Learning Objectives

After studying this chapter, you will be able to:

- List the primary purposes of the ignition system.
- Identify the components in a typical magneto system and describe the function of each part.
- Describe small engine ignition advance systems.
- List the advantages of a solid state ignition system.
- Identify the three general classifications of magneto ignition systems and explain the operation of each.
- Describe the operation of a battery ignition system.

Key Terms

- Alnico
- auto-transformer-type ignition coil
- capacitive discharge ignition (CDI) system
- center electrode condenser
- dry-charged batteries
dwell (cam angle)
electronic switching devices
flashover
heat ranges
ignition advance system
ignition coil
insulator
magneto systems
mechanical breaker
point ignition (MBI)
magneto system
mechanical breaker points
reach
spark plug
spark plug wire
transistor-controlled ignition (TCI) system
tungsten
wet-charged batteries

Basic Ignition System Operation

The primary purpose of the ignition system of a small gasoline engine is to provide sufficient electrical voltage to discharge a spark between the electrodes of the spark plug. See Figure 10-1. The spark must occur at exactly the right time to ignite the highly compressed air-fuel mixture in the engine’s combustion chamber.

The ignition system must be capable of producing as many as 30,000 volts to force electrical current (electrons) across the spark plug gap. The intense heat created by the electrons jumping the gap ignites the air-fuel mixture surrounding the electrodes.

The rate, or number of times per minute, at which the spark must be delivered is very high. For example, a single cylinder, four-cycle engine operating at 3600 rpm requires 1800 ignition sparks per minute. A two-cycle engine running at the same speed requires 3600 sparks per minute. In multi-cylinder engines, the number of sparks per minute for one cylinder is multiplied by the number of cylinders.

Every spark must take place when the piston is at exactly the right place in the cylinder and during the correct stroke of the power cycle. Refer to Chapter 5 of this text. Considering the high voltage required, the precise degree of timing, and the high rate of discharges, the ignition system has a remarkable job to do.

Most small gasoline engines use magneto systems to supply ignition spark. Magneto systems produce electrical current for ignition without any
The ignition system of a small engine works hard to produce enough voltage to force electrons to jump the spark plug gap.

outside primary source of electricity. They serve as simple and reliable ignition systems. Basic parts of a magneto system include:
- Permanent magnets.
- Spark plug.
- Spark plug wire.
- Ignition coil.
- Switching device.

A simplified magneto ignition system is shown in Figure 10-2. Note that the magnets are mounted in the flywheel and rotate past the coil assembly as the flywheel spins. In Figure 10-2A, the switching device is closed. As the magnets move past the coil, current is induced in the coils primary windings. This current causes a magnetic field to form around the primary windings. As the engine's piston nears TDC on its compression stroke, the switching device opens and the magnetic field in the primary windings collapses rapidly, inducing a high-voltage current in the secondary windings. The high voltage current travels to the spark plug, where it arcs across the spark plug gap and ignites the air-fuel mixture. See Figure 10-2B. An actual magneto ignition system is much more complex than the model shown here, but the basic operating principles are the same.

**Figure 10-2.**
The major parts of this small engine magneto system are the switching device, coil, flywheel magnets, spark plug wire, and spark plug.

**Ignition System Components**
The following sections detail the components commonly used in small engine ignition systems. An understanding of the construction and operation of these individual components will help you better understand the various systems discussed later in this chapter.
**Ignition Coil**

The *ignition coil* used in a magneto system operates like a transformer. The coil contains two separate windings of wire insulated from each other and wound around a common laminated iron core. See Figure 10-3. The primary winding is heavy-gage wire with fewer turns than the secondary winding, which has many turns of light-gage wire.

When electrical current is passed through the primary winding, a magnetic field is created around the iron core. When the current is stopped, the magnetic field collapses rapidly, cutting through the secondary windings. This rapid cutting of the field by the wire in the coil induces high voltage in the secondary circuit. The high secondary voltage, in turn, causes a spark to jump the spark plug gap and ignite the air-fuel mixture.

**Spark Plugs**

A *spark plug* is a device inserted into the combustion chamber of an engine that ignites the compressed air-fuel mixture. At first glance, an assortment of spark plugs may look very much alike. Actually, there are many variations. Using the correct spark plug for a given engine application can greatly increase the efficiency, economy, and service life of the engine.

