To My Father

Who Took the Time in Life

To Teach Me a Trade

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Engine Types

Four stroke, Two stroke, and Diesel

Defining Terms

Before we discuss the differences between the different engine types, some basic definitions must be made. There are several terms used when describing the movement of the piston inside the cylinder.

The first term to be defined is *top dead center.* As was described in a previous chapter, the piston moves up and down in the cylinder. The term *stroke* refers to the total distance travelled by the piston from the top of the cylinder to the bottom (thankfully we are not talking high cholesterol and blood pressure here). The very top of the piston's stroke is defined as *top dead center* (sometimes abbreviated as TDC).

When the piston is at top dead center, two things are happening:

- The piston is at the very *top* of its stroke.
- An imaginary line drawn through the center of the cylinder and the piston would divide the connecting rod down the very center.

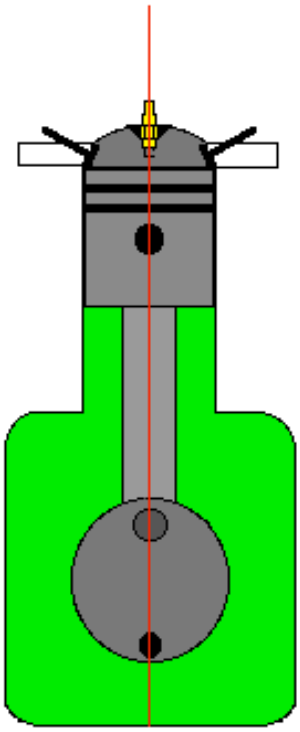

Figure 3:1 **- The piston is at the very top of the stroke. An imaginary line divides the rod down 'dead center.' Combining the two results in the term " Top Dead Center".**

By combining what is happening with these two separate engine parts (the piston is at the top, the connecting rod is at center), the term "top dead center" was coined.

The next term is *bottom dead center.* This is a very similar idea, with two things happening:

• The piston is at the very *bottom* of its stroke.

- The rod is again divided evenly by the imaginary line drawn through the center of the cylinder and piston.

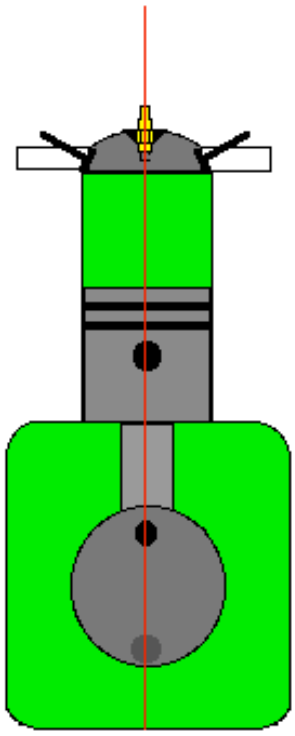

Figure 3:2 **- The piston is at the very bottom of the stroke. An imaginary line divides the rod down 'dead center.' Combining the two results in the term " Bottom Dead Center".**

Top dead center is an especially important idea, since this is the piston location used in setting the ignition timing in an engine. We will discuss this is greater detail in a later chapter. Interestingly enough, there is no special term to describe when the piston is half way between top dead center and bottom dead center.

Now that we know the names for the different piston positions, an explanation of the various engine types will make a lot more sense.

Four Cycle Engines

This was the first real internal combustion engine to be developed. It is known by several names, to include *four cycle engine; four stroke engine;* and the *Otto engine.* The engine itself was invented by Karl Otto in 1887, who was a former traveling salesman turned engine designer. Otto's natural mechanical abilities and perseverance was to change the world forever.

The Intake Stroke

As the name implies, there are four distinct phases of operation in a four stroke engine. The first phase begins when the piston is at top dead center. As the crankshaft turns, the piston moves in a downward direction, and the *intake valve* opens. The air and fuel mixture is allowed to rush into the cylinder, since a partial vacuum exists. This is the same action that occurs when a child sucks on a straw, but instead of apple juice entering the child's mouth, an air fuel mixture is entering into the cylinder. The *intake stroke* does not end until the piston reaches bottom dead center. At this exact moment, the intake valve magically closes (thanks to the careful timing of the camshaft). What we have is a cylinder full of the perfect ratio of fuel and air. The engine's crankshaft has turned one half of a revolution from the starting position.

