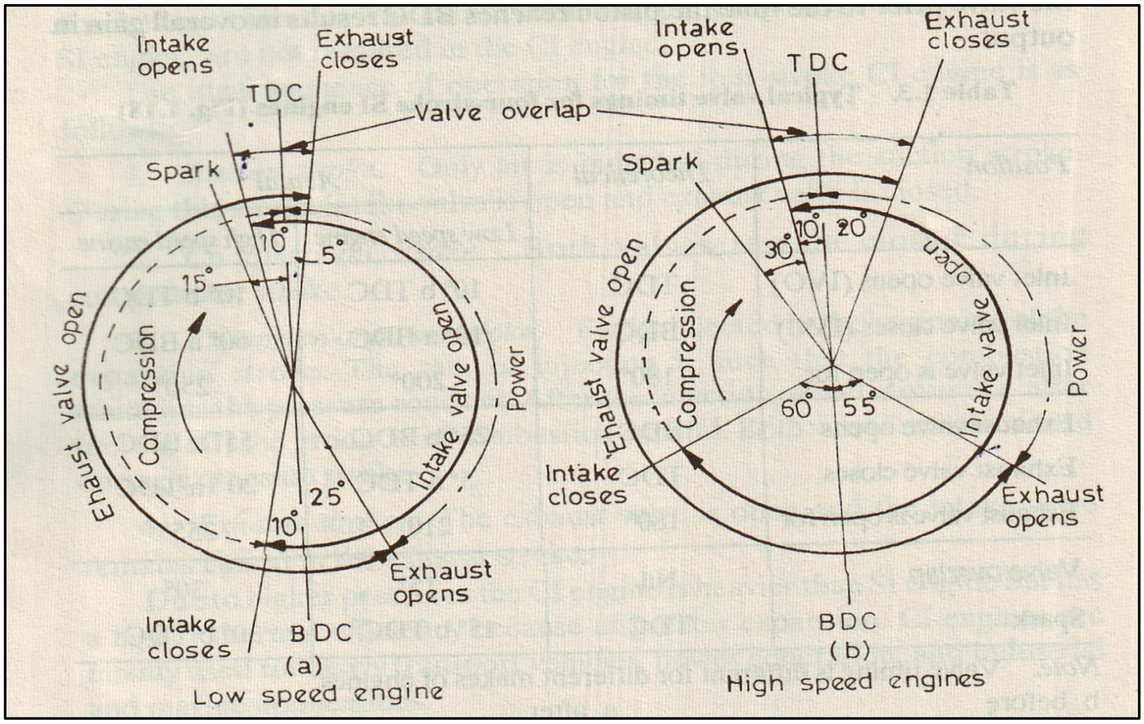
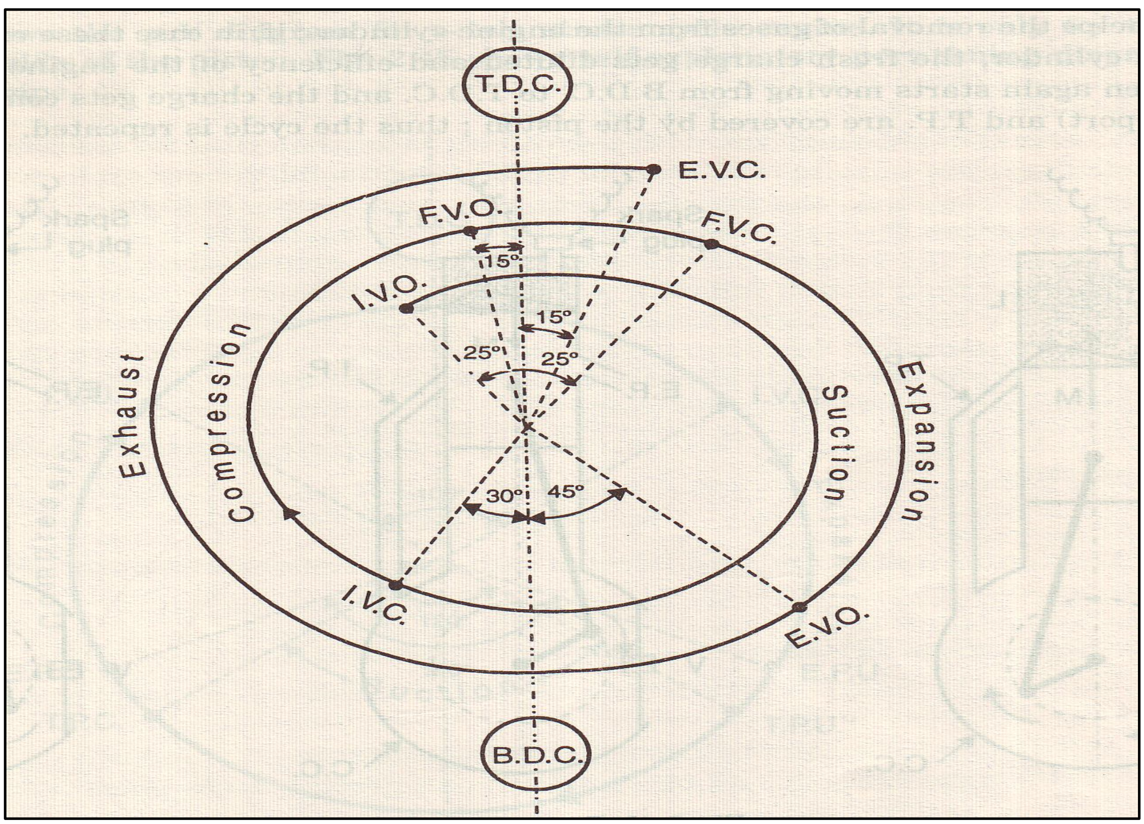
VALVE TIMING DIAGRAM FOR SI ENGINE



