# AI 3401 TRACTORS AND ENGINE SYSTEMS

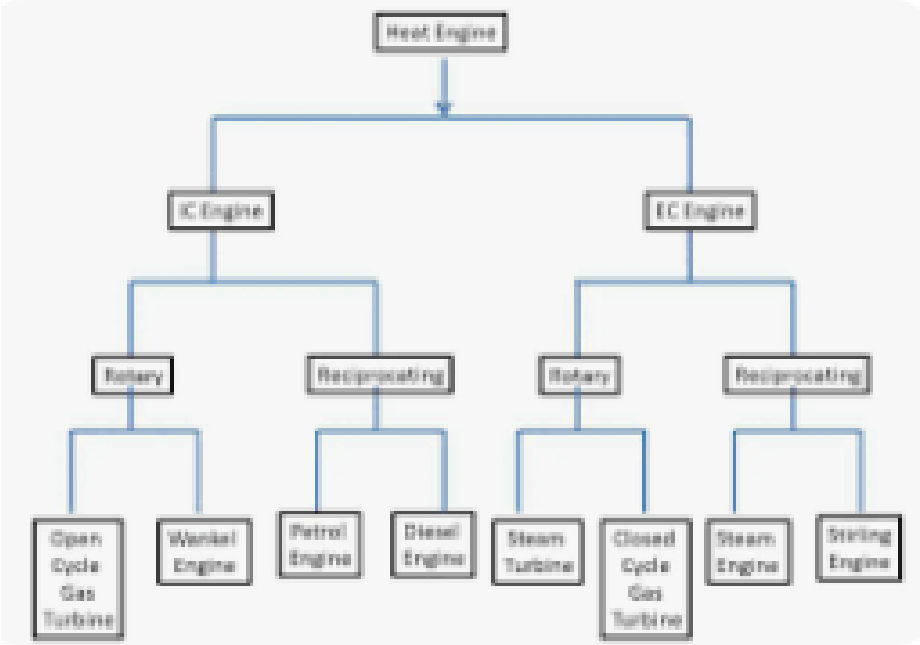
## UNIT I NOTES

**INTERNAL COMBUSTION ENGINE:**

A heat engine is a machine which converts heat energy into mechanical energy. Heat is generated by the combustion of a fuel, such as coal, petrol, heavy oil or some gas. This heat is supplied to a working substance at high temperature. By the expansion of this substance in suitable machines, heat energy is converted into useful work.

Heat engines can be further divided into two types (i) external combustion and (ii) internal combustion In a steam engine the combustion of fuel takes place outside the engine and the steam thus formed is used to run the engine. Thus, it is known as external combustion engine. In the case of internal combustion engine, the combustion of fuel takes place inside the engine cylinder itself.

To understand the basic principle of the internal combustion (IC) engine, consider how a gun propels a bullet from its barrel by the rapid burning (explosive power) of a combustible mixture (fuel charge). The cylinder of the IC engine corresponds to the gun barrel while the piston corresponds to the bullet. The piston, fitted with rings to seal in power, is connected to a crank by a connecting rod. Thus, instead of the power being forced out of the cylinder bore, the piston's outward movement converts it to the rotational movement of a crankshaft. The piston never leaves the cylinder bore. The momentum of the crankshaft and flywheel always returns the piston to its former position, ready to receive another power impulse




The IC engine can be further classified as: (i) stationary or mobile. (ii) Horizontal or vertical and (iii) low, medium or high speed. The two distinct types of IC engines used for either mobile or stationary operations are: (i) diesel and (ii) carburetor.