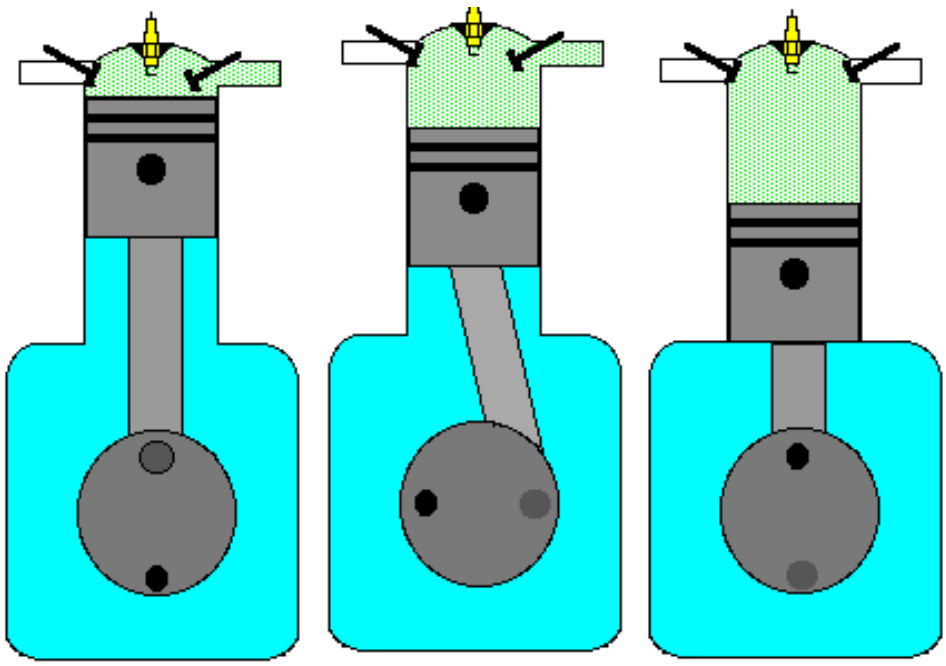

Figure 3:3 **- The intake stroke begins when the piston is at top dead center, and the intake valve is open. The intake stroke ends when the piston reaches bottom dead center and the intake valve closes (right).**

The Compression Stroke

The next step is the *compression stoke*. This begins when the piston is at bottom dead center, and when the cylinder contains the fresh charge of fuel and air. The compression stroke begins at the exact instant the intake stroke ends, and the intake valve closes.

The piston travels upwards and compresses the air and fuel mixture, as top dead center is approached. No valve opens to relieve this pressure. This increase in pressure is known as the engine's c*ompression* (thus the

name *compression stroke).* The compression stroke ends when the piston reaches to top dead center. The crankshaft has now rotated one complete revolution from the original starting point at the beginning of the intake stroke.

