UNIT 4 IGNITION SYSTEMS

Structure

4.1 INTRODUCTION

We know that in case of Internal Combustion (IC) engines, combustion of air and fuel takes place inside the engine cylinder and the products of combustion expand to produce reciprocating motion of the piston. This reciprocating motion of the piston is in turn converted into rotary motion of the crank shaft through connecting rod and crank.

This rotary motion of the crank shaft is in turn used to drive the generators for generating power.

We also know that there are 4-cycles of operations viz.: suction; compression; power generation and exhaust.

These operations are performed either during the 2-strokes of piston or during 4-strokes of the piston and accordingly they are called as 2-stroke cycle engines and 4-stroke cycle engines.

In case of petrol engines during suction operation, charge of air and petrol fuel will be taken in. During compression this charge is compressed by the upward moving piston. And just before the end of compression, the charge of air and petrol fuel will be ignited by means of the spark produced by means of for spark plug. And the ignition system does the function of producing the spark in case of spark ignition engines.

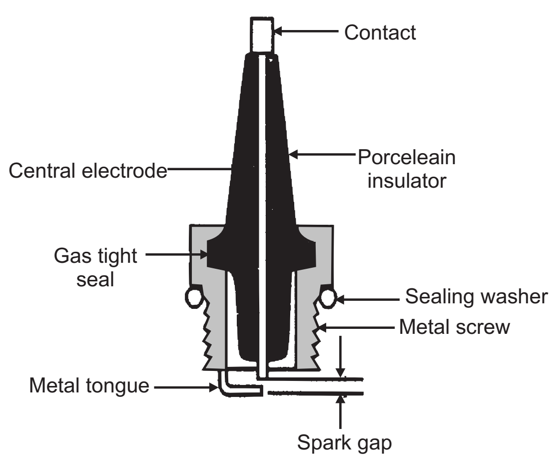


Figure 4.1 : Spark Plug

Figure 4.1 shows atypical spark plug used with petrol engines. It mainly consists of a central electrode and metal tongue. Central electrode is covered by means of porcelain insulating material. Through the metal screw the spark plug is fitted in the cylinder head plug. When the high tension voltage of the order of 30000 volts is applied across the spark electrodes, current jumps from one electrode to another producing a spark.

Whereas in case of diesel (Compression Ignition-CI) engines only air is taken in during suction operation and in compressed during compression operation and just before the end of compression, when diesel fuel is injected, it gets ignited due to heat of compression of air.

Once the charge is ignited, combustion starts and products of combustion expand, i.e. they force the piston to move downwards i.e. they produce power and after producing the power the gases are exhausted during exhaust operation.

Objectives

After studying this unit, you should be able to

- explain the different types of ignition systems,
- differentiate between battery and magneto ignition system
- know the drawbacks of conventional ignition system, and
- appreciate the importance of ignition timing and ignition advance.

4.2 IGNITION SYSTEM TYPES

Basically Convectional Ignition systems are of 2 types :

(a) Battery or Coil Ignition System, and

(b) Magneto Ignition System.

Both these conventional, ignition systems work on mutual electromagnetic induction principle.

Battery ignition system was generally used in 4-wheelers, but now-a-days it is more commonly used in 2-wheelers also (i.e. Button start, 2-wheelers like Pulsar, Kinetic Honda; Honda-Activa, Scooty, Fiero, etc.). In this case 6 V or 12 V batteries will supply necessary current in the primary winding.

Magneto ignition system is mainly used in 2-wheelers, kick start engines.
(Example, Bajaj Scooters, Boxer, Victor, Splendor, Passion, etc.).

In this case magneto will produce and supply current to the primary winding. So in magneto ignition system magneto replaces the battery.

Battery or Coil Ignition System

Figure 4.2 shows line diagram of battery ignition system for a 4-cylinder petrol engine. It mainly consists of a 6 or 12 volt battery, ammeter, ignition switch, auto-transformer (step up transformer), contact breaker, capacitor, distributor rotor, distributor contact points, spark plugs, etc.

Note that the Figure 4.1 shows the ignition system for 4-cylinder petrol engine, here there are 4-spark plugs and contact breaker cam has 4-corners. (If it is for 6-cylinder engine it will have 6-spark plugs and contact breaker cam will be a perfect hexagon).

