

Introduction and Working of IC Engines



Introduction :

- **Heat engine** : It can be defined as any engine that converts thermal energy to mechanical work output. Examples of heat engines include: steam engine, diesel engine, and gasoline (petrol) engine.
- On the basis of how thermal energy is being delivered to working fluid of the heat engine, heat engine can be classified as an internal combustion engine and external combustion engine.

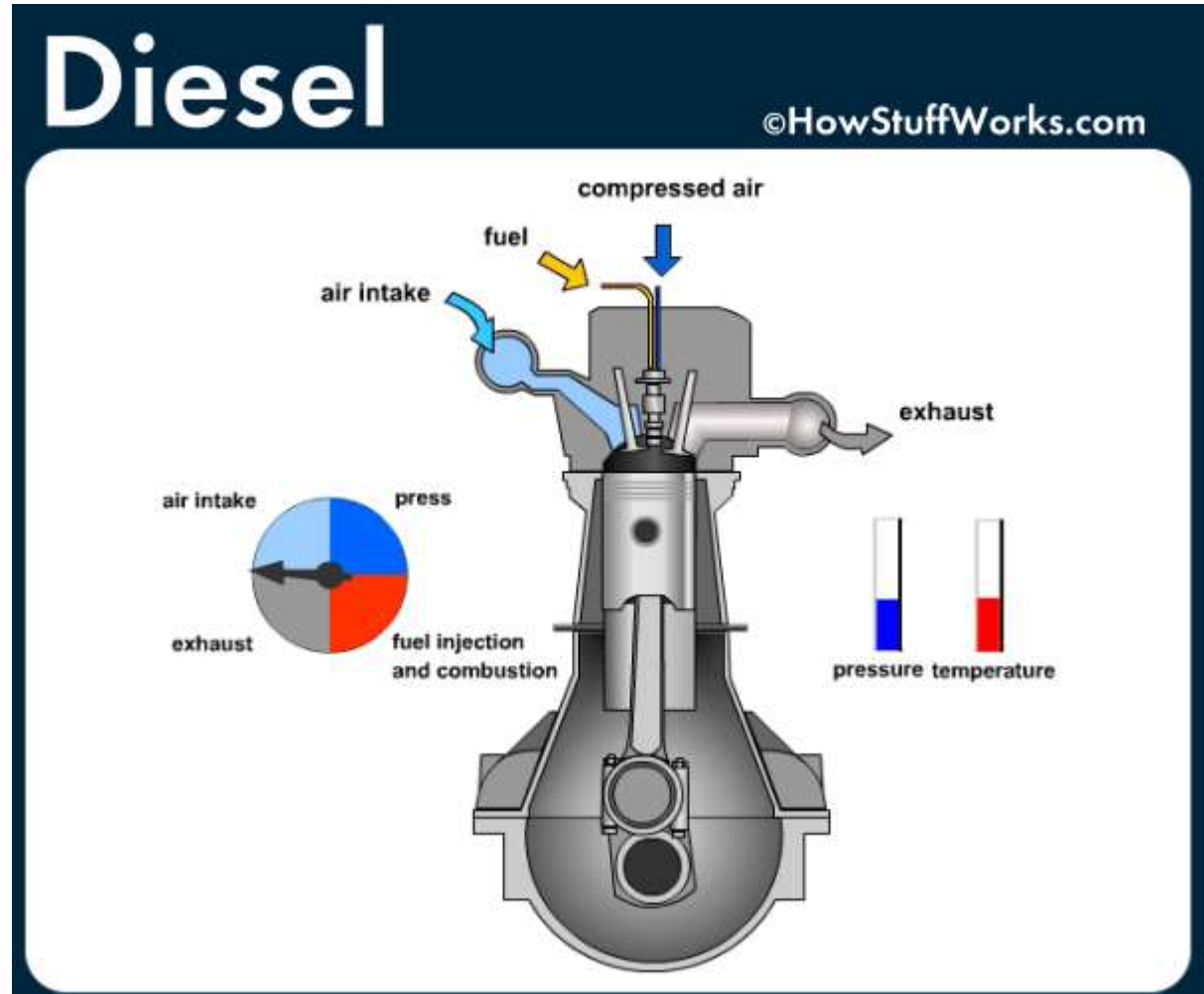
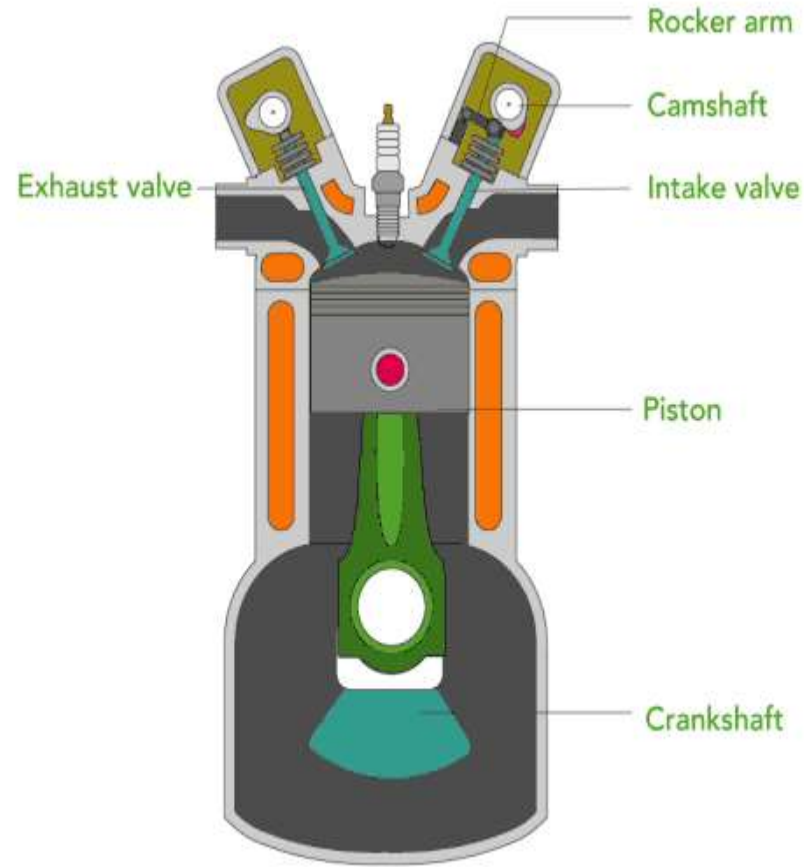


