Combustion engine

The classifications of combustion engines

The classifications on the type of fuel, the combustion engines a according to:

- Gas motors are combustion engines used CNG or LPG.
- Gasoline engines are mainly used for propulsion of motorcycles, passenger cars and other special vehicles. It is also possible to use alternative fuel like a alcohol or ethanol.
- Diesel engines designed for the propulsion of passenger cars, trucks, buses, tractors, construction machinery and other vehicles.
- Multi-fuel engines, these are engines that can combust several types of fuel, mainly because of the economy of operation. They are mainly used for the propulsion of passenger cars.

According to the method of forming the combustible mixture, the motors are divided into:

- Pre-Roll Formation Engines - These are engines that use easily evaporable fuels.
- Cylinder engines - mainly engines where the fuel is fed into the cylinder by direct injection.

According to the method of filling the cylinder with air

-Engines with atmospheric filling.

- Engines filled with turbocharger

According to fuel ignited

- Spark-ignition engines where the mixture is fired in the cylinder by means of an electric ignition
- Compression-ignition engines - which, due to high temperature and pressure, ignite the fuel.

According to the arrangement of cylinders

- One-row - standing, lying, sloping, and the like. Fig.1 and Fig.2.
- Multiradials - fork Fig.3, fan-shaped Fig.4, two-side Fig.5, lying Fig.6
- Rotary engine - Fig.7.

