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Principals of Internal Combustion Engine

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Abstract

An example of power equipment is an internal combustion engine, which directly turns the heat energy supplied by the fuel into power by burning the fuel inside the machine. The internal combustion engine is widely employed in all facets of industry and transportation. The next article will introduce and categorize the internal combustion engine as well as analyze its internal structure to help readers better grasp its power principle and performance.

Keywords: *Internal Combustion Engine; Machinery; Engine; Power Principle.*

Introduction

The internal combustion engine produces power through a combustion burst that combines liquid or air inside the cylinder's high-pressure combustion chamber. The heat engine in question also transforms heat energy into mechanical energy. The internal combustion engine is characterized by its small size, light weight, mobility, great thermal efficiency, and effective starting. However, internal combustion engines typically burn petroleum fuel, and a significant amount of hazardous gases are released during burning.

Categorization of internal combustion engines

1) Engines can be classified as follows: diesel engines, gasoline engines, CNG engines, ethanol engines, LPG engines, etc., as well as double-fuel engines also known as Bi-fuel engines.
2) Depending on how many strokes are used: two-stroke, four-stroke.
3) Depending on the piston's style of movement: rotary type, reciprocating type
4) Air-cooled or water-cooled, depending on how the cylinder is being cooled.
5) Single-cylinder engines and multi-cylinder engines are classified based on the number of cylinders.
6) Internal combustion engine speeds are classified as less than 300 rpm is low, between 300 to 1000 rpm is average, and more than 1000 rpm is high.
7) Naturally aspirated or pressurized, depending on the intake charge pressure
8) The following cylinder configurations are available: vertical, horizontal in line, V-shaped, opposing X-type, and star type.

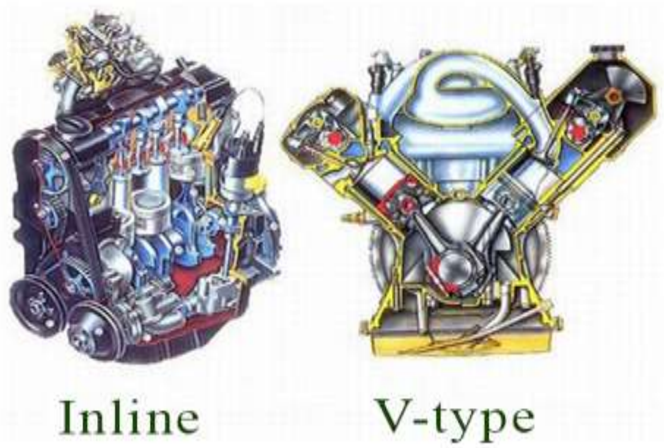

Figure 1 Inline and V- type combustion engine.

Structure of the internal combustion engine's system and mechanism

An engine is still a sophisticated device created of numerous mechanisms and a machine. Whether it is a four-strokes or two-strokes engine, whether it is a gasoline or diesel engine, or whether it has one or more cylinders. The following mechanisms and systems must be in place to complete the energy conversion, actualize the working cycle, and guarantee long-term continuous normal work.

Crank Linkage:

The major moving component of the engine that enables the operating cycle and completes the energy conversion is the crank linkage. This part consists of a crankshaft flywheel group and a body group. The piston transfers the gas pressure during the work stroke to move the cylinder linearly. This movement is transformed into the crankshaft's rotating motion by the connecting rod, and the crankshaft then produces power. The flywheel releases energy during the intake, compression, and exhaust strokes, changing the crankshaft's rotational motion into the piston's linear motion.

Figure 2 Crank Linkages

Gas Distribution Mechanism

The gas distribution mechanism periodically opens and closes the intake and exhaust valves by the engine's working sequence and operating procedure to allow combustible mixture or air to enter the cylinder and exhaust gas to be expelled from the cylinder to carry out the ventilation process. Most gas distribution systems use overhead valve designs, and the key parts of these systems are valve groups, valve transmission groups, and valve drive groups.