Figure 10-4 shows the major parts of a typical spark plug. The terminal nut is the external contact with the ignition coil. Some terminal nuts are removable, others are not. Many of the major parts of the spark plug are used to identify the actual type of the plug. Other considerations include construction, heat rating number, and firing end construction. To learn how to identify spark plug types, use the spark plug symbols chart in Figure 10-5.

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**Figure 10-3.**

An ignition coil consists of two windings. The coil functions as a step-up transformer to produce high voltage and low amperage from low voltage and high amperage.

**Figure 10-4.**

A spark plug carries high-voltage current produced by the ignition system. It also must withstand the high temperatures and shock of combustion, insulate the center electrode against current loss, and seal against compression leakage. (Deere & Co.)
Figure 10-5.
This chart explains how to identify spark plugs.
The spark plug *insulator* is usually an aluminum-oxide ceramic material, which has excellent insulating properties. The insulator must have high mechanical strength, good heat conducting quality, and resistance to heat shock. Generally, ribs on the insulator extend from the terminal nut to the shell of the plug to prevent flashover. *Flashover* is the tendency for current to travel down the outside of the spark plug instead of through the center electrode.

The *center electrode* carries the high voltage current to the spark gap. If the electrical potential is great enough to cause the current to jump the plug gap, the side electrode will complete the circuit to ground.

The gasket seal is a compacted powder that helps ensure permanent assembly and eliminates compression leakage under all operating conditions. The inside gasket also acts as a seal between the insulator and the steel shell.

Spark plug *reach* varies with type of spark plug. Some are long, others quite short. See Figure 10-6. Several standard thread sizes are commonly used. Threads on some spark plugs are metric sizes, usually 14mm.

**Spark Plug Heat Transfer**

Heat transfer in spark plugs is an important consideration. The heat of combustion is conducted through the plug as shown in Figure 10-7. Spark plugs are manufactured in various *heat ranges* from *hot* to *cold*. See Figure 10-8. Cold running spark plugs are those that transfer heat readily from the firing end. They are used to avoid overheating in engines having high combustion temperatures.

In figuring spark plug heat range, the length of the insulator nose determines how well and how far the heat travels. Spark plug A in Figure 10-8, for example, is a hot plug because the heat must travel a greater distance to the cylinder head. Spark plug D is comparatively colder than A. A cold plug installed in a cool running engine will tend to foul. Cool running usually occurs at low power levels, continuous idling, or in start/stop operation.

The tip of the insulator is the hottest part of the spark plug and its temperature can be related to preignition (firing of fuel charge prior to normal ignition) or plug fouling. Experiments show that if combustion chamber temperature exceeds 1750°F (954°C) in a four-cycle engine, preignition is likely to occur. If insulator tip temperature drops below 700°F (371°C), fouling or shorting of the plug due to carbon is likely to occur.

![Figure 10-6.](image)

Spark plug reach (length of thread) can vary considerably from one plug to another. Too long a reach can damage a piston. Too short a reach provides poor combustion.

![Figure 10-7.](image)

The heat of ignition and combustion must be conducted away from critical parts of the spark plug to prevent preignition and burning of the electrodes.

![Figure 10-8.](image)
Spark plug heat transfer determines whether the plug is hot or cold. Heat is controlled by the insulator nose.  
(AC Spark Plug Div., GMC)

**Spark Plug Wire**

The *spark plug wire* connects the output of the ignition coil secondary windings to the spark plug. The spark plug wire is heavily insulated because it carries high voltage. If the insulation deteriorates, much of the voltage can be lost by arcing to nearby metallic parts of the engine.

Two common methods of spark plug wire connections are shown in Figure 10-9. Application A uses the exposed clip, which is satisfactory in uses where moisture, oil, or dirt will not get on the plug or can easily be wiped off. The boot type, shown at B, provides better plug protection.

**Switching Devices**

Switching devices are used in the ignition system to control the primary current to the ignition coil. The switching devices are either mechanical or electronic.