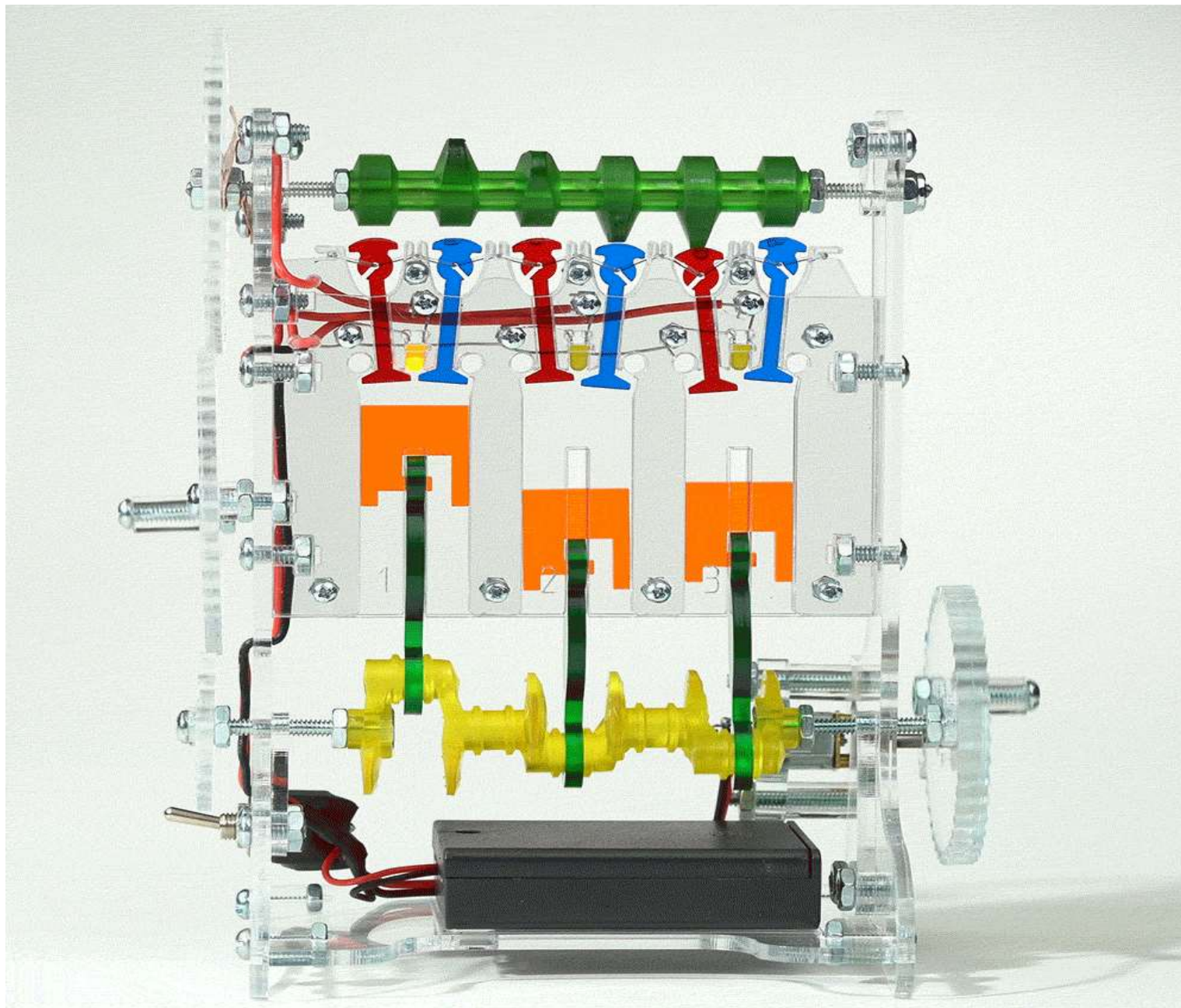
- In an **Internal combustion engine**, combustion takes place within working fluid of the engine, thus fluid gets contaminated with combustion products.
 - Petrol engine is an example of internal combustion engine, where the working fluid is a mixture of air and fuel.
- In an **External combustion engine**, working fluid gets energy using boilers by burning fossil fuels or any other fuel, thus the working fluid does not come in contact with combustion products.
 - Steam engine is an example of external combustion engine, where the working fluid is steam.