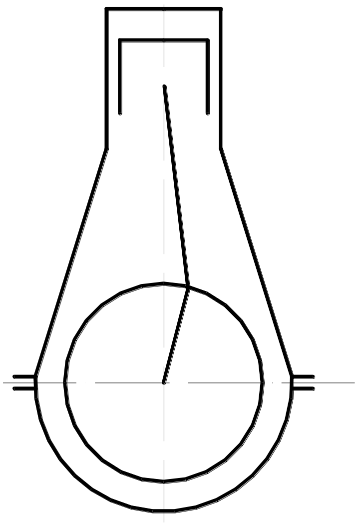


Fig.1

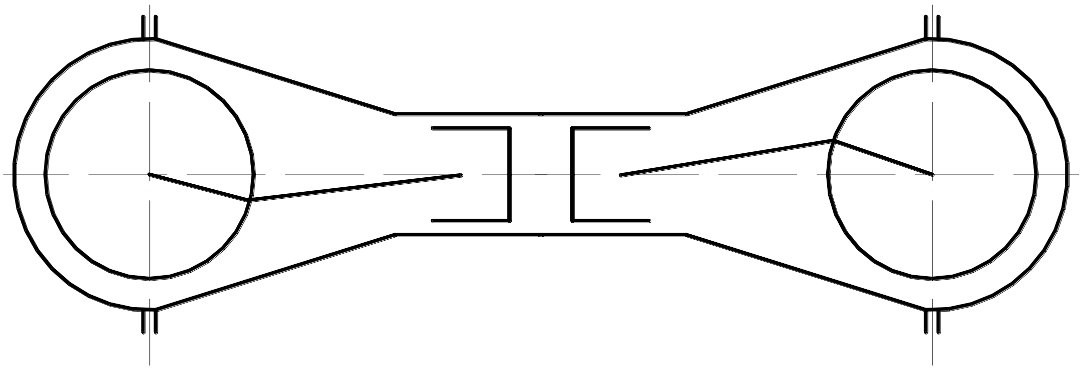


Fig.2

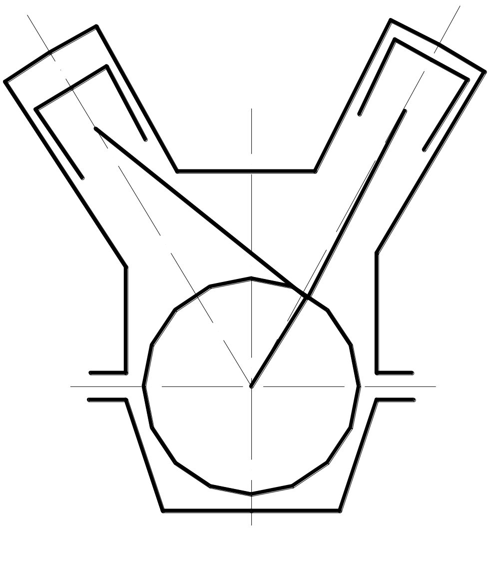


Fig.3

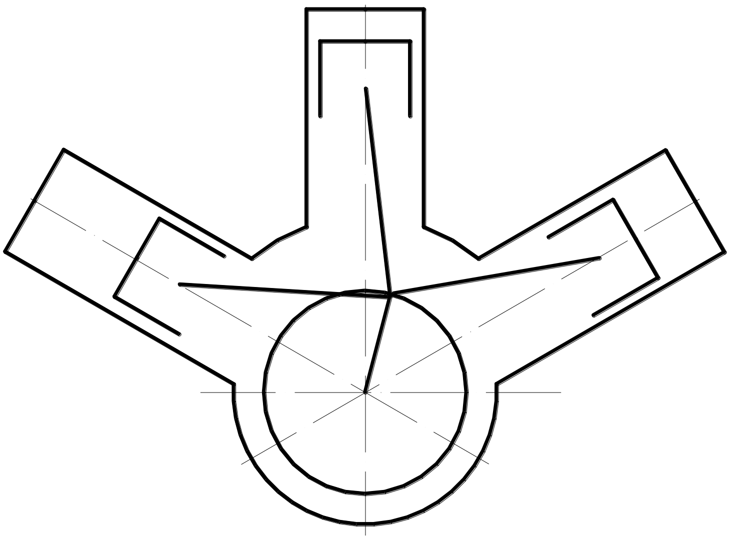


Fig.4

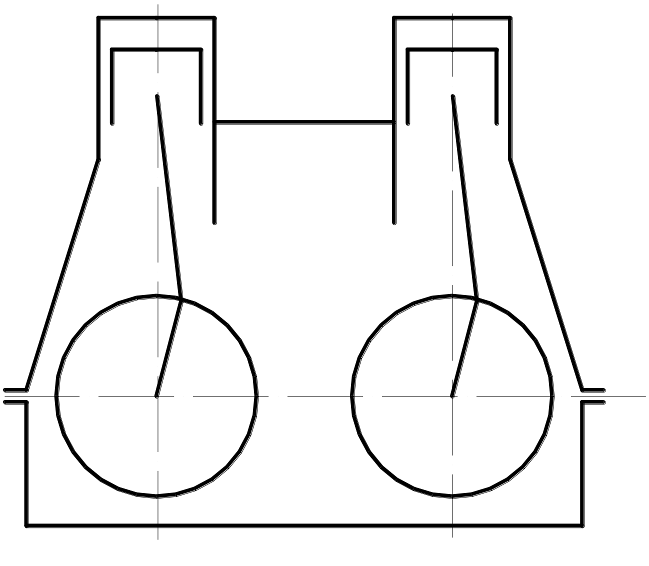


Fig.5

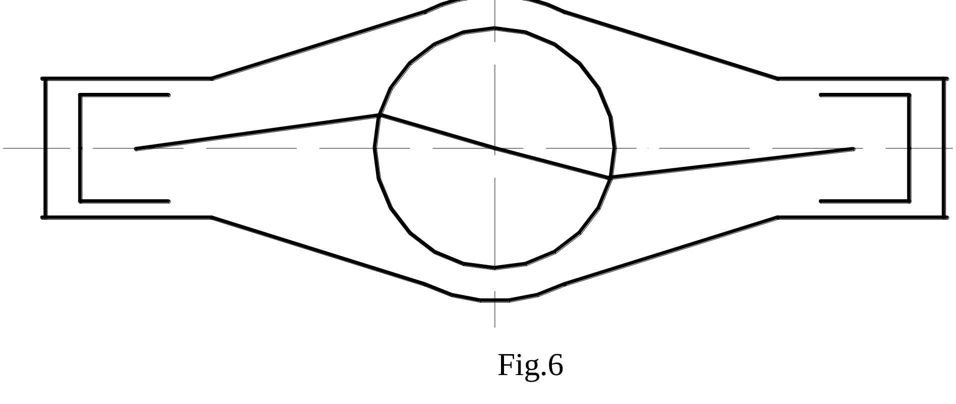


Fig.6

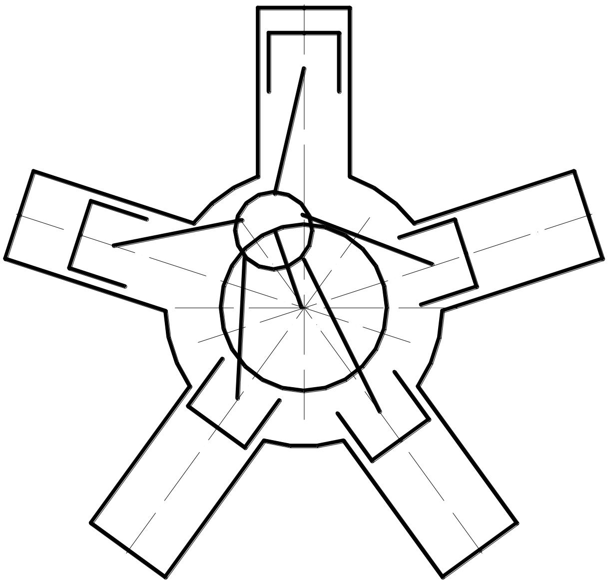


Fig.7

According to the cooling, the engines are cooled by air, liquid, or combined.

By working circle

- Two-stroke engines - The entire engine run is performed during one crankshaft rotation.
- Four-stroke engines - The work cycle is performed during two crankshaft rotation.