The ignition systems in some older engines use *mechanical breaker points* to control primary current to the coil. The breaker points generally consist of two tungsten contacts. One contact point is stationary, the other is movable. Each contact is fastened to a bracket. See Figure 10-10. Tungsten is a hard metal with a high melting temperature. These characteristics are needed to withstand the continual opening and closing that takes place and the eroding effect of the arc that occurs when the points break (start to open).

The ignition systems in most engines use *electronic switching devices* to control the primary current to the coil. An electronic switching device is more dependable than a mechanical type because it has no moving parts wear or burn out.
Magneto Ignition Systems

There are several types of magneto systems used on small engines. These systems are classified by the type of switching device they use to control primary current to the coil. Mechanical breaker point ignition (MBI) systems use mechanical breaker points to control current in the ignition coil. This type of system was used exclusively until the development of the solid state ignition system. Today, all ignition systems in late-model engines are of the solid state type. Solid state systems use electronic devices (transistors, capacitors, diodes, etc.) to control various ignition system functions. Solid state ignition systems provide many advantages over mechanical systems:

- Since there are no moving parts, mechanical adjustments are not required.
- No breaker points to burn, pit, or replace.
- Increase spark plug life.
- Easy starting, even with fouled plugs.
- Higher spark output and faster voltage rise.
- Spark advance is electronic and automatic. It never needs adjusting.
- Electronic unit is hermetically sealed and unaffected by dust, dirt, oil, or moisture.
- System delivers uniform performance throughout component life and under adverse operating conditions.
- Improves idling and provides smoother power under load.

The following are the three general classifications of magneto ignition systems.
1. A capacitor discharge ignition (CDI) system is a solid state (no moving parts) system that stores its primary energy in a capacitor and uses semiconductors for timing or triggering the system.
2. A transistor-controlled ignition (TCI) system is an inductive system that does not use mechanical breaker points. It utilizes semiconductors (transistors, diodes, etc.) for switching purposes.
3. A mechanical breaker point ignition (MBI) system is a flywheel magneto inductive system commonly used for internal combustion engines until the mid-1980's. It employs mechanical breaker points to time or trigger the system.

Note

Figure 10-11 compares these three types of magneto ignition systems. Study them carefully!

<table>
<thead>
<tr>
<th>Comparisons</th>
<th>Mechanical Breaker Ignition System</th>
<th>Transistor Controlled Ignition System</th>
<th>Capacitor Discharge Ignition System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abbreviation</td>
<td>MBI</td>
<td>TCI</td>
<td>CDI</td>
</tr>
<tr>
<td>Circuit type</td>
<td>Conventional</td>
<td>Solid state</td>
<td>Solid state</td>
</tr>
<tr>
<td>Energy source</td>
<td>Primary current of ignition coil</td>
<td>Primary current of ignition coil</td>
<td>Stored in capacitor</td>
</tr>
<tr>
<td>Trigger switch</td>
<td>Breaker contacts</td>
<td>Power transistor</td>
<td>Thyristor</td>
</tr>
<tr>
<td>Secondary voltage</td>
<td>Standard</td>
<td>Standard</td>
<td>Standard</td>
</tr>
<tr>
<td>Spark duration</td>
<td>Standard</td>
<td>Standard</td>
<td>Shorter</td>
</tr>
<tr>
<td>Rise time*</td>
<td>Standard</td>
<td>Standard</td>
<td>Shorter</td>
</tr>
<tr>
<td>Maximum operating speed</td>
<td>Standard</td>
<td>Higher</td>
<td>Higher</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Regap and retime</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

*Rise time—time required for maximum voltage to occur.

Figure 10-11

This chart compares mechanical breaker point, transistor-controlled, and capacitor discharge ignition systems.
Operation of Capacitive Discharge Ignition (CDI) System

The capacitive discharge ignition (CDI) system is a solid state ignition system. It is standard equipment in many applications and has improved the reliability of modern small gasoline engines. The only moving parts in a CDI system are the permanent magnets in the flywheel. Figure 10-12 shows a CDI module installed on a small gasoline engine.

Refer to Figure 10-13 to progressively trace current flow through the various electronic components in a typical CDI system.

As the flywheel magnets rotate across the CDI module laminations, they induce a low voltage alternating current (ac) in the charge coil. The ac passes through a rectifier and is changed to direct current (dc), which travels to the capacitor, where it is stored.