VALVE TIMING DIAGRAM FOR CI ENGINE



EFFECT OF VALVE TIMING DIAGRAM ON VOLUMETRIC EFFICIENCY:

Qu. 1:Why Inlet valve is closed after the Bottom Dead Centre (BDC)?

Ans: When piston moves from TDC to BDC during suction stroke, the fresh charge is drawn into the cylinder through the inlet valve.

When piston moves from BDC to TDC during the compression stroke the inertia of the entering fresh charge tends to cause it to continue to move into the cylinder (RAM Effect) to take advantages of this the Inlet Valve is closed after TDC so that maximum amount of air can be drawn into the cylinder. This in turn **increases** the Volumetric Efficiency.

Qu. 2: Why exhaust valve is closed after TDC?

Ans: The closing time of exhaust valve affects the volumetric efficiency by closing the exhaust valve a few degrees after TDC. The **inertia** of the exhaust gases tends to scavange (clearing) the cylinder by carrying out a greater mass of waste gases that are left in the clearance volume (Vc). This in turn increases the volumetric efficiency.

Dual Fuel Engine

Many large stationary engines use two fuels, one is gaseous and the other a liquid fuel is used to run an engine, which is called **Duel fuel engine**.

Working principle: The dual fuel engine works on Diesel engine. The gaseous fuel (primary fuel) is added to the air sucked by the engine or supplied by the supercharger at a pressure slightly above the atmospheric pressure. This 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 the top dead centre, a small charge of liquid fuel, called pilot fuel (or the secondary fuel), is injected through a conventional diesel fuel system.

Multifuel Engines

Almost all diesel engines are capable of burning a wide variety of fuels which include heavy diesel oil, crude oil, JP-4 and kerosene. These kinds of engines are called Multifuel engines.

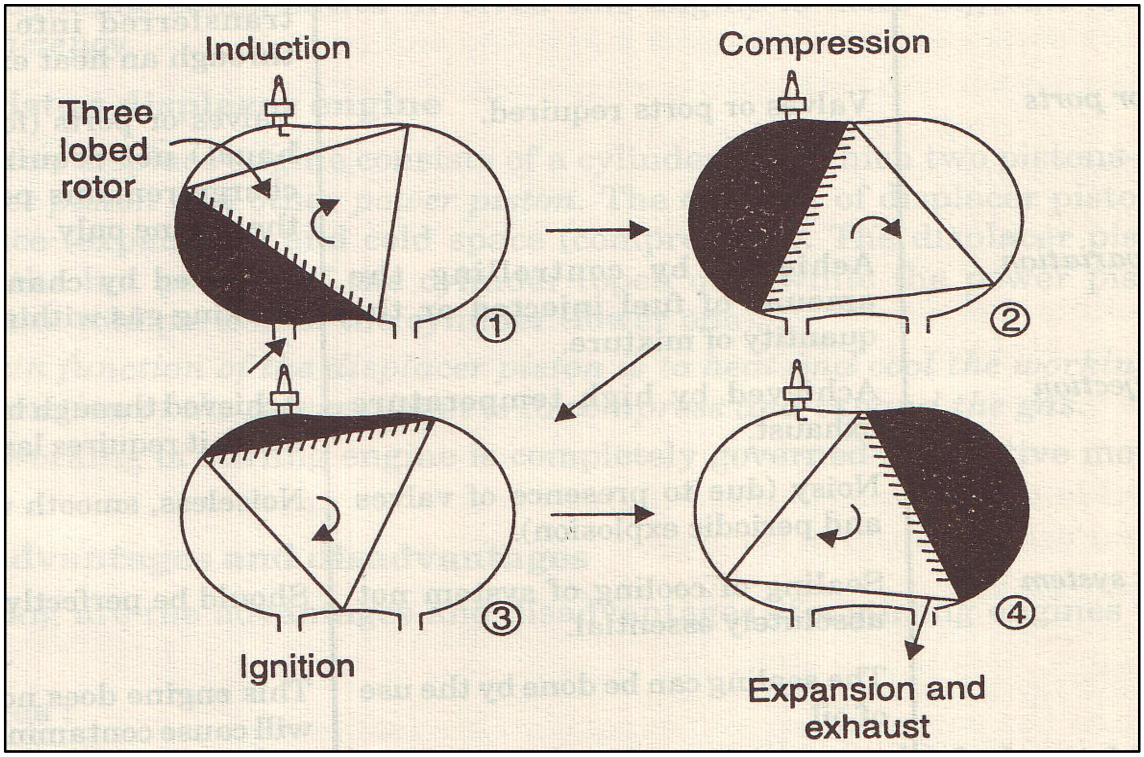
It has good combustion efficiency and it need higher compression ratio. It has the ability to burn wide variety of fuels.