The *top dead center* (TDC) of a piston is the position where it is nearest to the valves; *bottom dead center* (BDC) is the opposite position where it is furthest from them. A *stroke* is the movement of a piston from TDC to BDC or vice versa, together with the associated process. While an engine is in operation, the crankshaft rotates continuously at a nearly constant speed. In a 4-stroke ICE, each piston experiences 2 strokes per crankshaft revolution in the following order. Starting the description at TDC, these are:

Four stroke cycle gasoline engine.

1. **Intake** stroke: On the intake stroke, the air-fuel mixture from carburetor, (or fuel injection nozzle is use before inatke valves) enters the combustion chamber trough the intake valve as the piston moves down. The exhaust valve is closed. The new gasoline engines use the pressure of fuel injection from 1 MPa to 5 MPa.
2. **Compression**: On the next stroke or compression stroke - the piston move up, increasing the pressure on the fuel-air mixture. Both intake and exhaust valves are now closed.
3. **Power** or **working stroke**: As the piston copletes its upward compression stroke, the compressed fuel - air mixture is ignited by the spark plug. The force of the combustion

causes the piston to move downward with great force. both intake and exhaust valves remain closed.

4. **Exhaust**: On the exhaust stroke, the piston begins to move upward as the exhaust valve opens. Burned gases are forced out of the combustion chamber through the exhaust valve opening.

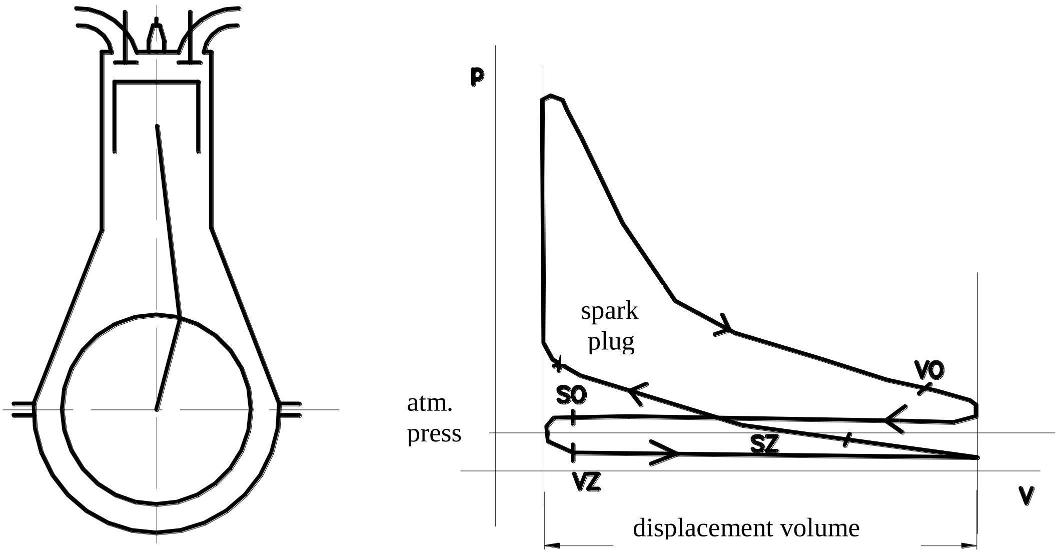


Fig.

SO- intake valve open
SZ - intake valve close
VO- exhaust valve open
VZ -exhaust valve close

Four stroke cycle diesel engine.

1. **Intake** stroke: The intake stroke in the diesel engine differs from that the gasoline engine in that only air is drawn into cylinder - not an air - fuel mixture as in the gasoline engine. The exhaust valve is closed.
2. **Compression**: The major difference between the compression stroke in the two engines (diesel versus gasoline) is the compression ratio in the cylinder. (16:1 to 22:1 - diesel engines, from 8:1 - gasoline engine). Another difference in the compression stroke of the diesel engine is that fuel is injected directly into the cylinder by fuel injector and is then mixed with the air already in the cylinder. The temperature of compressed air is over 600°C. The head of compression ignites the injected fuel. Both intake and exhaust valves are closed.
3. **Power** or **working stroke**: The temperature rises in the cylinder as the head of compression ignites the fuel (for common rail system is pressure over 200MPa) , and the tremendous pressure force the piston downward. Both intake and exhaust valves remain closed.

4. **Exhaust**: The axhaust valve opens shortly before the piston reaches bottom dead center. As the piston begin to move upward, it pushes the burned gases out of the exhaust valve port and clearing cylinder.

