### Internal Combustion Engines

The internal combustion engine is an engine in which the burning of a fuel occurs in a confined space called a **combustion chamber**. This exothermic reaction of a fuel with an oxidizer creates gases of high temperature and pressure, which are permitted to expand.

This contrasts with **external combustion engines**, such as steam engines, which use the combustion process to heat a separate working fluid, typically water or steam, which then in turn does work.
The term Internal Combustion Engine (ICE) is used to refer specifically to reciprocating engines, Wankel engines, Jet engines as well as most of the rockets and gas turbines.

**Applications**

Internal combustion engines are most commonly used for mobile propulsion in automobiles, equipment, and other portable machinery as they can provide high power to weight ratios together with excellent fuel energy-density. Where very high power is required, such as jet aircraft, helicopters and large ships, they appear mostly in the form of turbines. They are also used for electric generators and by industry.
CLASSIFICATION OF IC ENGINES

a) based on **fuel** used

- Petrol engines
- Diesel engines
- Gas engines

b) method of igniting the fuel

- spark ignition engines
- Compression ignition engines
c) based on the number of strokes per cycle
   - 2 stroke engines
   - 4 stroke engines

d) based on cooling systems
   - air cooled engines
   - water cooled engines

e) based on number of cylinders
   - single cylinder engines
   - multi cylinder engines
The four-stroke cycle of an internal combustion engine is the cycle most commonly used for automotive and industrial purposes today. The Thermodynamics cycles used in IC engines are the Otto Cycle for spark-ignition engines and the Diesel Cycle for compression-ignition engines.
The Otto cycle
The Otto cycle is characterized by four strokes, or straight movements alternately, back and forth, of a piston inside a cylinder:

intake (induction) stroke
compression stroke
power (combustion) stroke
exhaust stroke

The 4 Stroke Petrol Engine
Stroke 1:
The downward moving piston sucks a mixture of air and petrol vapour into the cylinder through the inlet valve.
**Stroke 2:**
The piston then moves upwards, compressing the gas mixture.

**Stroke 3:**
Just before the piston reaches the top of the cylinder a spark from the spark plug explodes the gas mixture. The pressure from the rapidly expanding gas pushes the piston down and causes a flywheel that it is connected to by the crankshaft to rotate.

**Stroke 4:**
The piston moves upwards in the
cylinder again to push out the gases through the exhaust valve into the exhaust system of the vehicle. As the piston moves down, it pulls more fuel/air mixture in to begin the cycle again.

The **diesel engine** has no spark plug, that it intakes air and compresses it, and that it then injects the fuel directly into the combustion chamber (direct injection). It is the heat of the compressed air that lights the fuel in a diesel engine.
The main differences between the gasoline engine and the diesel engine are:

A gasoline engine intakes a mixture of gas and air, compresses it and ignites the mixture with a spark. A diesel engine takes in just air, compresses it and then injects fuel into the compressed air. The heat of the compressed air lights the fuel spontaneously.

A gasoline engine compresses at a ratio of 8:1 to 12:1, while a diesel engine compresses at a ratio of 14:1 to as high as 25:1. The higher compression ratio of the diesel engine leads to better efficiency.

Gasoline engines generally use either carburetion, in which the air and fuel is mixed long before the air enters the cylinder, or port fuel injection, in which the fuel is injected just prior to the intake stroke (outside the cylinder). Diesel engines use direct fuel injection – the diesel fuel is injected directly into the cylinder.
TWO STROKE ENGINE

The two-stroke cycle of an internal combustion engine completes the four operations (intake, compression, power, exhaust) in only two strokes (linear movements of the piston).

There is a **power stroke** for every revolution of the **crank**, instead of every second revolution as in a four-stroke engine. For this reason, two-stroke engines provide high specific power, so they are valued for use in portable, lightweight applications.
The smallest gasoline engines are usually two-strokes. They are popular due to their **simple design** and **low cost** and very **high power-to-weight ratios**. The biggest **disadvantage** is that the engine **lubricant** is almost always **mixed** in with the **fuel**, thus significantly increasing the **emission of pollutants**. For this reason, two-stroke engines are being replaced with four-stroke engines in as many applications as possible.
2-Stroke cycle

**Scavenging & Intake** — As the piston moves downward and the transfer port opens, the movement of the piston causes the air/fuel mixture that has been compressed in the crankcase (primary compression) to pass through the transfer port into the cylinder in an exchange with the gas remaining from the last combustion.

