Case study on IC Engines

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Abstract –

An Internal Combustion Engine (IC Engine) is a type of Combustion Engine that converts chemical energy into thermal energy, to produce useful mechanical work. In an IC engine, combustion chamber is an integral part of the working fluid circuit. [1] Air-fuel mixture in the combustion chamber (inside the cylinder) is ignited, either by a spark plug (in case of Spark Ignition Engines) or by compression (in case of Compression Ignition engines). This ignition produces tremendous amount of heat and pressure inside the cylinder. This induces reciprocating motion in the piston.Power of the piston is transmitted to a crankshaft which undergoes rotary motion. The rotary motion is ultimately transmitted to the wheels of the vehicle, via a transmission system, to produce propulsion in the vehicle.As the combustion takes place internally inside the cylinder (a part of working fluid circuit), the engine is called internal combustion engine.

Keywords – IC Engines, Spark Ignition Engines, Compression Ignition engines.

Introduction I

The stroke is defined as the length of the path that the piston goes through inside the cylinder. The upper end of the cylinder is referred to as the Top Dead Centre (TDC), and the lower end is referred to as the Bottom Dead Centre (BDC). Using the crankshaft mechanism, the linear motion that comes out from the piston due to the combustion is converted into rotational motion.

Following is the explanation of the two-stroke and four-stroke engines.

TWO STROKE ENGINE:

A two-stroke, or two-cycle, engine is a type of internal combustion engine which completes a power cycle with two strokes (up and down movements) of the piston during only one crankshaft revolution. This is in contrast to a "four-stroke engine", which requires four strokes of the piston to complete a power cycle. In a two-stroke engine, the end of the combustion stroke and the beginning of the compression stroke happen simultaneously, with the intake and exhaust (or scavenging) functions occurring at the same time.

Two-stroke engines often have a high *power-to-weight ratio*, usually in a narrow range of rotational speeds called the "power band". Compared to four-stroke engines, two-stroke engines have a greatly reduced number of moving parts, and so can be more compact and significantly lighter.

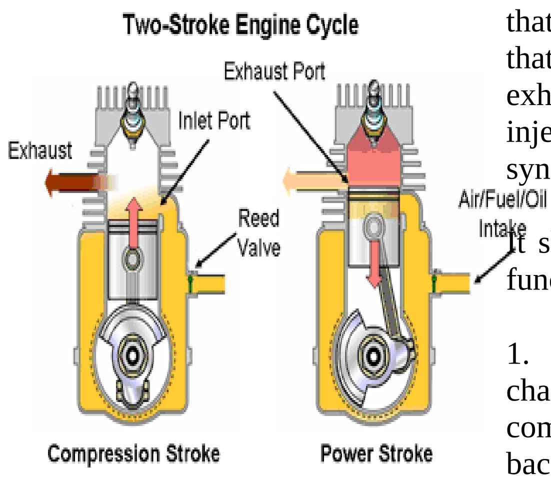

Fig 1.1 Two-Stroke Engine Cycle

Compression Stroke:

The compressed fuel-air mixture ignites and thereby the piston is pressed down. At the same time the intake port is covered by the piston. Now the new mixture in the crankcase becomes pre-compressed. Shortly before the piston approaches the lower dead centre, the exhaust port and the overflow conduit are uncovered. Being pressurized in the crankcase the mixture rushes into the cylinder displacing the consumed mixture (exhaust now).

Power Stroke:

The piston is moving up. The overflow conduit and the exhaust port are covered; the mixture in the cylinder is compressed. At the same time new fuel-air mixture is sucked into the crankcase. By means of a crank shaft the up and down motion is converted into a rotational motion. As the piston proceeds downward, another valve is opened which is the fuel/air valve. Air/fuel/oil mixtures come from the carburetor, where it was mixed, to rest in an adjacent fuel Chamber. When the piston moves downward more and the cylinder has no more gases, fuel mixture starts to flow to the combustion chamber and the second process of fuel compression starts. It is worth mentioning that the design carefully considers the point that fuel-air mixture should not mix with the exhaust. Therefore, the processes of fuel injection and exhausting should be synchronized to avoid the concern.