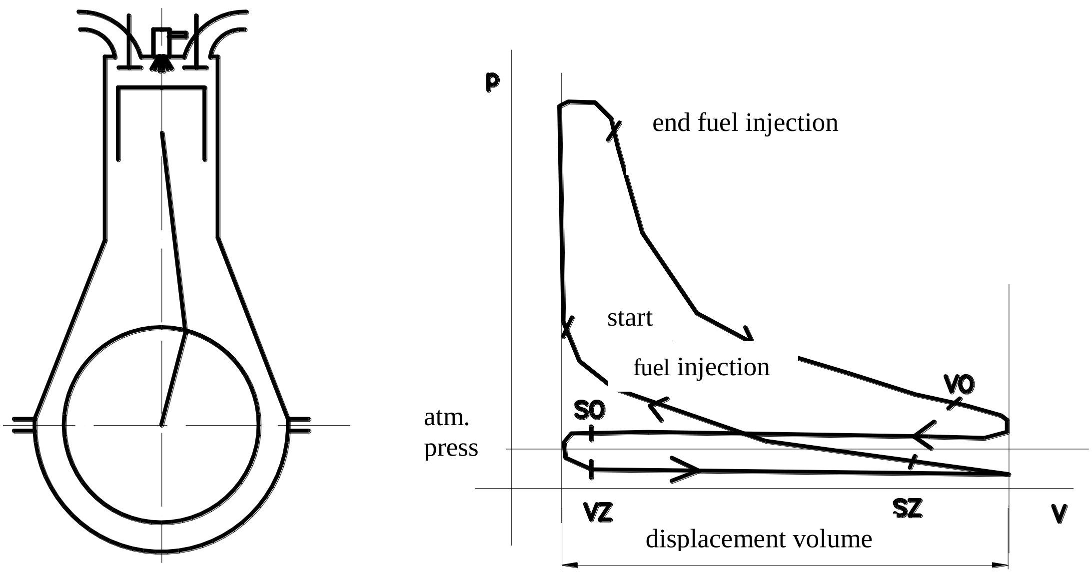


Fig.

<u>Two stroke cycle gasoline engine</u>

The defining characteristic of this kind of engine is that each piston completes a cycle every crankshaft revolution. The 4 processes of intake, compression, power and exhaust take place in only 2 strokes so that it is not possible to dedicate a stroke exclusively for each of them. Starting at TDC the cycle consist of:

1. **Power**: While the piston is descending the combustion gases perform work on it, as in a 4-stroke engine. The same thermodynamic considerations about the expansion apply.
2. **Scavenging**: Around 75° of crankshaft rotation before BDC the exhaust valve or port opens, and blowdown occurs. Shortly thereafter the intake valve or transfer port opens. The incoming charge displaces the remaining combustion gases to the exhaust system and a part of the charge may enter the exhaust system as well. The piston reaches BDC and reverses direction. After the piston has traveled a short distance upwards into the cylinder the exhaust valve or port closes; shortly the intake valve or transfer port closes as well.
3. **Compression**: With both intake and exhaust closed the piston continues moving upwards compressing the charge and performing a work on it. As in the case of a 4-stroke engine, ignition starts just before the piston reaches TDC and the same consideration on the thermodynamics of the compression on the charge.

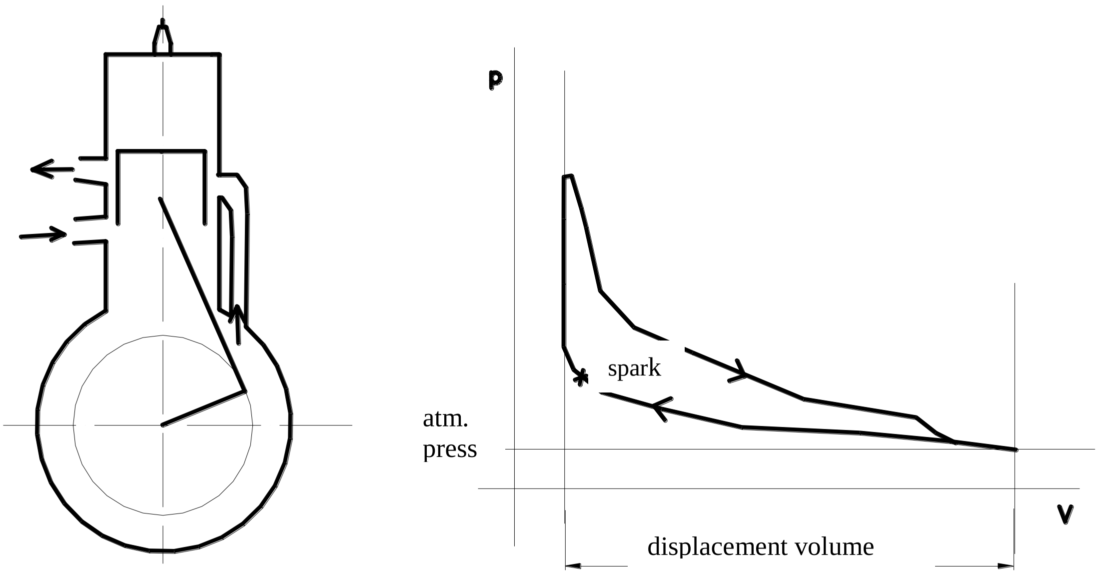
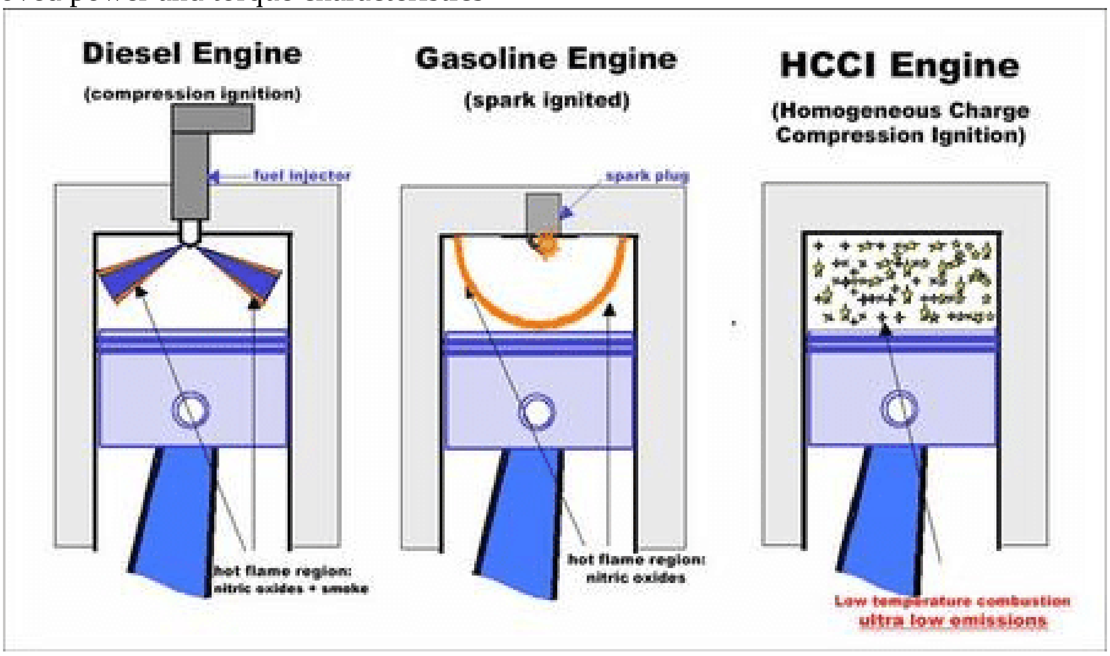


