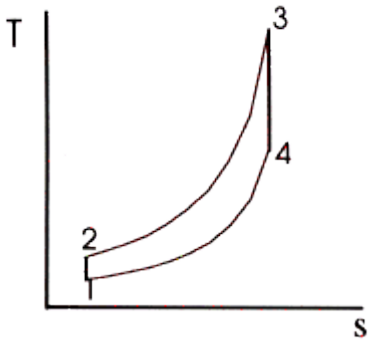
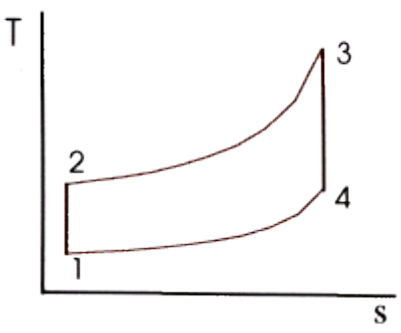
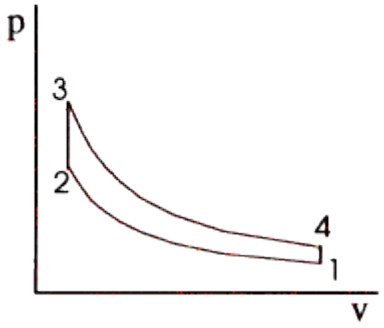
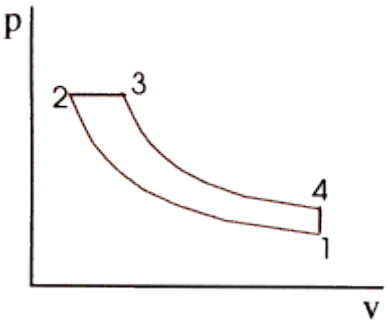
IC ENGINES

SI Engines work at constant volume. They have a compression ratio of around 6 - 10. But CI engines work at constant pressure and has a compression ratio of 16 - 20.

In four stroke engines, one power stroke is generated for two revolutions of crank shaft. However in case of two stroke engines, the cycle is completed in one revolution of crank shaft.

Differences between SI and CI engines:

SI Engine	CI Engine
Constant volume cycle.	Constant pressure cycle
Petrol is fuel, which has a high self ignition temperature	Diesel is used, has a low self ignition temperature.
These are high speed engines	Low speed engines
Low thermal efficiency	High thermal efficiency
Knocking takes place at the end of combustion.	Knocking takes place at the beginning of combustion.
Homogenous mixture of fuel and hence a high pressure is formed	Heterogeneous mixture, hence low pressure is generated.
Otto Cycle Ts Diagram 	Diesel Cycle Ts Diagram 

Otto Cycle pv Diagram	Diesel Cycle pv Diagram
	

Differences between Four stoke and Two stroke engines:

Four stroke Engine	Two Stroke Engine
Heavy flywheel is used	Lighter flywheel is used
Less lubrication, because of low wear and tear.	Heavy lubrication
Valve actuating mechanism is used	Only ports are used.
High volumetric and thermal efficiency	Lower volumetric and thermal efficiency.

Indicated power (Ip) = Energy in fuel - Loss in exhaust, coolant and radiation.

Brake power = Indicated power - Friction power

Mechanical efficiency = Brake power / Indicated power.

Engine Construction:

Cylinder Block:

It contains the following parts.

1. Cylinders in which pistons slide.
2. Port or opening for valves.
3. Passage for cooling water.

Mirror finish required in cylinder block is obtained by accurate grinding and honing process.

Cylinder Head :

The top of cylinder is covered by cylinder head. It contains combustion chamber and spark plug and also passage for the flow of cooling water.

Crank Case:

It is attached to bottom of cylinder block. It supports the crank shaft and cam shaft in suitable bearings.

Oil pan of sump:

The bottom half of crank case is called as oil pan. It acts as a reservoir for storage of lubricating oil. The oil pump draws oil from this oil pan and sends to all working parts of engine.

Cylinder Liner:

There are used inside cylinder block. They are used to prevent wear of cylinder block. There are 2 types of liners. They are dry and wet liners.

In *Dry liners* the outer surface of the liner bears against the cylinder block and hence has to be machined accurately. It is put in position by shrinking. This induces some amount of stress on the liners. The liner should not be too loose or tight in the cylinder block. Both can cause scuffing. The former because of poor heat dissipation and resulting in higher operating temperatures. The later due to distortion of the cylinder block, liner cracking , hot spots etc. They are not in direct contact with cooling water. The thickness is about 1.5 mm to 3.0 mm. They are hardened by nitriding or chrome plating.