**Carburetor Type IC Engine:**

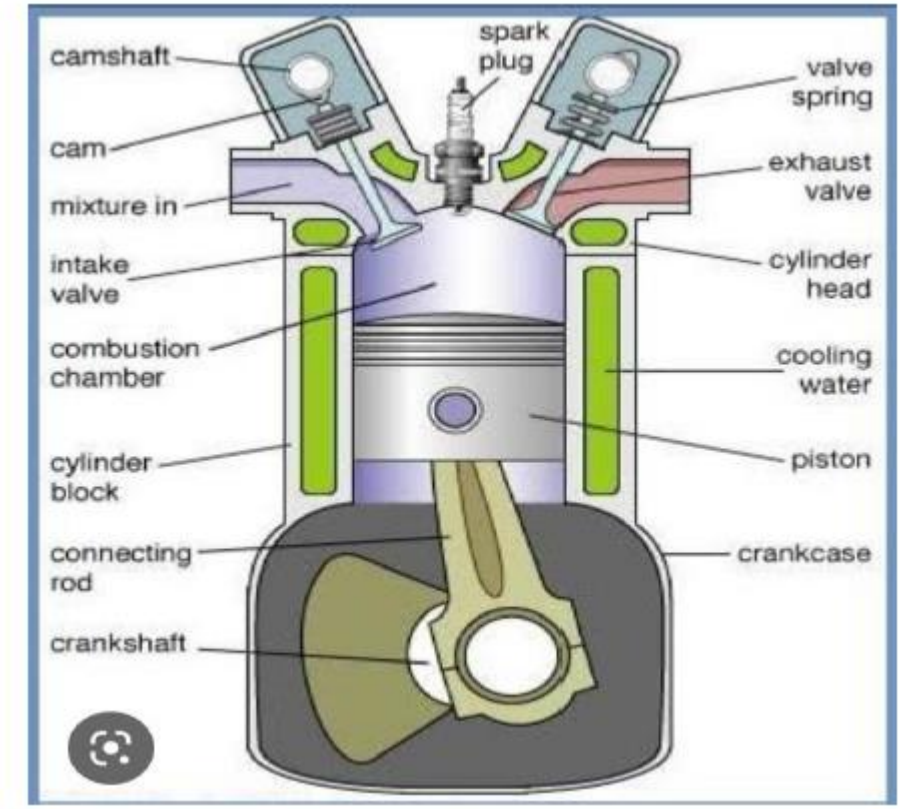
In this engine liquid fuel is atomized, vaporized and mixed with air in correct proportion before being taken to the engine cylinder through the intake manifolds. The ignition of the mixture is caused by an electric spark and is known as spark ignition.

**Diesel Type IC Engine:**

In this only the liquid fuel is injected in the cylinder under high pressure.

**CONSTRUCTIONAL FEATURES OF IC ENGINE**

The principal parts of such an engine are shown in Figure. A brief description of these parts is given below:




**Cylinder:**

The cylinder of an IC engine constitutes the basic and supporting portion of the engine power unit. Its major function is to provide space in which the piston can operate to draw in the fuel mixture or air (depending upon spark ignition or compression ignition), compress it, allow it to expand and thus generate power.

The cylinder is usually made of high grade cast iron. In some cases, to give greater strength and wear resistance with less weight, chromium, nickel and molybdenum are added to the cast iron.

The piston of an engine is the first part to begin movement and to transmit power to the crankshaft as a result of the pressure and energy generated by the combustion of the fuel. The piston is closed at one end and open on the other end to permit direct attachment of the connecting rod and its free action.

**Piston Rings:**

These are made of cast iron on account of their ability to retain bearing qualities and elasticity indefinitely. The primary function of the piston rings is to retain compression and at the same time reduce the cylinder wall and piston wall contact area to a minimum, thus reducing friction losses and excessive wear. The other important functions of piston

rings are the control of the lubricating oil, cylinder lubrication, and transmission of heat away from the piston and from the cylinder walls. Piston rings are classified as compression rings and oil rings depending on their function and location on the piston.

**Piston Pin:**

The connecting rod is connected to the piston through the piston pin. It is made of case hardened alloy steel with precision finish. There are three different methods to connect the piston to the connecting rod.

**Connecting Rod:**

This is the connection between the piston and crankshaft. The end connecting piston is known as small end and the other end is known as big end. The big end has two halves of a bearing bolted together. The connecting rod is made of drop forged steel and the section is of the F-beam type.