Internal combustion engines may be classified as :

- Spark Ignition engines.
- Compression Ignition engines.
- **Spark ignition engine (SI engine):** An engine in which the combustion process in each cycle is started by use of an external spark.
- **Compression ignition engine (CI engine):** An engine in which the combustion process starts when the air-fuel mixture self ignites due to high temperature in the combustion chamber caused by high compression.
 - Spark ignition and Compression Ignition engine operate on either a four stroke cycle or a two stroke cycle.







Classification

- According to type of fuel used.
 - Petrol engine.
 - Diesel engine.
 - Gas engine.
 - Bi-fuel engine.
- According to number of strokes per cycle.
 - 4 – stroke engines.
 - 2 – stroke engines.



Classification

- According to method of ignition.
 - Spark ignition.
 - Compression ignition.
- According to the cycle of combustion.
 - Otto cycle.
 - Diesel cycle.
 - Dual combustion.
- According to the number of cylinders.
 - Single cylinder.
 - Multi cylinder.



- Four stroke cycle : It has four piston strokes over two revolutions for each cycle.
- Two stroke cycle : It has two piston strokes over one revolution for each cycle.
- We will be dealing with Spark Ignition engine and Compression Ignition engine operating on a four stroke cycle.

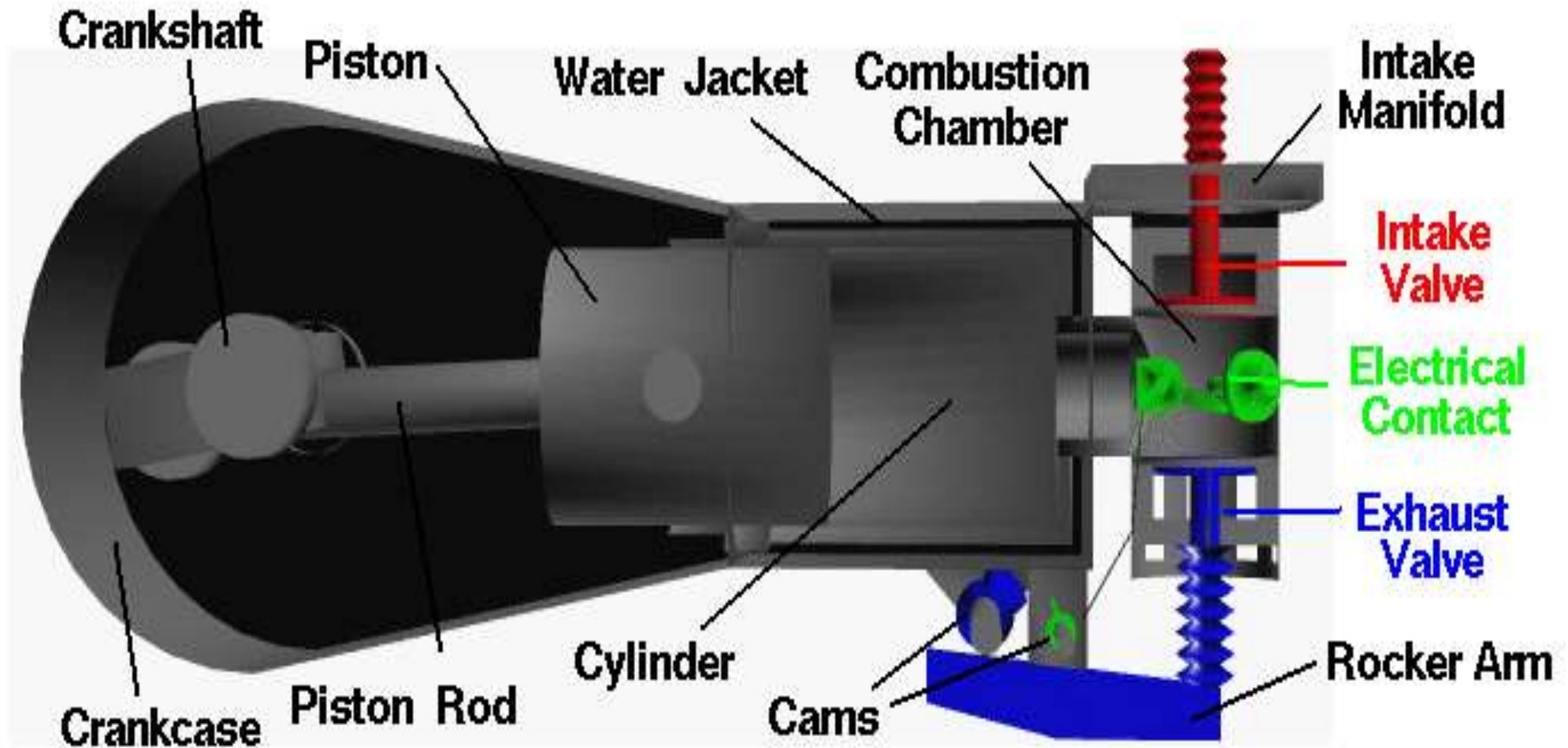


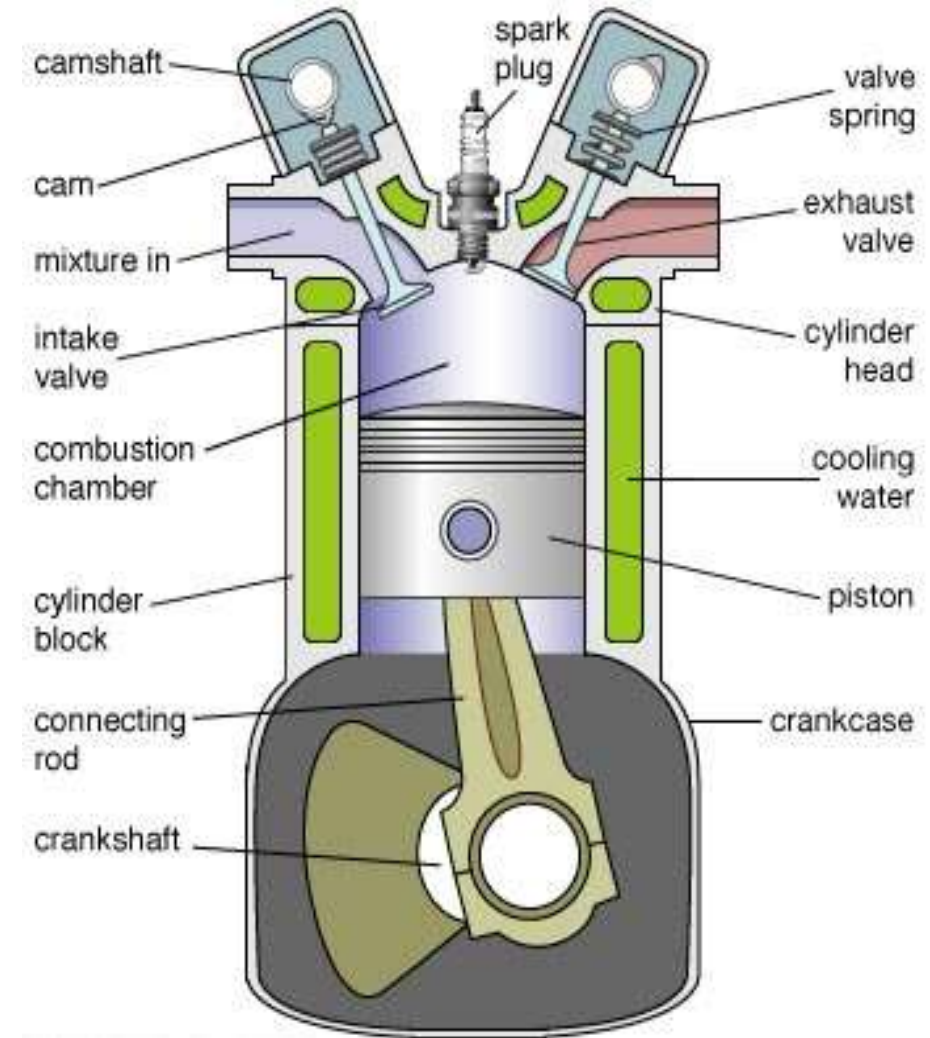
Figure2: Engine components



