

Marine Engine

Introduction to marine engine

Engine: Engine is a device which transforms the chemical energy of a fuel into thermal energy and uses this energy to produce mechanical work.

Heat engines are divided into two broad classes.

- External Combustion Engine
- Internal Combustion Engine

a) External Combustion Engine:

In an external combustion engine the product of combustion of air and fuel transfer heat to a second fluid which is the working fluid of the cycle as in case of steam engine or a steam turbine.

Plant where the heat of combustion is employed to generate steam which is used in a piston engine or turbine. In all steam engine, the steam is used as the working substance. (Steam is a vapour of water e.g. it is invisible when pure and dry when dry vapour is further heated in superheated or so it will become superheated vapour which behaves more or less like a perfect gas.) These steam engines operated on the principle of first law of thermodynamics. i.e., heat and work are mutually convertible. In a reciprocating steam engine, as the heat energy in the steam is converted into mechanical work by the reciprocating (to and fro) motion of the piston it is called reciprocating steam engine. turbine moreover as the combustion of fuel taken place outside the engine cylinder, it is so called as external combustion engines.

External combustion engines “advantages or external combustion plants advantages are – use of cheaper fuels including solid fuels, and high starting torque (Internal combustion are not self-

starting). The steam turbine plant which is the most important external combustion engine is mainly used for large electric power generation.

b) Internal Combustion Engine:

In an Internal combustion engine, the products of combustion are directly the motive fluid, petrol, gas and diesel engines, wankel engine and open cycle gas turbines are examples of internal combustion engines. Jet engines and rockets are also internal combustion engines.

Historical Development: Hygiene Gunpowder Engine (1680)

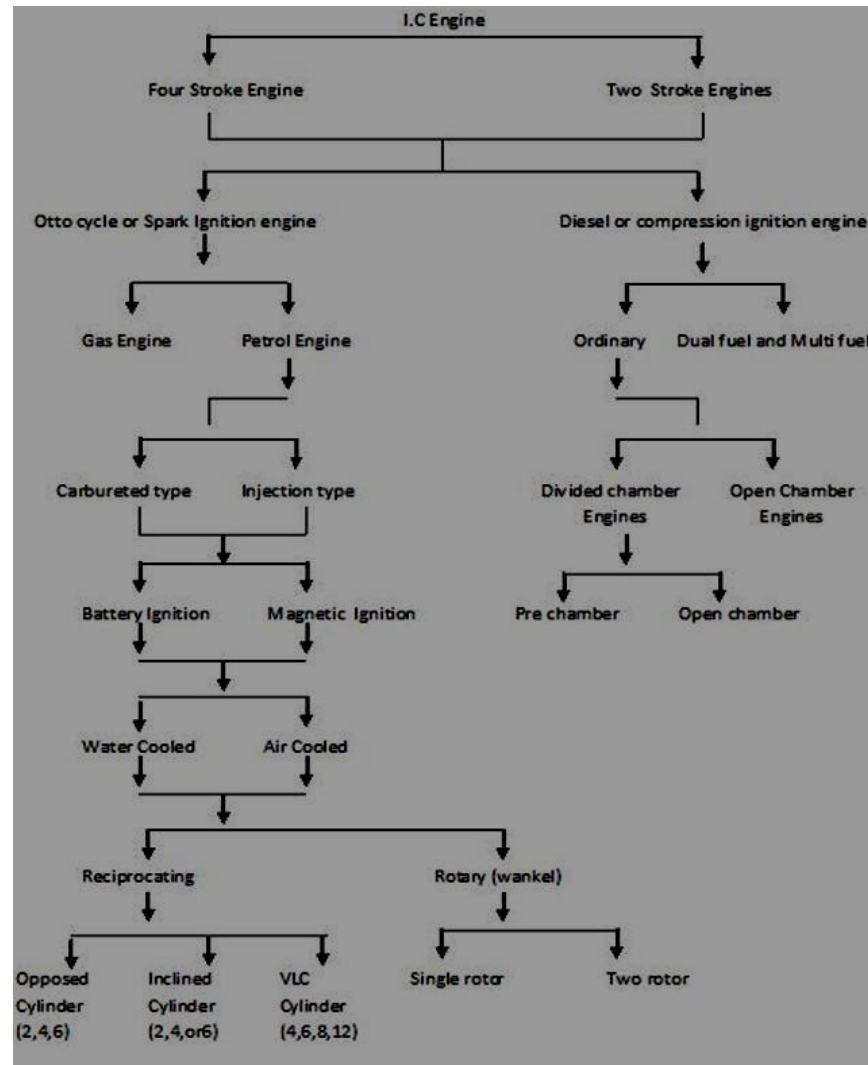
It consists of a vertical cylinder having a sliding fit type of piston. Explosion of a charge of gunpowder in the cylinder drawn the piston on its upward stroke and the returns stroke was caused by atmospheric pressure acting as the piston and arising from the drop in pressure in the cylinder as the gas products of the explosion began to cool. The useful work done on the downward stroke and by an arrangement of ropes and pulleys applied to raise loaded platform. He finds difficult to produce means for delivering the sequences of charges necessary for continuous operation and controlling the rate of explosion.

