Wind Mill

Basic Designs of Wind Turbines

- One convenient categorization is the following:
  - “Horizontal” Axis Machines
  - “Vertical” Axis Machines
- The words “horizontal” and “vertical” are normally used, but we are really referring to rotors with axes that are either parallel (horizontal) or perpendicular (vertical) to the local wind velocity.
- Each type has certain advantages and disadvantages

Wind Turbine Classification

- Horizontal Axis Machines: Machines in which axis of rotation is parallel to the direction of wind.
- Vertical Axis Machines: Machines in which axis is perpendicular to direction of wind.

Examples of Horizontal Axis Machines

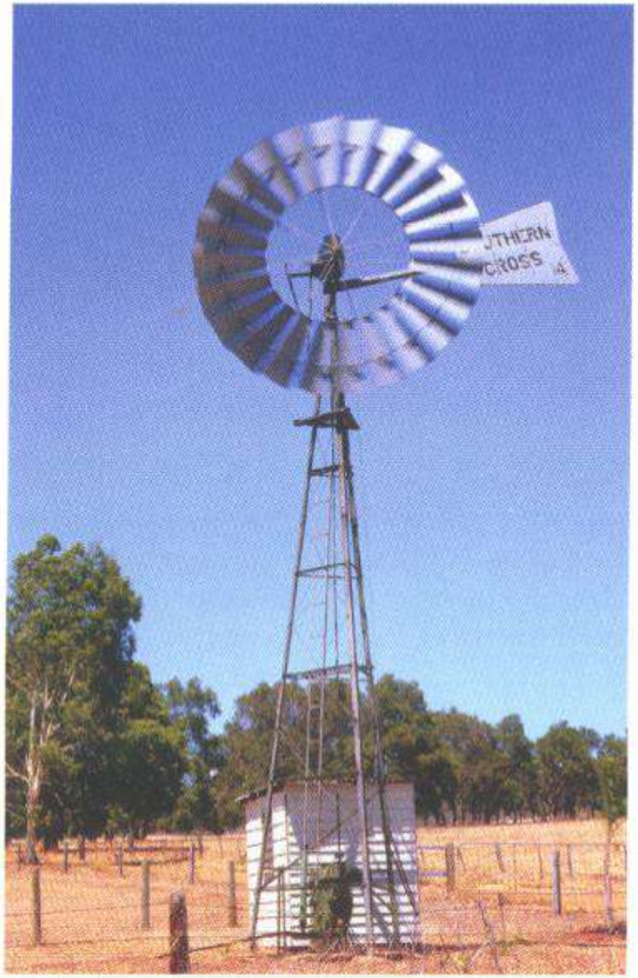
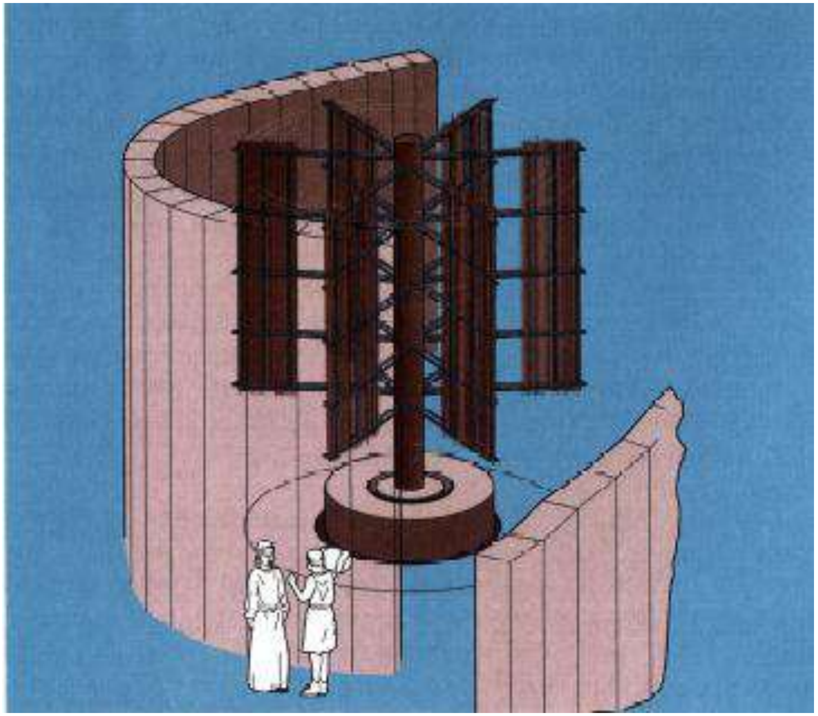


Figure 7.11 Multi-bladed wind pump

Figure 7.13 A three-bladed horizontal-axis wind turbine (Howden 330 kW)

Figure 7.10 Traditional north European tower windmill

Examples of Vertical Axis Machines



Turbine type	Advantages	Disadvantages
HAWT	• Higher wind energy conversion efficiency • Access to stronger wind due to tower height • Power regulation by stall and pitch angle control at high wind speeds	• Higher installation cost, stronger tower to support heavy weight of nacelle • Longer cable from top of tower to ground • Yaw control required
VAWT	• Lower installation cost and easier maintenance due to ground-level gearbox and generator • Operation independent of wind direction • More suitable for rooftops where strong winds are available without tower height	• Lower wind energy conversion efficiency (weaker wind on lower portion of blades & limited aerodynamic performance of blades) • Higher torque fluctuations and prone to mechanical vibrations • Limited options for power regulation at high wind speeds.

