IGNITION SYSTEM

The ignition system of an internal combustion engine is an important part of the overall engine system.

All conventional petrol[[1]] (gasoline)[[2]] engines require an ignition system. By contrast, not all engine types need an ignition system - for example, a diesel engine relies on compression-ignition, that is, the rise in temperature that accompanies the rise in pressure within the cylinder is sufficient to ignite the fuel spontaneously.

How it helps

It provides for the timely burning of the fuel mixture within the engine.

How controlled

The ignition system is usually switched on/off through a lock switch, operated with a key or code patch.

Earlier history

The earliest petrol engines used a very crude ignition system. This often took the form of a copper or brass rod which protruded into the cylinder, which was heated using an external source. The fuel would ignite when it came into contact with the rod. Naturally this was very inefficient as the fuel would not be ignited in a controlled manner. This type of arrangement was quickly superseded by spark-ignition, a system which is generally used to this day, albeit with sparks generated by more sophisticated circuitry.

Glow plug ignition

Glow plug ignition is used on some kinds of simple engines, such as those commonly used for model aircraft. A glow plug is a coil of wire (made from e.g. nichrome[[3]]) that will glow red hot when an electric current is passed through it. This ignites the fuel on contact, once the temperature of the fuel is already raised due to compression. The coil is electrically activated for engine starting, but once running, the coil will retain sufficient residual heat on each stroke due to the heat generated on the previous stroke. Glow plugs are also used to aid starting of diesel engines.

Magneto system

The simplest form of spark ignition is that using a magneto. The engine spins a magnet inside a coil, and also operates a contact breaker, interrupting the current and causing the voltage to be increased sufficiently to jump a small gap. The spark plugs are connected directly from the magneto output. Magnetos are not used in modern cars, but because they generate their own electricity they are often found on small engines such asmopeds, lawnmowers, snowblowers, chainsaws, etc. where there is no battery, and also in aircraft piston engines, where their simplicity and self-contained nature confers a generally greater reliability as well as lighter weight in the absence of a battery and generator or alternator. Aircraft engines usually have multiple magnetos to provide redundancy in the event of a failure. Some older automobiles had both a magneto system and a battery actuated system (see below) running simultaneously to ensure proper ignition under all conditions with the limited performance each system provided at the time.

Switchable systems

The output of a magneto depends on the speed of the engine, and therefore starting can be problematic. Some engines, such as aircraft but also the Ford Model T, utilized a system which relied on non rechargeabledry cells, (like large flashlight batteries, not what are usually thought of as automobile batteries today) to start the engine or for running at low speed; then the operator would manually switch the ignition over to magneto operation for high speed operation. In order to provide high voltage for the spark from the low voltage batteries, however, a "tickler" was used, which was essentially a larger version of the once ubiquitous electricbuzzer. With this apparatus, the direct current passes through an electromagnetic coil which pulls open a pair of contact points, interrupting the current; the magnetic field collapses, the spring-loaded points close again, the circuit is reestablished, and the cycle repeats rapidly. The rapidly collapsing magnetic field, however, induces a high voltage across the coil which can only relieve itself by arcing across the contact points; while in the case of the buzzer this is a problem as it causes the points to oxidize and/or weld together, in the case of the ignition system this becomes the source of the high voltage to operate the spark plugs. In this mode of operation, the coil would "buzz" continuously, producing a constant train of sparks. The entire apparatus was known as the Model T spark coil (in contrast to the modern ignition coil which is only the actual coil component of the system), and long after the demise of the Model T as transportation they remained a popular self-contained source of high voltage for electrical home experimenters, appearing in articles in magazines such as Popular Mechanics[[4]].

The magneto on the Model T (built into the flywheel) differed from modern implementations by not providing high voltage directly at the output; the maximum voltage produced was about 30 volts, and therefore also had to be run through the spark coil to provide high enough voltage for ignition, as described above, although the coil would not "buzz" continuously in this case, only going through one cycle per spark. In either case, the high voltage was switched to the appropriate spark plug by the timer mounted on the top of the engine, the equivalent of the modern distributor. The timing of the spark was adjustable by rotating this mechanism through a lever mounted on the steering column.

Battery operated ignition

With the universal adaptation of electrical starting for automobiles, and the concomitant availability of a large battery to provide a constant source of electricity, magneto systems were abandoned for systems which interrupted current at battery voltage, used an ignition coil (a type of autotransformer) to step the voltage up to the needs of the ignition, and a distributor to route the ensuing pulse to the correct spark plug at the correct time.

Mechanical ignition

Most four-stroke engines have used a mechanically timed electrical ignition system. The heart of the system is the distributor which contains a rotating cam running off the engine's drive, a set of breaker points, a condenser, a rotor and a distributor cap. External to the distributor is the ignition coil, the spark plugs, and wires linking the spark plugs and ignition coil to the distributor.

The power source is a lead-acid battery, kept charged by the car's electrical system, which generates electricity using a dynamo or alternator. The engine operates contact breaker points, which interrupt the current flow to an induction coil (known as the ignition coil).

The ignition coil consists of two transformer windings sharing a common magnetic core -- the primary and secondary windings. An alternating current in the primary induces alternating magnetic field in the coil's core. Because the ignition coil's secondary has far more windings than the primary, the coil is a step-up transformer which induces a much higher voltage across the secondary windings. For an ignition coil, one end of windings of both the primary and secondary are connected together. This common point is connected to the battery (usually through a current-limiting resistor). The other end of the primary is connected to the points within the distributor. The other end of the secondary is connected, via the distributor cap and rotor, to the spark plugs.

