight). As soon as the inlet port is uncovered. The fresh charge is sucked in the crankcase. The charging



The basic components of a two-stroke engine

is continued until the crankcase and space in the cylinder beneath the piston is filled with the charge. At the end of this stroke, the piston reaches the Top Dead Center (TDC) position.

Second Stroke: -

Slightly before the completion of the compression stroke, the compressed charge is ignited by means of a spark plug.

Pressure is exerted on the crown of the piston due to the combustion of the charge and the piston is pushed in the downward direction producing some useful power. The downward movement of the piston will first close the inlet port and then it will compress the charge already sucked in the crankcase.

Just at the end of power stroke, the piston uncovers the exhaust port and the transfer port simultaneously. The expanded gases escaping through the exhaust port and at the same time the fresh charge which is already compressed in the crank case, rushes into the cylinder through the transfer port and thus the cycle is repeated again.

The fresh charge, coming into the cylinder also helps in the exhausting the burnt gases out of the cylinder through the exhaust port. This is known as scavenging. A little amount of fresh mixture also is lost in this process.

Experiment-6

AIM: - TO STUDY ABOUT 4 CYLINDER 4 STROKE ENGINE PARTS.

EQUIPMENT REQUIRED: - Model of four stroke petrol engine.

THEORY:-

The main working parts of compression ignition four-stroke cycle engine are shown in Fig.( ) The engines vary greatly in size, power, and design. But parts from functional aspects are similar and described hereafter.

1. **Cylinder: -** The heart of the engine is the cylinder where the fuel is burnt and the power is developed. The liner of sleeve forms the inside of the cylinder. The inside diameter of the cylinder is called the bore. In the most of the engines the piston bears directly on the walls. Forming parts of the cylinder blocks, but in some , and particularly in engines with large cylinders, removable lines are used. Liners are of two types: -

a) Dry Liners

b) Wet Liners

a) Dry Liners: - a dry liner is one which is in contact with metal block over its whole length are nearly its whole length. The water jackets are provided in the cylinder blocks.

b) Wet Liners: - ones, which is supported by the blocks over narrows, belts only and is surrounded by cooling water between the belts.

2. **Cylinder head**: It closes on the end of the cylinder and often contains the valves through which air and fuel are admitted and exhaust gases discharged.

The cylinder head is usually a one piece casting bolted to the top of the cylinder block. In between the head is given copper asbestos gasket to make gas tight joint.

3. **Piston** : The other end of the working space of the cylinder is closed by the piston that transmits to the crank shaft the power developed by the burning of the fuel. The distance that the piston travels from one end of the cylinder to the other is called the stroke.
4. **Connecting Rod** : One end, called the small end of the connecting rod is attached to the wrist pin located in the piston. The other end, or the big end has a bearing for the crank pin, the continuously rotating crank during crank pin the working stroke and versa during other strokes.
5. **Crank shaft** : The crank shaft runs under the action of piston through the connecting rod and crank pin located between crank web or cheeks and transmits the work from the piston to the driven shaft. The parts of crank shaft supported by and rotating in the main bearing are called the journals.
6. **Crank web** : These are masses for balancing purpose.
7. **Main bearing** ; The crank shaft is supported and is turning in these main bearings.

8. **Crank pin And bearing** : This is a bearing between the big end of the connecting rod and crank pin.
9. **Fuel nozzle** : Fuel is delivered into the combustion space by an injection system consisting of a pump, fuel line and the injector, also called the fuel injection nozzle and spray nozzle. Fuel is delivered by this nozzle in a fine spray under pressure in diesel engines. In petrol engine it is replaced by spark plug.
10. **Piston Rings** :The piston rings lubricated with engine oil produce gas – tight seal between the piston and the cylinder liner.

These are also called compression rings, conduct the heat away from the piston head to the cylinder block. The material for the piston rings must be elastic and must have a fairly high ultimate strength.