It should be noted that the piston has three functions in its operation:

1. The piston acts as the combustion chamber with the cylinder, and it also compresses the air/fuel mixture and receives back the liberated energy and transfers it to the crankshaft.
2. The piston motion creates a vacuum in order to such the fuel/air mixture from the carburetor, and pushes it from the crankcase (adjacent chamber) to the combustion chamber.
3. The sides of the piston are acting like the valves, covering and uncovering the intake and exhaust ports drilled into the side of the cylinder wall.

FOUR STROKE ENGINE:

A Four-Stroke Engine (also known as Four Cycle) is an Internal Combustion (IC) engine in which the Piston completes four separate strokes while turning a crankshaft. A stroke refers to the full travel of the piston along the cylinder, in either direction.

STARTING POSITION: This figure shows the initial position of piston and cylinder.

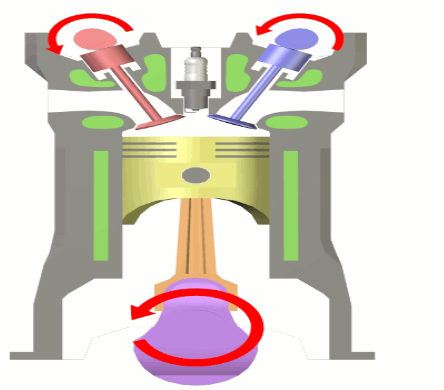

Fig 1.2 Initial position of piston and cylinder

The four separate strokes are termed:

INTAKE STROKE:

During the intake stroke of a spark ignition engine, the piston is moving down. The intake valve is open. Air-fuel mixture flows through the intake port and into the cylinder. The fuel system supplies the mixture. As the piston passes through the BDC, the intake valve closes. This seals off the upper end of the cylinder.

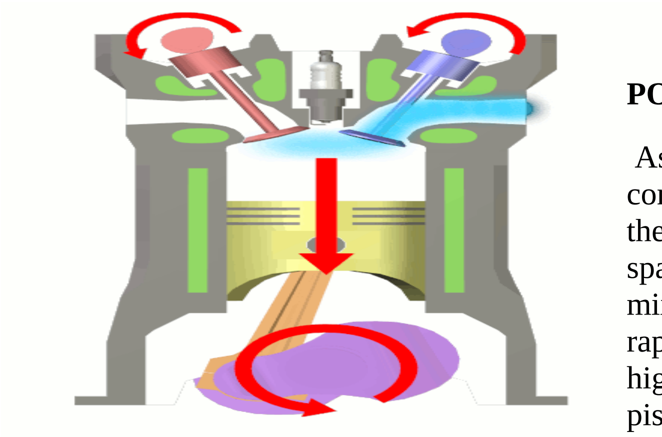

Fig 1.3 Intake stroke

COMPRESSION STROKE:

After the piston passes BDC, it starts moving up. Both valve s are closed. The upward moving piston compresses the air-fuel mixture into a smaller space, between the top of the piston and cylinder head. This space is combustion chamber. The mixture is compressed $1/8^{th}$ or less of its original volume. The amount by the mixture is compressed is compression ratio.

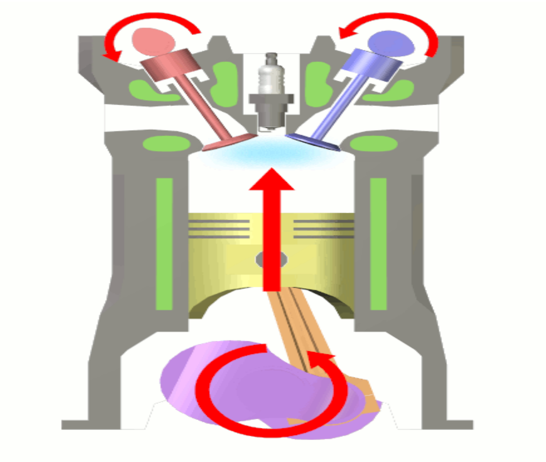

Fig 1.4 Compression stroke

POWER STROKE:

As the piston nears TDC at the end of the compression stroke, an electric spark jumps the gap at the spark plug. The heat from the spark ignites the compressed air-fuel mixture. The air-fuel mixture then burns rapidly. These high temperatures cause very high pressures which pushes down the piston. The connecting rod carries this force to the crank shaft, which turns to move the drive wheels.