The ignition firing sequence begins with the points (or contact breaker) closed. A steady current flows from the battery, through the current-limiting resistor, through the coil primary, across the closed breaker points and finally back to the battery. This steady current produces a magnetic field within the coil's core. This magnetic field forms the energy reservoir that will be used to drive the ignition spark.

As the engine turns, so does the cam inside the distributor. The points ride on the cam so that as the engine turns and reaches the top of the engine's compression cycle, a high point in the cam causes the breaker points to open. This breaks the primary winding's circuit and abruptly stops the current flow through the breaker points.

Without the steady current flow through the points, the magnetic field generated in the coil immediately begins to quickly collapse. This rapid decay of the magnetic field induces a high voltage in the coil's secondary windings.

At the same time, current exits the coil's primary winding and begin to charge up the capacitor ("condenser") that lies across the now-open breaker points. This capacitor and the coil’s primary windings form an oscillatingLC circuit. This LC circuit produces a damped, oscillating current which bounces energy between the capacitor’s electric field and the ignition coil’s magnetic field. The oscillating current in the coil’s primary, which produces an oscillating magnetic field in the coil, extends the high voltage pulse at the output of the secondary windings. This high voltage thus continues beyond the time of the initial field collapse pulse. The oscillation continues until the circuit’s energy is consumed.

The ignition coil's secondary windings are connected to the distributor cap. A turning rotor, located on top of the breaker cam within the distributor cap, sequentially connects the coil's secondary windings to one the several wires leading to each engine's spark plugs. The extremely high voltage from the coil's secondary – often higher than 1000 volts -- causes a spark to form across the gap of the spark plug. This, in turn, ignites the compressed air-fuel mixture within the engine. It is the creation of this spark which consumes the energy that was originally stored in the ignition coil's magnetic field.

Except that more separate elements are involved, this distributor-based system is not greatly different from a magneto system. There are also advantages to this arrangement. For example, the position of the contact breaker points relative to the engine angle can be changed a small amount dynamically, allowing the ignitiontiming to be automatically advanced with increasing revolutions per minute (RPM) and/or increased manifold vacuum, giving better efficiency. This system was used almost universally until the late 1970s, when electronicignition systems started to appear.

Electronic ignition

The disadvantage of the mechanical system is the use of breaker points to interrupt the low voltage high current through the primary winding of the coil; the points are subject to mechanical wear where they ride the cam to open and shut, as well as oxidation and burning at the contact surfaces from the constant sparking. They require regular adjustment to compensate for wear, and the opening of the contact breakers, which is responsible for spark timing, is subject to mechanical variations. In addition, the spark voltage is also dependent on contact effectiveness, and poor sparking can lead to lower engine efficiency. Electronic ignition (EI) solves these problems. In the initial systems, points were still used but they only handled a low current which was used to control the high primary current through a solid state switching system. Soon, however, even these contact breaker points were replaced by an angular sensor of some kind - either optical, where a vaned rotor breaks a light beam, or more commonly using a Hall effect sensor, which responds to a rotatingmagnet mounted on a suitable shaft. The sensor output is shaped and processed by suitable circuitry, then used to trigger a switching device such as a thyristor, which switches a large flow of current through the coil. The rest of the system (distributor and spark plugs) remains as for the mechanical system. The lack of moving parts compared with the mechanical system leads to greater reliability and longer service intervals. For older cars, it is usually possible to retrofit an EI system in place of the mechanical one. In some cases, a modern distributor will fit into the older engine with no other modifications.

Other innovations are currently available on various cars. In some models, rather than one central coil, there are individual coils on each spark plug. This allows the coil a longer time to accumulate a charge between sparks, and therefore a higher energy spark. A variation on this has each coil handle two plugs, on cylinders which are 360 degrees out of phase; in the four cycle engine this means that one plug will be sparking during the end of the exhaust stroke while the other fires at the usual time, a so-called "wasted spark" arrangement which has no drawbacks. Other systems do away with the distributor as a timing apparatus and use a magnetic crank angle sensor mounted on the crankshaft to trigger the ignition at the proper time.

During the 1980s, EI systems were developed alongside other improvements such as fuel injection systems. After a while it became logical to combine the functions of fuel control and ignition into one electronic system known as an engine management system.

Engine management

In an Engine Management System (EMS), electronics control fuel delivery, ignition timing and firing order. Primary sensors on the system are engine angle (crank or Top Dead Center (TDC) position), airflow into the engine and throttle demand position. The circuitry determines which cylinder needs fuel and how much, opens the requisite injector to deliver it, then causes a spark at the right moment to burn it. Early EMS systems usedanalogue computer circuit designs to accomplish this, but as embedded systems became fast enough to keep up with the changing inputs at high revolutions, digital systems started to appear.

Some designs using EMS retain the original coil, distributor and spark plugs found on cars throughout history. Other systems dispense with the distributor and coil and use special spark plugs which each contain their own coil (Direct Ignition). This means high voltages are not routed all over the engine, they are created at the point at which they are needed. Such designs offer potentially much greater reliability than conventional arrangements.

Modern EMS systems usually monitor other engine parameters such as temperature and the amount of uncombined oxygen[[5]] in the exhaust. This allows them to control the engine to minimise unburnt or partially burnt fuel and other noxious gases, leading to much cleaner and more efficient engines.

Source : http://engineering.wikia.com/wiki/Ignition_system