In *Wet liners* the surface is in direct contact with cooling water. Hence no need for accurate machining. Thickness is about1.5 mm - 6.0 mm. It forms the complete cylinder barrel and its flange fits with groove of cylinder block.

Piston:

This device converts chemical energy to mechanical energy. Transmits the energy to crank shaft via the connecting rod. The piston is provided with piston rings between the piston and cylinder wall. It operates at a temperature of 2000^{o} C -3000^{o} C. The top of piston is called as head. Grooves are cut along the circumference of piston for piston rings. The parts below the ring grooves is called as skirt. This portion is separating the grooves are called lands.

Piston Rings :

These are fitted in the grooves of piston to maintain the seal between the piston and cylinder wall. The following are the important functions.

1. To prevent blow by because of which the burnt gas in CC escape via the piston into crank case.
2. To provide heat transfer from the piston crown to the cylinder liners.

3. Controls the flow of oil to the skirt and rings. Prevents excess oil to reach the combustion chamber and prevent carbonization.

In the piston construction, there is a end gap. This is necessary in order to expand the ring and slip it over the piston into the ring grooves. The gap is almost closed when the engine runs. The ring width is usually 1.5 mm. Rings may be provided with porous phosphate coating to reduce the scoring of the surfaces during running.

There are two types of rings. They are compression rings and oil control rings. The compression rings seals the Air / Fuel as the mixture is compressed. But the oil rings scrap off excessive oil from the cylinder wall and return to oil pan.

The piston rings are split, so that they can be slipped insider the piston groove. Usually the Outer diameter of ring is larger than cylinder bore. When it is installed in the piston, the joint is closed and piston tightly presses against the cylinder walls. The number of compression rings depends upon the compression ratio. The *Piston pin* connects the piston and small end of connecting rod.

Piston clearance :

Some amount of clearance is provided between cylinder and piston. It is necessary for the following reasons.

1. A gap is necessary for lubricating fluid between piston and cylinder wall.
2. Prevents piston seizure at high operating temperature.

usually a gap of 0.025 - 0.100 mm is provided. If the clearance is large, then piston slap results. It means the sudden tilting of cylinder. Here the piston shifts from one side of the cylinder to another. If this clearance is small, then seizure of piston results.

Combustion Chamber :

The region between cylinder head and piston head when the piston is at TDC is called as combustion chamber. The inlet and outlet valves are closed and spark plug projects in it. Depending on the location of spark plug and valves there are different types of combustion chamber.

1. Spherical
2. I shape
3. T shape
4. F shape and
5. L shape.

Connecting Rod:

Connects the piston and crank shaft. The small end is connected to piston and bigger end is connected to crankshaft. The function of the connecting rod is to convert the linear motion of the piston to rotary motion of crankshaft. It is has a I -Beam section.

Crank Shaft:

Contains crank pins, balancing weights and main journals. Fly wheel is attached to the rear end of crank shaft.

Cam Shaft:

It is simply a shaft in which a number of cams at required angular positions for operating the valves at exactly the timings relative to the piston movement and in sequence compatible with the firing order. It is responsible for opening and closing of valve. The Cam shaft is rotated by crank shaft by means of gears and chains. Gears are used when the cam shaft is nearer to crank shaft. In over head valve arrangements chains or toothed belts are used. The cam shaft turns at half the speed of crank shaft.

Engine Valves:

To admit the air-fuel mixture in the engine cylinder and evacuate the exhaust gases at correct timings these valves are used. They are divided into three main categories namely Poppet valve, sleeve valve and Rotary valve.

Cylinder valve:

There are attached to the top of the cylinder block by means of studs fixed to the block. Gaskets are used to provide a tight leak proof joint at the interface of the head and the block The cylinder head forms part of the combustion chamber. It also contains spark plug or the injector head and cooling water jackets. Valve openings are also provided in the head upon which is mounted the complete valve operating mechanism. Depending upon the valve and port layout, the cylinder head may be classified as loop-flow type, offset cross flow type or the in-line cross flow type.

In loop flow type the inlet and exhaust valves manifolds are in the same side. It facilitates preheating of the intake air. The offset cross-flow type gives lower exhaust valve temperature. The in-line cross flow type gives better engine performance though costlier. The cylinder head may be cast integrated with cylinder block in case of racing engines. However, detachable cylinder head offers many advantages over the integral construction.

1. Production is easier,
2. De-carbonizing and valve grinding is simplified and
3. Slight changes in compression ratio is possible.

Engine Performance:

Piston Displacement:

The volume displaced by the engine, when it moves from TDC to BDC.

Engine Displacement:

The volume displaced by all pistons when they move from TDC to BDC.

Compression Ratio:

It is the ratio of volume of charge in cylinder when the piston is at BDC and volume when the piston is at TDC.