The free piston Otto – Large Engines (1866):

This consists of a piston which was not connected to any crankshaft but was free to move vertically outwards during the explosion and expansion strokes. After expansion, the product cooled down and piston falls. Under gravity causing downward stroke. During the downward stroke,

piston rod was connected by a ratchet and a rack and pinion device to the flywheel, doing useful work on fly wheel shaft on the downward stroke. The piston opened as exhaust valve of the sliding type. The inertia of the flywheel thus raised the piston from the bottom position and inducted a fresh air gas charge. The charge was ignited by a flame after about 300 of gear angle travel for the pistons from the bottom position. The connection between the frame and the combustion chamber was provided by means of an eccentric drives valve. The thermal efficiency of this was greater than of Lenoir (other) engines, the gas consumption being about 1/3 / h.p, but the operations was noisy. He got gold medal in historic Paris Exhibition.

Classification of Engines



Components of Engines

Cylinder:

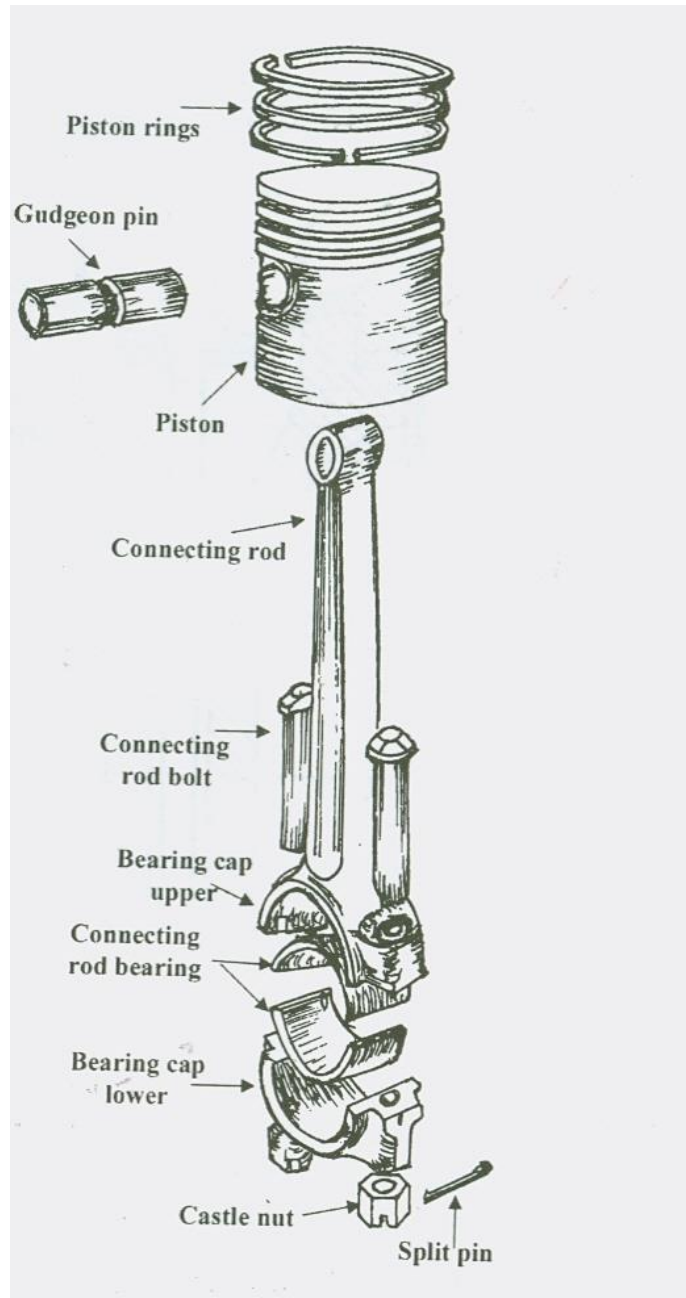
It is the heart of engine. Here only fuel is burnt and power is developed. The inner side of cylinder is formed by liner or sleeve, made of nickel chromium alloy steel. The inner diameter of cylinder is called bore of cylinder.