The ignition system is divided into 2-circuits :

(i) **Primary Circuit :** It consists of 6 or 12 V battery, ammeter, ignition switch, primary winding it has 200-300 turns of 20 SWG (Sharps Wire Gauge) gauge wire, contact breaker, capacitor.

(ii) **Secondary Circuit :** It consists of secondary winding. Secondary winding consists of about 21000 turns of 40 (S WG) gauge wire. Bottom end of which is connected to bottom end of primary and top end of secondary winding is connected to centre of distributor rotor. Distributor rotors rotate and make contacts with contact points and are connected to spark plugs which are fitted in cylinder heads (engine earth).

(iii) **Working :** When the ignition switch is closed and engine in cranked, as soon as the contact breaker closes, a low voltage current will flow through the primary winding. It is also to be noted that the contact beaker cam opens and closes the circuit 4-times (for 4 cylinders) in one revolution. When the contact breaker opens the contact, the magnetic field begins to collapse. Because of this collapsing magnetic field, current will be induced in the secondary winding. And because of more turns (@ 21000 turns) of secondary, voltage goes unto 28000-30000 volts.

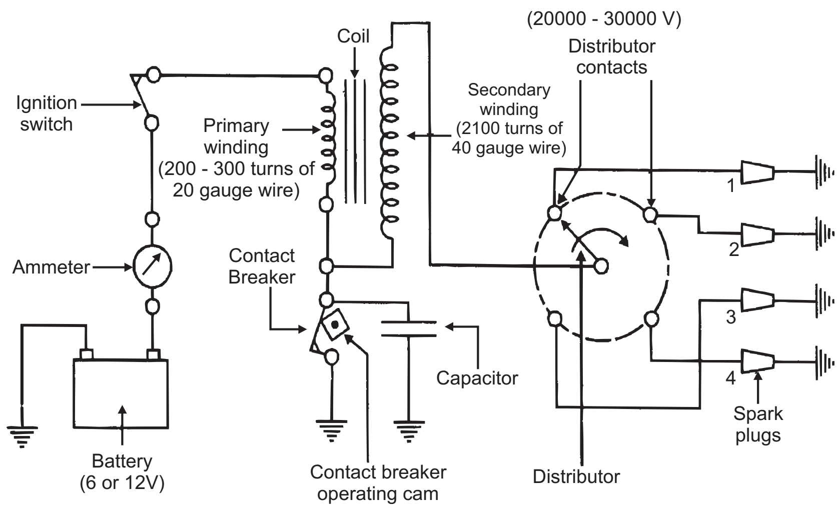


Figure 4.2 : Schematic Diagram of Coil/Battery Ignition System

This high voltage current is brought to centre of the distributor rotor. Distributor rotor rotates and supplies this high voltage current to proper stark plug depending upon the engine firing order. When the high voltage current jumps the spark plug gap, it produces the spark and the charge is ignited-combustion starts-products of combustion expand and produce power.

Note :

(a) The Function of the capacitor is to reduce arcing at the contact breaker (CB) points. Also when the CB opens the magnetic field in the primary winding begins to collapse. When the magnetic field is collapsing capacitor gets fully charged and then it starts discharging and helps in building up of voltage in secondary winding.

(b) Contact breaker cam and distributor rotor are mounted on the same shaft.

In 2-stroke cycle engines these are motored at the same engine speed. And in 4-stroke cycle engines they are motored at half the engine speed.

Magneto Ignition System

In this case magneto will produce and supply the required current to the primary winding. In this case as shown, we can have rotating magneto with fixed coil or rotating coil with fixed magneto for producing and supplying current to primary, remaining arrangement is same as that of a battery ignition system.

Figure 4.3 given on next page shows the line diagram of magneto ignition system.