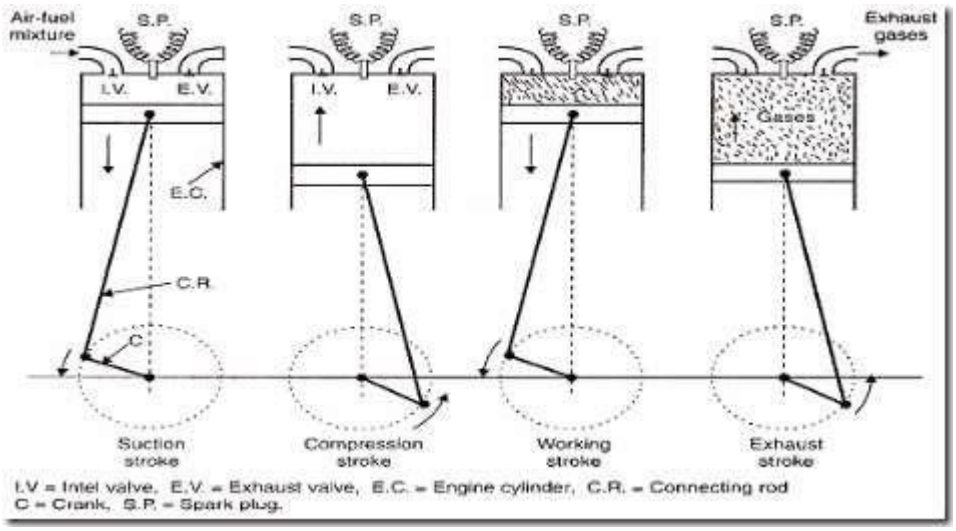
11. **Piston pin or wrist pin** : It connects to the piston to the upper end of the connecting rod. Each end of the piston pin fits into the bored in piston base. The center of the pin fits in connecting rod small end. This arrangement allows the rod to swing back and forth on piston pin.
12. **Intake valve** : Fresh air enters through this valve operated by a cam.
13. **Exhaust valve** : The products of combustion after doing work on the piston are removed via this valve. The Valves are mounted either in the cylinder head .
14. **Cam shaft:** It is driven from the crank shaft by a timing gear on a chain. It operates the intake valve through the cams, cams followers, push rods and rocker arms.
15. **Cam:** The profiles are made to give desired motion to follower. High carbon steel or medium carbon case hardened steel is used.
16. **Cam follower**.
17. **Push rod**.
18. **Rocker arms**.
19. **Valve springs:** These made from spring steel serve to close the valves.
20. **Cylinder block or crankcase:** Crankcase holds together the cylinder, piston and crankshaft. It is called the cylinder block.
21. **Flywheel:** It takes care of the fluctuation or the cyclic variations in speed. It stores energy during the power stroke and release during the other strokes thus giving a fairly constant output torque.
22. **Bedplate:** The lower portion of the crankcase, which is bolted the foundation, is called the bedplate.
23. **Cooling water jackets:** Normally the cooling water enters the jackets in the cylinder head, which is comparatively hotter and passes on the jackets of the cylinder. The purpose is to keep the combustion space walls cool.

Experiment No: 07

AIM: -. Constructional details and operation of 4-stroke petrol engine.
EQUIPMENT REQUIRED: - Model of 4 -stroke petrol engine.

THEORY: -

The four stroke-cycles refers to its use in petrol engines, gas engines, light, oil engine and heavy oil engines in which the mixture of air fuel are drawn in the engine cylinder. Since ignition in these engines is due to a spark, therefore they are also called spark ignition engines.