Cylinder head:

It is usually a single piece of casting made of alloy iron, bolted to the top of the engine. It covers the top end of cylinder and has provision for fitting inlet and exhaust valve arrangement.

Piston:

It is fast moving part inside the cylinder which converts thermal energy into useful mechanical energy.

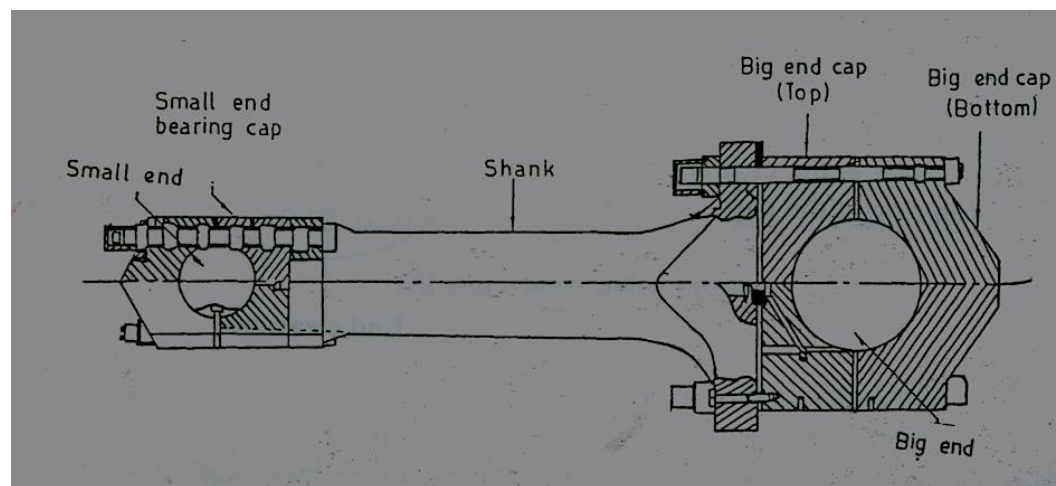


Piston ring:

These are rings fitted to the body of the piston. Piston rings are classified into compression ring and oil ring according to their purpose. Compression rings are fitted to the top of the body provides a seal to maintain power developed. Oil rings are used for circulating lubrication oil over the entire body of the piston and cylinder to reduce wear and tear.