**Crankshaft:**

This is connected to the piston through the connecting rod and converts the linear motion of the piston into the rotational motion of the flywheel. The journals of the crankshaft are supported on main bearings, housed in the crankcase Counter-weights and the flywheel bolted to the crankshaft help in the smooth running of the engine.

**Engine Bearings:**

The crankshaft and camshaft are supported on anti-friction bearings. These bearings must be capable of withstanding high speed, heavy load and high temperatures. Normally, babbit, cadmium, silver or copper lead is coated on a steel back to give the above characteristics. For single cylinder vertical/horizontal engines, the present trend is to use ball bearing in place of main bearings of the thin shell type.

**Valves:**

To allow the air to enter into the cylinder or the exhaust, gases to escape from the cylinder, valves are provided, known as inlet and exhaust valves respectively. The valve are mounted either on the cylinder head or on the cylinder block.

**Camshaft:**

The valves are operated by the action of the camshaft which has separate cams for the inlet and exhaust valves. The cam lifts the valve against the pressure of the spring and as soon as it changes position the spring closes the valve. The cam gets drive through either the gear or sprocket and chain system from the crankshaft. It rotates at half the speed of the camshaft crankshaft.

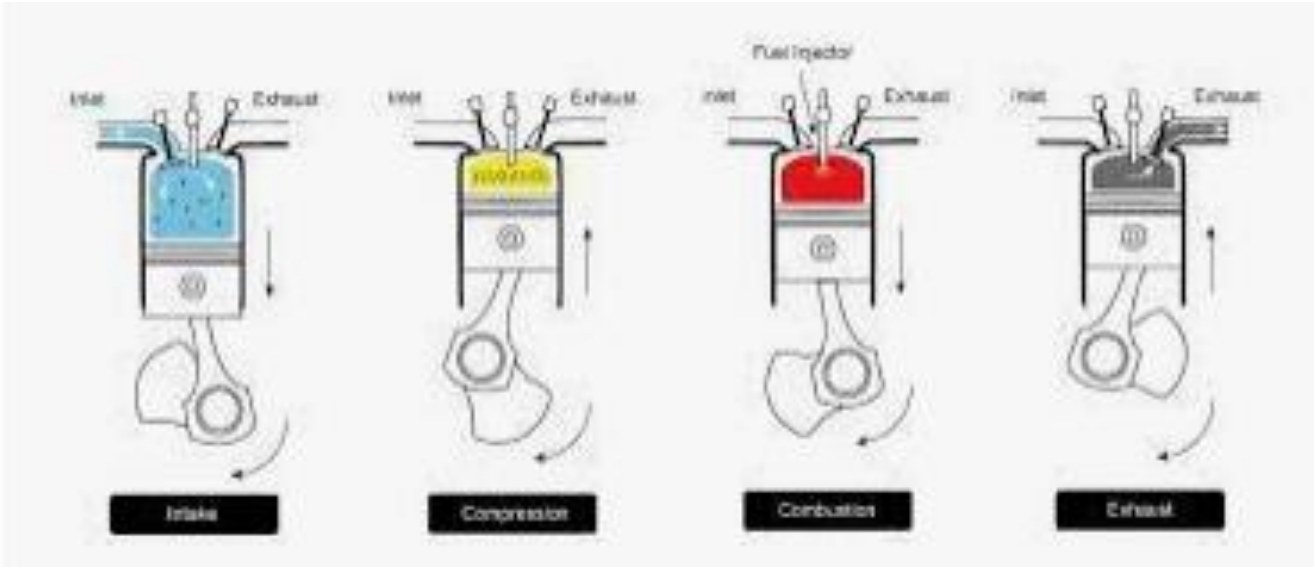
**Flywheel:**

This is usually made of cast iron and its primary function is to maintain uniform engine speed by carrying the crankshaft through the intervals when it is not receiving power from a piston. The size of the flywheel varies with the number of cylinders and the type and size of the engine. It also helps in balancing rotating masses.