WANKEL ROTARY ENGINE (Application: Racing cars)

Figure shows the schematic diagram of a Wankel rotary combustion engine. The engine has a **three lobe rotor** which is driven eccentrically in a casing in such a way that there are three separate volumes trapped between the rotor and the casing. These three volumes perform suction, compression, combustion, expansion, and exhaust process in sequence and this design therefore has a good power/volume ratio. Sealing, seal wear and heat transfer were some of the initial development problems of the Wankel Engine.

Features of the Rotory engine:

- There are no reciprocating parts.
- There are no separate intake-exhaust valve mechanisms.
- The time for one stroke is 270 degrees in terms of the rotating angle of the output shaft.

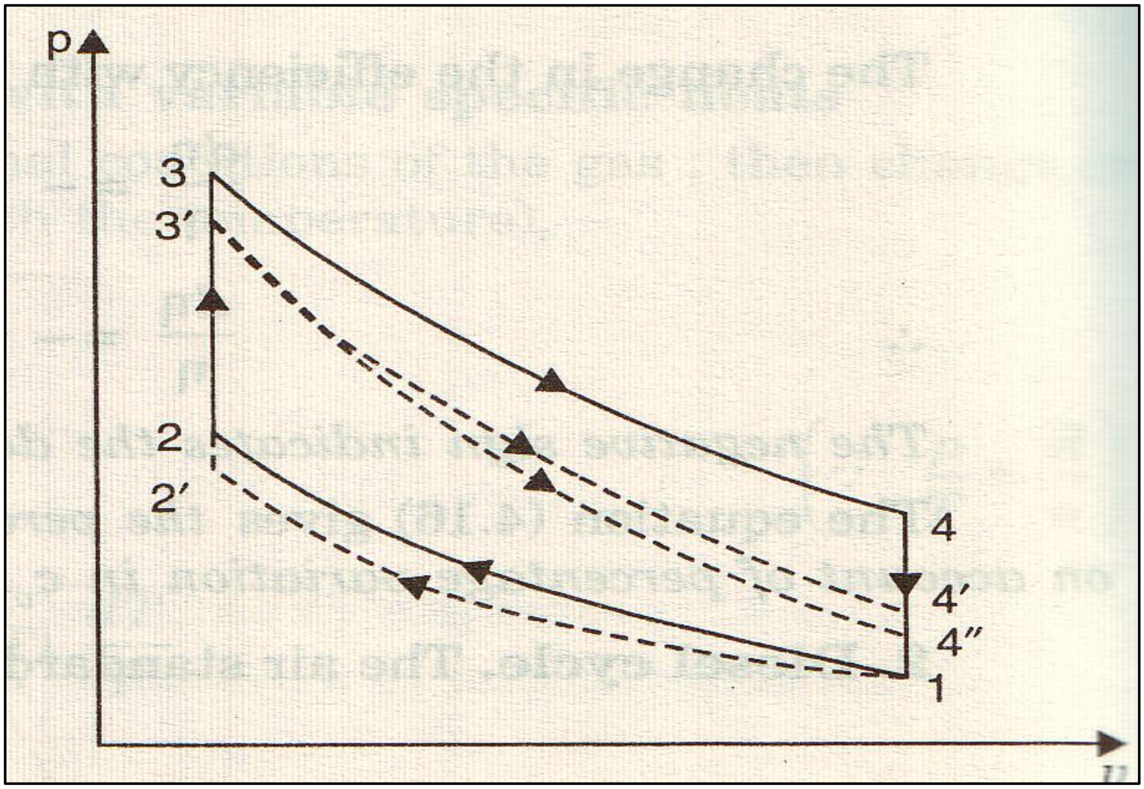


REASON OF DEVIATION OF ACTUAL CYCLE FROM AIR STANDARD CYCLE

- The working substance is not air but a mixture of air and fuel
- The specific heat of gases changes with respect to temperature
- Compression and expansion are not isentropic
- Combustion of fuel not only adds the heat but changes the chemical composition also

- There is always some heat loss due to heat transfer from the hot gases to cylindrical valves
- There is exhaust blow down loss due to early opening of exhaust valve
- Losses due to friction and leakage also
- Residual gases changes the composition temperature and amount of fresh charge at the constant volume combustion is not possible

Variation of specific heat



REASONS BEHIND DIFFERENCE BETWEEN REAL CYCLE & FUEL AIR CYCLE

- Time loss
- Direct heat loss
- Pumping loss
- Exhaust blow down loss
- Rubbing friction loss