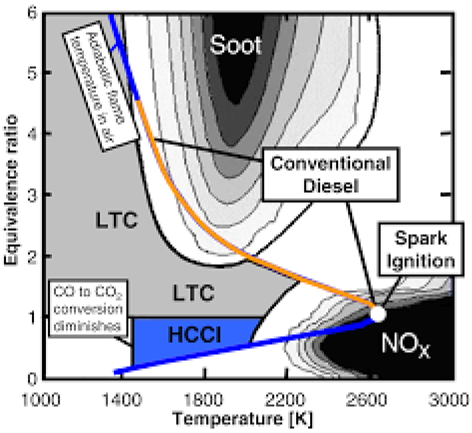
Fig.

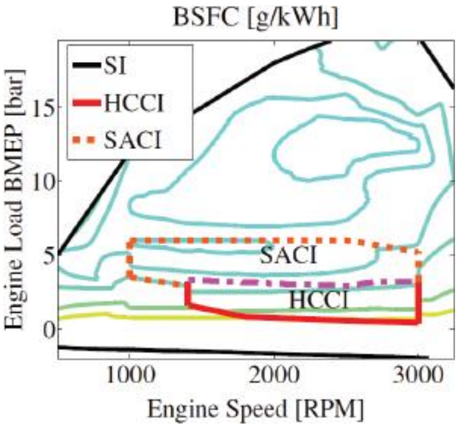
Trends of develop combustion engines

- main criterions: low emissions, low fuel consumption, increasing efficiency, increased power, improved power and torque characteristics