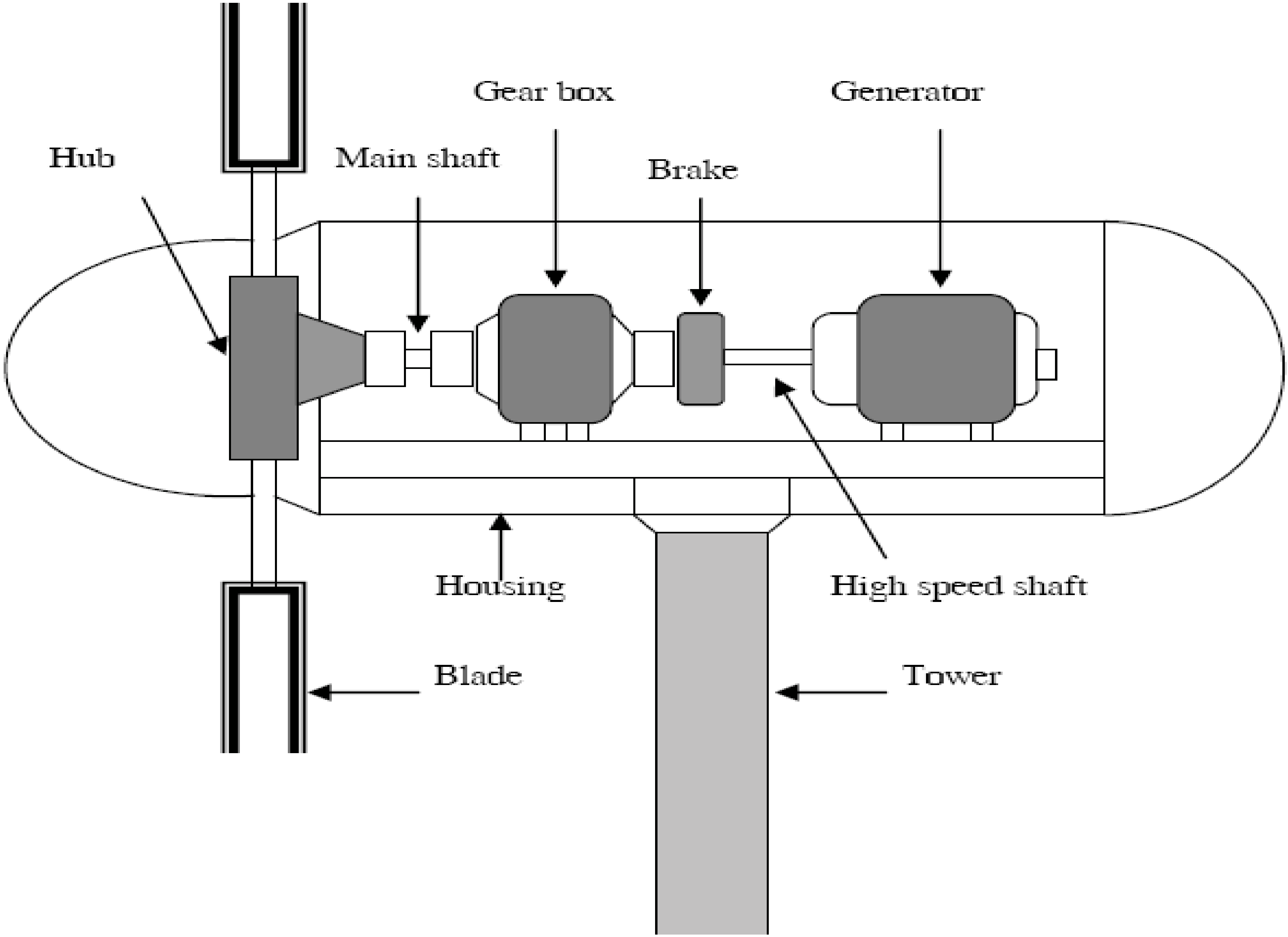
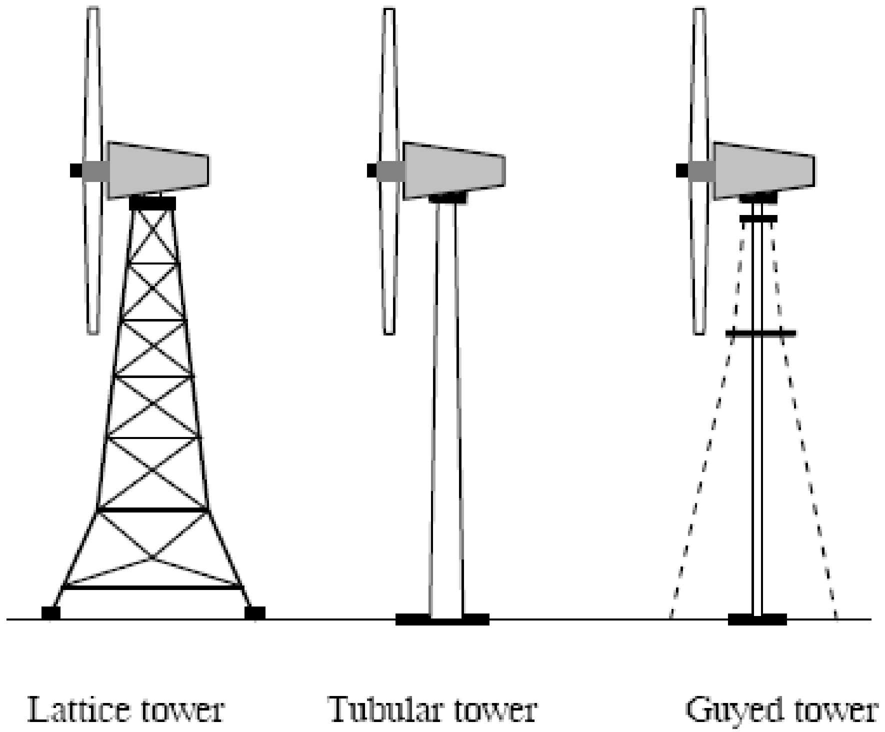


Fig. 4.1. Components of a wind electric generator

- Electricity generation is the most important application of wind energy today. The
- major components of a commercial wind turbine are:
- 1. Tower
- 2. Rotor
- 3. High speed and low speed shafts
- 4. Gear box
- 5. Generator
- 6. Sensors and yaw drive
- 7. Power regulation and controlling units
- 8. Safety systems

Tower



Tower

- Tower supports the rotor and nacelle of a wind turbine at the desired height. The major types of towers used in modern turbines are lattice tower, tubular steel tower and guyed tower.

- The lattice towers are fabricated with steel bars joined together to form the structure as shown in the figure. They are similar to the transmission towers of electric utilities. Lattice towers consume only half of the material that is required for a similar tubular tower. This makes them light and thus cheaper. For example, lattice tower for a typical turbine may cost $ 25,000 less than the tubular option of similar size.
- Legs of these towers are spread widely as shown in the figure.
- As the load is distributed over a wider area, these towers require comparatively lighter foundation, which will again contribute to the cost reduction.

- Tubular towers are fabricated by joining tubular sections of 10 to 20 m length. The complete tower can be assembled at the site within 2 or 3 days. The tubular tower, with its circular cross-section, can offer optimum bending resistance in all directions. These towers are aesthetically acceptable and pose less danger to the avian population.

Rotor

- Rotor is the most important and prominent part of a wind turbine. The rotor receives the kinetic energy from the wind stream and transforms it into mechanical shaft power. Components of a wind turbine rotor are blades, hub, shaft, bearings and other internals.
- Though it is possible to design the rotor with a single blade, balancing of such rotors would be a real engineering challenge. Rotors with single blade run faster and thus create undue vibration and noise. Further, such rotors are not visually acceptable.

- Two bladed rotors also suffer from these problems of balancing and visual acceptability. Hence, almost all commercial designs have three bladed rotors.
- Some of the small wind turbines, used for battery charging, have more number of blades- four, five or even six-as they are designed to be self starting even at low wind speeds.
- Size of the rotor depends on the power rating of the turbine. The turbine cost, in terms of $ per rated kW, decreases with the increase in turbine size. Hence, MW sized designs are getting popular in the industry.

- Blades are fabricated with a variety of materials ranging from wood to carbon composites. Use of wood and metal are limited to small scale units. Most of the large scale commercial systems are made with multi layered fiberglass blades. Attempts are being made to improve the blade behavior by varying the matrix of materials, reinforcement structures, ply terminations and manufacturing methods.
- The traditional blade manufacturing method is open mold, wet lay-up. Some of the manufacturers are making their blades by vacuum assisted resin transfer molding (VARTM).

- The blades of the rotor are attached to hub assembly. The hub assembly consists of hub, bolts, blade bearings, pitch system and internals. Hub is one of the critical components of the rotor requiring high strength qualities. They are subjected to repetitive loading due to the bending moments of the blade root. Due to the typical shape of the hub and high loads expected, it is usually cast in special iron alloys like the spherical graphite (SG) cast iron. Forces acting on the hub make its design a complex process. Three dimensional Finite Element Analysis (FEA) and topological optimization techniques are being effectively used for the optimum design of the hub assembly.

- The main shaft of the turbine passes through the main bearings. Roller bearings are commonly used for wind turbines. These bearings can tolerate slight errors in the alignment of the main shaft, thus eliminating the ossibility of excessive edge loads. The bearings are lubricated with special quality grease which can withstand adverse climatic conditions. To prevent the risk of water and dirt getting into the bearing, they are sealed, sometimes with labyrinth packing. The main shaft is forged from hardened and tempered steel.