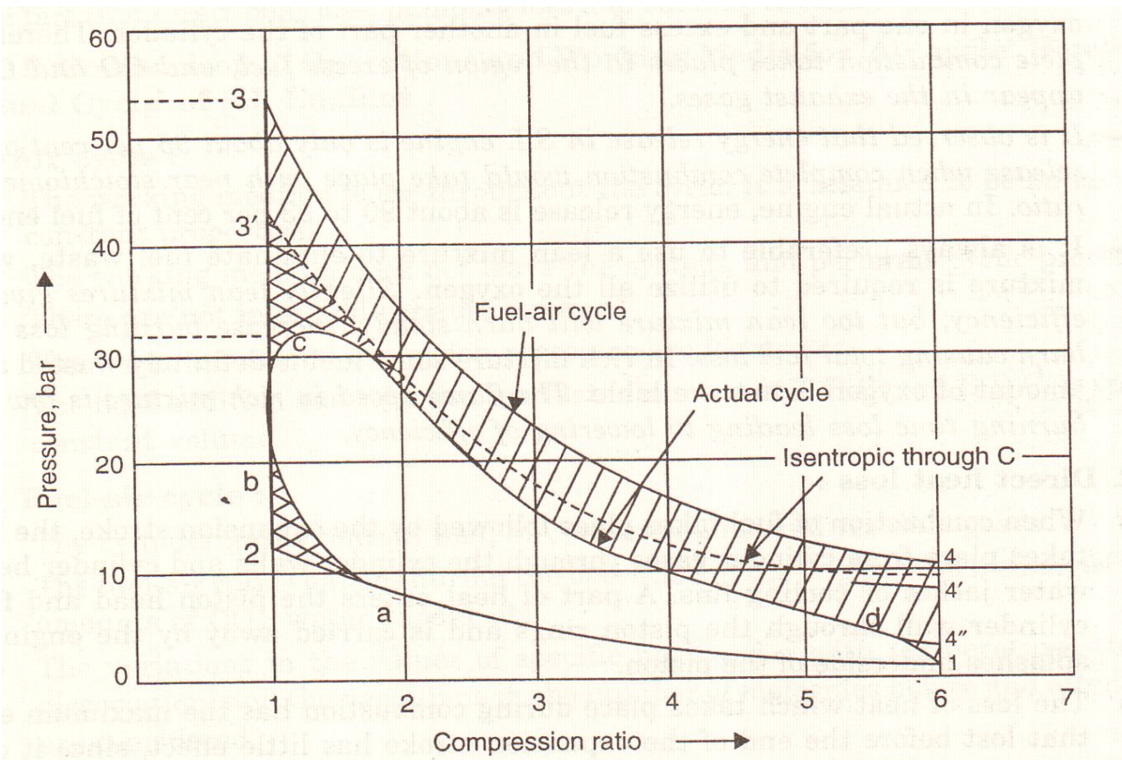
Time losses

- This loss is due to time required for mixing of fuel and air for combustion
- Heat loss due to flow of heat from gases to cylinder walls
- Loss of work on the expansion stroke due to early opening of exhaust valve