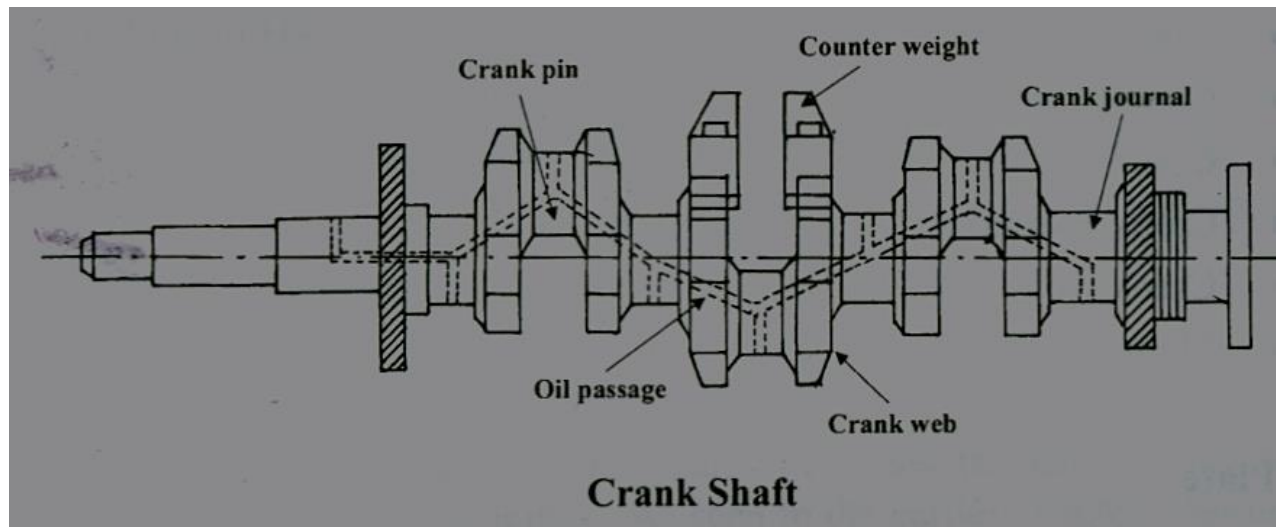
Connecting rod:

This is tapering rod with small end connected to the piston and big end connected to the crankshaft. The small end is connected to the piston by means of piston pin. The big end is split in two halves to facilitate fixing with the crankshaft. This connecting rod converts reciprocating motion of piston into rotary motion of crankshaft.



Cam shaft:

It consists of cams arranged on it with suitable phase difference in order to control the opening of the valves at different times as and when required. It gets its drive from the crankshaft by suitable gear and chain mechanism.



Cam:

These are the parabolic projections machined on a cam shaft or ellipsoidal metal pieces attached to the cylindrical shaft in such way that there is parabolic projection. This projection lifts the cam follower thereby opening the corresponding valve.

Cam follower:

This is flat piece attached to end of push rod which transmits the motion from cam to push rod.

Push rod:

This is rod which transmits motion to the rocker arm assembly by a suitable ball and socket arrangement.

Rocker arm:

This is actuated by the suitable lifting of push rod which in turn opens the valve.

Valve spring:

When the cam is released, the opened valve is closed back into position by the tension in the spring.

Crank shaft:

This is output shaft, which delivers the useful work to the driven shaft. It is supported by two bearings fixed in the crank case. To one end of the shaft a fly wheel is attached.

Fly wheel:

It takes care of fluctuation of the cyclonic vibration in speed. It stores energy during power stroke and release during other stroke, thus giving fairly constant output torque.

Cooling water jackets:

To cool the cylinders head and wall a jacket is provided to circulate the cooling water.

Fuel nozzle:

Fuel is delivered by this nozzle in a fine spray under pressure in diesel engine. This is an optional part of diesel engine.

Spark plug:

At the end of the compression stroke, the air fuel-mixture supplied to the engine cylinder is ignited by an electric spark, produced by spark plug. This is an optional part in petrol engine.

Inlet Valve:

To supply air at the suction stroke.

Exhaust Valve:

To remove the exhaust gas at the exhaust stroke.