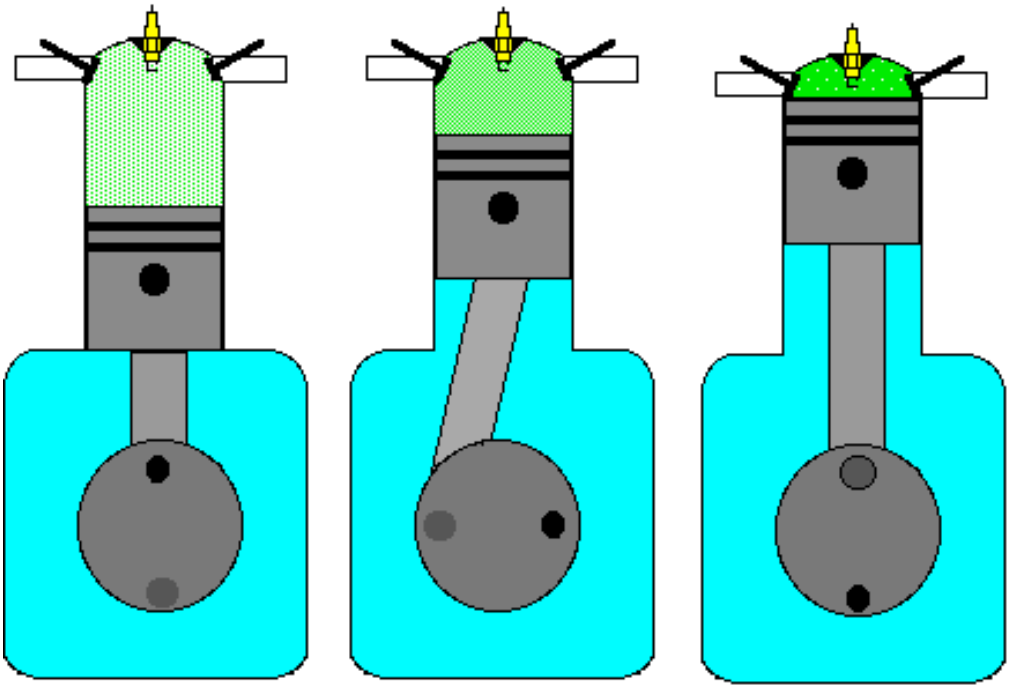

Figure 3:4 **- The compression stroke begins when the piston is at bottom dead center when both the exhaust valve and intake valve is closed (left). The compression stroke ends when the piston reaches top dead center (right).**

Compression Ratio

Engine designers (and other smart people) talk about an engine's *compression ratio.* Mechanics are fond of discussing how much compression an engine has (or how much is left, in the case of a used engine).

Why is this? Compression is important, because it is a major factor of how much power an engine can deliver. More compression generally means more power, but only to a certain degree. As we will discuss later, increasing compression also means increasing the temperature of the compressed gas. If taken to an extreme, very high engine compression may allow the fuel mixture to ignite on its own. This can result in a poor running engine that knocks and backfires.

In the circumstances where really high compression is needed in an engine (like a drag racer), special fuels are used that resist being ignited too early by the heat generated by the compressed gasses.

There will be more about compression ratios in chapter 6.

The Power Stroke

The third step is the most fun - the *power stroke!* It is here that the compressed fuel and air are ignited, causing a small scale explosion. The resulting force from the rapidly expanding gasses causes the piston to be pushed downwards, much in the same way the tin can was shot into the air by the exploding firecracker discussed earlier. The power stroke

begins just after the piston reaches top dead center, and continues until the piston reaches bottom dead center.

In a perfect world (and a perfect engine) combustion would continue until the piston reaches bottom dead center. This would allow for a constant ‘push’ as the piston moved towards bottom dead center, further maximizing the power delivered to the piston.

Alas, in the real wold, engines are not quite so efficient, and some unburned fuel may be left over after the power stroke. This, of course, contributes to the pollution the engine produces.

At the completion of the power stroke, the crankshaft has completed one and one half revolutions from the original starting position at the beginning of the intake stroke.