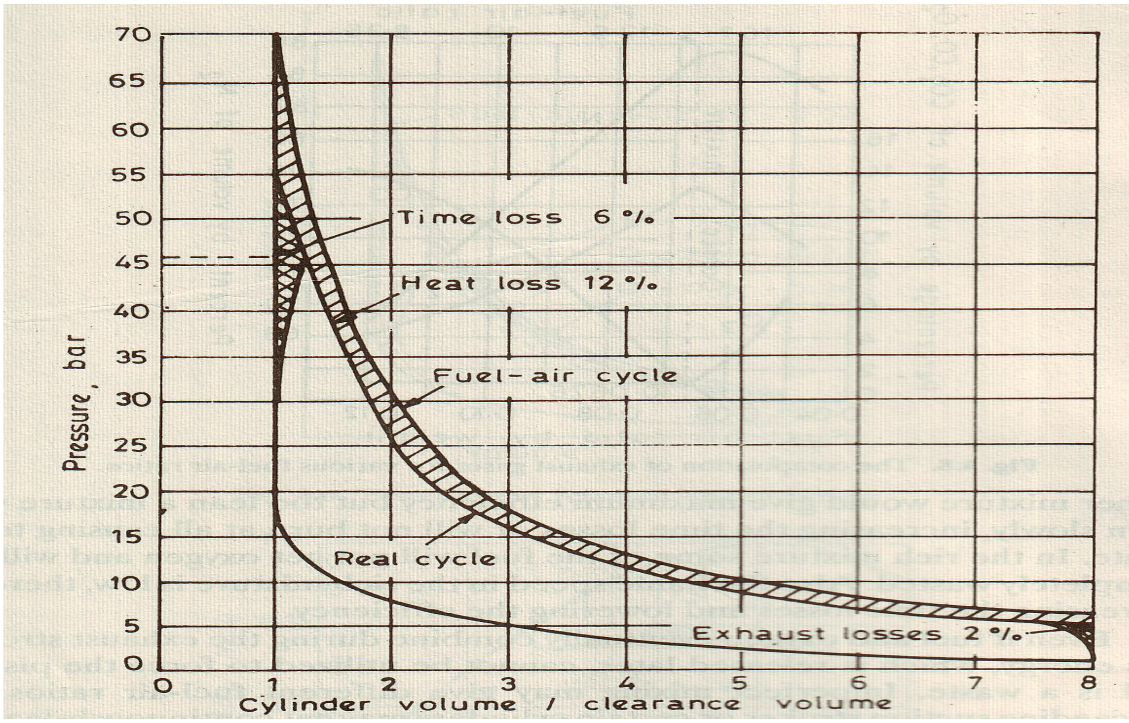
Loss due to time requirement

- Burning time loss
- Effect of spark timing
- Incomplete combustion loss

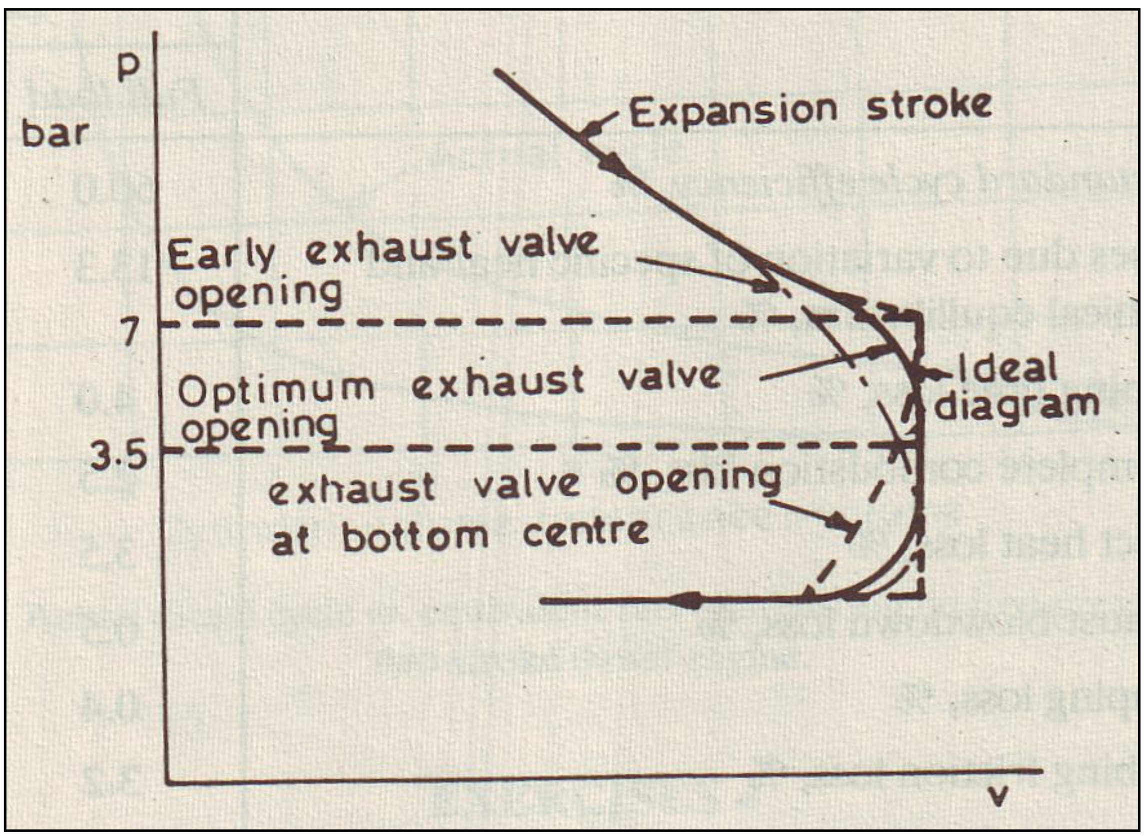
Effect of time loss on p-v diagram



Effect of direct heat loss on p-v diagram



Exhaust blow down loss



Pumping loss

The pumping loss increase at part throttle because throttling reduces the suction pressure and increases with speed.

Rubbing friction loss

These losses are due to friction between piston and cylinder walls, friction in various bearings and increases with speed.

PURPOSE AND THERMODYNAMIC CYCLE OF SUPERCHARGING

Definition:

"**Supercharging** is the method of increasing the inlet air density, thereby to increase the power output of the engine".

"This is done by supplying air at a pressure higher than the pressure at which the engine naturally aspirates air from the atmosphere by using a 'pressure-boosting-device' called a **Supercharger**".

The power output can also be increased by increasing the thermal efficiency of the engine, say, by increasing the compression ratio.

Purpose of Supercharging:

1) The purpose of supercharging is to increase the mass of air trapped in the cylinder of the engine, by increasing the inlet pressure, thus, raising air density.
2) This allows more fuel to be burnt, increasing the power output of the engine, for a given swept volume of the cylinders. Thus the power to weight and volume ratios of the engine is increased.

Objectives of Supercharging:

1) To increase the power output for a given weight and bulk of the engine. It is generally used in aircraft, marine and automotive engines where weight and space are important.

2) To compensate (balance) for the loss of power due to altitude, examples aircraft engines and automobiles running at high altitude region.

3) To obtain more power from an existing engine.

Useful Information:

A compressor is used to achieve the increase in air density and two methods are used to drive the compressor.

a) If the compressor is driven from the crankshaft of the engine, the system is called ***'mechanically driven supercharging'*** or often just '***supercharging***'. This loss can be up to 15% of engine output.

b) If the compressor is driven by a turbine, which itself is driven by the exhaust gas from the cylinders, the system is called **'Turbocharging'.**

Advantage of 'Turbocharging' over 'Supercharging':

The advantage of the turbocharger, over a mechanically driven supercharger, is that the power required to drive the compressor is extracted from exhaust gas energy rather than the crankshaft.

Thus, Turbocharging is more efficient than mechanical supercharging.