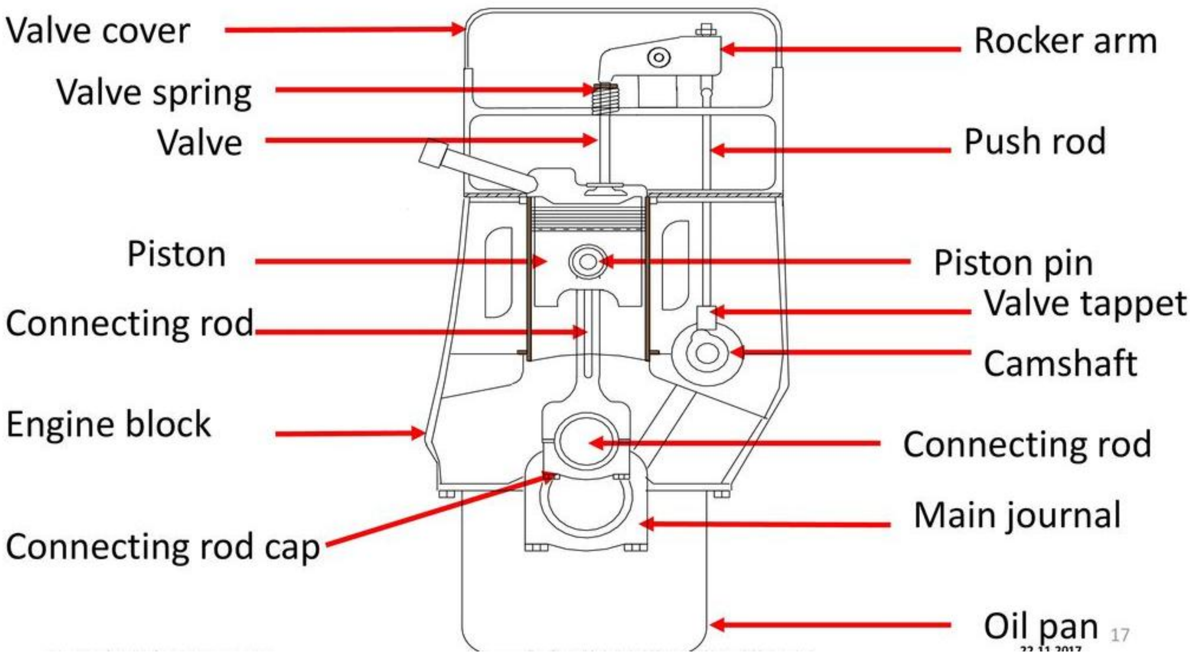


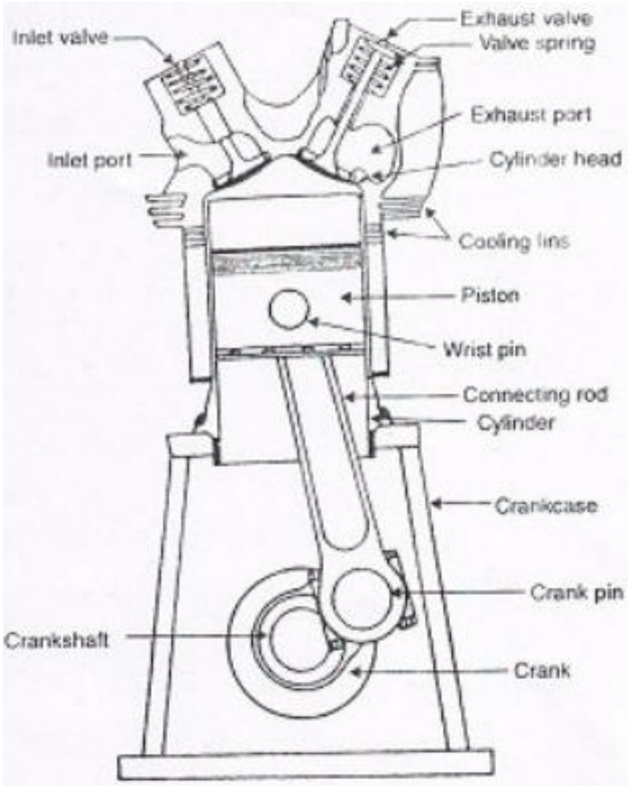
Necessary condition: variable compression ratio : compression ratio in the cylinder 8:1 to 14:1