Systems of diesel Engines

The desired result, i.e., the development of useful power by the engine is achieved only when these parts function as a group only. Some parts have similar functions to perform or some parts assist other parts in carrying out their respective functions. In other words a diesel engine's performance or operation can be easily understood if the different functions are grouped together into "Systems of operation". These operating systems of a diesel engine can be broadly classified as:

- Frame System
- Energy Generating System
- Power Transmission System
 - Intake Exhaust System
 - Valve Mechanism System
 - Fuel System
 - Lubrication System
 - Cooling System
 - Starting System

Frame System:

The heaviest system of the diesel engine which supports all the vulnerable part is the frame system. Cylinder, crankcase, bed plate, main bearing etc., are some fo the important parts of this system. One of the main function of the frame system is to hold the dead load of all the

components, the inertia load of the moving parts, the forces arising due to the combustion pressure etc., So utmost care has to be taken not only in designing but also in the material used for manufacturing these components which should have sufficient strength and stiffness to bear all the above said loads.

Energy generating system:

This system develops the energy. In a diesel energy is developed by the burning of fuel inside the combustion chamber. The lower part of the cylinder head, top part of the piston and the cylinder liner form parts of this system.

Power Transmission System:

The generated energy has to be transmitted outside the engine where it can be utilized. The power transmission system consists of piston pin, connecting rod, crankshaft, flywheel which performs this task. The parts of this system are all movable and also subjected to torsional and transverse forces. Hence they have to be abrasive resistant and able to withstand high torsional forces.

Intake and Exhaust System:

Suction and exhaust ports, manifolds, silencers etc., form the main parts of this system which is responsible for giving oxygen for combustion inside the cylinder as well as scavenge the unwanted gases outside the cylinder.

Valve Mechanism System:

Valve mechanism system works in conjunction with the intake and exhaust system. Controlling the timing, quantity of air admitted and expelling burnt gases out are performed by the intake and exhaust valves, cam, push rod, rocker arms and these parts constitute this system.

Fuel system:

Like the heart of a human being fuel system can be termed as the heart of S for combustion. It has various parts which are explained in the detailed study.

Lubricating and Cooling and Starting System: These are auxiliary systems but for which the smooth starting and operation of the engine cannot be affected. Like the fuel system all these systems have a series of accessories as well as various methods of operation which are elaborately explained in the specific chapters.

Estimation of engine power for fishing

Power estimation for small fishing vessels are determined by empirical means and also tank tests is utilized for some vessels' power calculation. Free running speed is generally estimated from Shaft Horse Power of Brake Horse Power curves drawn for a number of displacements on a common length. The power of trawlers in a certain fleet of fishing vessels does not normally vary much, although there is a distinct tendency to increase the power in relation to the size and to an 'inflation' in the rating of engines. The power is expressed in 'HP' which, according to the metric system, denotes the work of lifting 75kg/m/s. Although this definition is a simple one, many different HP are used to determine the size of propulsion of vessels. The most important different horse powers are given below

Power:

Rate of doing work is called power.

Horse power:

It is a unit of measurement of power. It is given as

$$1 \text{ HP} = 75 \text{ Kg-m/s or } 745 \text{ watts}$$

$$1 \text{ HP} = 4500 \text{ Kg-m/min}$$

$$1 \text{ Watt} = 1 \text{ J/s} = 745.5 \text{ Nm/s}$$

$$1 \text{ J} = 1 \text{ Nm} = (745.5/9.8) \text{ Kgm/s}$$

$$\text{N} = (1/9.8) \text{ Kg}$$

1. Thermal Horse Power (THP):

It is a horsepower produced by the combustion of fuel

$$\text{THP} = [\text{Fuel consumption} \times \text{calorific value of fuel (Kcal/min)} \times J] / 4500$$

Where, J = Mechanical equivalent of heat.

