S.E. MECH.-APPLIED THERMODYNAMICS

IC ENGINE IGNITION SYSTEMS(PART OF UNIT 5)

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Ignition considerations –

- The combustible mixture of air and petrol is set alight by a spark occurring between two electrodes in the combustion chamber at the end of compression stroke just before TDC.
- The function of ignition system is to periodically provide a spark of sufficient heat intensity to ignite the charge mixture at the predetermined position in the engine's cycle under all speed and load conditions.
- For a four stroke cycle engine, individual cylinders require a single spark every second revolution, so the frequency of firing for a four cylinder engine say at a maximum speed of 6000 rev/min will be (6000/2) X 4 = 12000 sparks per minute or 200 sparks per second. There is thus an extremely short interval between firing.
- The voltage necessary to ionize the air between the electrodes so that the spark will bridge the air gap can vary from as little as 5000 volts when the gap is small, the engine is hot, the cylinder pressure is low, and a chemically correct air fuel mixture is being burnt, to a value of 2000 volts when the spark plug electrodes are badly eroded, the air gap is large, the engine is cold, high cylinder pressures exist, and either very weak or very rich mixtures are induced into the cylinders.

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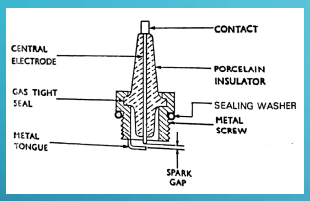

Fig. 1 Spark plug

Spark plug – Refer Fig. 1

- A spark plug is used as the means by which ignition is accomplished in the cylinder.
- It consists of a central porcelain insulator through the length of which passes a central electrode which has an external contact at the top. The central electrode protrudes for a short length through the bottom of the insulator.
- Surrounding the bottom part of insulator, and making a gas tight seal with it, there is a metal screw which usually has a spanner flats at the top for tightening purposes.
- On the bottom of the metal screw is welded a metal tongue which bends over to lie across the end of the protruding central electrode but with a small gap between it and the electrode. It is across this gap that the high tension electric spark jumps to ignite the charge in the engine cylinder, and the gap is called the spark gap. It usually ranges between 0.5 and 0.8 mm, a typical value is 0.6 mm.
- The spark plug is screwed into the cylinder head such that the spark gap protrudes slightly into the combustion space.
- A gas tight seal is made between the sparking plug and cylinder head by means of a sealing washer between the plug and the head. The plug is pulled down hard on to this washer.

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Spark plug (continued) –

- Electrical contact from the external circuit is made to the contact on top of the plug insulator.
- The other side of the electrical circuit is connected to the engine.
- The flow of a high tension current will then produce a high intensity spark across the gap which is now in the combustion space in the engine cylinder head. The charge in the cylinder will thus be ignited.
- If spark plugs are operated for excessively long periods without removal of the deposits of carbon formed over the central electrode insulation during cold starting and under load, the high voltage may track to earth over the dry or sometimes wet deposits so that insufficient energy will be available to jump the spark gap of the electrodes.
- Spark plugs are normally renewed every 15000 km and they should be removed, inspected, cleaned, and adjusted at intervals of 7500 km.

Modern ignition systems –

- The development of a high speed, high compression, IC engine necessitated the development of a reliable high speed ignition system. This has been met by the development of the high tension ignition system which uses the fixed gap sparking plug as the means by which ignition is accomplished in the cylinder. The electrical energy to the sparking plug is supplied by external apparatus. The external electrical apparatus can be divided as follows –
    - The coil ignition system
    - The magneto ignition system
    - The electronic ignition system

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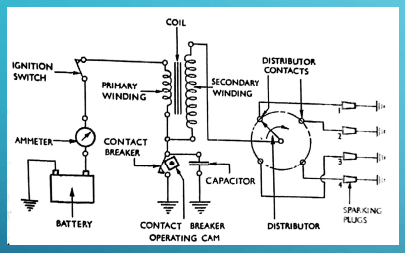