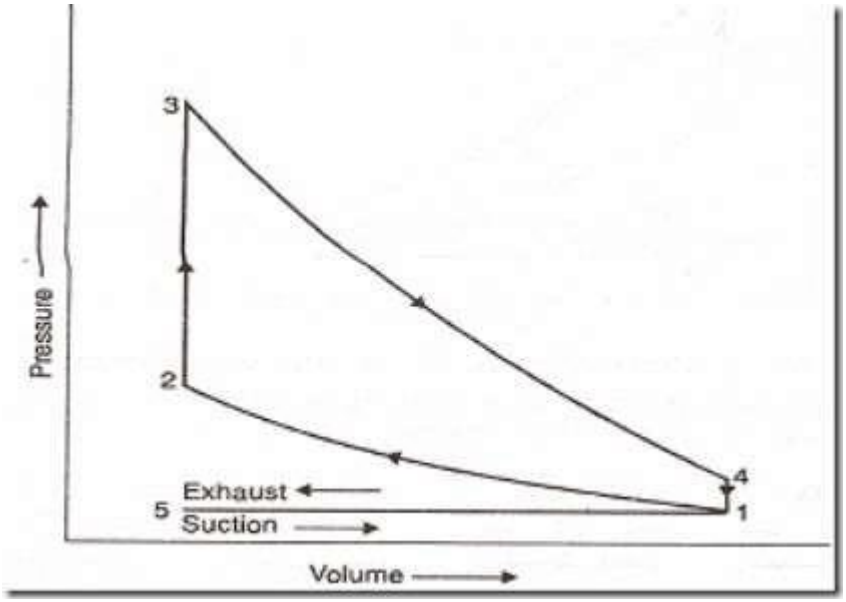


SUCTION STROKE: In this Stroke the inlet valve opens and proportionate fuel-air mixture is sucked in the engine cylinder. Thus the piston moves from top dead centre (T.D.C.) to bottom dead centre (B.D.C.). The exhaust valve remains closed through out the stroke.

COMPRESSION STROKE: In this stroke both the inlet and exhaust valves remain closed during the stroke. The piston moves towards (T.D.C.) and compresses the enclosed fuel-air mixture drawn. Just before the end of this stroke the operating plug initiates a spark which ignites the mixture and combustion takes place at constant pressure.

POWER STROKE OR EXPANSION STROKE: In this stroke both the valves remain closed during the start of this stroke but when the piston just reaches the B.D.C. the exhaust valve opens. When the mixture is ignited by the spark plug the hot gases are produced which drive or throw the piston from T.D.C. to B.D.C. and thus the work is obtained in this stroke.

EXHAUST STROKE: This is the last stroke of the cycle. Here the gases from which the work has been collected become useless after the completion of the expansion stroke and are made to escape through exhaust valve to the atmosphere. This removal of gas is accomplished during this stroke. The piston moves from B.D.C. to T.D.C. and the exhaust gases are driven out of the engine cylinder; this is also called **SCAVENGING**.



Theoretical P-*V* diagram of a four-stroke engine

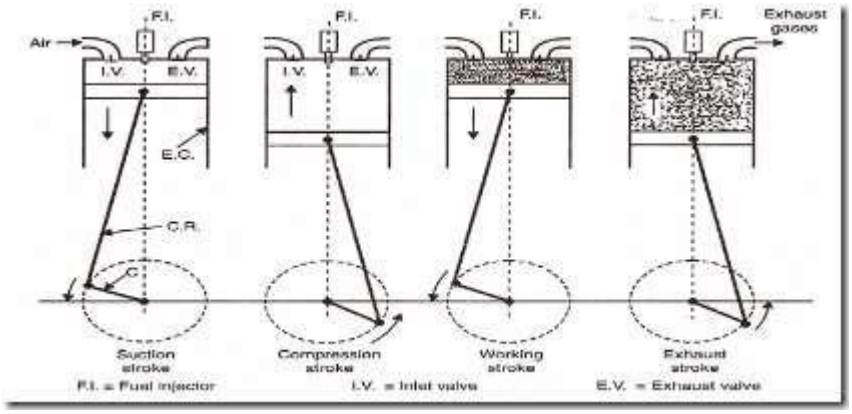
Experiment No: 08

AIM: -. Constructional details and operation of 4-stroke diesel engine.
EQUIPMENT REQUIRED: - Model of 4 -stroke petrol engine.