2. Indicated Horse Power (IHP):

It is the power generated in the engine cylinder and available at the top of the piston.

$$\text{IHP} = [P L A N_p] \times n / 4500$$

Where, P = Mean effective pressure(Kg/cm²)

L = Length of the piston stroke (m)

A = Cross section area of piston (cm²)

n = number of cylinder

N_p = number of power stroke (for two stroke engine the rpm of engines is N and for four stroke engine N_p is N/2)

3. Brake Horse Power (BHP)

It is the horsepower delivered by the engine at the end of the crankshaft. It is measured by dynamometer fitted at a suitable position, just near the end of the crankshaft.

$$\text{BHP} = (2 \pi NT/4500)$$

Where,

N = rpm of engine; T - Torque (kg-m) = $(r \times f)$, r is the radius of flywheel and f is force exerted on the periphery of flywheel.

4. Friction Horse Power (FHP):

It is the power required to run the engine at a speed with out producing any useful work. It represents the friction and pumping losses of the engine.

$$FHP = IHP - BHP$$

5. Shaft Horse Power (SHP):

It is the power delivered to the propulsion shafting. It is sum of the power required to overcome the resistance of the vessel, losses at the propeller and the losses in the shaft bearings and stuffing boxes

$$SHP = 0.94 \times BHP$$

6. Effective Horse Power (EHP):

In addition to these main definitions, the naval architectures also work with the effective horse power (EHP), which is the power that would be required to tow the vessel (thrust movement of vessel). It is calculated by the tank test through model vessel

$$EHP = 0.23 \times SHP$$

By considering 20% sea margin for fishing vessel

$$EHP = 0.23 \times 0.80 \times BHP \equiv 0.25BHP$$

7. Break Mean Effective Pressure (BMEP):

The pressure, which is developed in side the cylinder to work the system effectively.

For four stroke, $BMEP = [BHp \times 4500 / L \times A \times N \times n/2]$.

For two stroke, $BMEP = [BHp \times 4500 / L \times A \times N \times n]$

8. Thermal efficiency:

It is the ratio of the horsepower out put of an engine to the fuel horse power.

Brake thermal efficiency (η_B)

$\eta_B = BHP \times 4500 / (\text{fuel consumption per hr} \times \text{calorific value of the fuel})$