Figure 10-12.
The CDI ignition module is compact and maintenance free. The only moving parts in a CDI system are the flywheel magnets.

Figure 10-13.
The flywheel magnets induce a low-voltage alternating current in the charge coil. As the alternating current passes through the rectifier, it is changed to direct current. The direct current continues to the capacitor, where it builds up a charge. When the capacitor nears its full charge, the flywheel magnets induce a small current in the trigger coil. The current briefly activates the silicon controlled rectifier (SCR), which allows the 300V stored in the capacitor to discharge through the primary windings of the spark coil. This induces a much higher voltage in the secondary windings, which fires the spark plug.
When the silicon controlled rectifier is triggered, the 300V dc stored in the capacitor travels to the spark coil. At the coil, the voltage is stepped up instantly to a maximum of 30,000V. This high voltage current is discharged across the spark plug gap.

In Figure 10-14, the flywheel magnets rotate approximately 351° before passing the CDI module laminations and inducing a small electrical charge in the trigger coil. At starting speeds, this electrical charge is just great enough to turn on the silicon controlled rectifier (SCR) in a retarded firing position (9° BTDC). This provides for easy starting.

In Figure 10-15, when the engine reaches approximately 800 rpm, advanced firing begins. The flywheel magnets travel approximately 331°, at which time enough voltage is induced in the trigger coil to energize the silicon controlled rectifier in the advanced firing position (29° BTDC).

**Operation of Transistor-Controlled Ignition (TCI) System**

The individual components that make up the transistor-controlled ignition (TCI) system are given in a chart in Figure 10-16. Study the function of each part carefully.

There are a variety of transistor-controlled circuits. Each has its own unique characteristics and modifications. Figure 10-17 illustrates a typical circuit for a transistor-controlled ignition. Refer to this circuit as its principles are described in the following section.

As the engine flywheel rotates, the magnets on the flywheel pass by the ignition coil. The magnetic field around the magnets induces current in the primary windings of the ignition coil.

The base circuit of the ignition system has current flow from the coil primary windings, common grounds, resistor (R1), base of the transistor (T1), emitter of the transistor (T1), and back to the primary windings of the ignition coil.

Current flow for the collector circuit in Figure 10-17 is from the primary windings of the coil, common grounds, collector of transistor (T1), emitter of transistor (T1), and back to the primary windings.

When the flywheel rotates further, the induced current in the coil primary increases. When the current is high enough, the control circuit turns on...
### Table of Components

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diode (D1, D2)</td>
<td>Allows one way current from Anode “A” to Cathode “K” as rectifier.</td>
</tr>
<tr>
<td>Flywheel</td>
<td>Provides magnetic flux to primary windings of ignition coil.</td>
</tr>
<tr>
<td>High-tension lead</td>
<td>Conducts high voltage current in secondary windings to spark plug.</td>
</tr>
<tr>
<td>Ignition coil</td>
<td>Generates primary current, and transforms primary low voltage to secondary high voltage.</td>
</tr>
<tr>
<td>Ignition switch</td>
<td>No spark across gap of spark plug when switch is at “STOP” position.</td>
</tr>
<tr>
<td>Resistor (R1, R2)</td>
<td>Resists current flow.</td>
</tr>
<tr>
<td>Spark plug</td>
<td>Ignores fuel-air mixture in cylinder.</td>
</tr>
<tr>
<td>Thyristor (S)</td>
<td>Switches from blocking state to conducting state when trigger current/voltage is on gate “G”.</td>
</tr>
<tr>
<td>Transistor (T, T1, T2)</td>
<td>Very small current in the base circuit (B to E) controls and amplifies very large current in the collector circuit (C to E). When the base current is cut, the collector current is also cut completely.</td>
</tr>
</tbody>
</table>

### Figure 10-16.
Study the components of transistor-controlled ignition systems.

![Diagram of Ignition System Components](image)

### Figure 10-17.
Study how this transistor circuit is used to operate the ignition coil. Note differences and similarities.

and begins to conduct current. This causes transistor (T2) to turn on and conduct. A strong magnetic field forms around the primary winding of the ignition coil.