THEORY: -

The four stroke-cycles refers to its use in petrol engines, gas engines, light, oil engine and heavy oil engines in which the mixture of air fuel are drawn in the engine cylinder. Since ignition in these engines is due to a spark, therefore they are also called spark ignition engines.

FOUR STROKE DIESEL ENGINE



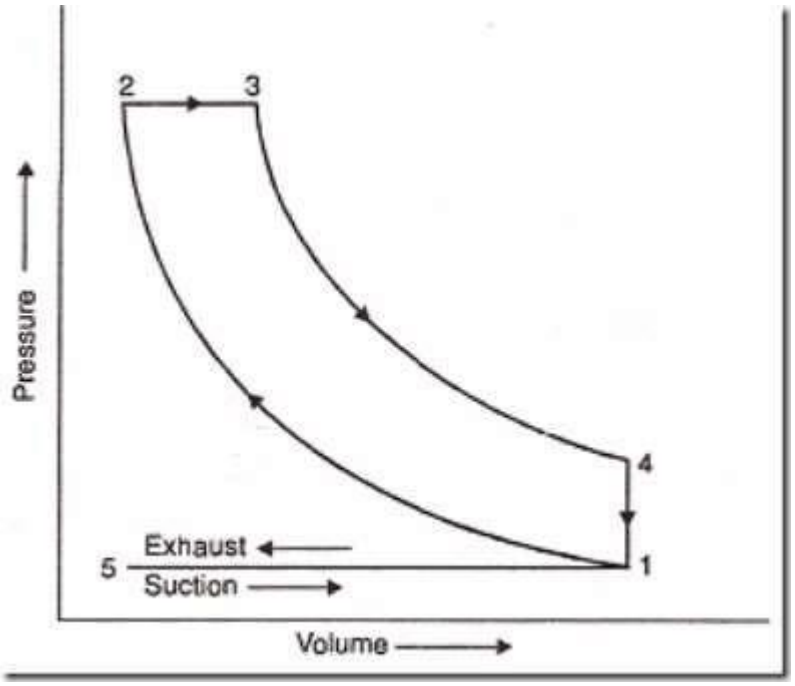
SUCTION STROKE: With the movement of the piston from T.D.C. to B.D.C. during this stroke, the inlet valve opens and the air at atmospheric pressure is drawn inside the engine cylinder; the exhaust valve however remains closed. This operation is represented by the line 5-1

COMPRESSION STROKE: The air drawn at atmospheric pressure during the suction stroke is compressed to high pressure and temperature as the piston moves from B.D.C. to T.D.C. Both the inlet and exhaust valves do not open during any part of this stroke. This operation is represented by 1-2

POWER STROKE OR EXPANSION STROKE: As the piston starts moving from T.D.C to B.D.C, the quantity of fuel is injected into the hot compressed air in fine sprays by the fuel injector and it (fuel) starts burning at constant pressure shown by the line 2-3.

At the point 3 fuel supply is cut off. The fuel is injected at the end of compression stroke but in actual practice the ignition of the fuel starts before the end of the compression stroke. The hot gases of the cylinder expand adiabatically to point 4. Thus doing work on the piston.

EXHAUST STROKE: The piston moves from the B.D.C. to T.D.C. and the exhaust gases escape to the atmosphere through the exhaust valve. When the piston reaches the T.D.C. the exhaust valve closes and the cycle is completed. This stroke is represented by the line 1-5.



Theoretical p- *V* diagram of a four-stroke Diesel Engine

EXPERIMENT NO: 09

AIM: - To find the performance of a diesel engine (BHP, thermal efficiency, fuel consumption, air consumption)

EQUIPMENT REQUIRED: - Diesel engine test rig, water supply, stop watch, tachometer

THEORY: -

B.H.P. (Brake Horse Power) : - The brake horse power of an engine is the horse power available at the crank shaft of the engine for doing external work. It is measured by using some form of brake arrangement.