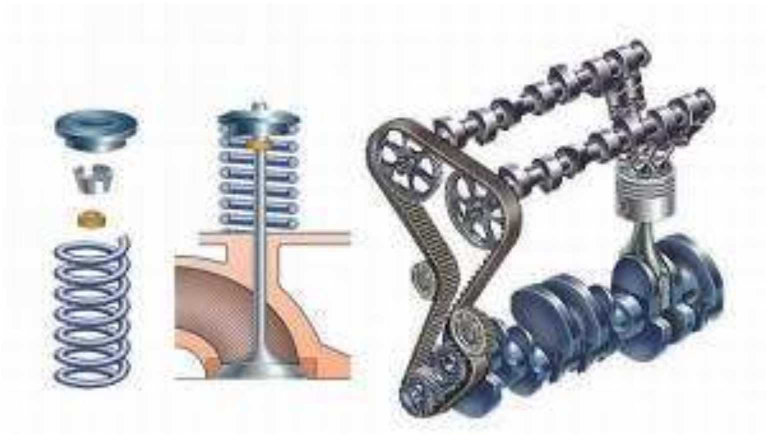

Figure 3 Gas Distribution Mechanism of engine

Functions of Gasoline Engine and Fuel Delivery System

For a gasoline engine, the fuel supply system prepares a specific volume and concentration of mixed gas according to the engine's requirements, supplies it to the cylinder, and releases the exhaust gas into the atmosphere for a diesel engine. The fuel supply system supplies diesel and air separately and mixes them in the combustion chamber and burns them before finally releasing the exhaust gas after combustion.

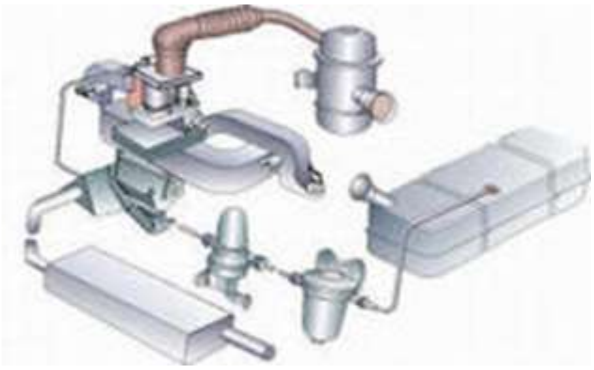

Figure 4 Fuel Supply System

System of Lubrication

The purpose of the lubrication system is to provide a precise quantity of clean lubricating oil to the surface of the components that are moving relative to one another to achieve liquid friction, reduce friction resistance, and diminish the wear of mechanical parts. The part's surface is washed and chilled. The lubrication system typically consists of oil filters, valves, and routes for lubricating oil.

Cooling system

The cooling system's job is to disperse some of the heat that is quickly absorbed by the heated components so that the engine can run at the correct temperature. A cooling water jacket, fan, water tank, thermostat, and other components make up the cooling system of a water-cooled engine.

Figure 5 Cooling system of engine

Ignition system

In gasoline engines, the spark plug head protrudes into the combustion chamber to ignite the combustible mixture inside the cylinder, which is why it is positioned on the cylinder head of the gasoline engine. The term "ignition system" refers to any device that is capable of producing electric sparks between the electrodes of a spark plug on demand. An ignition system typically consists of a generator, an ignition coil, and a spark plug.

Starting System

The combustible mixture in the cylinder must burn and expand for the engine to move from a static to a functioning state. To accomplish this, you must first rotate the engine's crankshaft using an external force. This causes the piston to reciprocate and the crankshaft to turn. Only then will the engine be able to operate independently, and the work cycle will run automatically. As a result, the entire procedure from the moment the crankshaft starts to turn under the influence of an external force until the engine starts to idle on its own is referred to as. The engine's starting system is the component needed to complete the starting procedure. The system is made up of the shank connecting rod mechanism, the gas distribution mechanism, the fuel supply system, the lubrication system, the cooling system, the ignition system, and the starting system; The diesel engine is made up of the two major mechanisms mentioned above as well as four major systems, including the crank connecting rod mechanism, gas distribution mechanism, fuel supply system, lubrication system, cooling system, and starting system. Additionally, because diesel engines use compression ignition, an ignition system is not necessary.

Internal combustion engines with reciprocating pistons are made up of several different parts, the most important of which are the crank connecting rod mechanism, body and gas distribution mechanism, oil supply system, lubrication system, cooling system, beginning, and so forth.

The cylinder is a metal device with a cylindrical shape. The sealed cylinder serves as the source of the operating cycle and power production. A cylinder head covers the top of each cylinder to seal it off, and a cylinder liner is installed in the body of each cylinder. A sealing area with a predictable volume change is created as the piston moves back and forth in the cylinder liner and encloses the cylinder from the lower half of the cylinder. In this area, the fuel burns, producing gas power that moves the piston. The crank connecting rod mechanism, which comprises a piston group, connecting rod group, crankshaft, and flywheel, is the main part of an internal combustion engine for transmitting power.