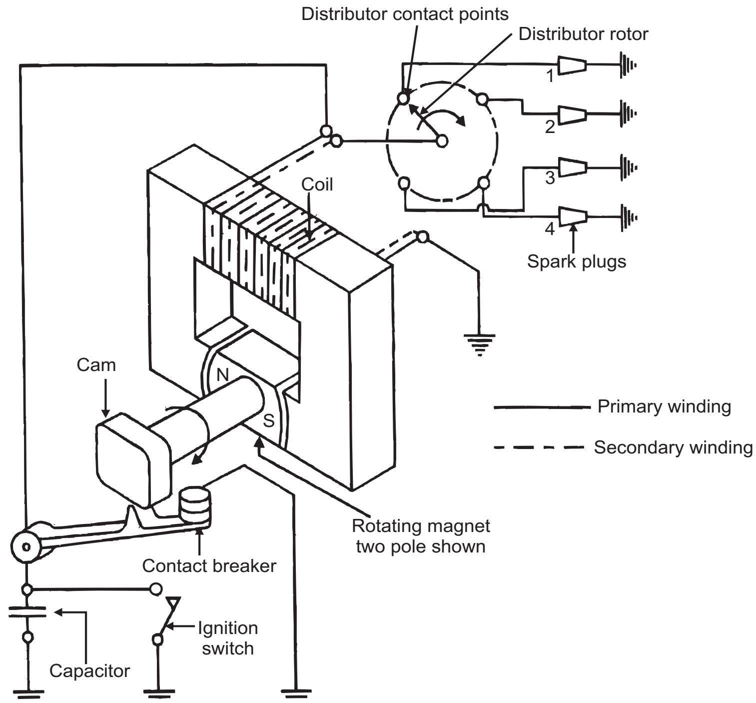


Figure 4.3 : Schematic Diagram of Magneto Ignition System

4.3 COMPARISON BETWEEN BATTERY AND MAGNETO IGNITION SYSTEM

Battery Ignition	Magneto Ignition
Battery is a must.	No battery needed.
Battery supplies current in primary circuit.	Magneto produces the required current for primary circuit.
A good spark is available at low speed also.	During starting the quality of spark is poor due to slow speed.
Occupies more space.	Very much compact.
Recharging is a must in case battery gets discharged.	No such arrangement required.
Mostly employed in car and bus for which it is required to crank the engine.	Used on motorcycles, scooters, etc.
Battery maintenance is required.	No battery maintenance problems.

4.4 DRAWBACKS (DISADVANTAGES) OF CONVENTIONAL IGNITION SYSTEMS

Following are the drawbacks of conventional ignition systems :

(a) Because of arcing, pitting of contact breaker point and which will lead to regular maintenance problems.

(b) Poor starting : After few thousands of kilometers of running, the timing becomes inaccurate, which results into poor starting (Starting trouble).

(c) At very high engine speed, performance is poor because of inertia effects of the moving parts in the system.

(d) Some times it is not possible to produce spark properly in fouled spark plugs.

In order to overcome these drawbacks Electronic Ignition system is used.

4.5 ADVANTAGES OF ELECTRONIC IGNITION SYSTEM

Following are the advantages of electronic ignition system :

(a) Moving parts are absent-so no maintenance.

(b) Contact breaker points are absent-so no arcing.

(c) Spark plug life increases by 50% and they can be used for about 60000 km without any problem.

(d) Better combustion in combustion chamber, about 90-95% of air fuel mixture is burnt compared with 70-75% with conventional ignition system.

(e) More power output.

(f) More fuel efficiency.

4.6 TYPES OF ELECTRONIC IGNITION SYSTEM

Electronic Ignition System is as follow :

(a) Capacitance Discharge Ignition system

(b) Transistorized system

(c) Piezo-electric Ignition system

(d) The Texaco Ignition system

Capacitance Discharge Ignition System

It mainly consists of 6-12 V battery, ignition switch, DC to DC convertor, charging resistance, tank capacitor, Silicon Controlled Rectifier (SCR), SCR-triggering device, step up transformer, spark plugs.

A 6-12 volt battery is connected to DC to DC converter i.e. power circuit through the ignition switch, which is designed to give or increase the voltage to 250-350 volts. This high voltage is used to charge the tank capacitor (or condenser) to this voltage through the charging resistance. The charging resistance is also so designed that it controls the required current in the SCR.