Measurement of Brake Horse Power : When a resisting force F is overcome through a certain distance S, work to the extent of F x S will be done in doing so Power is the rate of doing work and one horse power is defind as 45oo kgm of work per minute.

Measurement the B.H.P. of engine is done by using Rope Brake arrangement: As per fig rope makes one complete turn around the rim of a crank shaft of the wheel keyed to the crank shaft of the engine . One end of the rope carries a dead load weight and the other end is connected to a spring balance and the direction of rotation of the brake wheel being against the pull of the dead load i.e. in the clockwise direction.

The engine is started with the load off, and increasing load may be applied by adding weight to the dead load hanger. At any stead load ,with the engine running a constant speed.

Fig

Let,

W = Dead wt.'on the rope in kg

S = Spring balance reading in kg

D = Diameter of the brake wheel in m

'd = Diameter of the rope in m

N = r.p.m. of the engine (reading of tachometer/2)

Net resisting force acting on the brake wheel = (W – S) kg.

The effective radius R at which the net resisting force is acting

$$= \frac{D + d}{2} \text{ m}$$

Therefore resisting torque acting on the brake wheel is given by

$$W.D = (W - S) \times \frac{D+d}{2} \times 2\pi N \quad \text{Kgm/ mint}$$

Hence B.H.P. of the engine

$$= \frac{2\pi NT}{4500}$$

Where $T = (W - S)\frac{D+d}{2}$

$$= \frac{(W - S) \times \frac{D+d}{2} \times 2\pi N}{4500}$$

If diameter of the rope is neglected, i.e. d = 0 then the expression for B.H.P. will reduce to

$$\text{B.H.P.} = \frac{(W - S)\pi D N}{4500}$$

Thermal Efficiency : It is the ratio of brake or shaft work done to the energy supplied by fuel.

$$\text{Thermal Efficiency} = \frac{\text{Heat equivalent to B.H.P. per min}}{\text{Heat supplied by fuel per min.}}$$

$$= \frac{\text{BHP} \times 4500}{W_f \times C \times J}$$

Where W_f is weight of fuel consumed per min, C is the calorific value of fuel and j is constant 427.
In I.C. engine this term is also known as over all efficiency.

Air consumption : For air consumption air box method is used as shown in fig. A metal tank which has a orifice plate by that air is sucked and supplied to the engine. This tank is attached with manometer

$Q = C_d \times Va \times A$
Where C_d is Co-officient fo discharge
Va is Velocity of air = $C\sqrt{2gH}$
C is air box volume m^3
H is difference of manometer tube converted into air column.
A is cross-section area of orifice plate (m^2)

S.no.	Orifice Dia	ManometerTube reading		Difference of tube reading $H = H_2 - H_1$	
		H_1	H_2		

Fuel consumption :

$$\text{Fuel consumption per hour} : \frac{\Delta \mathbf{L} \times \mathbf{A} \times \rho}{T}$$

Where ΔL is difference of initial and final reading of fuel tube
A is cross section area of fuel tube. ρ is density of fuel.

T is total time taken to consume fuel (Table no. 3)

S.no.	Initial read	Final reading	Time taken	

How to conduct the practical on test rig :

First check that the test rig is ready for the experiment by consulting lab. technician. and then fill the fuel in the fuel tube (Burette). Then note the reading of fuel tube at the start of engine. Write the reading in the table no-3 Start the engine and start the stop watch and adjust the acceleration and run the engine at constant speed. After this take the reading of spring balance for error of spring balance. (Open the valve of the tap for cooling the engine in case of water cooling test rig.) Check the speed of engine by tachometer by contacting with the flywheel without applying the weight. Now add the wt. in hook of the rope dynamometer. Now note down it in the table no2. now again check the speed of engine by tachometer by contacting with the flywheel. Also note the readings of spring balance & r. p. m in table no 2. repeat the cycle of adding the wt. and note the reading of spring balance in the table no 2. At the end stop the engine by press the pump rack operating lever (External) towards the fuel pump and hold that position until the engine stops.