**PRINCIPLES OF OPERATION OF IC ENGINES**

**Four-Stroke Cycle Diesel Engine**

In four-stroke cycle engines there are four-strokes completing two revolutions of the crankshaft. These are respectively, the suction, compression, power and exhaust strokes. In Figure, the piston is shown descending on its suction stroke. Only pure air is drawn into the cylinder during this stroke through the inlet valve, whereas, the exhaust valve is closed. These valves can be operated by the cam, push rod and rocker arm. The next stroke is the compression stroke in which the piston moves up with both the valves remaining closed. The air which has been drawn into the cylinder during the suction stroke is progressively compressed as the piston ascends. The compression ratio usually varies from 14:1 to 22:1. The pressure at the end of the compression stroke ranges from 30 to 45 kg/cm$^2$. As the air is progressively compressed in the cylinder, its temperature increases, until when near the end of the compression stroke, it becomes sufficiently high (650- 800°C) to instantly ignite any fuel that is injected into the cylinder. When the piston is near the top of its compression stroke, a liquid hydrocarbon fuel, such as diesel oil, is sprayed into the combustion chamber under high pressure (140-160 kg/cm$^2$), higher than that existing in the cylinder itself. This fuel then ignites, being burnt with the oxygen of the highly compressed air.




During the fuel injection period, the piston reaches the end of its compression stroke and commences to return on its third consecutive stroke, viz., power stroke. During this stroke the hot products of combustion consisting chiefly of carbon dioxide, together with the nitrogen left from the compressed air expand, thus forcing the piston downward. This is only the working stroke of the cylinder.

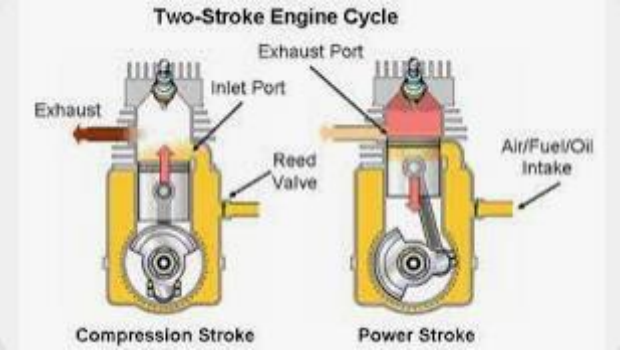
During the power stroke the pressure falls from its maximum combustion value (47-55 $kg/cm^2$), which is usually higher than the greater value of the compression pressure (45 kg/cm2) to about 3.5-5 $kg/cm^2$ near the end of the stroke. The exhaust valve then opens, usually a little earlier than when the piston reaches its lowest point of travel. The exhaust gases are swept out on the following upward stroke of the piston. The exhaust valve remains open throughout the whole stroke and closes at the top of the stroke.

**Two-Stroke Cycle Diesel Engine:**

The cycle of the four-stroke of the piston, Le, the suction, compression, power and exhaust strokes of a four-stroke cycle engine is completed only in two strokes in the case of a two-stroke engine. The air is drawn into the crankcase due to the suction created by the upward stroke of the piston. On the down-stroke of the piston it is compressed in the crankcase. The compression pressure is usually very low, being just sufficient to enable the air to flow into the cylinder through the transfer port when the piston reaches near the bottom of its down stroke.

The air thus flows into the cylinder, where it is compressed by the piston as it ascends, till the piston is nearly at the top of its stroke. The compression pressure is increased

sufficiently high to raise the temperature of the air above the self-ignition point of the fuel used. The fuel is injected into the cylinder head just before the completion of the compression stroke and only for a short period. The burnt gases expand during the next downward stroke of the piston. These gases escape into the exhaust pipe to the atmosphere through the piston uncovering the exhaust port.