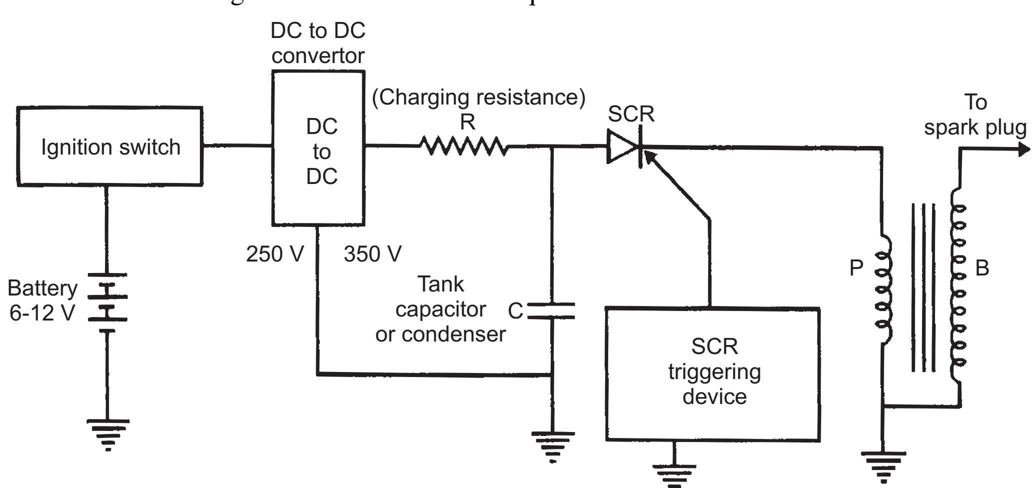


Figure 4.4 : Capacitance Discharge Ignition System

Depending upon the engine firing order, whenever the SCR triggering device, sends a pulse, then the current flowing through the primary winding is stopped. And the magnetic field begins to collapse. This collapsing magnetic field will induce or step up high voltage current in the secondary, which while jumping the spark plug gap produces the spark, and the charge of air fuel mixture is ignited.

Transistorized Assisted Contact (TAC) Ignition System

Figure 4.5 shows the TAC system.

Advantages

(a) The low breaker-current ensures longer life.

(b) The smaller gap and lighter point assembly increase dwell time minimize contact bouncing and improve repeatability of secondary voltage.

(c) The low primary inductance reduces primary inductance reduces primary current drop-off at high speeds.

Disadvantages

(a) As in the conventional system, mechanical breaker points are necessary for timing the spark.

(b) The cost of the ignition system is increased.

(c) The voltage rise-time at the spark plug is about the same as before.

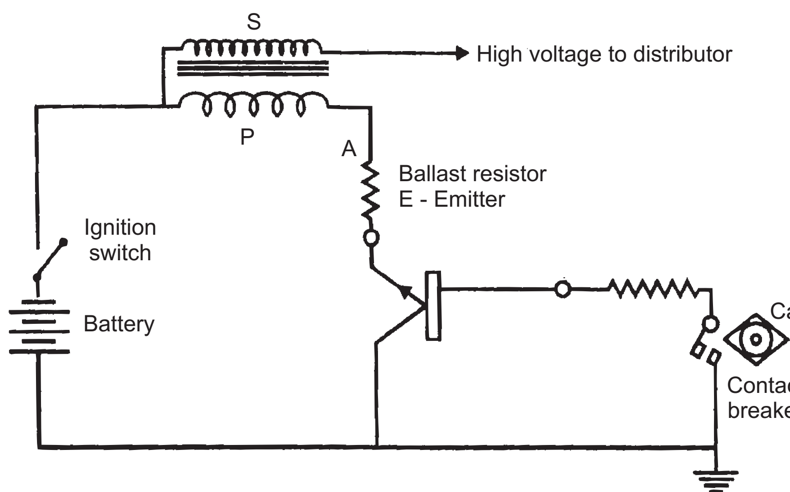


Figure 4.5 : Transistorized Assisted Contact (TAC) Ignition System

Piezo-electric Ignition System

The development of synthetic piezo-electric materials producing about 22 kV by mechanical loading of a small crystal resulted in some ignition systems for single cylinder engines. But due to difficulties of high mechanical loading need of the order of 500 kg timely control and ability to produce sufficient voltage, these systems have not been able to come up.

The Texaco Ignition System

Due to the increased emphasis on exhaust emission control, there has been a sudden interest in exhaust gas recirculation systems and lean fuel-air mixtures.

To avoid the problems of burning of lean mixtures, the Texaco Ignition system has been developed. It provides a spark of controlled duration which means that the spark duration in crank angle degrees can be made constant at all engine speeds. It is a AC system. This system consists of three basic units, a power unit, a control unit and a distributor sensor.