- Replacing the bearings of an installed turbine is a very costly work. Hence, to ensure longer life and reliable performance, hybrid ceramic bearings are used with some recent designs. The advantages of ceramic hybrids are that they are stiffer, harder and corrosion free and can sustain adverse operating conditions. These bearings are light in weight and offer smoother performance. Electrically resistant nature of ceramic hybrids eliminates the possibilities of electrical arcing. These bearings are costlier than the standard bearings. However, they can be economical in the long run due to its better performance.

Gear box

- Gear box is an important component in the power trains of a wind turbine. Speed of a typical wind turbine rotor may be 30 to 50 r/min whereas, the optimum speed of generator may be around 1000 to1500 r/min. Hence, gear trains are to be introduced in the transmission line to manipulate the speed according to the requirement of the generator.

- An ideal gear system should be designed to work smoothly and quietly-even under adverse climatic and loading conditions-throughout the life span of the turbine. Due to special constraints in the nacelle, the size is also a critical factor.

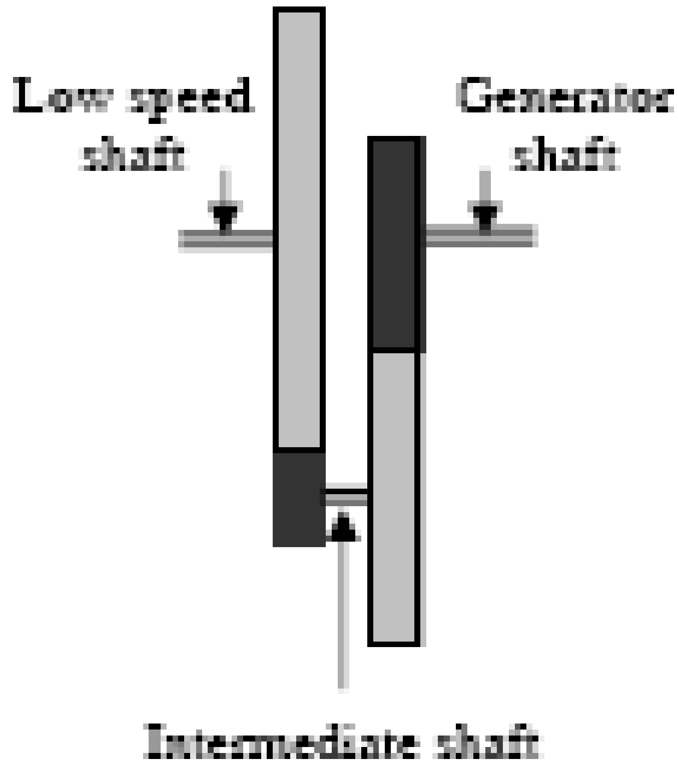


Fig. 4.8. Gear arrangements of a small wind turbine

- If higher gear ratios are required, a further set of gears on another intermediate shaft can be introduced in the system. However, the ratio between a set of gears are normally restricted to 1:6. Hence, in bigger turbines, integrated gear boxes with a combination of planetary gears and normal gears are used.
- A typical gear box may have primary stage planetary gears combined with a secondary two staged spur gears to raise the speed to the desired level. By introducing the planet gears, the gear box size can be considerably reduced. Moreover, planet gears can reliably transfer heavy loads.

Safety brakes

- During the periods of extremely high winds, wind turbines should be completely stopped for its safety. Similarly, if the power line fails or the generator is disconnected due to some reason or the other, the wind turbine would rapidly accelerate.
- .

Generator

- Generator is one of the most important components of a wind energy conversion system. In contrast with the generators used in other conventional energy options, generator of a wind turbine has to work under fluctuating power levels, in tune with the variations in wind velocity. Different types of generators are being used with wind machines. Small wind turbines are equipped with DC generators of a few Watts to kilo Watts in capacity. Bigger systems use single or three phase AC generators. As large-scale wind generation plants are generally integrated with the grid, three phase AC generators are the right option for turbines installed at such plants. These generators can either be induction (asynchronous) generators or synchronous generators.

Induction generators

- Most of the wind turbines are equipped with induction generators. They are simpleand rugged in construction and offer impressive efficiency under varying operating conditions. Induction machines are relatively inexpensive and require minimum maintenance and care.
- Characteristics of these generators like the over speed capability make them suitable for wind turbine pplication. As the rotor speed of these generators is not synchronized, they are also called asynchronous generators.
- Induction machines can operate both in motor and generator modes.

- The cross sectional view of an induction motor is shown in Fig. 4.15. Stator
- consists of a number of wound coils placed inside its slots. The stator windings are connected to the power supply. They are wound for a specified number of poles depending on the speed requirement.

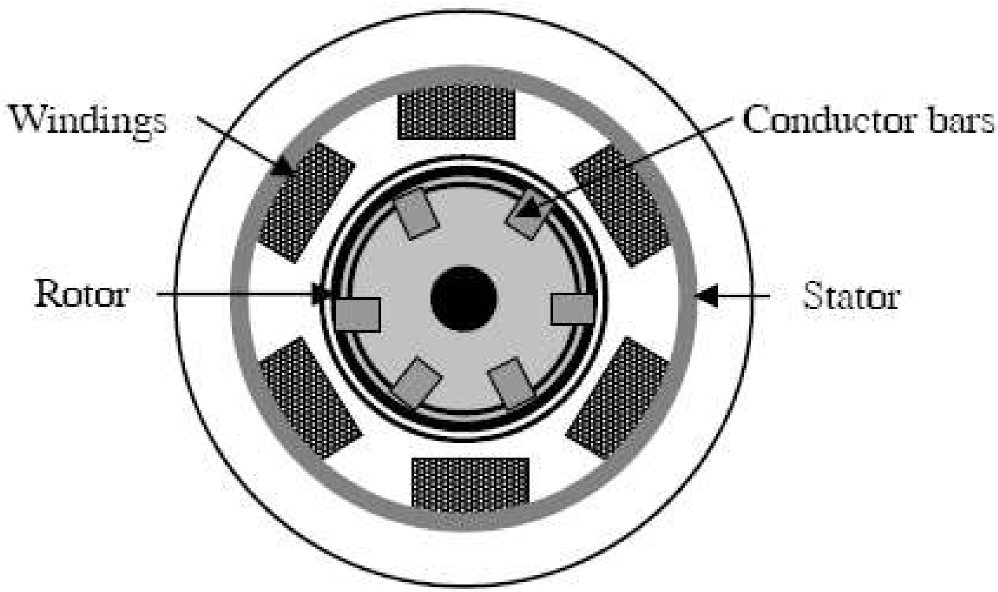


Fig. 4.15. Cross-sectional view of an induction motor

Syncronous generator

- Cross-sectional view of a synchronous generator, in its simplest form, is shown in Fig. 4.17.