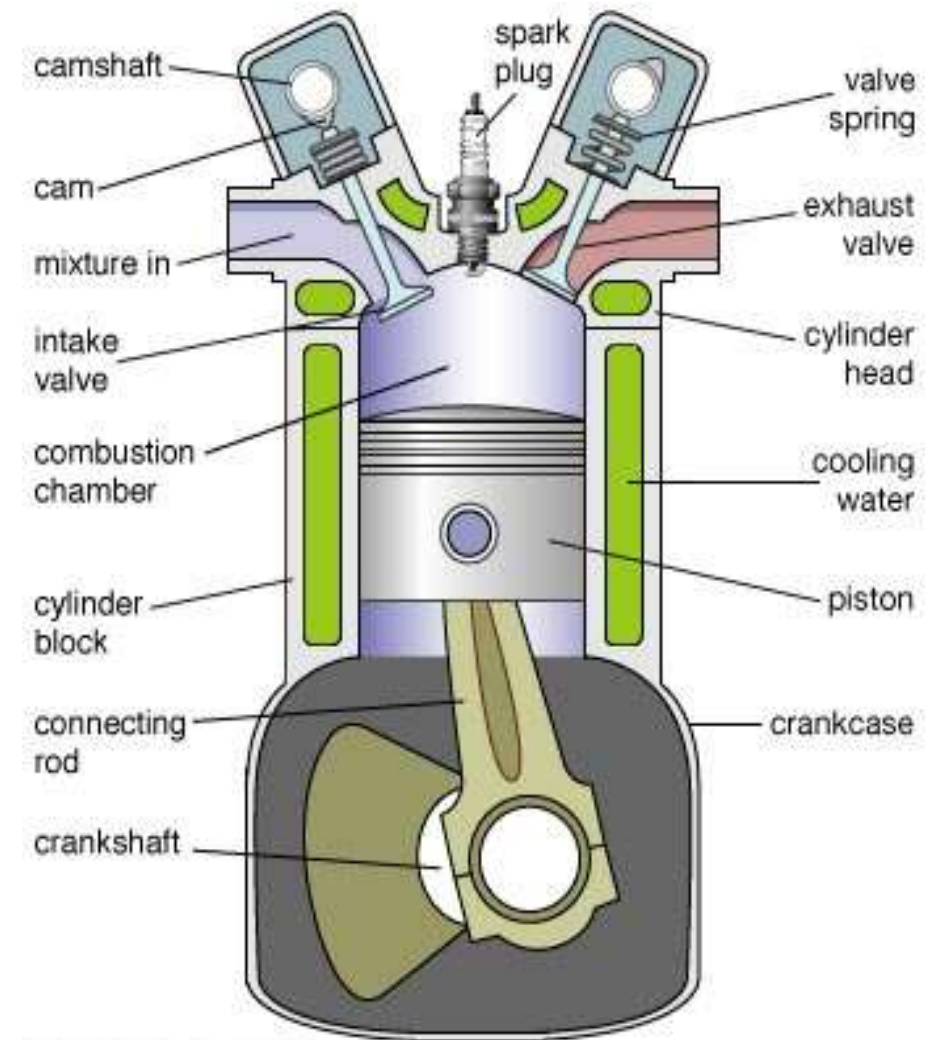
Internal combustion Engine Components:



- I.C. Engine components shown in figure1 and figure2 are defined as follows:
- **Block** : Body of the engine containing cylinders, made of cast iron or aluminium.
- **Cylinder** : The circular cylinders in the engine block in which the pistons reciprocate back and forth.
- **Head** : The piece which closes the end of the cylinders, usually containing part of the clearance volume of the combustion chamber.
- **Combustion chamber**: The end of the cylinder between the head and the piston face where combustion occurs.
 - The size of combustion chamber continuously changes from minimum volume when the piston is at TDC to a maximum volume when the piston at BDC.