The trigger circuit for this ignition system consists of the primary windings, common grounds, control circuit, base of transistor (T2), and emitter of transistor (T2).

When transistor (T2) begins to conduct current, the base current flow is cut. This causes the collector circuit to shut off, and the transistor (T1) stops conducting current.

When transistor (T1) stops conducting, current stops flowing through the primary of the ignition coil. This causes the primary magnetic field to collapse across the secondary windings of the ignition coil. High voltage is then induced into the secondary winding to fire the spark plug.

The secondary circuit includes the coil secondary windings, spark plug wire, spark plug, and common grounds returning to the coil secondary.
When the ignition switch is off, the primary circuit is grounded to prevent the plug from firing. Diode (D1) is installed in the circuit to protect the TCI module from damage.

The ESG circuit shown in Figure 10-17 is used to retard the ignition timing. At high engine rpm, the ESG circuit conducts. This bypasses the trigger circuit and delays when the current reaches the base of transistor (T2).

**Operation of the Mechanical Breaker Point Ignition (MBI) System**

For many years, the mechanical breaker point ignition (MBI) system supplied the ignition spark on most small engines. Major components and operation of a typical MBI system are illustrated in Figure 10-18. The coil, condenser, and breaker points may be found inside or outside of the flywheel. This varies with engine type, but the principles of operation remain basically the same.

The **condenser** plays an important part in MBI system operation. Its primary purpose is to prevent current from arching across the breaker point gap as the points open. If arcing were to occur, it would burn the points and absorb most of the magnetic energy stored in the ignition coil. Not enough energy would be left in the coil to produce the necessary high voltage surge in the secondary circuit. The condenser absorbs current the instant the breaker points begin to separate. Since the condenser absorbs most of the current, little is left to form an arc between the points.

Magnets are usually cast into the flywheel and cannot be removed. They are strong permanent magnets made of **Alnico** (aluminum, nickel, cobalt alloy) or a ceramic magnetic material.

The breaker points in the MBI system are mechanically actuated, opened by the cam and closed by the breaker point spring. As the flywheel turns, the magnets pass over the legs of the laminated core of the coil. When the north pole of the magnet is over the center leg of the coil, the magnetic lines of force move down the center leg through the coil, across the bottom of the lamination, and up the side leg to the south pole. See Figure 10-18.

As the flywheel continues to turn, the north pole of the magnet comes over the side leg and the south pole is over the center leg of the core. Now the lines of force move from the north pole down through the side leg, up through the center leg and coil, and to the south pole. At this point, the lines of force have reversed direction.

Figure 10-19 shows the field reversal taking place in the center leg of the core and coil. The reversal induces low-voltage current in the primary circuit through the breaker points. Current flowing in the primary winding of the coil creates a primary magnetic field of its own, which reinforces and helps maintain the direction of the lines of force in the center leg of the lamination. It does this until the magnets’ poles move into a position where they can force the existing lines of force to change direction in the center leg of the lamination. Just before this happens, the breaker points are opened by the cam.

Opening of the points breaks the primary circuit, and the primary magnetic field collapses through the turns of the secondary winding. See
**Figure 10-19.**
The change in the magnetic field through the core induces a voltage in the primary circuit. Since the breaker points are closed, the current is able to flow through the circuit. The current through the primary windings builds a magnetic field that passes through the secondary windings.

**Figure 10-20.**
When the breaker points open, the magnetic field around the primary windings collapses quickly through the secondary windings. This induces high voltage in the secondary windings, which is required to fire the spark plug. The field collapse also cuts through the primary windings, where it induces a moderate voltage that is absorbed by the condenser.

**The Stop Switch**

The spark plug can only fire when the ignition points open the primary circuit. Using this as a basis for a stop switch, the switch is designed to ground the movable breaker point so that, in effect, the points never open. Therefore, the engine stops running.

Another common method of stopping single cylinder engines is by means of a strip of metal fastened to one of the cylinder head bolts. When the engine is running, the strip is suspended about 1/2" from the spark plug wire terminal. By depressing the strip against the plug wire, the current flows down the strip to the cylinder head, preventing a spark at the plug. There is no danger of shock to the operator.
Figure 10-21.
The spark plug fires, and the condenser discharges voltage back into the primary circuit.