Pistons, piston rings, and other components make up the piston group. The piston is shaped like a cylinder and has piston rings to seal the cylinder during reciprocation. The lower piston rings are known as oil rings and are used to scrape off the excess on the cylinder wall to prevent lubricating oil from entering the cylinder. The top piston rings sometimes referred to as air rings, are utilized to seal the cylinder and stop gas leaks. The pinhole on the piston and the small head of the connecting rod are both sized to accommodate the cylindrical piston pin, which joins the piston and connecting rod. The two sides of the big head end of the connecting rod are joined by a connecting rod screw that is fastened to the crank pin of the crankshaft. When the connecting rod is in operation, the tiny head end of the rod reciprocates with the piston, the big head end of the rod spins with the crank pin around the crankshaft axis, and the connecting rod between the large and small heads produces a complicated rocking motion.

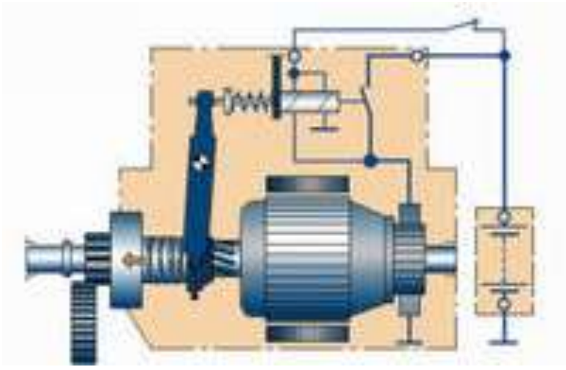

Figure 6 Starting system

The flywheel, which is situated on the crankshaft's back end, receives the work from the expansion stroke by the crankshaft, which converts the piston's reciprocating action into a rotational motion. The remaining piston can work well because of the flywheel, which stores energy and rotates the crankshaft consistently. The mass is properly balanced on the internal combustion engine's crankshaft to counteract inertial forces and reduce vibration.

Working principle of the internal combustion engine

Intake and exhaust ducts, as well as intake and exhaust valves, are present in the cylinder head. The intake pipe, the intake tract, and the inlet filling cylinder are all passed through by the fresh charge, which can be either air or a combustible mixture of air and fuel. After passing through the exhaust valve and exhaust duct, the expanded gas is released into the atmosphere. Through transmission components including tappets, pushers, rocker arms, and valve springs, the upper intake and exhaust cams regulate the opening and shutting of the intake and exhaust valves. This group of mechanical parts is referred to as the internal combustion engine gas distribution mechanism. It typically comprises an exhaust muffler, intake pipe, air filter, and exhaust pipe.

Internal combustion engines have a fuel delivery system to deliver fuel to the cylinders. At the intake end of the intake pipe, the gasoline engine mixes air and gasoline in a specific ratio (air-fuel ratio), supplies the cylinder through the intake pipe, and periodically ignites the electric spark regulated by the gasoline engine ignition system. The diesel engine's fuel is fed into the combustion chamber, where it self-ignites under extreme heat and pressure.

An internal combustion engine's cylinders heat when fuel burns inside of them, heating components like pistons, cylinder liners, cylinder heads, and valves as the temperature rises. The components must function at the authorized temperature and not suffer from overheating for the internal combustion engine to run normally, necessitating the installation of a cooling system.

The crankshaft of an internal combustion engine must be spun by an outside force for it to transition from the shutdown condition to the operational state. This apparatus is referred to as producing external force. Electric starting, compressed air beginning, gasoline engine starts, and human starting are all often employed.

Processes including air intake, air compression, combustion and expansion, exhaust, etc. make up the internal combustion engine's working cycle. The other steps are all necessary to actualize the work process more fully; only the expansion process involves external work. Work cycles can be categorized into two groups: four-stroke and two-stroke, depending on how many strokes are required to complete one.