Compression Ratio = (Clearance volume + Displacement Volume) / Clearance volume.

Volumetric Efficiency:

The volume of A / F mixture taken in to the cylinder to the volume of cylinders.

IHP:

The actual power developed by the combustion of fuel is called IHP.

BHP:

The actual power that the engine delivers for outside work is called as BHP. It is usually 70 % of IHP.

Stochimetric A / F ratio:

A mixture that contains sufficient air for the complete combustion of all fuel in the mixture.

Equivalent ratio = Actual A/F ratio / Stoichiometric A/F ratio.

Different cycles:

Cycle	Process Involved
Carnot Cycle	2 Isothermal process & 2 adiabatic process
Ericsson Cycle	2 Isothermal process & 2 Constant volume process
Otto Cycle	2 Isothermal process & 2 Constant pressure process
Diesel cycle	2 Isentropic & 2 Constant volume process
Dual Cycle	2 Isentropic, 1 Constant volume & 1 Constant Pressure process
Lenoir Cycle	1 Isentropic, 1 Constant volume & 1 Constant Pressure process

Brayton Cycle	2 Isentropic, 1 Constant volume & 2 Constant Pressure process

Rating of fuels:

Octane number is used for rating petrol engines. Resistance to knock is the important characteristic of fuel for SI engines.

Cetane number is used for rating diesel engines.

Lead tetraethyl lead is used as anti knock agent in petrol engines and Amyl nitrate is used as antiknock agent in diesel engines.

Carburetion:

The formation of required combustible fuel mixture by mixing fuel and air before admission to engine cylinder is called carburetion. There are three different types of carburetors.

1. Solex carburetor.
2. Carter carburetor
3. SU Carburetor.

Dual fuel engines:

Availability of liquid fuel is less. Gaseous fuel is cheaper. Hence both fuel could be successfully used in high compression ratio engine. The dual fuel engine works on diesel cycle. The gaseous fuel (The primary fuel) is added to the air inducted. The mixture of air and gaseous fuel is compressed in the cylinder just like air in a normal diesel operation. At some point in the compression stroke, near top dead center, a small charge of liquid fuel called secondary fuel is injected through a conventional diesel fuel system. Pilot injection acts as a source of ignition. The gas-air mixture at the vicinity of the injected spray ignites at number of places establishing a number of flame fronts. Thus combustion starts smoothly and rapidly. In a dual fuel engine combustion starts in a manner similar to CI engine but it propagates by flame front in a manner similar to SI engine.

The power output of the engine is normally controlled by changing the amount of gaseous fuel. The pilot oil quantity is usually kept constant for a given engine and is 5 - 7 percent of the total heat of engine at full load. The dual fuel engine is capable of running on either gas to diesel or a combination of these two over a wide range of mixture ratios. Without gaseous fuel the pilot fuel burns like that in a diesel operation.

Multi fuel operating engines:

A multi fuel engine is the one which would operate satisfactorily on a wide variety of fuels ranging from diesel oil, crude oil, lubricating oil, kerosene to gasoline. The main reason for the development is military requirement. They require open combustion chamber and the injection pump needs modification. Variable compression ratio engines and stratified charge

engines are examples of multi fuel engines. Methanol and Ethanol are good source of alternate fuels. Ethanol can be produced by fermentation of carbohydrates.

Methanol

It can be produced from coal, a relatively abundant fossil fuel. Methanol has a lower heating value than petrol and is a poisonous liquid. It is made of bio mass and is in liquid state under normal pressure and temperature. Following are the unique merits.

- It is in liquid state at Normal conditions of pressure and temperate and can be easily stored.
- Can be handled easily and safely.
- Can be transported over a long distance by pipeline.
- Has a higher conversion efficiency.
- It can be obtained from renewable bio mass.
- Single boiling point unlike petrol
- More power from the same engine.

Biomass:

The potential for application of bio mass as an alternative source of energy in our country is very great. Bio mass is produced in nature through photosynthesis achieve by solar energy conversion. The conversion cycle is shown below

Solar Energy -------- Photosynthesis -------- Biomass -------- Energy generaation

Bio mass means organic matter. The simplest form of reaction in the process of photosynthesis is given by

$$H_2O + CO_2 \text{ ------- } CH_2O + OO_2$$

CH_2O is the basic molecule forming carbohydrate stable at low temperature. Bio mass falls under three categories.

1. In its traditional form (Wood and agricultural residue)
2. Bio mass in non traditional form (Converted into liquid fuels)
3. Bio mass is fermented an-aerobically to obtain a gaseous fuel called bio-gas.

Source:

http://www.oocities.org/venkatej/mech/IC_Engines/IC_Engines.html