Warning
When stopping single cylinder engines by means of a strip of metal fastened to one of the cylinder head bolts, do not touch the spark plug directly.

Ignition Advance Systems

Some MBI systems have mechanical systems that retard occurrence of spark for starting. For intermediate- and high-speed operation, the ignition advance system causes the spark to occur earlier in the cycle.

One type of ignition advance system is illustrated in Figure 10-22. Two different spark timings are provided, one for starting and one for running. For starting, the spark-advance flyweight holds the cam in a position so that the ignition spark occurs at 6° of crankshaft rotation before the piston reaches top dead center (TDC). See Figure 10-22A.

When the engine reaches a speed of nearly 1000 rpm, centrifugal force moves the flyweight out, forcing the cam to rotate. This position of the cam causes the points to open and a spark to occur at 26° before top dead center. See Figure 10-22B.

Dwell and Cam Angle

Dwell (cam angle) is the time the breaker points stay closed during one revolution of the cam. Dwell is measured in degrees of cam rotation from the point of closing to the point of opening. Figure 10-23 shows the direct relationship between the breaker point gap setting and dwell time.

Figure 10-23A indicates what might be considered normal dwell time. Figure 10-23B shows a large point gap with a correspondingly short dwell. Note that the wear block must travel quite a distance to a lower position on the lobe before the points make contact. Then, they open with just the slightest rise in the lobe.

The narrow point gap illustrated in Figure 10-23C causes the breaker points to close after only a slight travel down the lobe, but more distance is required up the lobe to open the points.

Remember that the cam is driven directly from the crankshaft. When the breaker points open, the spark plug fires. Obviously, then, changing the point setting can also change spark timing. The engine manufacturer specifies which gap setting

Magneto Ignition Systems for Two-Cylinder Engines

The magneto systems used in two-cylinder engines must fire the spark plug in each cylinder at the correct time. This is accomplished in one of two ways. Some systems use two coil assemblies to fire the plugs. These assemblies are mounted near the flywheel and are located 180° apart. As the magnets in the flywheel move past each assembly, the corresponding spark plug fires at the proper time.

Other two-cylinder engines use a waste-spark system to fire the spark plugs. In this type of system, the coil assembly has two secondary outputs and fires both spark plugs at the same time. The spark occurs when the piston in one cylinder is on its compression stroke and the piston in the other cylinder is on its exhaust stroke. The spark that occurs during a cylinder’s exhaust stroke has no effect on engine operation and is, therefore, considered a “waste” spark.

Battery Ignition Systems

The battery ignition system has a low voltage primary circuit and a high voltage secondary circuit. Like the magneto system, it consists of a coil, solid state switching device (or points and condenser), and spark plug. The basic difference is that the source of current for the primary circuit is supplied by a lead-acid battery. See Figure 10-24.

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**Figure 10-24.**

A battery ignition system is similar to a magneto system, except that the battery replaces the flywheel magnets. (Kohler Co.)
When the ignition switch is turned on, current flows from the positive post of the battery to the ignition coil. Current traveling through the primary windings of the coil builds up a magnetic field. See Figure 10-25. During this time, the switching device is closed. Ignition at the plug is not required, so the current returns to the battery through the common ground.

Then, at the exact time when ignition at the plug is required, the switching device opens. Current flow stops abruptly, causing the magnetic field surrounding the coil to collapse. See Figure 10-26. This rapid change of magnetic flux causes voltage to be induced in every turn of the secondary windings.

The voltage built up in the secondary winding of the coil can become as high as 30,000V. The secondary windings have approximately 100 times as many turns of wire as the primary. See Figure 10-27. Normally, the voltage does not reach this value. Once it becomes great enough to jump the spark plug gap, the voltage drops. Usually, the amount required to jump the gap is between 6000V and 20,000V. The actual amount of voltage required depends on variables such as compression, engine speed, shape and condition of electrodes, spark plug gap, etc.

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**Figure 10-25.**
When the switching device closes in a battery ignition system, primary current builds a magnetic field around the coil. (Kohler Co.)