A four-stroke is a cycle of work in which the crankshaft revolves twice during each of the four strokes of the air intake, compression, work (expansion), and exhaust. The intake valve opens, and the exhaust valve closes during the intake stroke. The intake pipe and intake valve allow the air passing through the air filter or the combustible mixture created by mixing gasoline and the carburetor to enter the cylinder; The gas in the cylinder is compressed, the pressure rises, and the temperature rises when the stroke is compressed; Before compressing the top dead center, the expansion stroke is used to inject oil or ignite the mixture to cause it to burn, creating high temperatures and high pressures that force the piston downward and do work; The exhaust gas in the piston pushes the cylinder via the exhaust valve during the exhaust stroke. The next working cycle then starts with the intake stroke.

A two-stroke is when a working cycle is finished in two strokes with just one crankshaft rotation between them. First, the intake and exhaust ports are opened with the live plug at the bottom dead center, the fresh charge is poured into the cylinder, and the exhaust gas is swept out of the cylinder and released via the exhaust port; When the piston is close to top deceased center, the piston is ignited or injected, which causes the combustible mixture in the cylinder to burn; the piston then rises, the intake and exhaust ports are closed, and the charge in the cylinder starts to be compressed; The piston is then forced downward to perform work as the gas in the cylinder expands;

The ventilation process of an internal combustion engine refers to both the exhaust and the intake processes. The fundamental goal of ventilation is to remove as much exhaust gas from the previous cycle as possible, allowing the current cycle to provide as much fresh charge as possible, and allowing the cylinder to burn as much fuel as possible entirely, producing greater power. The effectiveness of the internal combustion engine is directly impacted by the ventilation process' quality. For this reason, it's crucial to make the intake and exhaust valves open and close at the right times in addition to lowering the flow resistance of the intake and exhaust systems.

The exhaust gas is released when the piston's downward exhaust outlet opens, and the piston then proceeds to drop to the bottom dead center, completing a working cycle.

To ensure that the intake valve has a large opening when the piston is descending, the intake valve is opened before the top dead center. This can reduce the flow resistance at the beginning of the intake process, reduce the work required by suction, and fill the engine with a fresh charge. Due to the airflow's inertia, when the piston reaches the bottom dead center during the intake stroke, the fresh charge can still be added to the cylinder, delaying the intake valve's closure after the bottom dead center.

To use the higher gas pressure in the cylinder to automatically flow the exhaust gas out of the cylinder and move the piston from the bottom dead center to the dead center when the gas pressure in the cylinder is lower, the exhaust valve is also opened before the bottom dead center. This reduces the power required by the piston to expel the exhaust gas out of the cylinder. Closing the exhaust valve after the top dead center serves to remove any remaining exhaust gases more effectively from the cylinder by utilizing the exhaust flow's inertia.

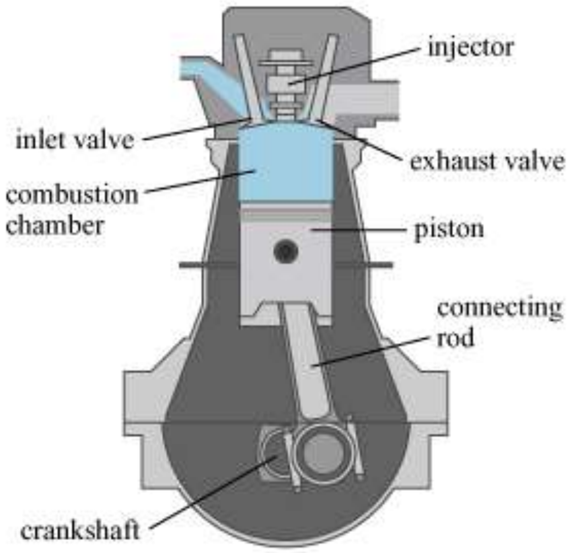

Figure 7 Internal combustion engine

Working indicators of internal combustion engines

1. Dynamic performance indicators:

How much power is generated and where is the power/torque reserve?

2. Economic Performance Indicators:

Unit power per unit time.

3. Reliability and durability indicators:

Maximum uptime and trouble-free long-term capabilities between overhauls or replacement parts

4. Environmental performance indicators (NOx, HC, CO, particulates)

Hazardous material emissions per unit of power and time.

Performance and development of internal combustion engines

Power and efficiency are the two fundamental components of internal combustion engine performance. The terms "power performance" and "torque performance" relate to the power (or torque) that an internal combustion engine produces, which serves as a measure of the engine's efficiency in converting energy. Thermal efficiency is one of the factors that characterize the economic performance. Economic performance is defined as the amount of fuel burned when a specific amount of electricity is provided.