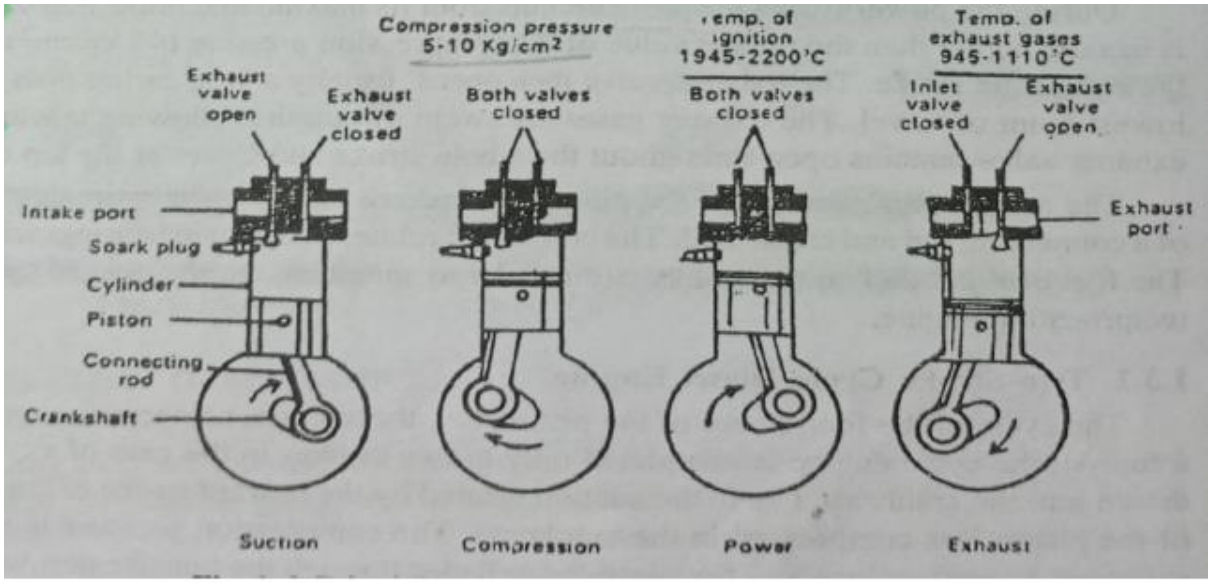



**Modern Two-Stroke Cycle Diesel Engine:**

The crankcase method of air compression is unsatisfactory as the exhaust gases do not escape the cylinder during port opening. Also there is a toss of air through the exhaust ports during the cylinder charging process To overcome these disadvantages blowers are used to pre-compress the air. This pre-compressed air enters the cylinder through the port. An exhaust valve is also provided which opens mechanically just before the opening of the inlet ports.

**Four-Stroke Spark Ignition Engine:**

In this gasoline is mixed with air, broken up into a mist and partially vaporized in a carburetor. The mixture is then, sucked into the cylinder. There it is compressed by the upward movement of the piston and is ignited by an electric spark. When the mixture is burned, the resulting heat causes the gases to expand. The expanding gases exert a pressure on the piston (power stroke). The exhaust gases escape in the next The strokes are similar to those discussed under four-stroke diesel engines. The various temperatures and pressures are shown in Fig. 1.6. The compression ratio varies from 4:1 to 0.8:1 and the air-fuel mixture from 10:1 to 20:1.




**Two-Stroke Spark Ignition Engine:**

The two-cycle carburetor type engine makes use of an air tight crankcase for partially compressing the air-fuel mixture. As the piston travels down, the mixture previously drawn into the crankcase is partially compressed. As the piston nears the bottom of the stroke, it uncovers the exhaust and intake ports. The exhaust flows out, reducing the pressure in the cylinder. When the pressure in the pressure in the combustion chamber is lower than the pressure in the crankcase through the port openings to the combustion chamber, the incoming mixture is deflected upward by a baffle on the piston. As the piston moves up, it compresses the mixture above and draws into the crankcase below a new air- fuel mixture.