**Figure 10-26.**
The switching device opens and the field collapses, inducing high voltage in the secondary windings of the coil. (Kohler Co.)
Summary

The primary purpose of the ignition system is to provide sufficient voltage to discharge a spark between the electrodes of a spark plug. Many small engines use magneto systems to supply ignition spark. Magneto systems are self-contained systems that produce electrical current for ignition without an outside primary source of electricity. Basic magneto system parts include permanent magnets, coil, switching devices, spark plug wire, and spark plug.

Using the correct spark plug can greatly increase engine efficiency and service life. Reach, heat range, and electrode type must all be considered.

Many small engines are equipped with solid state ignition systems that use electronic devices in place of one or more mechanical ignition components. Most solid state systems have no moving parts and do not require mechanical adjustments. The two most common solid state systems are the capacitive discharge ignition (CDI) system and the transistor-controlled ignition (TCI) system.

The CDI system stores primary energy in a capacitor and uses semiconductor devices to trigger the ignition system. The TCI system is an inductive system that utilizes semiconductor devices (transistors, diodes, etc.) for switching purposes.

The mechanical breaker point ignition system is a flywheel magneto inductive system. It employs mechanical breaker points to time the triggering of the ignition system. Some small engines are equipped with mechanical systems that retard and advance timing. Dwell (cam angle) is the amount of time that the breaker points stay closed during one revolution of the cam.

Instead of a magneto, some ignition systems use a lead-acid battery to supply primary current. These systems generally employ an auto-type ignition coil. Because the battery is the only source of energy for battery ignition systems, a generator is used to replenish energy in the battery.

Review Questions

Answer the following questions on a separate sheet of paper.

1. Describe the two major tasks performed by an ignition system.
2. If a four-cycle engine runs at 3600 rpm, the number of sparks per minute required at the spark plug would be ______.
3. Name the main electrical components that make up the magneto ignition system.
4. The coil acts as a transformer that ______.
   A. steps down the voltage and increases the output amperage
   B. steps up the voltage and amperage
   C. steps down the voltage and amperage
   D. steps up the voltage and decreases the output amperage
5. In the ignition coil, the primary winding has ______.
   A. many turns of fine wire
   B. few turns of fine wire
   C. few turns of heavy wire
   D. many turns of heavy wire
6. What is the purpose of the ribs on the spark plug insulator?
7. Would a cool spark plug have a short or long insulator nose?
8. Define preignition.
9. When the switching device in the magneto is closed, ______.
   A. current is induced in the primary circuit by the flywheel magnets
   B. the spark plug fires
   C. a high voltage is induced in the secondary circuit
   D. All of the above.
10. True or False? Electronic switching devices are more dependable than mechanical switching devices.
11. Breaker point contacts are made of a very hard material called ______.
12. Name five advantages of a solid state ignition system.

13. The only moving parts in a CDI system are the _____ in the flywheel.

14. What is the purpose of the condenser used in an MBI system?

15. The ignition advance system causes spark to occur _____ in the cycle during intermediate- and high-speed operation.

16. When breaker points are set with a wider gap, the dwell _____.
   A. becomes greater  
   B. becomes less  
   C. does not change

17. Describe the operation of a waste-spark ignition system.

18. The amount of voltage required to jump the spark plug gap depends on _____.
   A. spark plug gap  
   B. electrode condition  
   C. engine speed  
   D. All of the above.

19. When connecting the auto-type ignition coil in the circuit, the positive terminal of the battery must be connected to _____.
   A. the positive terminal of the coil  
   B. the negative terminal of the coil  
   C. either terminal of the coil

20. A(n) _____ is used to replenish energy in the battery used in battery ignition systems.

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**Suggested Activities**

1. Make a visible magneto mounted on a display board or built into a clear acrylic box so that it can be manually turned with a crank. Old, but usable, engine parts can be used.

2. A workable battery ignition system can be built and mounted as a display board. Demonstrate the operation and principles involved in this system.

3. Make a collection of various kinds of spark plugs.

4. Section an old ignition coil to show the primary and secondary windings around the core.

5. Carefully open a condenser to display the lamination of aluminum foil and insulation.

6. Disassemble a magneto and demonstrate how it works.
This walk-behind greens mower is used for golf course maintenance. It is driven by a four-cycle, overhead valve 3.7 horsepower engine. (Deere & Co.)
CHAPTER 10
Ignition Systems

Learning Objectives

After studying this chapter, you will be able to:

- List the primary purposes of the ignition system.
- Identify the components in a typical magneto system and describe the function of each part.
- Describe small engine ignition advance systems.
- List the advantages of a solid state ignition system.
- Identify the three general classifications of magneto ignition systems and explain the operation of each.
- Describe the operation of a battery ignition system.