Internal combustion engine development in the future will concentrate on enhancing the combustion process, enhancing and lowering heat dissipation losses, and decreasing fuel consumption rates; expansion of fuel resources, non-petroleum product fuel development, and use; Reducing the dangerous substances in the exhaust, the noise and vibration, and the pollution of the environment; adopt high, strengthen internal combustion engines more, and increase the single engine's power; creation of composite engines, including turbo composite engines; the best performance of internal combustion engines is achieved by using microprocessors to control them; To increase working reliability and life, structural strength research should be strengthened. Continuously developing variable valves, variable lifts, variable phases, and even stopping several cylinders of technology have not been successful in achieving continuous bore change in the march, but they are equivalent.

A round hole in the center of the barrel bottom follows the barrel bottom on this engine's barrel-shaped block. The cake body is also included in the barrel, closed into a hollow cylinder chamber, as how a chopstick would pass through a thick round cake and glue. The chopsticks are the shaft, and this shaft also passes through the hole at the bottom of the barrel cylinder. For instance, by fastening the barrel and pushing the shaft with a mechanical or hydraulic mechanism, the volume of this cylinder cavity can be changed.

A rectangular plate is inserted between the round hole's edge and the inner barrel wall at the bottom of the barrel; a rectangular plate is also inserted between the round hole's edge and the shaft at the top of the cake; together, the two rectangular plates can divide the cylinder cavity in half to create two sealed cylinder cavities, the first sealing cylinder cavity, and the second sealing cylinder cavity. A rectangular plate of the barrel wall is used to open one of the sealed cylinder chambers, which is then filled with high-pressure gas or an oil-gas mixture and ignited. A rectangle plate is then used to deflate the second sealing chamber from the barrel wall at the location of the first opening. To spin the bucket, the cake and chopsticks are pulled by the rectangular plate, and vice versa.

The initial sealing chamber can be made to cease providing gas from the smallest and inflate to a particular phase (corner) by using valves or by regulating the flow of oil and gas. The first seal cylinder cavity's air pressure will drop until it is just a little below the surrounding air pressure as the high-pressure gas expands as the unit rotates, producing rotational resistance. Therefore, a hole must be made in the second rectangular plate close to the head's edge, a check valve must be added, and additional air must be pumped within. When the second rectangular plate moves to the second aperture, the air pressure in the first sealed cylinder cavity is precisely equal to or nearly equal to the ambient air pressure, which is the most economical situation if the initial air pressure is appropriate. When there is just a tiny bit of residual pressure, that is the third scenario.

It is necessary to keep two rectangular plates apart when they are ready to collide. A hollow cylinder is placed on the side that emerges from the bottom of the barrel from the shaft, and the outer round face is carved with a curved chute, fitted with a sliding block, and connected to the first rectangular plate. As a result, a chute was cut from the inner skirt of the barrel, and a sliding block was installed and connected to a second rectangular plate. The chute controls the rectangular plate's forwarding, jacking, and withdrawing, which consists of a circle and cycloid. It won't pull off since the cake and the bottom of the barrel are both thick enough. The second rectangular plate rotates in the same direction as the pie; in the axial direction, it is controlled by the chute on the barrel, so when the volume is changed, it may still be pressed against the bottom of the barrel. The first rectangular plate always hits the pie's inner surface in the same way.

It is a powerful mechanical device that uses an arc-shaped trajectory on a force surface to transform the internal energy of high-pressure gas into kinetic energy. It can then be utilized mechanically to brake or reverse rotation to create compressed air. Create a small-capacity compressor, high-pressure oil, and gas, with an igniting device, and then a large-capacity mechanical device that, after combustion, transforms the internal energy of a lot of high-temperature and high-pressure gas into kinetic energy, which is an engine.

Its work has an arc-shaped trajectory, and the capacity may be modified sleeplessly, indicating that it is changeable. After combustion, cooperation can adjust the air pressure and allow for variable speed changes; It can adapt to different loads within a specified range by adjusting the displacement and collaborating with the transmission, and the "most economical" approach mentioned above is chosen. The shaft's bending can be minimized by using multiple sets of opposing rectangular plates; noise is minimal because the exhaust is continually discharged; The power is stable, and multiple sets of cylinders can be staggered and coupled. It is a good energy-saving technology because it can reduce residual pressure emissions and adopt the most cost-effective working conditions under various circumstances.

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