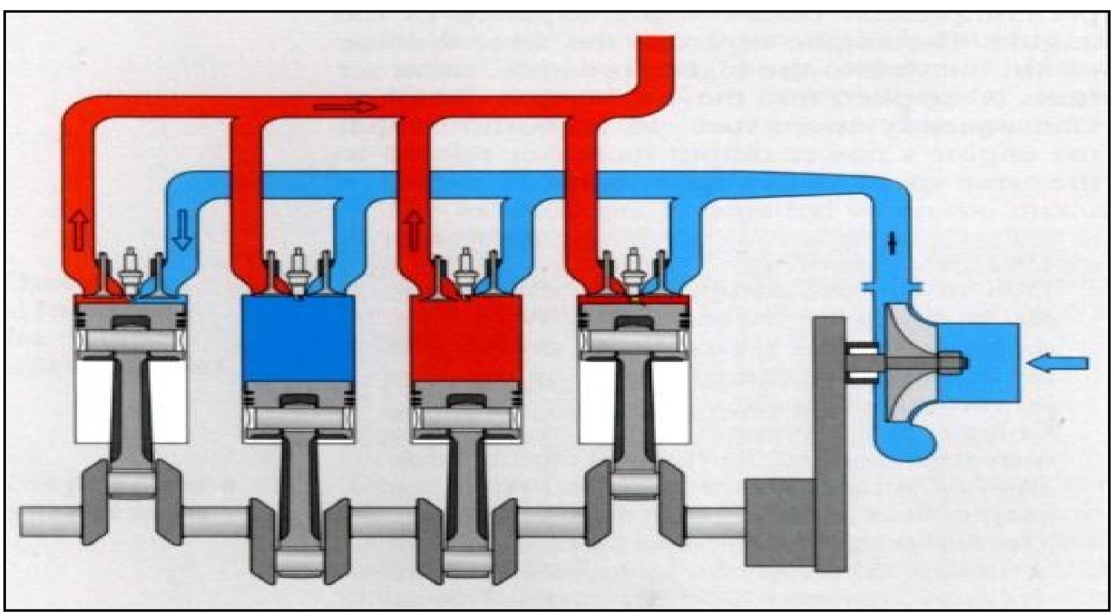


Fig. (1a): Mechanically Driven Supercharger

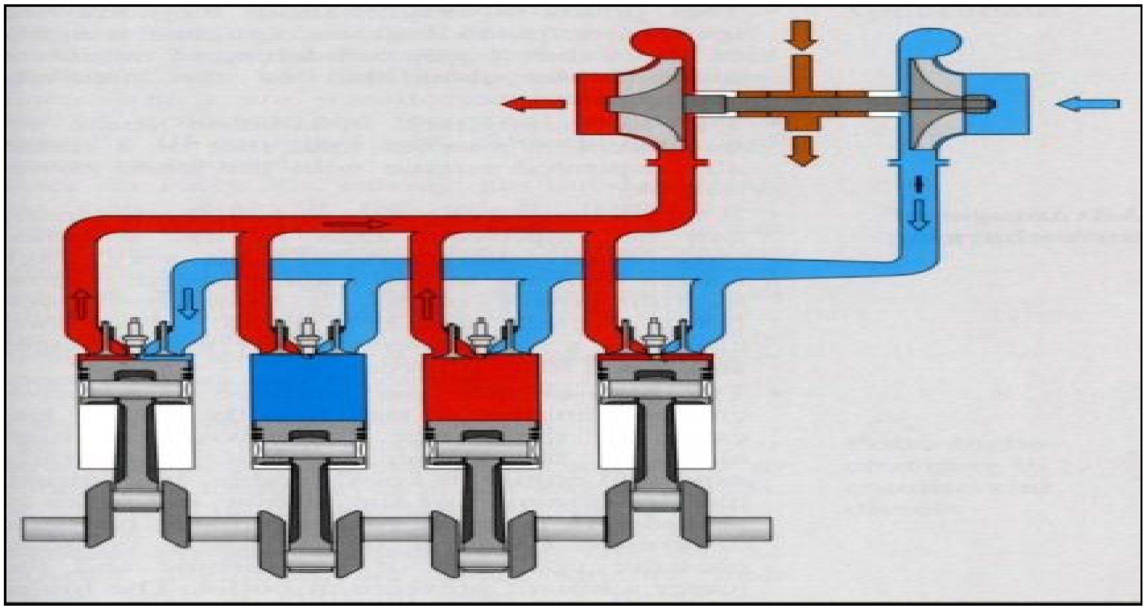


Fig. (1b): Supercharger and Turbocharger

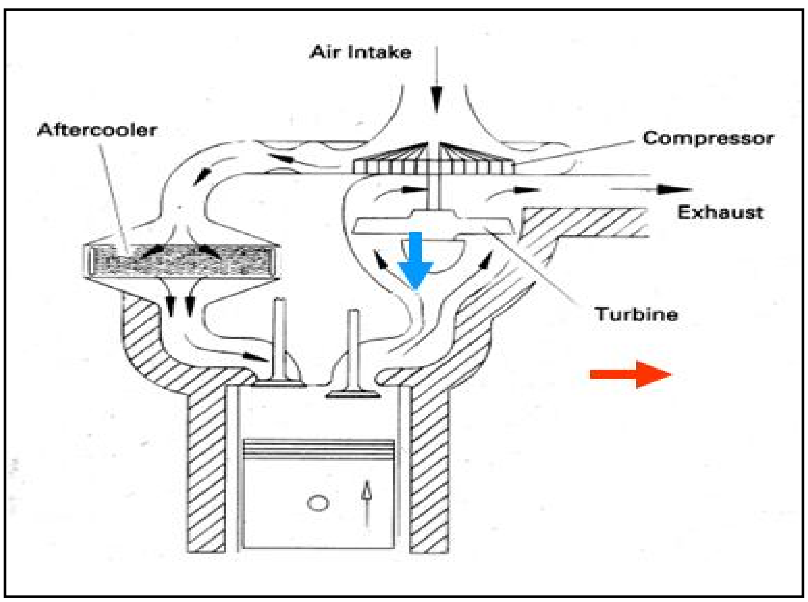


Fig. (1c): Supercharger and Turbocharger

After-cooler

The pressure rise across the compressor increases the density, but the temperature rise reduces the density. Lower the isentropic efficiency of the compressor, the greater the temperature rise for a given pressure ratio. So after-coolers are used after the compressor to drop the temperature and thus increase the air density.

Special applications of supercharging:

(I) Air density decreases with the altitude and hence the power output. This negative effect can be controlled by using Supercharger.

(II) Volumetric efficiency can be controlled by supercharging.

(III) Supercharging can be very effectively improving **Scavenging** efficiency that controls the performance of two-stroke engines.

Advantages of Supercharging:

(I) It increases specific power (KJ/kg) which will reduce size, space and weight power ratio.

(II) It increases the brake thermal efficiency and hence reducing specific fuel consumption.

(III) Supercharging helps achieving flatter characteristics (efficiency and specific fuel consumption) with changing engine speed.

(IV) In some supercharging design, emissions are reduced.

Disadvantages of Supercharging:

(I) It increases the mechanical stresses (because of pressure) that require increasing cylinder thickness that lead to increasing the cost and weight. In the same time, if the thickness does not increase, the life time of the engine decreases.

(II) Supercharging increases the maximum temperature of the cycle and hence materials that withstand higher temperatures are needed.

(III) Ability of fast acceleration decreases.