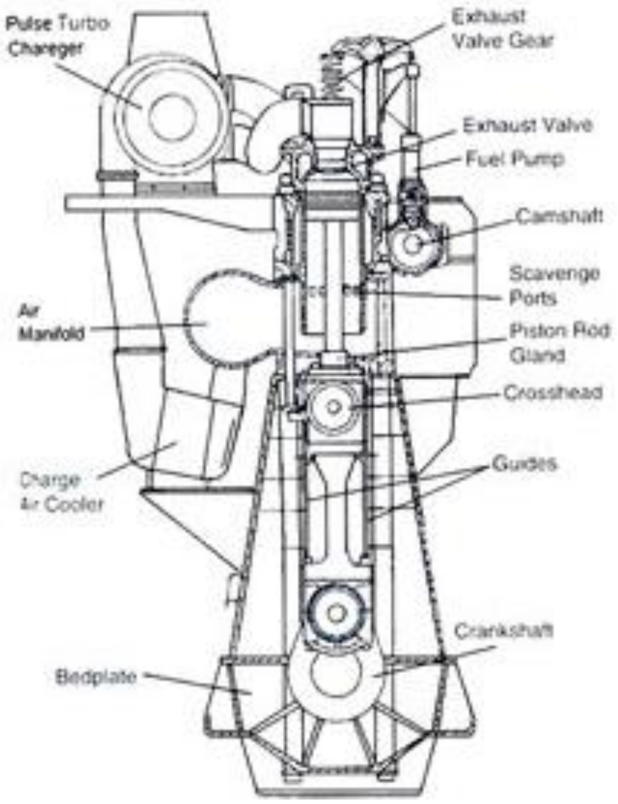


The main parts of combuston engine

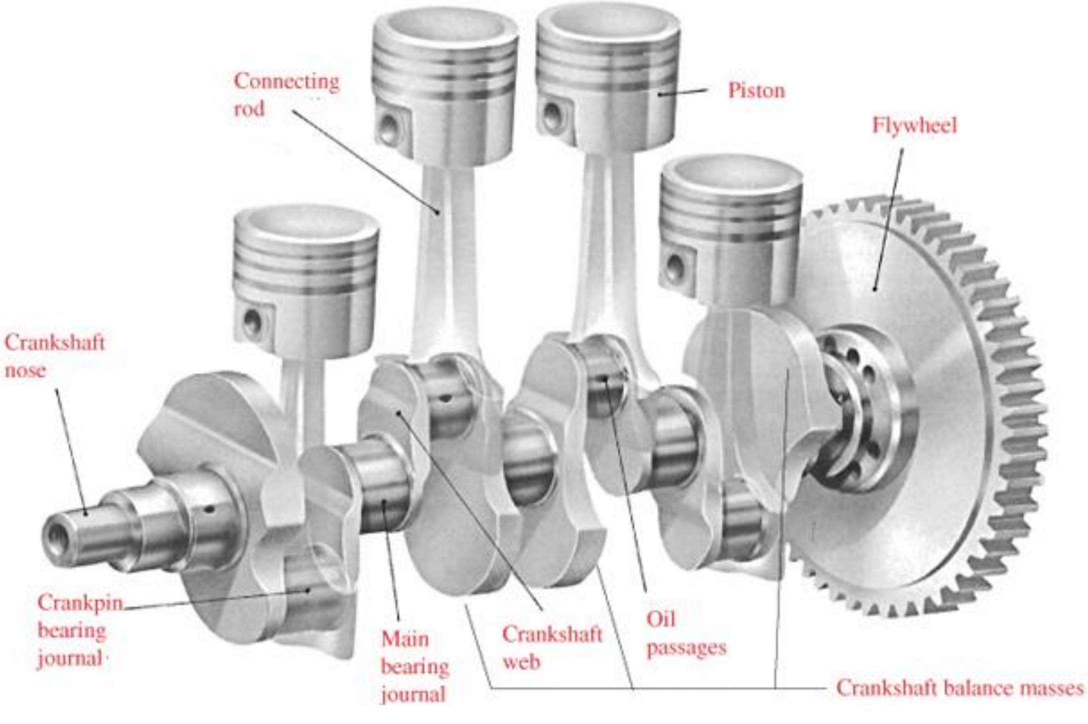


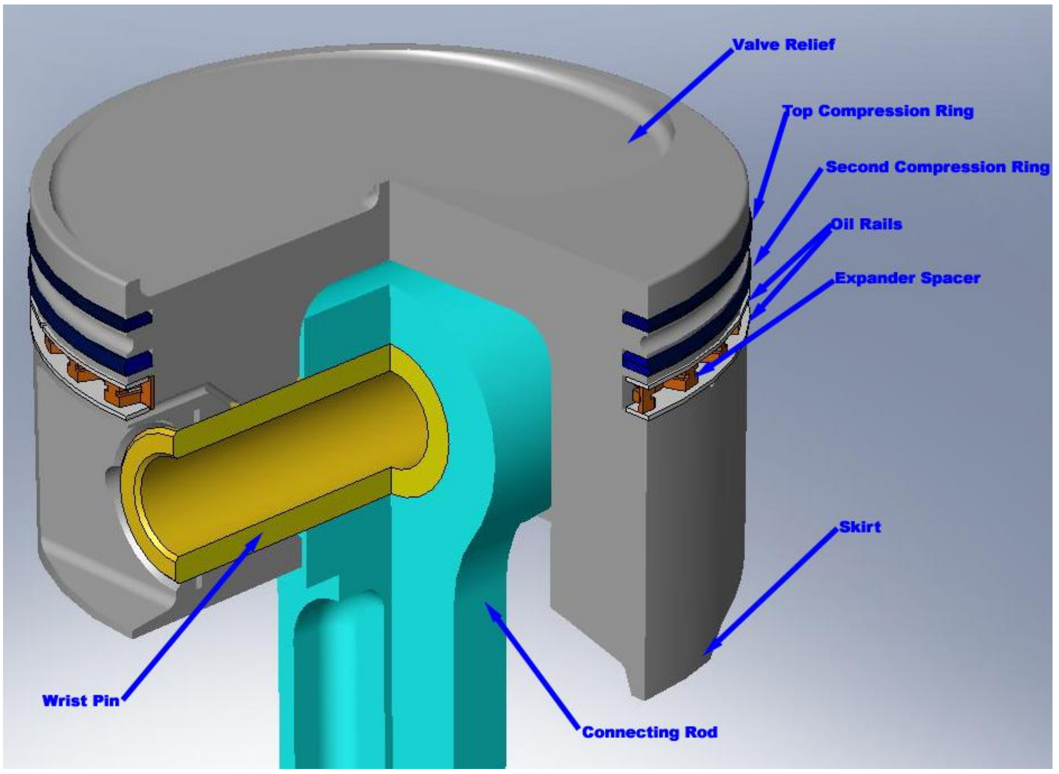


Air cooled engine



Large- volume and slowly speed engine with turbocharger





Compustion engine power

The determination of engine power can only be made under a few conditions. The magnitude of the output depends on the amount of heat that is released per unit time by burning the mixture in the working space of the cylinder. We can perform a separate calculation of engine power in various ways. A simple way is to use the average values that are achieved with an engine of the same type. In the case of a single-cylinder engine, the work transferred to the crankshaft is determined by means of the pressure diagram Fig. the difference between the size of the consumed and performed work, which can be determined from the areas of diagram A1, A2. The variable pressure