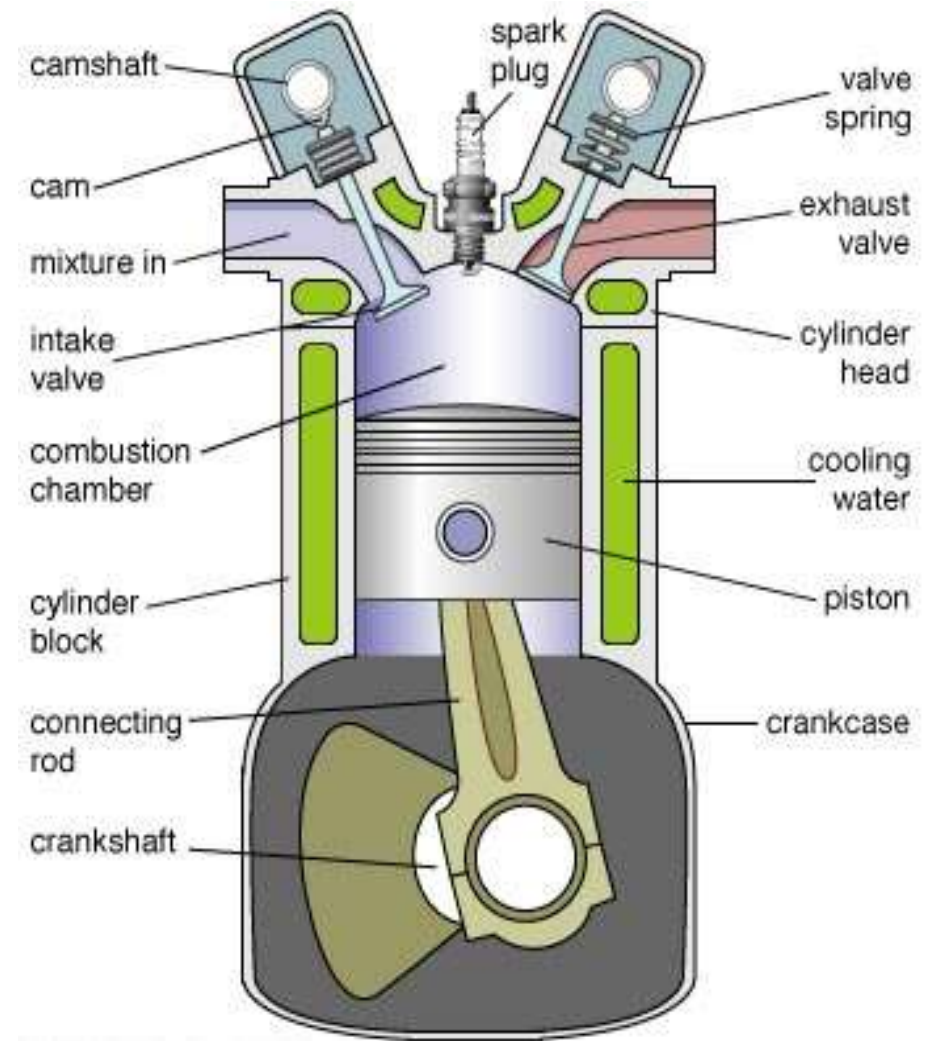


- **Crankshaft** : Rotating shaft through which engine work output is supplied to external systems.
 - The crankshaft is connected to the engine block with the main bearings.
 - It is rotated by the reciprocating pistons through the connecting rods connected to the crankshaft, offset from the axis of rotation. This offset is sometimes called crank throw or crank radius.
- **Connecting rod** : Rod connecting the piston with the rotating crankshaft, usually made of steel or alloy forging in most engines but may be aluminum in some small engines.
- **Piston rings**: Metal rings that fit into circumferential grooves around the piston and form a sliding surface against the cylinder walls.