This system can give stable ignition up to A/F ratios as high as 24 : 1.

4.7 FIRING ORDER

- The order or sequence in which the firing takes place, in different cylinders of a multicylinder engine is called Firing Order.
- In case of SI engines the distributor connects the spark plugs of different cylinders according to Engine Firing Order.

Advantages

(a) A proper firing order reduces engine vibrations.

(b) Maintains engine balancing.

(c) Secures an even flow of power.

- Firing order differs from engine-to-engine.
- Probable firing orders for different engines are :
  - 3 cylinder = 1-3-2
  - 4 cylinder engine (inline) = 1-3-4-2
1-2-4-3
  - 4 cylinder horizontal opposed engine = 1-4-3-2
(Volkswagen engine)
  - 6-cylinder in line engine = 1-5-3-6-2-4
(Cranks in 3 pairs) 1-4-2-6-3-5
1-3-2-6-4-5
1-2-4-6-5-3
  - 8 cylinder in line engine 1-6-2-5-8-3-7-4
1-4-7-3-8-5-2-6
8 cylinder V type 1-5-4-8-6-3-7-2
1-5-4-2-6-3-7-8
1-6-2-5-8-3-7-4
1-8-4-3-6-5-7-2

Cylinder 1 is taken from front of inline and front right side in V engines.

4.8 IMPORTANCE OF IGNITION TIMING AND IGNITION ADVANCE

Ignition timing is very important, since the charge is to be ignited just before (few degrees before TDC) the end of compression, since when the charge is ignited, it will take some time to come to the required rate of burning.

Ignition Advance

The purpose of spark advance mechanism is to assure that under every condition of engine operation, ignition takes place at the most favorable instant in time i.e. most favorable from a standpoint of engine power, fuel economy and minimum exhaust dilution. By means of these mechanisms the advance angle is accurately set so that ignition occurs before TDC point of the piston. The engine speed and the engine load are the control quantities required for the automatic adjustment of the ignition timing. Most of the engines are fitted with mechanisms which are integral with the distributor and automatically regulate the optimum spark advance to account for change of speed and load. The two mechanisms used are :

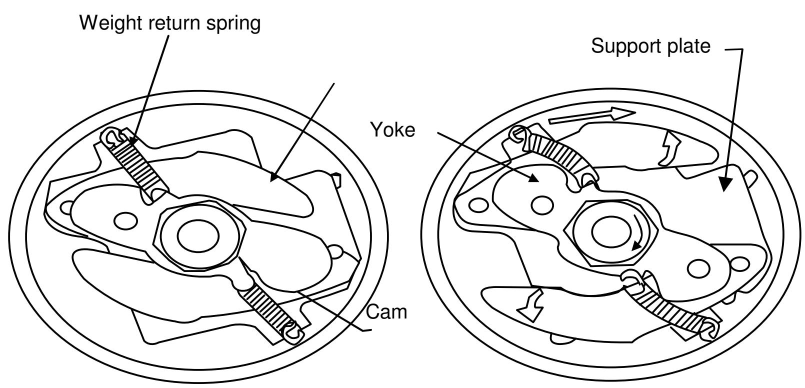
(a) Centrifugal advance mechanism, and

(b) Vacuum advance mechanism.

Centrifugal Advance Mechanism

The centrifugal advance mechanism controls the ignition timing for full- load operation. The adjustment mechanism is designed so that its operation results in the desired advance of the spark. The cam is mounted, movably, on the distributor shaft so that as the speed increases, the flyweights which are swung farther and farther outward, shaft the cam in the direction of shaft rotation. As a result, the cam lobes make contact with the breaker lever rubbing block somewhat earlier, thus shifting the ignition point in the early or advance direction. Depending on the speed of the engine, and therefore of the shaft, the weights are swung outward a greater or a lesser distance from the center. They are then held in the extended position, in a state of equilibrium corresponding to the shifted timing angle, by a retaining spring which exactly balances the centrifugal force. The weights shift the cam either or a rolling contact or sliding contact basis; for this reasons we distinguish between the rolling contact type and the sliding contact type of centrifugal advance mechanism.