**Compression** — As the piston moves upward and the scavenging port and exhaust port close, the air/fuel mixture is compressed (secondary compression). As this happens the crankcase develops negative pressure that opens the reed valve and causes new air/fuel mixture to enter the crankcase.
**Combustion Process** — As the piston approaches top dead center a spark from the spark plug causes the air/fuel mixture to ignite and the resulting sudden rise in heat and pressure causes expansion of the combustion gas that pushes the piston downward.

**Exhaust Process** — As the piston moves downward and the exhaust port opens, the combustion gas rushes out of the exhaust port under its own pressure. As this is happening, pressure builds up in the crankcase (primary compression), starting the preparation for the next scavenging process.
The idea behind an engine is to burn gasoline to create pressure, and then to turn the pressure into motion. A remarkably tiny amount of gasoline is needed during each combustion cycle. The **goal** of a carburetor is to **mix just the right amount of gasoline with air** so that the engine runs properly. If there is not enough fuel mixed with the air, the engine "runs lean" and either will not run or potentially damages the engine. If there is too much fuel mixed with the air, the engine "runs rich" and either will not run (it floods), runs very smoky, runs poorly (bogs down, stalls easily), or at the very least wastes fuel. The carb is in charge of getting the mixture just right.

**Carburettor**
The parts of a carburetor:

A carburetor is essentially a tube. There is an adjustable plate across the tube called the throttle plate that controls how much air can flow through the tube. At some point in the tube there is a narrowing, called the venturi, and in this narrowing a vacuum is created. In this narrowing there is a hole, called a jet, that lets the vacuum draw in fuel.
The carb is operating "normally" at full throttle. In this case the throttle plate is parallel to the length of the tube, allowing maximum air to flow through the carb. The air flow creates a nice vacuum in the venturi and this vacuum draws in a metered amount of fuel through the jet.

When the engine is **idling**, the throttle plate is nearly closed. There is not really enough air flowing through the venturi to create a vacuum. However, on the back side of the throttle plate there is a lot of vacuum (because the throttle plate is restricting the airflow). If a tiny hole is drilled into the side of the carb's tube just behind the throttle plate, fuel can be drawn into the tube by the throttle vacuum. This tiny hole is called the idle jet.
The ignition system

The system in an internal combustion engine that initiates the chemical reaction between fuel and air in the cylinder charge by producing a spark.

The basic components of the ignition system are the ignition coil, high voltage ignition wires, distributor and of course, the spark plugs. Let's see how the system has evolved over the years.

The battery is the source of the voltage for the spark we need to ignite the mixture at the proper microsecond in the cylinder. This spark requires thousands of volts to occur, as much as 120,000 volts. The ignition coil is the source of the high voltage we need.
The ignition coil stores electrical energy during the dwell (current-on) period and acts as a transformer at the end of dwell by converting the low-voltage-high-current energy stored in the primary to high-voltage-low-current energy in the secondary. The distributor selects the fired spark plug by positioning the rotor opposite the terminal connected to one spark plug. The plug selected depends on the cylinder firing order, which in turn depends on the engine design. The distributor is driven at one-half engine speed from the camshaft.
Fuel pump

A mechanical or electrical pump for drawing fuel from a storage tank and delivering it to an engine or furnace for drawing fuel from a storage tank and forcing it to an engine or furnace.
The type of pump chosen depends on the volatility of the liquid to be pumped. In a gasoline engine the fuel is highly volatile at ambient temperature. Therefore, the fuel line is completely sealed from the tank to the carburetor or fuel-injection system to prevent escape of fuel and to enable the pump to purge the line of vapor in the event of vapor lock—a condition in which the fuel vaporizes owing to abnormally high ambient temperature. Most carbureted gasoline engines use a spring-loaded diaphragm-type mechanical pump. Diesel engines normally use a gear, plunger, or vane-type pump to supply fuel to the injection pump.
There are two kinds of fuel pumps: the mechanical fuel pump, which was used in carbureted cars, and the electric fuel pump, which is used in cars with electronic fuel injection.