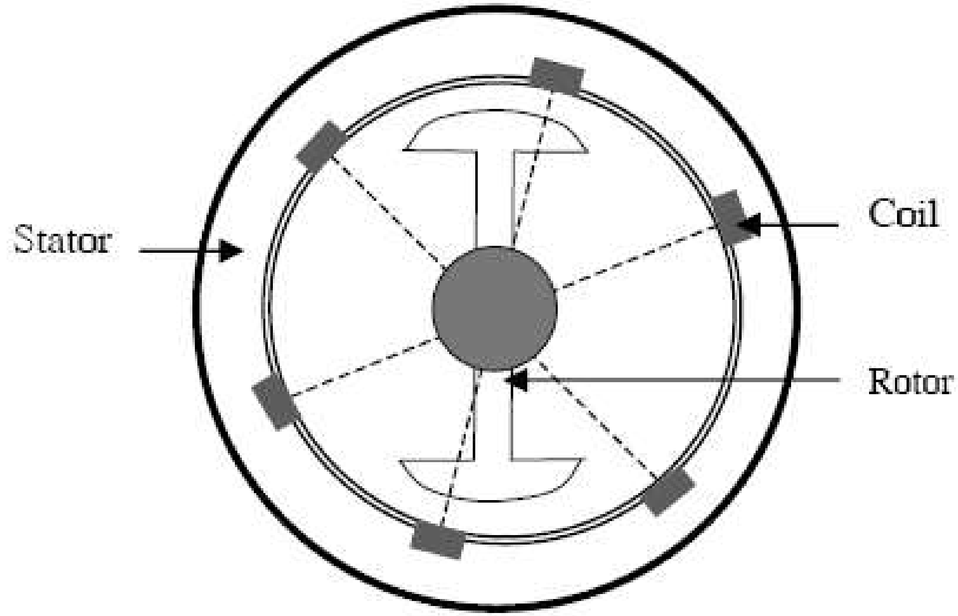


Fig. 4.17. Principle of synchronous generator

It consists of a rotor and a three-phase stator similar to an induction generator. The stator and rotor have the same number of poles. The generator shown in the figure has two poles. The stator has coils wound around them, which are accommodated in slots as shown in the figure. The stator windings are displaced circumferentially at 120º interval.

Engine Lubricants
and
Lubricating Systems

Functions of Engine Oils

1. Reduce wear
2. Reduce friction
3. Seal Compression
4. Reduce noise
5. Cool engine parts
6. Reduce rust
7. Keep parts clean

Organizations Providing Uniform Standards for Oil

- S.A.E.
  - Society of Automotive Engineers
- A.P.I.
  - American Petroleum Institute
- A.S.T.M.
  - American Society of Testing & Materials
- American Automobile Manufacturers Association
- Engine Manufacturers Association
- I.S.O.
  - International Standards Organizations

Properties of Motor Oils

- Viscosity
- Viscosity Index (VI)
- Flash Point
- Pour Point
- Per cent sulfated ash
- Per cent zinc.

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- Viscosity
- Viscosity Index (VI)
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Viscosity

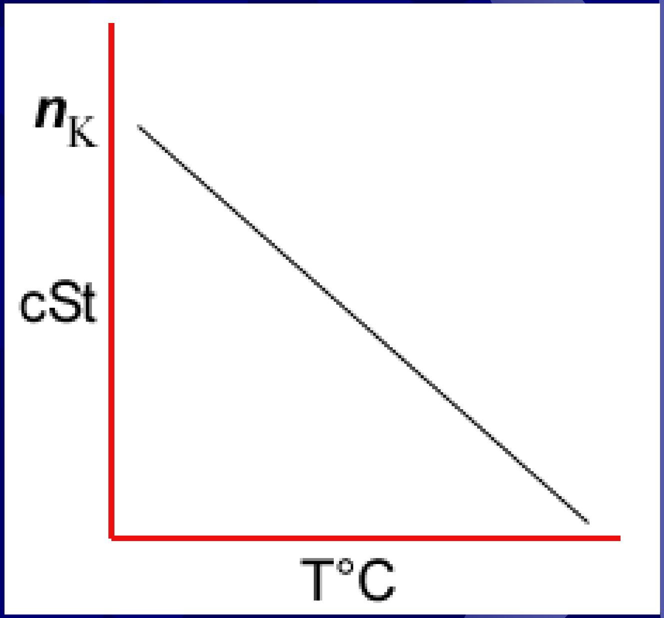
- Measure of the "flowability“
- High viscosity - thick oils
  - Too high viscosity may not reach all parts
- Low viscosity – thin oil
  - Too low viscosity may not provide enough strength to keep parts from wearing

Weight of oils

- Common term identifying viscosity for oils
- Numbers assigned by the S.A.E.
  - correspond to "real" viscosity, as measured by accepted techniques.
  - These measurements are taken at specific temperatures.
  - Oils that fall into a certain range are designated 5, 10, 20, 30, 40, 50 by the S.A.E.
  - The W means the oil meets specifications for viscosity at 0 F and is therefore suitable for Winter use.

Viscosity index

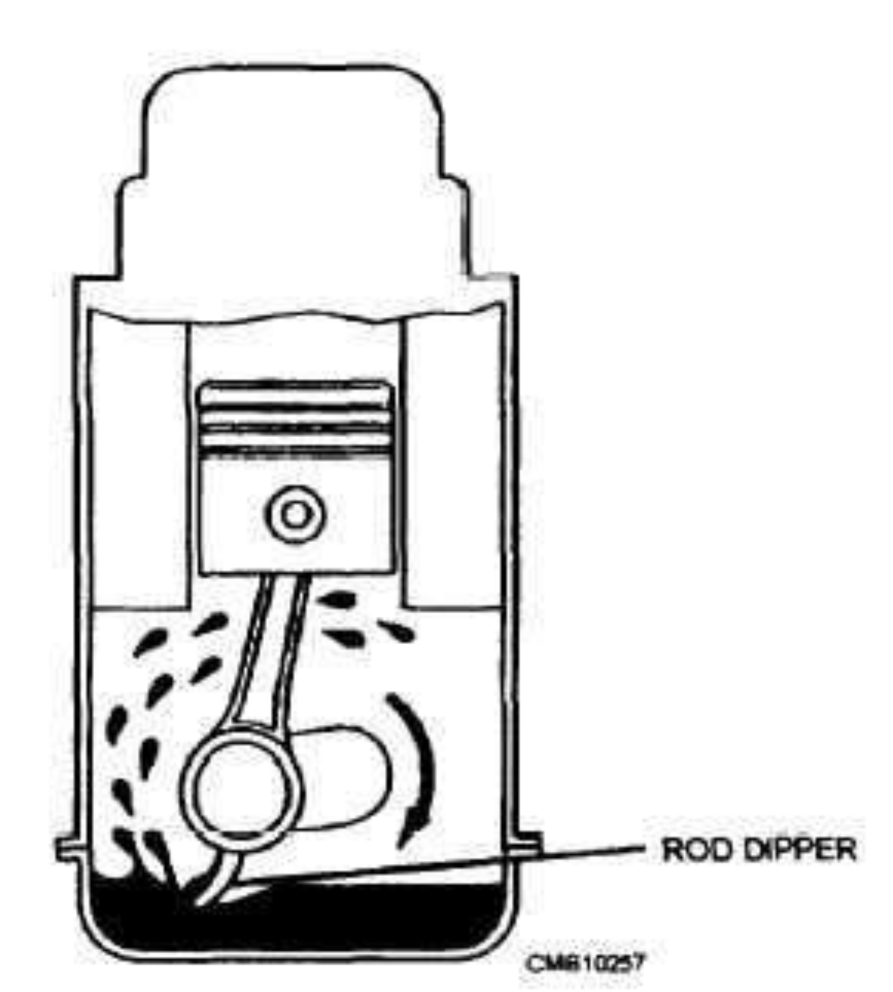
- The measure of an oil's ability to resist changes in viscosity when subjected to changes in temperature.
  - As temperature increases viscosity decreases.
  - Low temperatures – High viscosity
  - High temperature – Low viscosity