Fig. 2 Coil ignition system

Coil ignition system – Refer Fig. 2

- The power for such a circuit is often supplied from a 6 or 12 volt battery. There are two circuits – the primary circuit and the secondary circuit.
- The primary circuit consists of a battery, one side of which is connected to earth. The earth is usually the engine itself. The other side of the battery is connected, via an ammeter and ignition switch in series, to the primary winding of a coil. The coil is, in effect, an auto transformer.
- The other end of primary winding is connected to one side of the contact breaker. The contact breaker, is in effect, a spring closed switch, and is operated by means of a cam. The other side of the contact breaker is connected to earth.
- A capacitor is connected across the contact breaker points to earth. The points, as they are called, are the contact breaker contact surfaces. This completes the primary circuit.
- The secondary circuit is as follows – The bottom end of the secondary winding of the coil is connected to the bottom end of the primary winding. The top end of the secondary winding is connected to the center of the distributor rotor. The distributor rotor is a rotating contact which sweeps past, and makes contact with, fixed contacts which in turn are connected to the sparking plugs gaps in the engine. The other side of the sparking plugs are connected to the engine earth. This completes the secondary circuit.

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Coil ignition system (continued) –

- The operation of the complete circuit is as follows –
- With the ignition switch closed and the engine running, a current will flow in the primary circuit as soon as the contact breaker closes. The build up of current in the primary winding of the coil is relatively slow, since it must overcome the counter e.m.f. of its own magnetic field. The contact breaker cam, which is continuously revolving, now opens the contact breaker. Immediately, the magnetic field in the coil begins to collapse. This collapse of the magnetic field tends to keep the current flowing in the primary winding, with the result that the capacitor is rapidly charged. As soon as it is fully charged, the capacitor will begin to discharge through the primary winding and hence increases the rate of collapse of the magnetic field. This rapidly collapsing magnetic field will induce a current flow in the secondary winding of the coil which, because of its high turns ratio, will produce a very high voltage in the secondary circuit. At the same time that the contact breaker in the primary circuit opens, the distributor rotor connects with a contact to a sparking plug and hence a high voltage will be set up across the sparking plug gap. This will cause a high intensity arc to spread across this gap, thus igniting the cylinder charge.
- The capacitor across the contact breaker points not only helps to collapse the magnetic field, but also prevents excessive arcing across the contact breaker. This is because the major proportion of the current flow in the primary circuit is discharged into the condenser instead of producing an arc across the points as they open.

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Coil ignition system (continued) –

- Fig. 2 is the circuit for a four cylinder engine.
- It will be noted that the contact breaker cam is square, having four lobes, thus effecting four openings of the contact breaker per revolution of the cam.
- The distributor has four contacts. Usually the number of cam lobes and the number of distributor contacts is the same as the number of engine cylinders.
- Both the cam and the distributor rotor are motored in phase and are usually mounted on the same shaft.
- In the two stroke cycle engine, they are motored at engine speed. In the four stroke cycle engine they are motored at half engine speed.

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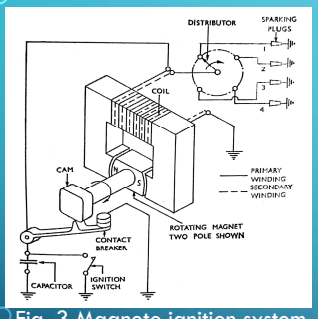

