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AE260 Principles of Small Gasoline Engine Operation

Matches these 2015 National AFNR Career Cluster Content Standards:
PST.03.01.
Common Core State Standards:
Reading #1, 4 and 7; Writing #7; and Language #4. Click for CCSS details.

MAIN IDEA: How do small engines operate?

The first engines were external combustion engines. This type of engine refers to the burning of fuel that takes place outside the engine. Usually, the heat from combustion outside the engine turned water into steam, which in turn powered pistons inside the engine. The drawbacks of this type of engine were that they were large, cumbersome and heavy. Multiple people were often required to operate these engines. These early steam engines were initially stationary engines which were pulled to and from job sites by animals. They saw limited use on the farm.

Internal combustion engines burn fuel inside the engine and provide more efficient power at a much reduced size and weight. As with the steam engine, the power for an internal combustion engine comes about as a result of a piston moving inside a cylinder.

Almost all machinery used on modern farms is powered by internal combustion engines. Large engines run tractors, combines and other harvesting equipment where a great deal of power is needed. The engines on large farm equipment usually have from three to six cylinders. Generally these engines are expensive and require regular maintenance.

Small engines usually have only one or two cylinders and are lightweight, powerful and relatively inexpensive. Most of these small engines are simple to operate, maintain and repair. Almost anyone with a minimal amount of tools and know-how can do the maintenance and repairs required to use these machines. A thorough understanding of how small engines operate is essential to maintenance and repair.

ENGINE COMPONENTS

A small engine consists of a piston that operates within a cylinder that is only slightly larger in diameter than the piston. The piston is connected to a crankshaft that converts the up and down motion of the piston into rotary motion that in turn rotates a gear, wheel or other implement.

The cylinder is capped with a thick plate called a head that seals the cylinder. Within the block (the mass of metal that contains the cylinder) or within the head are two valves. One valve, the intake valve, lets in the fuel mixture; and the

other, the exhaust valve, lets the exhaust fumes out. Some modern, large engines may have as many as four valves to every cylinder.

A device known as a carburetor mixes gasoline with air to provide fuel to the cylinders. A governor keeps the engine running at a constant speed.

An ignition system consisting of a magneto and spark plug provides a means to ignite the fuel in the cylinder.

TYPES/CLASSIFICATIONS OF ENGINES

There are 3 different ways to classify engines. They can be classified by 1) the manufacturer, 2) the crankshaft orientation and 3) by the number of strokes per cycle.

Classification by manufacturer:

The first way to classify engines is by the manufacturer of the engine. This can include company names like Honda, Briggs and Stratton, Kawasaki and Kohler just to name a few. Many who have limited knowledge of engines simply describe them this way.

Classification by crankshaft orientation:

A second way to classify engines is by its crankshaft orientation. The crankshaft is the portion of the engine attached to the piston. The crankshaft converts the linear motion of the piston into circular motion that is needed for work. One end of the crankshaft is attached to the starting mechanism of the engine, while the other end is attached to the work. For example, in a small lawn mower, one end of the crankshaft is attached to the pull rope and the other end is attached to the blade.

There are three crankshaft orientations: 1) horizontal, 2) vertical and 3) multi-position. A horizontal crankshaft is installed from side to side, while a vertical crankshaft is installed up and down.

In a horizontal crankshaft engine, the crankshaft runs horizontally through the engine block. An example of the use of these engines would be a tiller or pressure washer.

In a vertical crankshaft engine, the crankshaft runs vertically through the engine block. This would be used in a traditional push lawn mower.

Both the horizontal and vertical shaft engine positions are used in four-stroke cycle engines. Four-stroke cycle engines will be discussed later in this lesson. Engines with a horizontal crankshaft are designed to be used only in a horizontal position, while those with a vertical crankshaft are designed to be used only in a vertical position.

The multi-position crankshaft is used only in two-stroke cycle engines, such as chain saws or string trimmers. This multi-position crankshaft, while stationary in the engine block, allows the equipment to be operated in any direction or position.

Classification by number of strokes

The third way to classify engines is by the number of strokes per cycle. A stroke is the movement of the piston in the engine cylinder. A cycle is the completion of all events that must occur in an internal combustion engine. These events are intake of fuel and air, compression of the fuel and air, combustion of the fuel and air, and expelling of the burned gases. There are both two-stroke cycle engines and four-stroke cycle engines.

Two-stroke engines are lightweight and can be operated in any position. They are used on chain saws, string trimmers, leaf blowers, etc. Oil is mixed with the fuel and requires no separate oil reservoir. For this reason, the engine can be run

in any position, even upside down.