IV) Supercharging causes non-flatter torque characteristic with changing engine speed.

V) Matching problem between compressor and turbine.

VI) Detonation possibility increases when petrol (Spark Ignition) engine is supercharged.

Thermodynamic cycle of supercharging

1. SUPERCHARGING OF SI ENGINES

An ideal supercharged Otto cycle is shown on P-V diagram. The power loop, 1 - 2 - 3 - 4 - 1 has higher pressures on all the salient points.

The pumping loop 1- 5 - 6 - 7 -1 is positive and gives additional power.

But the higher pressure *P4* results in loss of power-as high pressure gas is exhausted.

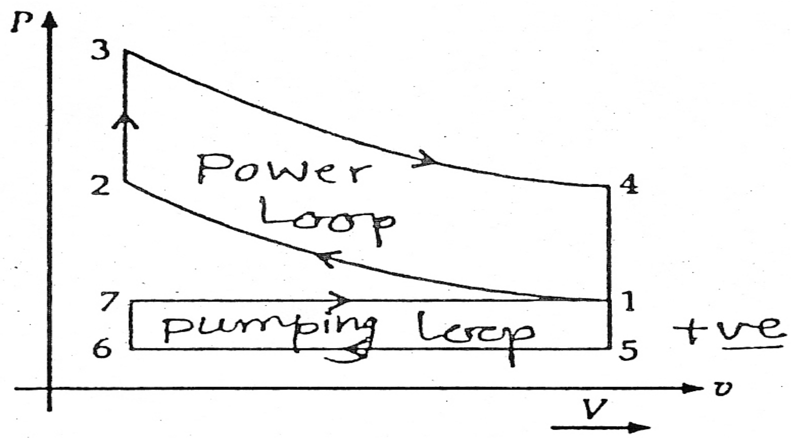


Fig. 2 Diagram for a Supercharged Otto Cycle

Indicated Power = Area of power loop (1- 2 -3- 4 -1) + Area of pumping loop (1 - 5 - 6 - 7 -1).

There is power consumption if the blower is directly connected to the engine.

Shaft power = (Indicated power × η_m) - (power consumed by supercharger)

Important Notes:

1. The increase in supercharging pressure increases its tendency to detonate. Therefore, compression ratio has to be decreased resulting in loss of efficiency. Supercharging is employed in SI engines only for aircrafts and racing cars.

2. Supercharging of petrol engines, because of its **poor fuel economy**, is not very popular and is used only when more power is needed to compensate altitude loss.

2. SUPER-CHARGING OF C.I. ENGINES

An ideal supercharged Diesel- cycle is shown on p-υ diagram. Supercharging in Diesel engine is very beneficial as it improves combustion process due to **better mixing** of air and fuel as a result of **turbulent effect** created by supercharger.

Increase in pressure and temperature of the intake air reduces the ignition delay significantly. The rate of pressure rise results in better, quieter and smoother combustion. Increase in air density results in higher volumetric efficiency and power output.