or

$$\eta_B = (BHP/THP) \times 100$$

9. Mechanical efficiency (η_M)

It is the ratio of the BHP to IHP of the engine and is expressed as

$$\eta_M = (BHP/IHP) \times 100$$

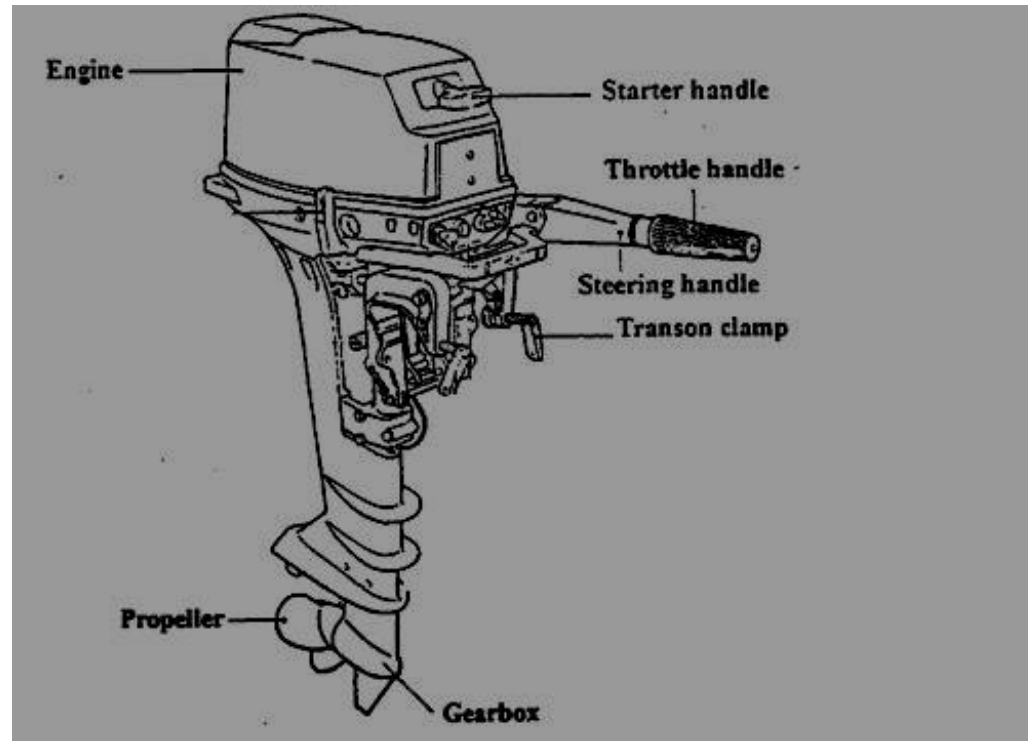
Outboard and In board Engine

Outboard Engine

Out boards Engine (OBE) is a machine which is fixed outside of the hull of the boat and which drives the propeller and moves the boat. They are integral mechanism, which has an internal combustion engine and the propeller unit coupled together as a compact unit. These easy and compact mechanisms give the following advantage for an out board motors.

- It is easy to maneuver.
- It is easy to maintain the boat fitted with OBE as the OBE can be removed from the boat and the boat can be beached anywhere.
 - It is easy to handle the boat fitted with OBE.
 - It can be fitted on any restricted space.

In India when the motorization of the fishing crafts have been started just after independence the traditional artisanal fishing crafts of India like canoes, catamarans etc were fitted with out board engines. The out board engines are powered with internal combustion engine run by petrol/ kerosene. Of late diesel engines were also used.



In board Engines

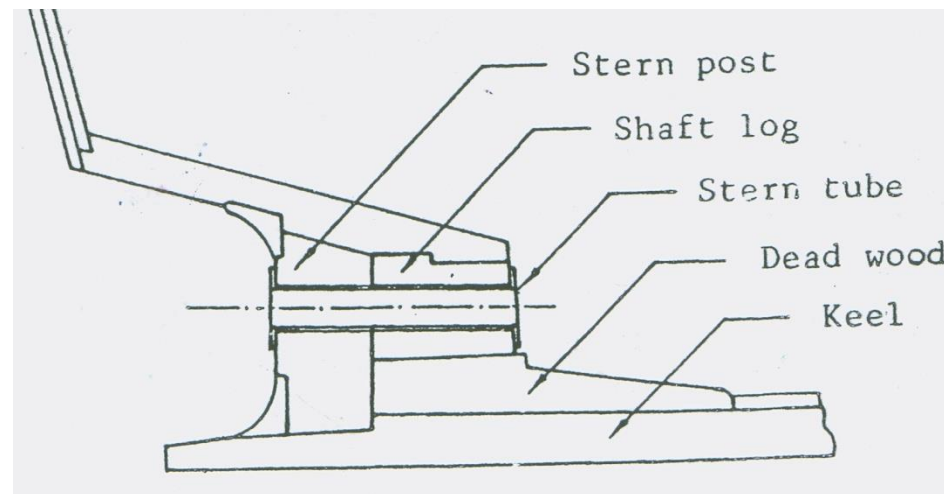
Because of its capacity an OBM can be utilized only on smaller crafts. For bigger vessels more power is required for propulsion. This is met by installing inboard engines. These inboard engines are mainly internal combustion engines installed inside the vessel hull, or bed plates which serve as the prime movers for navigating the vessels. The power developed by these prime movers has to be transmitted to the propeller for navigating the vessel. For this purpose a series of

transmission machinery are used in a vessel. The propeller should be able to give both ahead and astern movement to the vessel. It should also give enough thrust for pulling the fishing gear.

Stern tube arrangement

Stern tube is a pipe which extends from the stern post of the hull below the transom of the vessel.