A **mechanical fuel pump** runs off of the engine's rotation; as a result, the fuel pump in a carbureted car is located alongside the engine.

The **electronic fuel pump** is powered and controlled electronically. A computer controls the system, closely monitoring factors such as the position of the throttle, the air-fuel ratio, and the contents of the exhaust. Because the system does not use a pre-existing force, such as vacuum, to draw the fuel along the lines, the fuel pump must be located at the source -- that is, inside or next to the fuel tank itself.
Fuel Injectors

Fuel Injection is a *method or system for metering fuel into an internal combustion engine*. The fuel injector acts as the **fuel-dispensing nozzle**. It injects liquid fuel directly into the engine's air stream. The pump and injector are only two of several components in a complete fuel injection system. The diesel engine must be supplied with fuel from the injection nozzle at a pressure of 10–35 megapascals for indirect-injection engines, and up to 100 MPa or higher for direct-injection engines. The high pressure is necessary to deliver fuel against the highly compressed air in the engine cylinders at the end of the compression stroke, and to break up the fuel oil which has low volatility and is often viscous. The gasoline fuel injector is an electromagnetic (solenoid-operated) or mechanical device used to direct delivery of or to meter pressurized fuel, or both.
The cooling system

Most of the energy in the gasoline (around 70%) is converted into heat, and it is the job of the cooling system to take care of that heat. The primary job of the cooling system is to keep the engine from overheating by transferring this heat to the air. The engine in a car runs best at a fairly high temperature. When the engine is cold, components wear out faster, and the engine is less efficient and emits more pollution. So another important job of the cooling system is to allow the engine to heat up as quickly as possible, and then to keep the engine at a constant.

How Does a Cooling System Work?

Actually, there are two types of cooling systems found on motor vehicles: Liquid cooled and Air cooled.
The cooling system is made up of the passages inside the engine block and heads, a *water pump* to circulate the coolant, a *thermostat* to control the temperature of the coolant,
a **radiator** to cool the **coolant**, a **radiator cap** to control the pressure in the system, and some plumbing consisting of interconnecting hoses to transfer the coolant from the engine to radiator and also to the car's heater system where hot coolant is used to warm up the vehicle's interior on a cold day.

A cooling system works by sending a liquid coolant through passages in the engine block and heads. As the coolant flows through these passages, it picks up heat from the engine. The heated fluid then makes its way through a rubber hose to the radiator in the front of the car. As it flows through the thin tubes in the radiator, the hot liquid is cooled by the air stream entering the engine compartment from the grill in front of the car. Once the fluid is cooled, it returns to the engine to absorb more heat. The water pump has the job of keeping the fluid moving through this system of plumbing and hidden passages.
Lubrication System

An I C engine would not run if the moving parts were allowed to make metal-to-metal contact. The heat generated due to the tremendous amounts of friction would melt the metals, leading to the destruction of the engine. To prevent this, all moving parts ride on a thin film of oil that is pumped between all the moving parts of the engine.

The lubricating oil serves two purposes.

- to lubricate the bearing surfaces.

- to cool the bearings by absorbing the friction generated heat.

The flow of oil to the moving parts is accomplished by the engine's internal lubricating system.
Lubrication system working

The engine lubrication system is designed to deliver clean oil at the correct temperature and pressure to every part of the engine. The oil is sucked out the sump into the pump, being the heart of the system, than forced through an oil filter and pressure fed to the main bearings and to the oil pressure gauge. From the main bearings, the oil passes through feed-holes into drilled passages in the crankshaft and on to the big-end bearings of the connecting rod. The cylinder walls and piston-pin bearings are lubricated by oil fling dispersed by the rotating crankshaft. The excess being scraped off by the lower ring in the piston. A bleed or tributary from the main supply passage feeds each camshaft bearing. Another bleed supplies the timing chain or gears on the camshaft drive. The excess oil then drains back to the sump, where the heat is dispersed to the surrounding air.