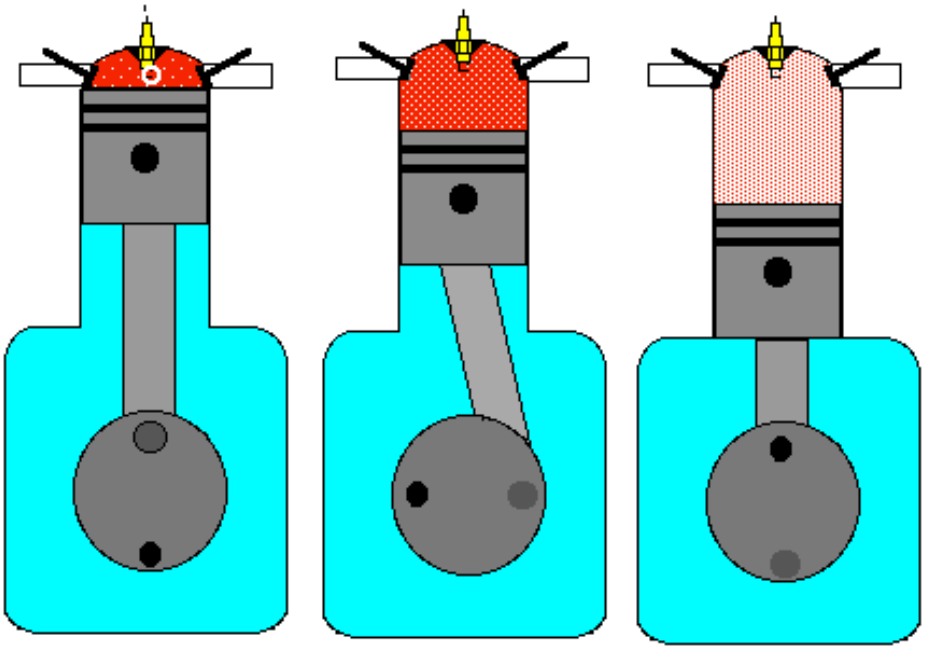

Figure 3:5 **- The power stroke begins when the piston is at top dead center, and the air fuel mixture is at maximum compression. Both the intake and exhaust valves are closed. The heat from the electrical spark at the spark plug ignites the fuel. The expanding burning gasses push the piston down (right).**

The Exhaust Stroke

The final (and fourth) stroke is the *exhaust stroke*. Nothing exciting going on here, just the engine eliminating the by products of combustion, affectionately known as *engine exhaust.* The exhaust stroke begins at bottom dead center, after the completion of the power stroke. As the piston starts traveling upwards, the *exhaust valve* opens on cue, and the hot exhaust gasses are pushed out of the engine by the piston moving toward top dead center.

Since this step is rather loud, the exhaust gasses pass though a *muffler* of some sort, to help dampen the noise to an acceptable level. (Of course, what an 'acceptable level' of engine noise varies considerably, especially with the engine owner's age, and the perceived need to impress members of the opposite sex.)

At the completion for the exhaust stroke the piston is again at top dead center. The exhaust valve closes, and the next intake stroke is ready to begin. The crankshaft has turned a total of two complete revolutions from the starting point at the intake stroke. After the completion of the exhaust stroke, all four engine cycles have been completed.

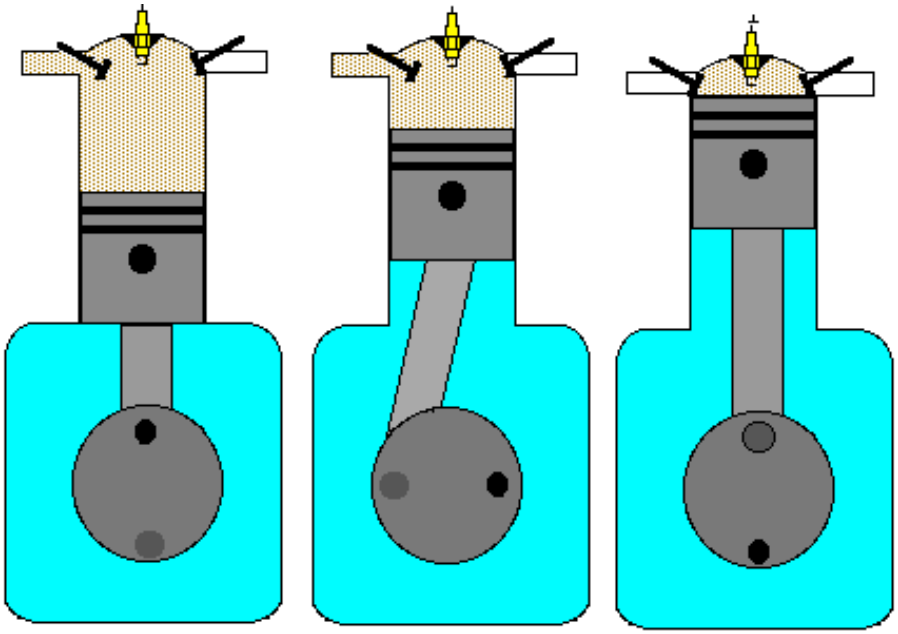

Figure 3:6 **- The exhaust stroke begins immediately following the completion of the power stroke, when the piston is at bottom dead center. As the crankshaft continues to turn, the piston moves upwards. The exhaust valve opens, and the exhaust is pushed out of the engine. Once the piston reaches top dead center, the exhaust valve closes (right). The crankshaft has turned 2 revolutions from the starting point at the intake stroke. After completion of the exhaust stroke, the whole process will begin again with another intake stroke.**

It is interesting to note an inherent inefficiency of the four cycle engine. Notice that it takes three engine strokes to support a single power stroke. In other words, the engine is 'coasting' three quarters of the time! This can be compensated for with a variety of ways. The most common is to place a heavy flywheel on the crankshaft to provide extra momentum needed to carry over to the next power stroke. Another strategy is to place several pistons in the engine, with power strokes placed at different times. All car engines use a combination of these two strategies for smoother performance and increased power.