The position of the stern tube in vessel is given as below. The purpose of the stern tube is to support the shaft with the help of stern tube bearings and to make a water tight joint on the hull where the shaft enters the hull. It also keeps the propeller shaft on the centre line of the vessel.



The stern tube is made up of steel in modern vessels. Brass or steel bushes are fitted on the forward and aft ends of the tube. These bushes are called stern tube bushes. The bushes are locked to the stern tube. The bushes are lined inside with soft material like lignum vitae, cutlass rubber and white metal. This complete part is called stern tube bearing. The propeller shaft or the tail end shaft rotates inside the stern tube or these stern tube bearings.

Care and Maintenance of engine

Performance of an engine degrades with time as its components deteriorate or wears out. Cleaning, inspection and maintenance of various parts have to be carried out periodically for the purpose of smooth engine operation and to avoid engine troubles.

Maintenance can be classified as

- Routine/ scheduled maintenance.
 - Preventive maintenance.
 - Breakdown maintenance.

1) Preparations before starting

The following points need to be checked for starting any engine

- Check batteries for specific gravity, loose terminal connections, and proper battery voltage for an electrically started engine.
 - Check the air pressure in the air bottles and fill it to 30 kg/cm² for air started engines
 - Check lubrication oil level of engine gearbox, turbo charger and replenish if low.
 - Remove water from fuel service tank, strainers, fuel pumps and also purge air from fuel system (if overhauled)
- Pre lubricated the engine either manually, hand pump or electrically driven pump as the case may be and also run the cooling water pumps.
 - Check and oil the valves if they are hand lubricated.
 - Preheat the cooling water in cold weather or cold temperature places.
 - De clutches the engine from propeller shaft.

- After all the above checks are performed before start the engine, observe its performance for sometime and then the load to the engine can be given

2) Precaution for stopping the engine

- Make sure the air bottles have sufficient air for next starting. It is advisable to keep air bottles always with the maximum of 30 kg/cm² Pressure
 - Lubricate manually the valves etc if required to prevent sticking.
 - Run the engine at no load before stopping
- Check the condition of bearing, crank pin etc. by opening side cover if engine is overhauled recently.
 - Drain out the cooling water for long shut downs.
- Operate the auxiliary cooling water pump and lubrication oil pump for larger engines so that the engine is cooled effectively.
- For supercharged engines observe the rotation and stopping supercharger. The speed of supercharge should reduce gradually. Abrupt reduction of speed means defective supercharger.
 - List out the repairs to be carried out before next operation.

The maintenance cycle varies according to the type of engine, service conditions purpose etc. and to greater extent determined by each manufacturers. However the following may form a guideline or reference for the maintenance specially the routine and preventive maintenance of an engine.

- Daily inspection

- Inspection at every 100hrs. Or 10 days
- Inspection at every 500hrs. of operation or 1.5 months
- Inspection at every 1000hrs. of operation or 3 months
- Inspection at every 3000hrs. of operation or 6 months
- Inspection at every 6000hrs. of operation or 1 year.

i) Daily inspection

- Inspect the quantity of lubricant oil in the sump of the engine gearbox & super charger and make up if necessary.
 - Inspect quantity of cooling fresh water in the tank make up if necessary.
 - Remove water if present in fuel system.
 - Grease or oil the parts, which require manual lubrication.

ii) Inspection at 100 hours

- Cleaning of lubricant oil, fuel oil filters, air filters.
 - Inspection of V-belts for tension.

iii) Inspection at 500 hours

- Cleaning of exhaust valve and capping

- Testing of injection pressure and atomizing conditions of injector valves
 - Replace of engine and super charger lubrication oil

iv) Inspection at 1000 hours

- Inspection of tightness of cylinder head bolts and connecting rod bolts
 - Checking of valve taper clearances and fuel timings
 - Cleaning air filters for superchargers

v) Inspection at 3000 hours

- Decarbonisation or top over hauling
- Inspection of reverse gear thrust bearing
 - Inspection at 6000 hours
 - Major over hauling