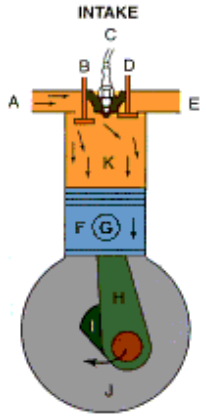
Four-stroke engines are larger than two-cycle engines and are used on lawn mowers, tillers, grain augers, etc. Fuel and oil are separate. Four-stroke engines can only be operated in one position -- either horizontal or vertical, depending on the crankshaft position.

The four-stroke engine:

As the name indicates, a four-stroke engine must complete four movements of the piston before the cycle is complete. The movement of the piston is all the way to the top (called top dead center or TDC) and all the way to the bottom (called bottom dead center or BDC) of the cylinder. Each of these movements is called a stroke and each stroke serves a particular purpose.

1. Intake stroke: The four-stroke cycle begins with the piston moving down. When this occurs, the intake valve opens and a mixture of fuel and air enters the cylinder. This is called the intake stroke. At the completion of this stroke, the piston is at the bottom of the cylinder and both valves are closed.

KEY:
A = Intake passage
B = Intake valve
C = Spark plug
D = Exhaust valve
E = Exhaust passage
F = Piston
G = Piston pin
H = Connecting rod
I = Crankshaft
J = Crankcase
K = Combustion chamber



2. Compression stroke: When the piston reaches the bottom of the cylinder on the intake stroke, the piston starts back up in the compression stroke. Both valves are closed. At the top of this stroke, the fuel mixture is compressed tightly into the space between the top of the piston and the cylinder head.

At the top of the compression stroke, the air and fuel mixture has been compressed into just the area in the head called the combustion chamber.

The relationship between the volume of the cylinder plus combustion chamber at the beginning and end of this stroke is known as the compression ratio. Compression ratios for small gasoline engines are around six to one. The ratio is written as 6:1.

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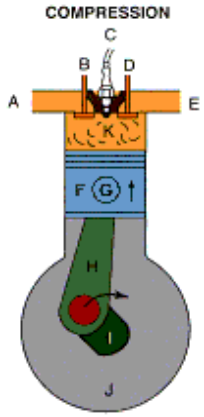

3. Power stroke: As the piston nears the top of the cylinder on the compression stroke, a spark from the spark plug ignites the mixture for gasoline powered engines. Diesel engines work differently. The resulting rapid expansion of the burning mixture pushes the piston back down in the power stroke.

During the power stroke, both valves are tightly closed. Usually, the larger the cylinder and piston, the more power the engine can produce. This is because there is more room for the gasoline/air mixture and a larger amount of energy is released when the gases are ignited.

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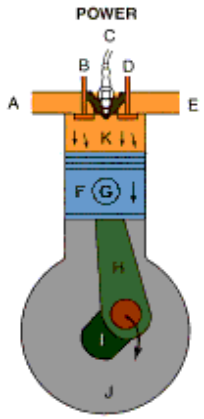

4. Exhaust stroke: When the piston reaches the bottom, it starts back up in the exhaust stroke. As the piston moves up, the exhaust valve opens and the exhaust fumes are pushed out of the cylinder. The exhaust stroke is completed with the piston at top dead center, when the exhaust valve opens and the exhaust gases are removed. As the piston starts back down, the exhaust valve closes, the intake valve opens, the intake stroke begins, and the cycle is repeated.

The crankshaft makes two complete turns or revolutions in the cycle and four strokes of the piston. It is the momentum or turning force of the weights on the flywheel and other moving parts that carries the engine through the three nonpower strokes. In engines with more than one cylinder, one cylinder will be on the power stroke while the other cylinders are on their nonpower strokes.

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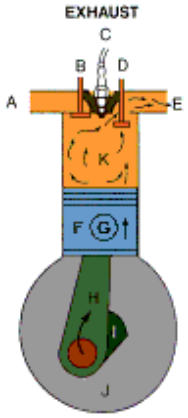


The two-stroke engine:

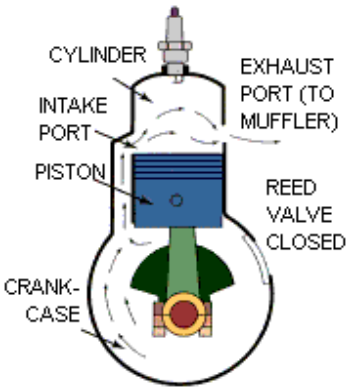
The two-stroke engine completes the intake, compression, power and exhaust stages in two strokes. The crankcase of the engine does not contain a separate oil reservoir. Instead, the gasoline and oil are premixed. This allows these engines to be operated in any position.