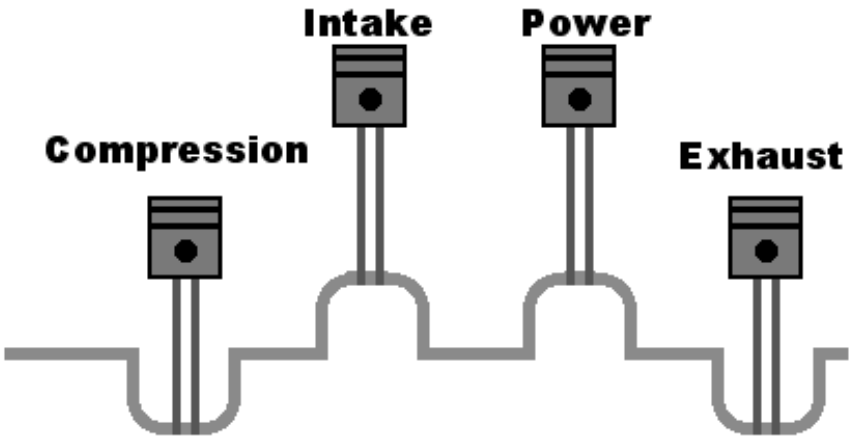

Figure 3:7 **- A multi cylinder engine uses pistons placed at different positions to provide smoother power and increased performance.**

To summarize, the stages of a four cycle engine include *intake, compression, power,* and *exhaust*. After these cycles are completed, the crankshaft has made two complete revolutions.

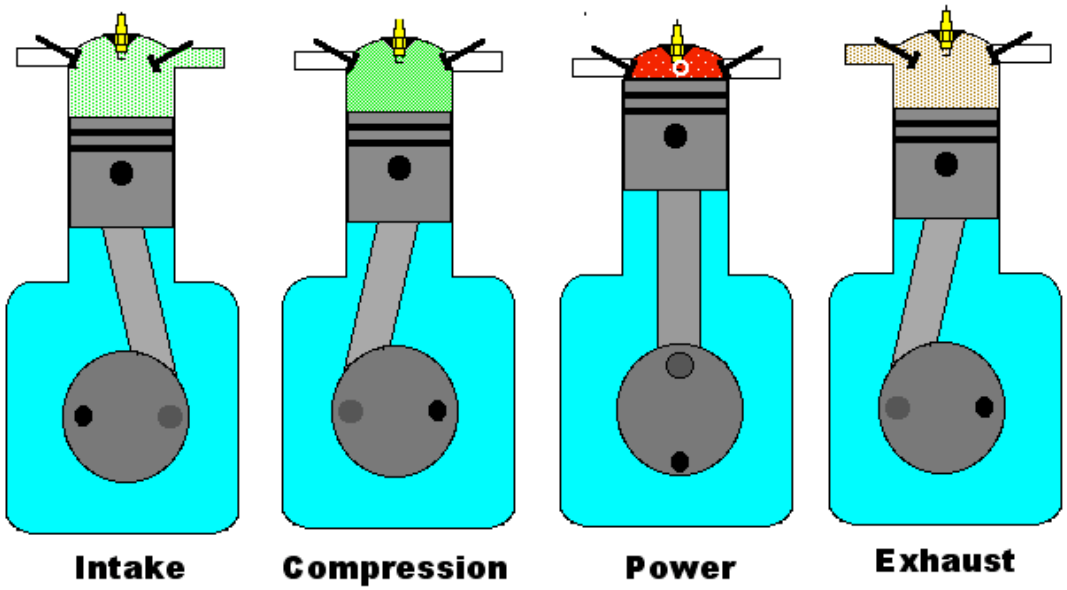

Figure 3:8 **- The four strokes of a four stroke engine include (from left to right) Intake, Compression, Power, and Exhaust.**