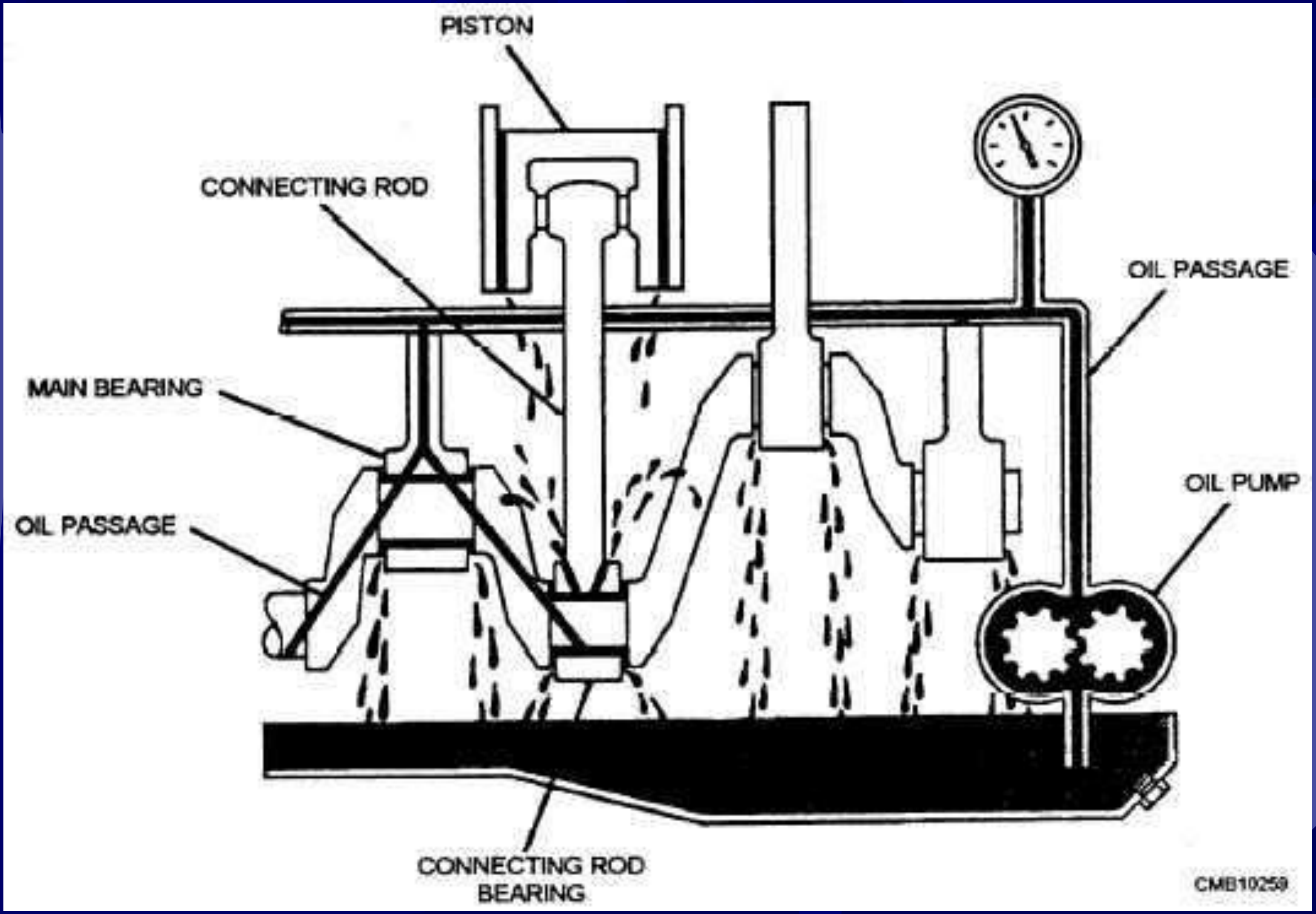
Lubrication Systems

- Splash
  - Dipper
  - Slinger
- Force Feed & Splash
- Full Force Feed

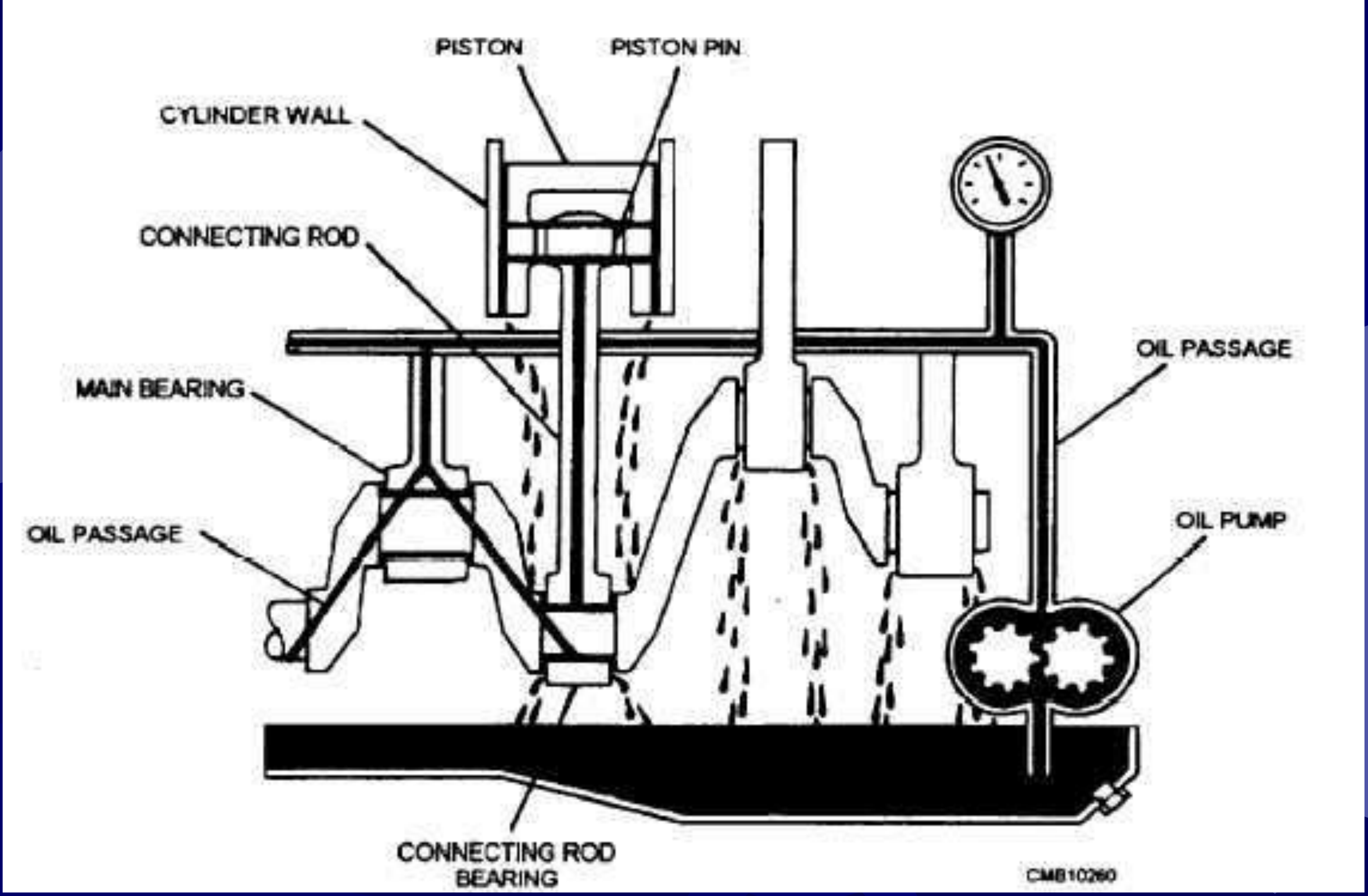
Splash Lubrication



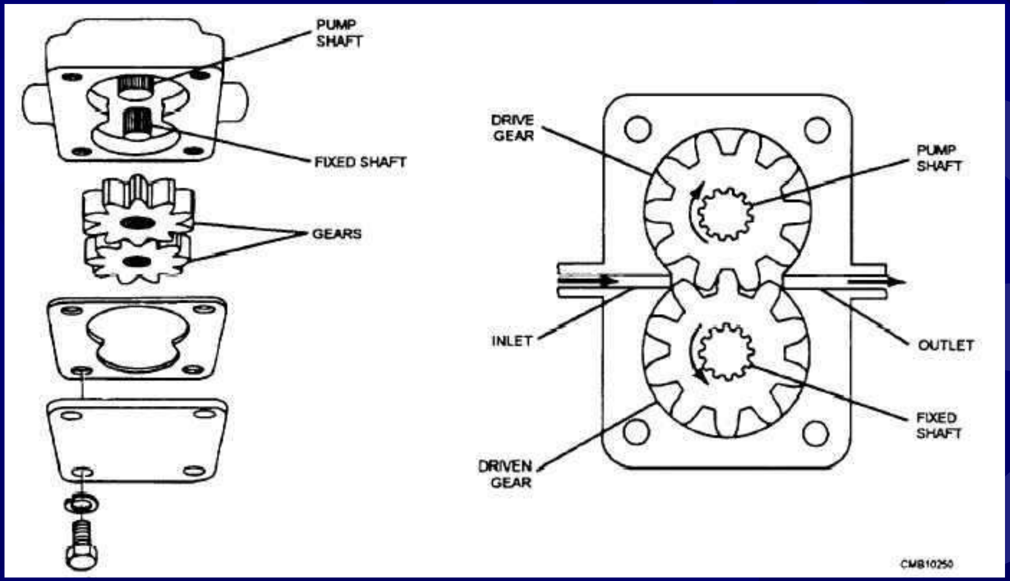
Force Feed and Splash



Full Force Feed



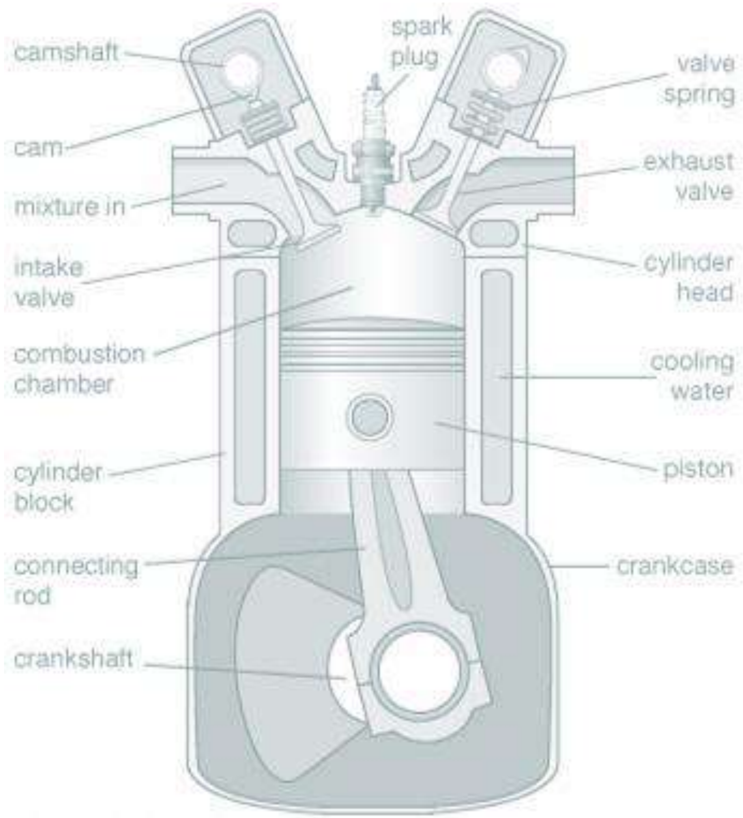