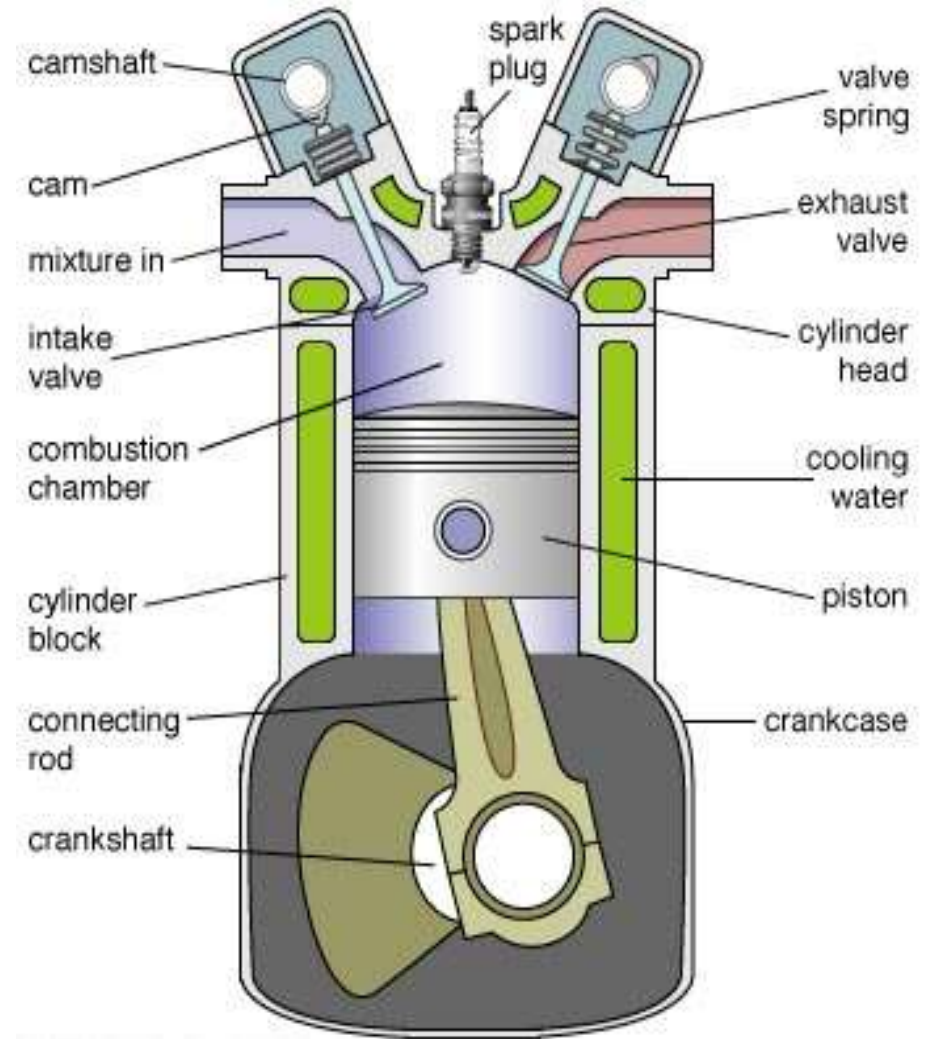


- **Camshaft** : Rotating shaft used to push open valves at the proper time in the engine cycle, either directly or through mechanical or hydraulic linkage (push rods, rocker arms, tappets) .
- **Push rods** : The mechanical linkage between the camshaft and valves on overhead valve engines with the camshaft in the crankcase.
- **Crankcase** : Part of the engine block surrounding the crankshaft.
 - In many engines the oil pan makes up part of the crankcase housing.
- **Exhaust manifold** : Piping system which carries exhaust gases away from the engine cylinders, usually made of cast iron .





- **Intake manifold** :Piping system which delivers incoming air to the cylinders, usually made of cast metal, plastic, or composite material.
 - In most SI engines, fuel is added to the air in the intake manifold system either by fuel injectors or with a carburetor.
 - The individual pipe to a single cylinder is called runner.
- **Carburetor** : A device which meters the proper amount of fuel into the air flow by means of pressure differential.
 - For many decades it was the basic fuel metering system on all automobile (and other) engines.
- **Spark plug** : Electrical device used to initiate combustion in an SI engine by creating high voltage discharge across an electrode gap.





I.C. Engine components apart from components shown in the figure:

- **Exhaust System:** Flow system for removing exhaust gases from the cylinders, treating them, and exhausting them to the surroundings.
 - It consists of an exhaust manifold which carries the exhaust gases away from the engine, a thermal or catalytic converter to reduce emissions, a muffler to reduce engine noise, and a tailpipe to carry the exhaust gases away from the passenger compartment.
- **Flywheel :** Rotating mass with a large moment of inertia connected to the crank shaft of the engine.
 - The purpose of the flywheel is to store energy and furnish large angular momentum that keeps the engine rotating between power strokes and smooths out engine operation.



- **Fuel injector** : A pressurized nozzle that sprays fuel into the incoming air (SI engines)or into the cylinder (CI engines).
- **Fuel pump** : Electrically or mechanically driven pump to supply fuel from the fuel tank (reservoir) to the engine.
- **Glow plug** : Small electrical resistance heater mounted inside the combustion chamber of many CI engines, used to preheat the chamber enough so that combustion will occur when first starting a cold engine.
 - **The glow plug is turn off after the engine is started.**
- **Starter** : Several methods are used to start IC engines. Most are started by use of an electric motor (starter) geared to the engine flywheel. Energy is supplied from an electric battery.