The two-stroke engine does not contain valves like a four-stroke engine. The two-stroke engine contains a reed valve or port which serves to admit the air-fuel mixture from the carburetor when the piston moves away from the crankshaft, and to exhaust gases out when the piston moves toward the crankshaft.

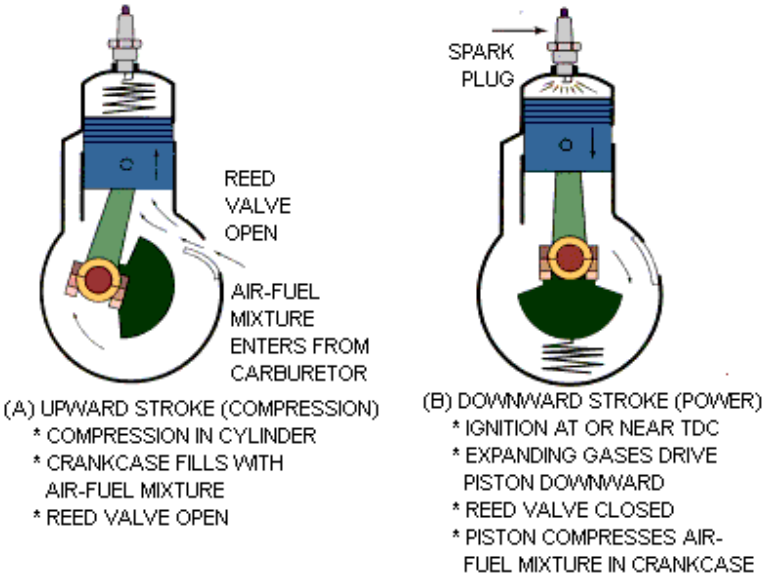
To begin a cycle, the piston moves upward and creates a vacuum in the crankcase of the engine. The air-fuel mixture from the carburetor rushes into the crankcase to fill the vacuum. When the piston stops its upward movement, the reed valve closes by its own spring action. The piston then moves down and as the piston nears the bottom of its stroke, it uncovers the intake and exhaust port(s). The air-fuel mixture in the crankcase rushes through a passage to the intake port and enters the cylinder. This incoming gaseous mixture pushes air or exhaust out of the cylinder. Therefore, intake and exhaust functions occur with very little movement of the piston.

The cylinder now is filled with an air-fuel mixture. The piston moves upwards, closes the intake and exhaust ports, and compresses the air-fuel mixture trapped in the cylinder. At the same time, a new supply of air and fuel rushes into the crankcase.

At or near top dead center (TDC) the spark plug fires to ignite the mixture. The burning and expanding gases drive the piston downward through the power stroke. As the piston moves down, the exhaust port is uncovered and borned gases are expelled out of the engine. The cycle begins again as a new supply of fuel mixture is taken into the cylinder.



(C) ACTION AT BOTTOM DEAD CENTER (EXHAUST INTAKE)



INTERNET RESOURCES:

** Briggs & Stratton
https://www.briggsandstratton.com/na/en_us/home.html

** Briggs & Stratton - How a 4-Cycle Engine Works
3:04-minute video uses animation to show how a 4-cycle engine works
https://www.youtube.com/watch?v=cPaLFLQfQeA

** Castrol Motor Oils
https://www.castrol.com/en_us/united-states.html

** How Engines Work - See Through Engine in Slow Motion - Smarter Every Day
8:30-minute video uses a transparent engine to view the strokes in a 4-cycle engine.
https://www.youtube.com/watch?v=xfIY5uS-nnw

** Kohler Engines
https://kohlerpower.com/en/engines

** Lawn-Boy
https://www.lawnboy.com/

** MechanicsTips - How 2 Stroke Engine Works
2:11-minute video uses animation to demonstrate how a 2-cycle engine works.
https://www.youtube.com/watch?v=xNLE8G3pC0k

** Poulan, Poulan Pro and Weed Eater
http://www.poulanpro.com/us/

** Solidworks - One Cylinder Four Stroke Engine
1:20-minute video uses animation to illustrate the movements in a 4-cycle engine
https://www.youtube.com/watch?v=XJtY-5dugTk

** Tecumseh
http://www.tecumseh.com/en/united-states

This lesson was written by Dr. Ray V. Herren, Professor, Agricultural Leadership, Education, and Communications, The University of Georgia.

The lesson was reviewed and updated by Stacey Beacham, Master of Agricultural Leadership.

Photo credit: U.S. Navy photo by Petty Officer 3rd Class Ja'lon A. Rhinehart shows a chain saw being used to remove fallen trees in Gulfport, Mississippi, after Hurricane Katrina. Chain saws are two-stroke internal combustion engines.

END STUDENT SECTION