Oil Pump


PUMP SHAFT
FIXED SHAFT
GEARS
DRIVE GEAR
PUMP SHAFT
INLET
OUTLET
FIXED SHAFT
DRIVEN GEAR
CMB10250

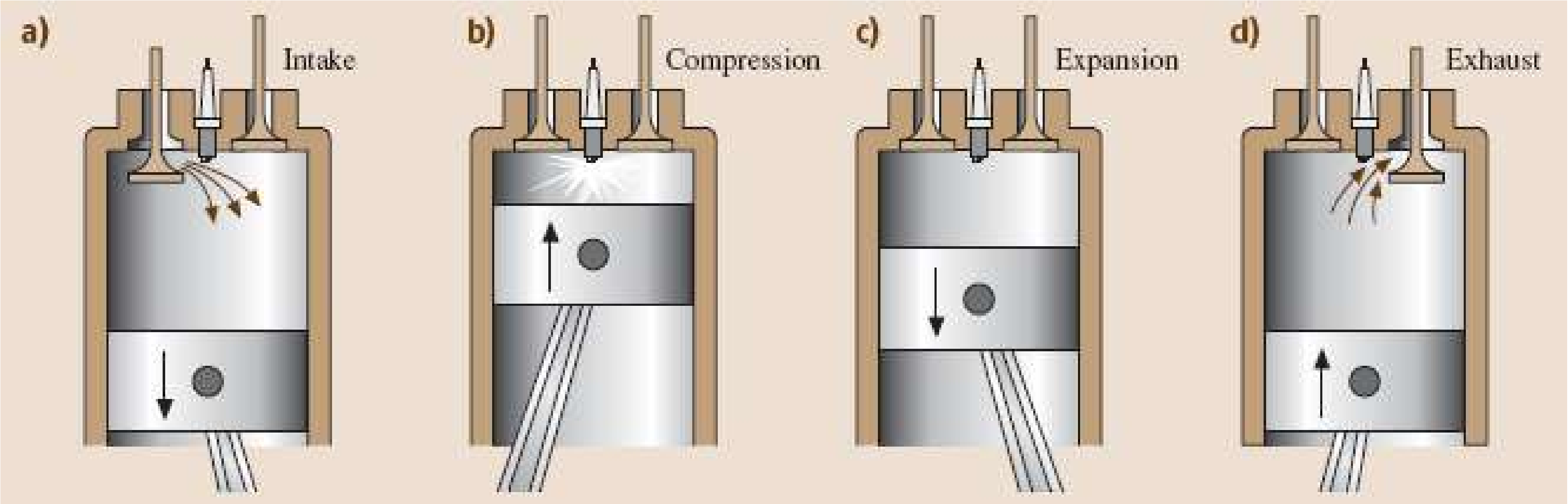
UNIT 2

Introduction to

Internal Combustion Engines

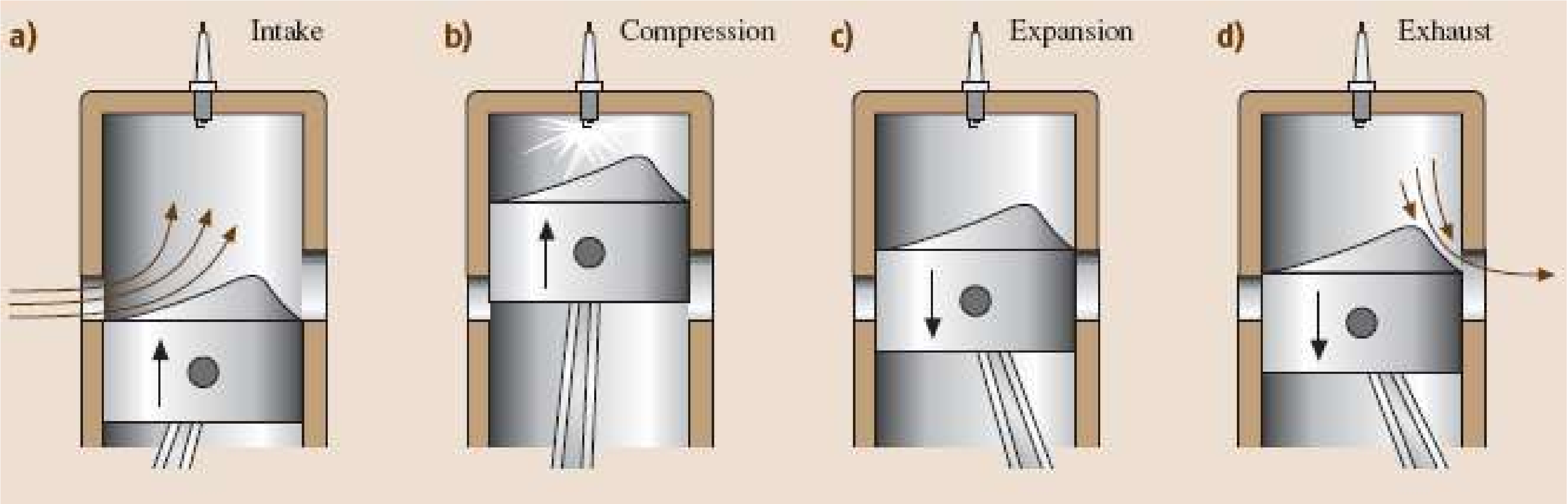


4 STROKE



4 Stroke Engine

4 STROKE



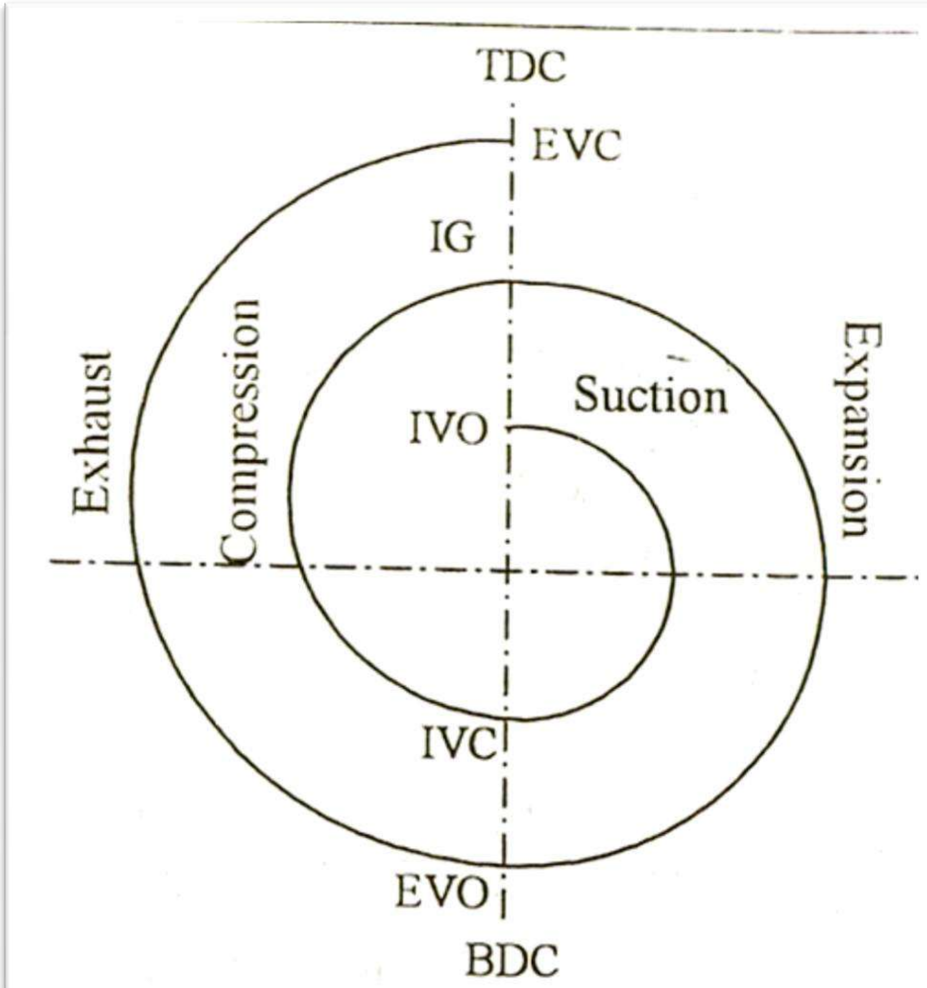
VALVE TIMING DIAGRAM

A VALVE TIMING DIAGRAM IS A DIAGRAM OF THE CRANK ROTATION ON WHICH THE TIME OF THE OPENING CLOSING OF INLET VALVE, EXHAUST VALVES ARE SHOWN.

VALVE TIMING MECHANISM IS CONVERNED WITH RELATIVE CLOSING AND OPENING OF VALVES AND THEIR DURATION WITH RESPECT TO CYLINDER POSITION AND DEGREE OF CRANKSHAFT ROTATION