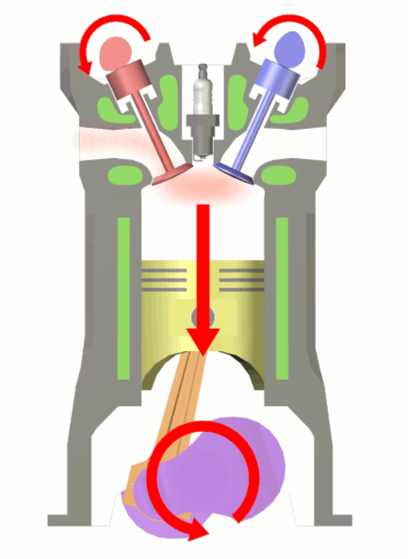

Fig 1.5 Power stroke

EXHAUST STROKE:

As the piston approaches BDC on the power stroke, the exhaust valve opens after passing through the BDC, the piston moves up again. The burned gases escape through the exhaust port. As the piston nears TDC, the intake valve opens. When the piston passes through the TDC and starts down again, the exhaust valve closes.

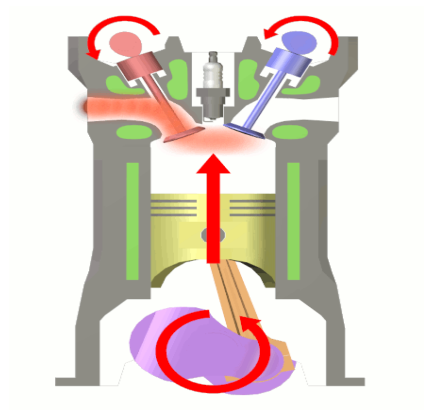

Fig 1.6 Exhaust stroke

1.2 INTRODUCTION TO PISTON

Fig 1.7 Piston

A piston is a component of *reciprocating engines*, reciprocating *pumps*, *gas compressors* and *pneumatic cylinder*s, among other similar mechanisms. It is the moving component that is contained by a *cylinder* and is made gas-tight by *piston rings*. In an engine, its purpose is to transfer force from expanding gas in the cylinder to the *crankshaft* via a *piston rod* and/or *connecting rod*. In a pump, the function is reversed and force is transferred from the crankshaft to the piston for the purpose of compressing or ejecting the *fluid* in the cylinder. In some engines, the piston also acts as a *valve* by covering and uncovering *ports* in the cylinder wall.

Credit for inventing history's first piston engine goes to French physicist Denis Papen, who published his design for a piston steam engine in 1690. The basic design evolved by the early eighteenth century: Thomas Newcomen of England and James Watt of Scotland improved upon Papen's innovation by adding a boiler and steam condenser to the cylinder.

A ***piston*** is a cylindrical engine component that slides back and forth in the cylinder bore by forces produced during the combustion process. The piston acts as a movable end of the combustion chamber. The stationary end of the combustion chamber is the cylinder head. Pistons are commonly made of a cast aluminum alloy for excellent and lightweight thermal conductivity. ***Thermal conductivity*** is the ability of a material to conduct and transfer heat. Aluminum expands when heated and proper clearance must be provided to maintain free piston movement in the cylinder bore. Insufficient clearance can cause the piston to seize in the cylinder. Excessive clearance can cause a loss of compression and an increase in piston noise.

In general, a piston is a sliding plug that fits closely inside the bore of a cylinder. Its purpose is either to change the volume enclosed by the cylinder, or to exert a force on a fluid inside the cylinder**.**

CONCLUSION

Although the piston appears to be a simple part, it is actually quite complex from the design and manufacturing stand point. The efficiency and economy of the engine primarily depends on the working of the piston. So the working of the piston be more efficient. It must operate in the cylinder with minimum friction and should be able to withstand the high explosive force developed in the cylinder and also withstand very high temperature ranging from 2000 C to 2800 C during operation. To avoid the wear and noise between cylinder walls and piston rings, piston rings should manufacture with wear resistant materials like cast iron and steel.

In this project, Finite element analysis for static structural and thermal conditions of the engine piston with different materials was performed. The main objective of this project was to study the response of aluminum alloys and SiC reinforced ZrB2 composite material for the applied temperatures and pressure. From the results it is concluded that the piston with SiC reinforced ZrB2 composite material is having less stress, while the piston with aluminum alloys are having more stresses for the applied temperatures and pressures. It is also observed that the stresses for all the materials are within the allowable limits of the respective material. So, it is concluded that the piston with SiC reinforced ZrB2 composite material is the best choice for the manufacturing of the piston.

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