The beginning of the timing adjustment in the range of low engine speeds and the continues adjustment based on the full load curve are determined by the size of the weights by the shape of the contact mechanisms (rolling or sliding contact type), and by the retaining springs, all of which can be widely differing designs. The centrifugal force controlled cam is fitted with a lower limit stop for purposes of setting the beginning of the adjustment, and also with an upper limit stop to restrict the greatest possible full load adjustment. A typical sliding contact type centrifugal advance mechanism is shown in Figures 4.6(a) and (b).



(a) **(b)**

Figure 4.6 : Sliding Contact Type Centrifugal Advance Mechanism

Vacuum Advance Mechanism

Vacuum advance mechanism shifts the ignition point under partial load operation. The adjustment system is designed so that its operation results in the prescribed partial load advance curve. In this mechanism the adjustment control quantity is the static vacuum prevailing in the carburetor, a pressure which depends on the position of the throttle valve at any given time and which is at a maximum when this valve is about half open. This explains the vacuum maximum.

The diaphragm of a vacuum unit is moved by changes in gas pressure. The position of this diaphragm is determined by the pressure differential at any given moment between the prevailing vacuum and atmospheric pressure. The beginning of adjustment is set by the pre-established tension on a compression spring. The diaphragm area, the spring force, and the spring rigidity are all selected in accordance with the partial –load advance curve which is to be followed and are all balanced with respect to each other. The diaphragm movement is transmitted through a vacuum advance arm connected to the movable breaker plate, and this movement shifts the breaker plate an additional amount under partial load condition in a direction opposite to the direction of rotation of the distributor shaft. Limit stops on the vacuum advance arm in the base of the vacuum unit restrict the range of adjustment.

The vacuum advance mechanism operates independent of the centrifugal advance mechanism. The mechanical interplay between the two advance mechanisms, however, permits the total adjustment angle at any given time to be the result of the addition of the shifts provided by the two individual mechanisms operates in conjunction with the engine is operating under partial load. A typical vacuum advance mechanism is shown in Figure 4.7.

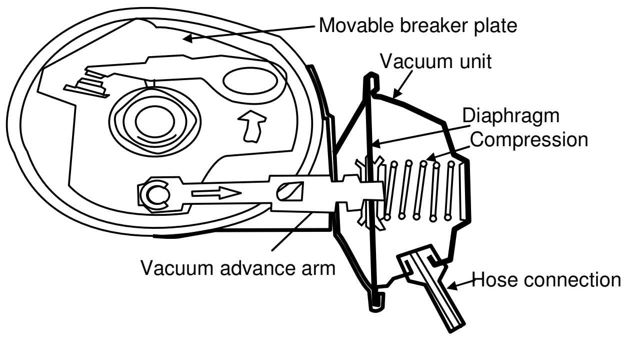


Figure 4.7 : Vacuum Advance Mechanism

SAQ 1

(a) What do you understand by 'ignition'? How is it related to 'combustion'?

(b) What are the requirements of an ignition system for an IC engines?

(c) Differentiate between battery and magneto ignition system.

(d) Explain in brief the drawbacks of conventional ignition system.

(e) What is the difference between 'ignition timing' and 'firing order'?

(f) List the various electronic ignition system in use.

4.9 SUMMARY

In SI engines, the combustion process is initiated by a spark between the two electrodes of spark plug. This occurs just before the end of compression stroke. Ignition is only a pre-requisite of combustion. In this unit, we have learnt in detail the different types of ignition systems. The difference between battery and magneto ignition systems lies only in the source of electrical energy. Battery ignition system uses a battery, magneto ignition system uses a magneto to supply low voltages all other system components being similar.

The order or sequence in which the firing takes place, in different cylinders of a multi-cylinder engine is called firing order.

4.10 KEY WORDS

Battery Ignition System : It is commonly used because of its combined cheapness, convenience of maintenance, attention and general suitability.

Magneto Ignition System : It is an efficient, reliable, self contained unit, which is often preferred for air craft engines because storage batteries are heavy and troublesome.

Firing Order : It is the order in which various cylinders of a multi-cylinder engine fire.

Ignition Timing : It is the correct instant for the introduction of spark near the end of compression stroke in the cycle.

4.11 ANSWERS TO SAQs

Refer the preceding text for all the Answers to SAQs.