VALVE TIMING AND PORT TIMING DIAGRAMS

❖ **Valve timing and port timing diagrams**

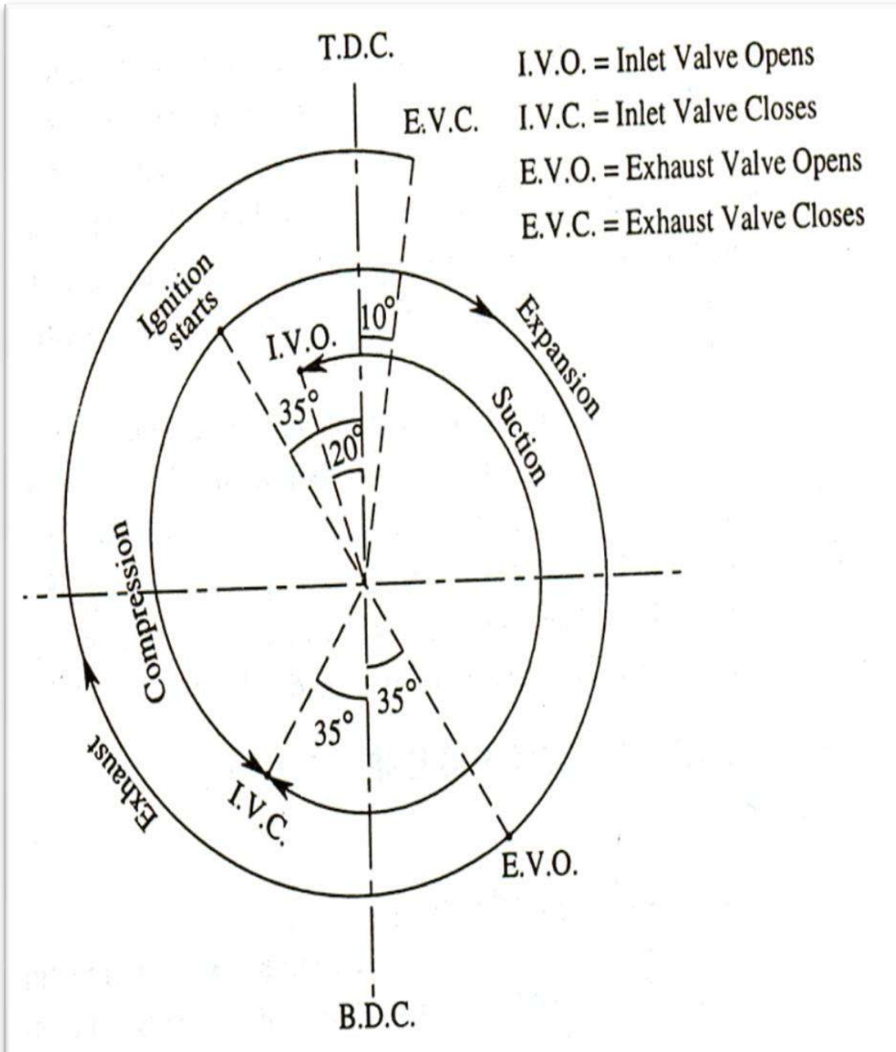


IVO	⇒	Inlet Valve Open.
IVC	⇒	Inlet Valve Close
IS	⇒	Ignition starts
EVO	⇒	Exhaust valve Open
EVC	⇒	Exhaust valve Close
TDC	⇒	Top Dead Center
BDC	⇒	Bottom Dead Center

Theoritical Valve Timing Diagram

VALVE TIMING AND PORT TIMING DIAGRAMS

❖ Valve timing and port timing diagrams



Valve Timing Diagram of 4 stroke Petrol Engine

IVO - 10° to 30° before TDC

IVC - 30° to 60° after BDC

IVO - 20° + 180° + 35° = 235°

EVO - 35° before BDC

EVC - 10° after TDC

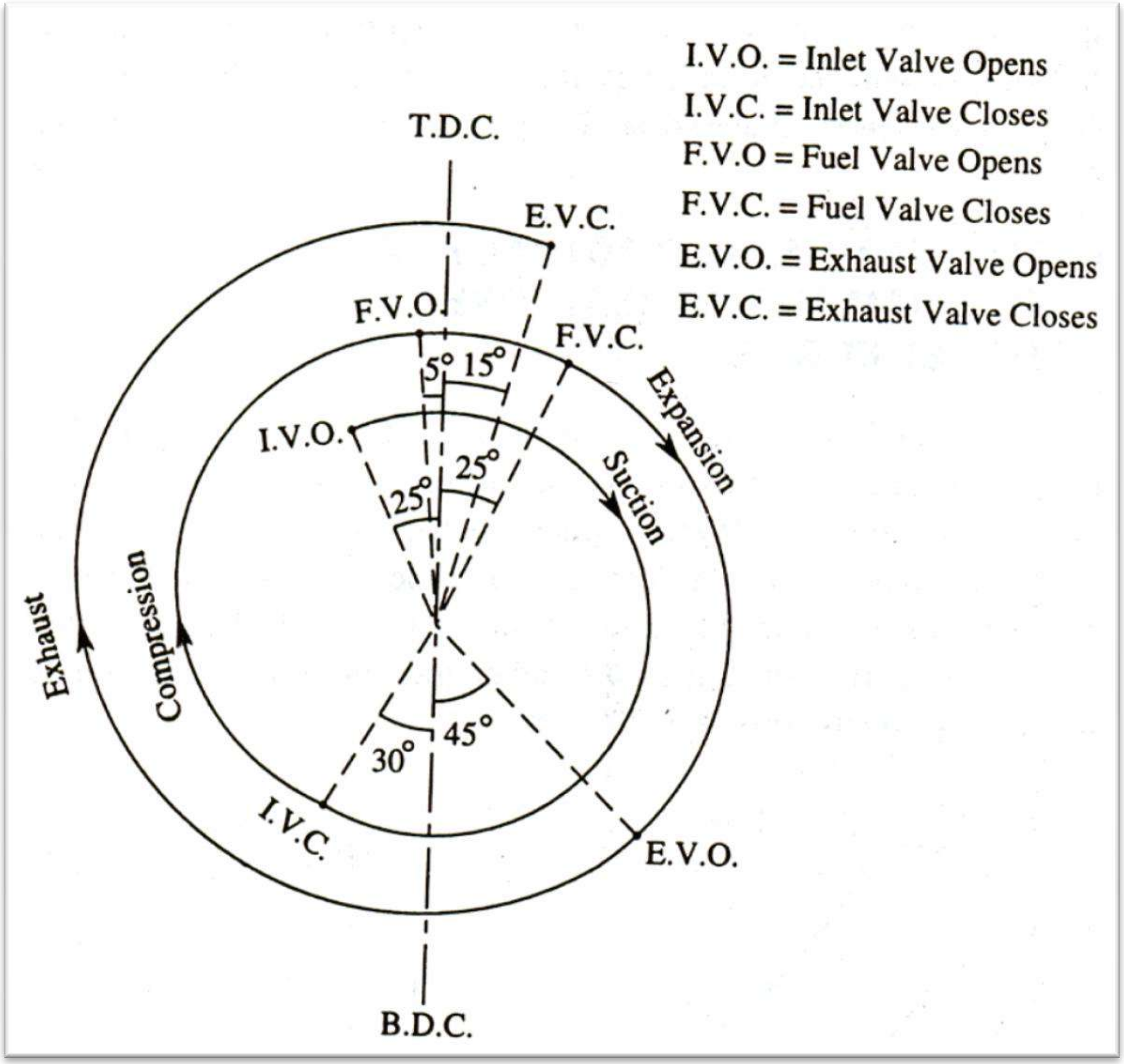
EVO - 35° + 180° +10° = 225°

IGN - 30° to 40° before TDC

Inlet Valve opening and closing : In an actual engine , the inlet valve begins to open 5°C to 20 °C before the piston reaches the TDC during the end of exhaust stroke. This is necessary to ensure that the valve will be fully open when the piston reaches the TDC. If the inlet valve is allowed to close at BDC , the cylinder would receive less amount of air than its capacity and the pressure at the end of suction will be below the atmospheric pressure . To avoid this the inlet valve is kept open for 25° to 40°after BDC Exhaust valve opening and closing Complete clearing of the burned gases from the cylinder is necessary to take in more air into the cylinder . To achieve this the exhaust valve is opens at 35° to 45° before BDC and closes at 10° to 20° after the TCC. It is clear from the diagram , for certain period both inlet valve and exhaust valve remains in open condition.

VALVE TIMING AND PORT TIMING DIAGRAMS

❖ Valve timing and port timing diagrams



Valve Timing Diagram of 4 stroke Diesel Engine

IVO - 10° to 25° before TDC

IVC - 25° to 50° after BDC

EVO - 30° to 50° before BDC

EVC - 10° to 15° after TDC

FVO - 5° to 10° before TDC
15° to 25° after TDC

THANK YOU