in the cylinder can be replaced by the mean indicated pressure. The mean indicated pressure p_i is a pressure of constant value that would do as much work during one cycle as the variable pressure in the cylinder.

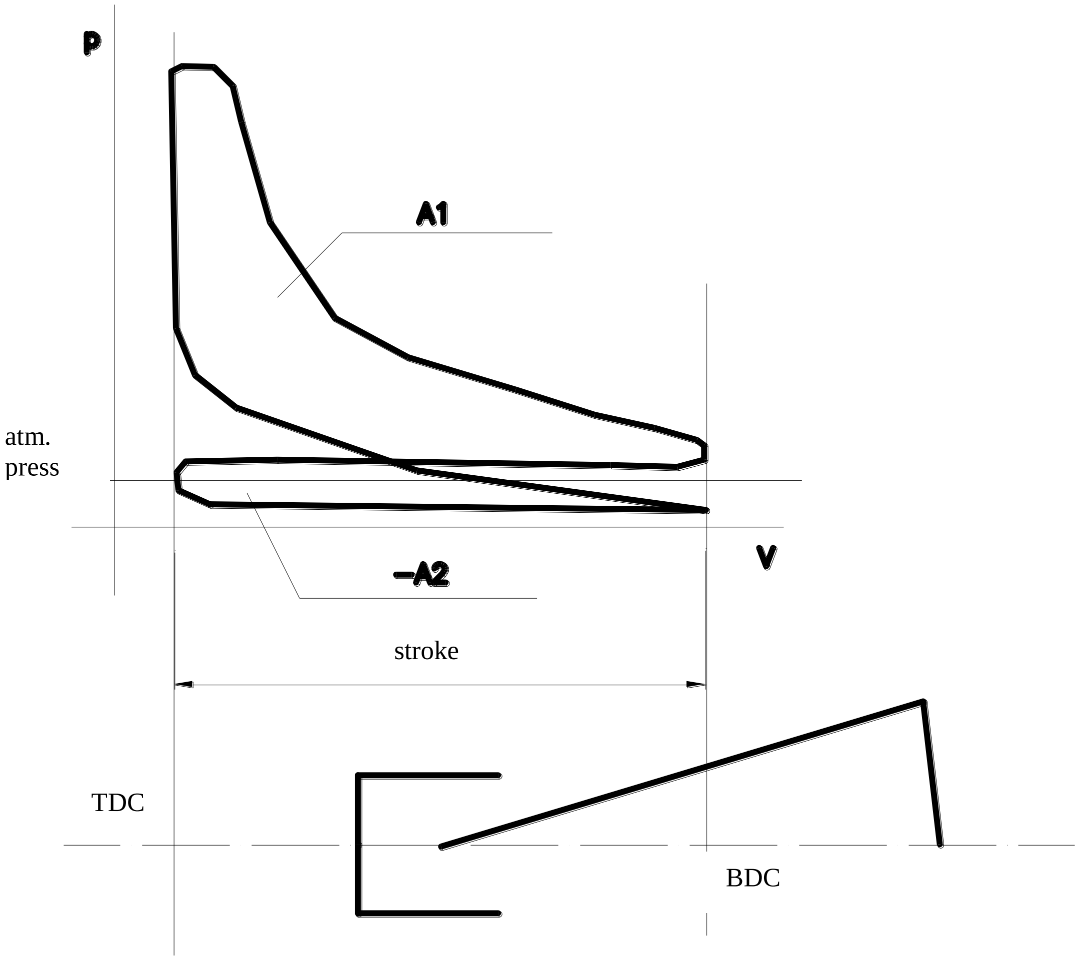


Fig. p-V diagram CI

The work during one stroke can then be determined as follows:

$$A = p_i . V$$

if:
V- volume cylinder [m^3]

The indicated engine power is the power inside the cylinder and is given by its work per time unit as follows:

$$P_i = A . n . a$$

if:
n- revolutions [s^{-1}],
a - constant expressing the number of expansions per revolution of the crankshaft. For two-stroke engines a = 1 for four-stroke engines a = 0,5.

The indicated power is transmitted to the crankshaft. The power we receive on the crankshaft is called the effective power P_e. This is power reduced by engine losses:

$$P_e = P_i . \eta_m$$

if:
η_m – mechanical efficiency of the engine