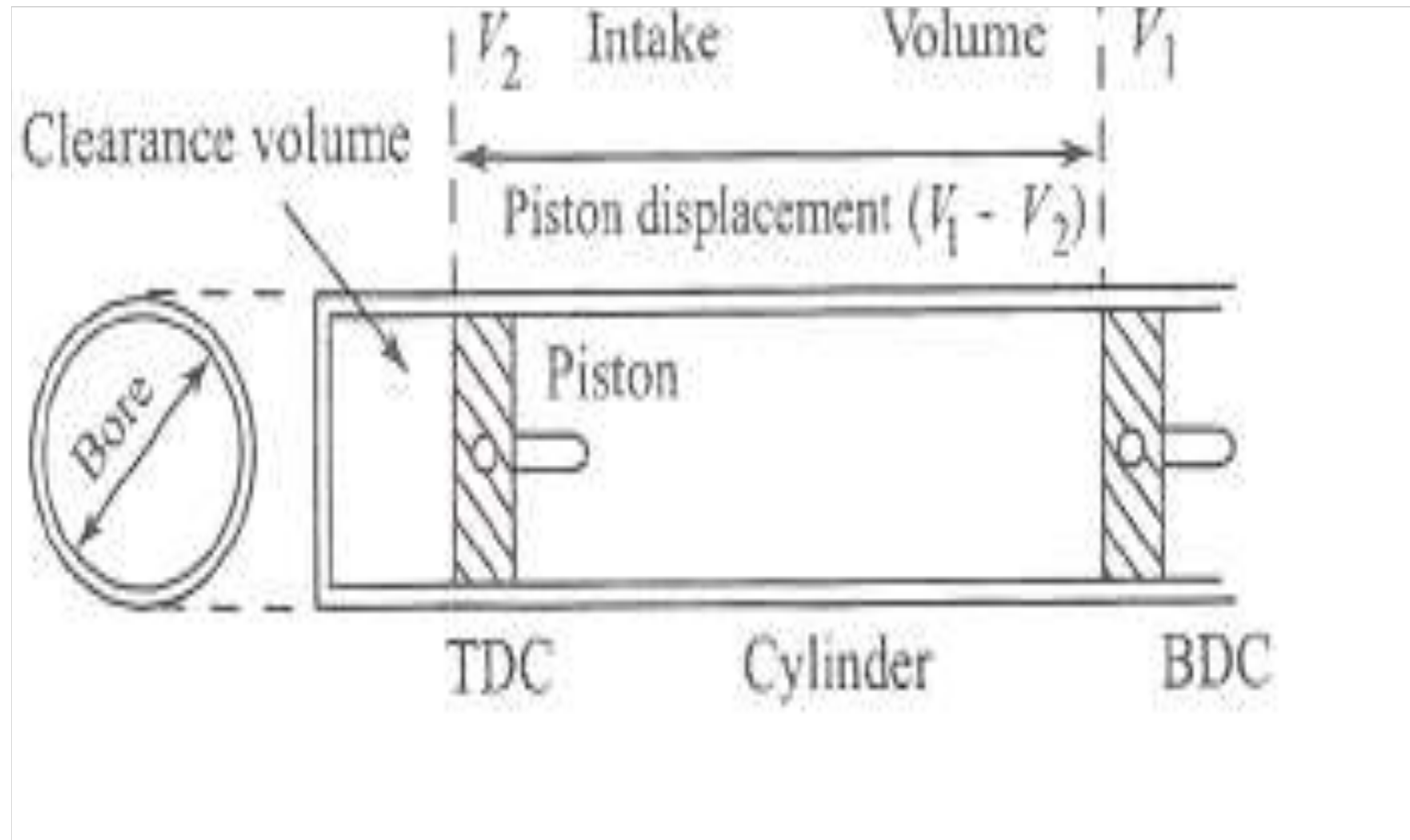


Figure3 : Engine Terminology



Engine Terminology :

Figure 3, shows the pressure volume diagram of ideal engine cycle along with engine terminology as follows:

- **Top Dead Center (TDC):** Position of the piston when it stops at the furthest point away from the crankshaft.
 - Top because this position is at the top of the engines (not always), and dead because the piston stops at this point. Because in some engines **TDC** is not at the top of the engines(e.g: horizontally opposed engines, radial engines,etc,.) Some sources call this position **Head End Dead Center (HEDC)**.
 - Some source call this point **TOP Center (TC)**.
 - When the piston is at TDC, the volume in the cylinder is a minimum called the clearance volume.



- **Bottom Dead Center (BDC):** Position of the piston when it stops at the point closest to the crankshaft.
 - Some sources call this **Crank End Dead Center (CEDC)** because it is not always at the bottom of the engine. Some source call this point **Bottom Center (BC)**.
- **Stroke :** Distance traveled by the piston from one extreme position to the other : TDC to BDC or BDC to TDC.
- **Bore :**It is defined as cylinder diameter or piston face diameter; piston face diameter is same as cylinder diameter(minus small clearance).
- **Swept volume/Displacement volume :** Volume displaced by the piston as it travels through one stroke.
 - Swept volume is defined as stroke times bore.
 - Displacement can be given for one cylinder or entire engine (one cylinder times number of cylinders).



- **Clearance volume** : It is the minimum volume of the cylinder available for the charge (air or air fuel mixture) when the piston reaches at its outermost point (top dead center or outer dead center) during compression stroke of the cycle.
 - Minimum volume of combustion chamber with piston at TDC.
- **Compression ratio** : The ratio of total volume to clearance volume of the cylinder is the compression ratio of the engine.
 - Typically compression ratio for SI engines varies form 8 to 12 and for CI engines it varies from 12 to 24