The reliability and durability of a supercharged engine increase over naturally aspirated engine due to smoother combustion and lower exhaust temperature.

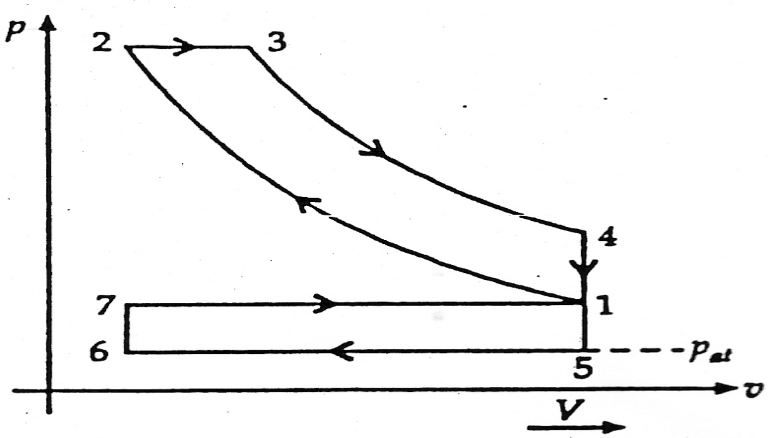


Fig. 7.8. p-v diagram for a supercharged Diesel cycle

Fig. 3 P-V diagram for a supercharged Diesel Cycle

Important Notes :

1. The power output of a supercharged engine is higher than naturally aspirated engine, due to higher volumetric, combustion and scavenging efficiencies.
2. There is additional power required to drive the mechanical supercharger. But the mechanical efficiency of a supercharged engine is slightly better than naturally aspirated engine.
3. In spite of better mixing and combustion due to reduced ignition delay, mechanically supercharged Otto engines have more specific fuel consumptions than a naturally aspirated engine. **Therefore, C.I. engines are more suitable for supercharging than S.I. engines.**

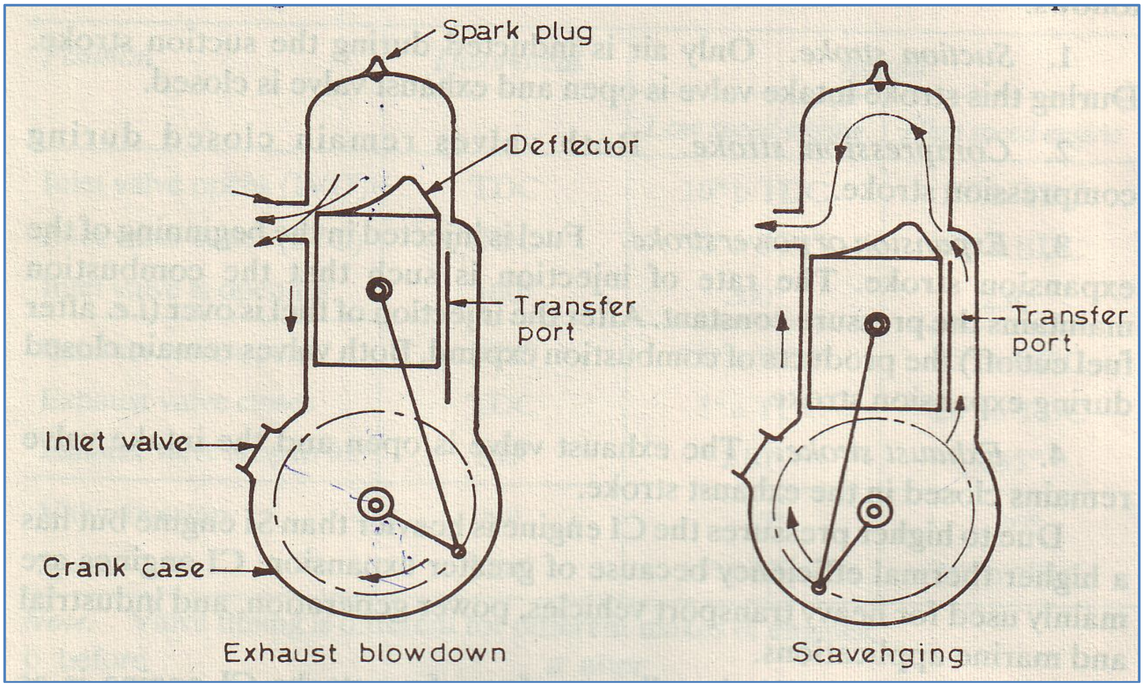
Scavenging

Scavenging is a process of clearing the cylinder, after the expansion stroke that is during the exhaust stroke.

The efficiency of a **two stroke engine** depend a great degree on the effectiveness of the scavenging process.

The scavenging process provides sufficient oxygen to the engine so that complete combustion can occur, which results in lower specific fuel consumption.

DIAGRAM OF TWO STROKE ENGINE



Questions:

- How the power output of an engine is affected at high altitude ? Explain the working of various types of superchargers.
- What is the effect of supercharging on the following parameters.

  Power output,

  Mechanical efficiency,

  Fuel consumption.
- Define Supercharging. What are the objectives of supercharging ?
- Which engine is more suitable for supercharging either S.I. engine or C.I. engine ? Why?

Write short note on supercharging in I. C. Engines.