Instructions: After studying the chapter, complete the following questions and problems.

1. The primary purpose of the ignition system of a small gasoline engine is to provide sufficient electrical voltage to discharge ____.
   A. gasoline
   B. air
   C. a spark between the electrodes of the spark plug
   D. a spark to create flashover

2. The ignition system must be capable of producing as much as ____ volts to force the electrical current across the plug gap.

3. A single cylinder, four-cycle engine running at 3600 rpm requires ____ ignition sparks per minute.

4. Magneto systems produce electrical current for ignition without an outside primary source of ____.
5. Identify the basic parts of the magneto ignition system shown below.

6. In an ignition coil, the primary windings are _____.
   A. light gage with many turns
   B. heavy gage with few turns
   C. light gage with few turns
   D. heavy gage with many turns

7. Identify the spark plug parts indicated below.

8. List three characteristics the ceramic spark plug insulator must have.

9. Ribs on the ceramic spark plug insulator are there to prevent _____.

10. A cold spark plug installed in a cool running engine will tend to _____.
11. In figuring spark plug heat range, the length of the ___ determines how far and how well the heat travels.

12. The hottest part of the spark plug is the ___ of the insulator.

13. Experiments show that preignition is likely to occur if combustion chamber temperature exceeds ____ in a four-cycle engine.

14. If the insulator tip temperature is below 700°F (371°C), plug ____ or ____ is likely to occur.

15. The breaker point contacts are made of ____.

16. A(n) ____ ignition system is a flywheel magneto inductive system that employs mechanical breaker contacts to time or trigger the system.

17. A(n) ____ ignition system uses electronic devices to control various ignition system functions.

18. Explain why no mechanical adjustments are necessary in a solid state ignition system.

20. A(n) ____ ignition system is a solid state system that stores its primary energy in a capacitor and uses semiconductors for timing or triggering the system.

21. In CDI ignitions systems, the ____ is triggered to create a path to ground through the coil.
   A. exciter coil
   B. capacitor
   C. secondary circuit
   D. SCR

19. List ten advantages of solid state ignition systems.
22. The main purpose of the condenser is to prevent ____ across the breaker point gap as the points open.

23. The breaker points are opened by the ____ and closed by the breaker point spring.

24. The high voltage to spark the spark plug is induced in the secondary windings only when the breaker points ____.

25. Two methods commonly used to stop the engine are to ground the breaker points with a stop switch, or to ground the ____ wire.

26. High-speed operations require the spark timing to be automatically ____.

27. When starting an engine with an advance system, the spark timing should be ____.

28. Dwell is the time the breaker points stay ____ during one revolution of the cam.

29. A large breaker point gap will produce a(n) ____ dwell.

30. Changing the point gap setting can also change spark ____.

31. The basic difference between a magneto and a battery ignition system is that the ____ current is supplied by a(n) ____ battery.

32. The engine stop switch in a magneto ignition system ____ the primary circuit. In a battery ignition system the stop switch ____ primary circuit.
   A. opens, shorts
   B. shorts, opens

33. The auto-transformer coil used on some small engines increases low-voltage ____ current to the high voltage required to bridge the spark plug gap.

34. The positive terminal of the coil must be connected to the ____ side of the battery.

35. In a lead-acid battery, the cell plates are made of ____ and a(n) ____ acid and water solution serves as the electrolyte.

36. The ampere-hour rating (capacity) of a battery is directly related to the number of ____ per ____.

37. Each cell of a battery in good condition contributes approximately ____ volts to the total charge of the battery.
Research and write complete answers to the following questions.

38. Explain how the capacitive discharge (CDI) magneto ignition system works. Describe the function of each of the components.

39. Describe the importance of the spark plug gap setting and heat range. What controls or determines the heat range of a spark plug?

40. Describe proper care of a lead-acid battery including testing and charging procedures. Include safe handling and emergency procedures.