Fig. 3 Magneto ignition system

Magneto ignition system – Refer Fig. 3

- In this system, a battery is not required, since the magneto acts as its own generator. It may consist either of rotating magnet in fixed coils or rotating coils in fixed magnets. The first of these types is illustrated in Fig. 3.
- The rotating magnet is of two pole type and as the poles f the magnet pass between the shoes of the coil, a rapid change of magnetic flux in the coil takes place.
- As a result of this, a current is induced in the primary winding of the coil. When the current is at its maximum, the contact breaker is opened by means of a cam on the magneto rotor shaft, and then the circuit operates in the same way as the coil system.
- It will be noted that there will be two current reversals per revolution of the rotating magnet shown, and hence two sparking plugs can be fed per revolution of the magneto. The direction of the current through the sparking plugs is not important.
- The principle and position of the ignition switch is changed in this circuit. The switch is placed across the contact breaker and in the engine "on" position is actually open circuit. If the switch is closed, any current build up in the primary circuit is shorted to earth, and hence the circuit is out of operation.
- In the magneto, the speed of the rotor must be governed to cover the number of magnet poles used together with the number of engine cylinders. In the two pole case shown, feeding a 4 cylinder, 4 stroke cycle engine, the rotor would rotate at engine speed, giving 4 current reversals in 2 revolutions of the engine.

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Magneto ignition system (continued) –

- If the same magneto fed an 8 cylinder, 4 stroke cycle engine, then the rotor would have to run at twice engine speed.
- The magneto must be turned over at a sufficient speed to supply the necessary current. The lowest speed at which the necessary current is supplied is called the "coming in" speed. It is usually about 100 rev/min. If the speed is unattainable, usually at start, boost from a battery or a hand cranked magneto is necessary.
- Both the coil and magneto ignition system have a mechanically operated contact breaker system. This mechanical type system suffers from some disadvantages, which include wear (of the cam lobes), burnt contact breaker points due to electric arcing, operational speed limitation, and the need for periodic contact breaker readjustment and renewal.

Electronic ignition system –

- The electronic ignition system works in mostly the same way as already described but, instead of the mechanically operated contact breaker, a breakerless system is substituted.
- Such a system is "triggered" (turned on and off) by means of either a magnetic sensor, or a photo electric device, which takes the place of the mechanical contact breaker.
- Associated with the trigger arrangement is an Electronic Control Unit (ECU) which is usually transistor operated to provide the necessary electrical impulses to the remainder of the ignition system which then functions in the manner described earlier.
- Once initially set, there should be no requirement for further adjustment in the case of electronic ignition system.

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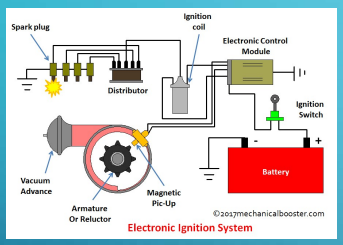

Fig. 4 Electronic ignition system

Electronic ignition system – Refer Fig. 4

- When the driver switches ON the ignition switch in order to start a vehicle the current starts flowing from the battery through the ignition switch to the coil primary winding, which in turn starts the armature pickup coil to receives and send the voltage signals from the armature to the ignition module.
- When the tooth of the rotating reluctor comes in front of the pickup coil as shown in the Fig., the voltage signal from pickup coil is sent to the electronic module which in turn senses the signal and stops the current to flow from primary coil.
- When the tooth of the rotating reluctor goes away from the pickup coil, the change in voltage signal is sent by pickup coil to the ignition module and a timing circuit inside ignition module turns ON the current flow.
- A magnetic field is generated in the ignition coil due to this continuous make and break of the circuit which induces an EMF in secondary winding which increases the voltage upto 50000 Volts.
- This high voltage is then sent to distributor, which has the rotating rotor and distributor points which is set according to the ignition timing.
- When the rotor comes in front of any of those distributor points, the jumping of voltage through the air gap from the rotor to the distributor point takes place which is then sent to the adjacent spark plug terminal through the high tension cable and a voltage difference is generated between the central electrode and ground electrode which is responsible for generating a spark at the tip of the spark plug and finally the combustion takes place.
- The vacuum advance system is designed to provide additional advance to increase the timing accuracy given by the mechanical advance system at varying driving speeds.

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Electronic ignition system (continued) –

- It is used in modern and hyper cars like Audi A4, Mahindra XUV-500 etc. and bikes like KTM Duke 390 cc, Ducati super sports etc. to meet the high reliability and performance need.
- It is also used in aircrafts engine due to its better reliability and less maintenance.

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