

MODULE 4

TIDAL POWER

Energy from tides : Tide is a periodic rise and fall of the water level of sea due to the gravity of sun and moon on the earth water.

The main feature of the tidal cycle is the difference in water surface elevations at high tide and low tide.

If this differential head is utilized in operating a hydraulic turbine, the tidal energy could be converted into electrical energy.

Origin and nature of tidal energy :

Tides are produced mainly by the gravitational attraction of the moon and sun on the water of the earth.

About 70% of the tide producing force is due to moon & 30% due to sun.

Surface water is pulled away from the earth on the side facing the moon and at the same time the solid earth is pulled away from the water on the opposite side.

Thus the ocean height increases both near and far sides of the earth as shown in fig (a) below & fig (b)

There are two tidal cycles occur during a lunar day of 24 hrs 50 minutes. It means that the time between high tide and low tide is 6 hrs 12.5 minutes.

The difference between high and low water levels is called the range of the tide & represented as 'R'.

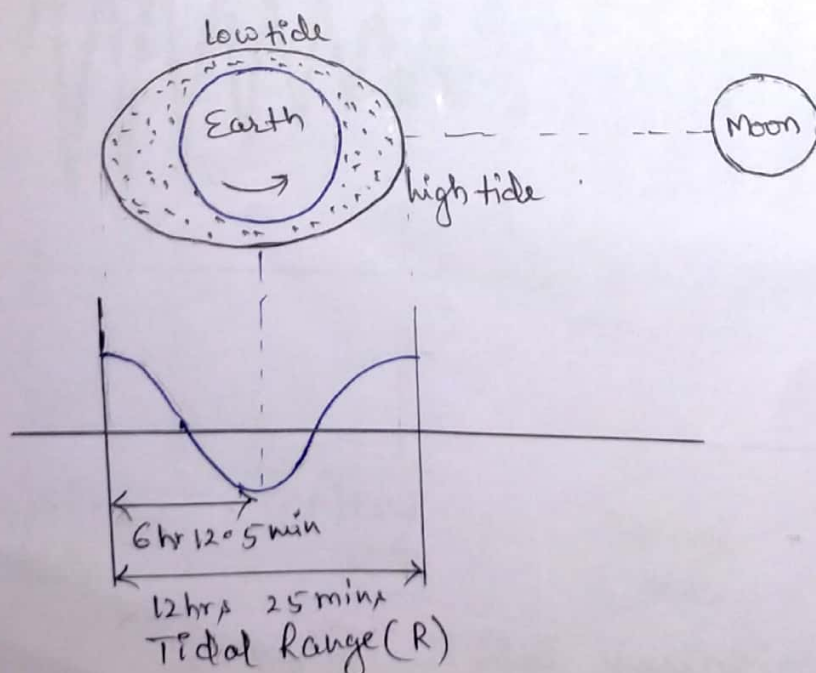


fig (a) Bulge on near & far sides of earth

fig (b) Tidal wave.

A time, near full & new moon, when sun, moon and earth are approximately in a line, the gravitational forces of sun and moon enhance each other. The tidal range is then exceptionally large, the high tides are higher and low tides are lower than the average. These high tides are called "Spring tides" which occurs during new moon and full moon day. On the other hand, near the first and third quarters of the moon when the sun and moon are at right angles with respect to the earth, "Neap tides" occur. The tidal range is then exceptionally small. as shown in fig (c) below & fig (d)

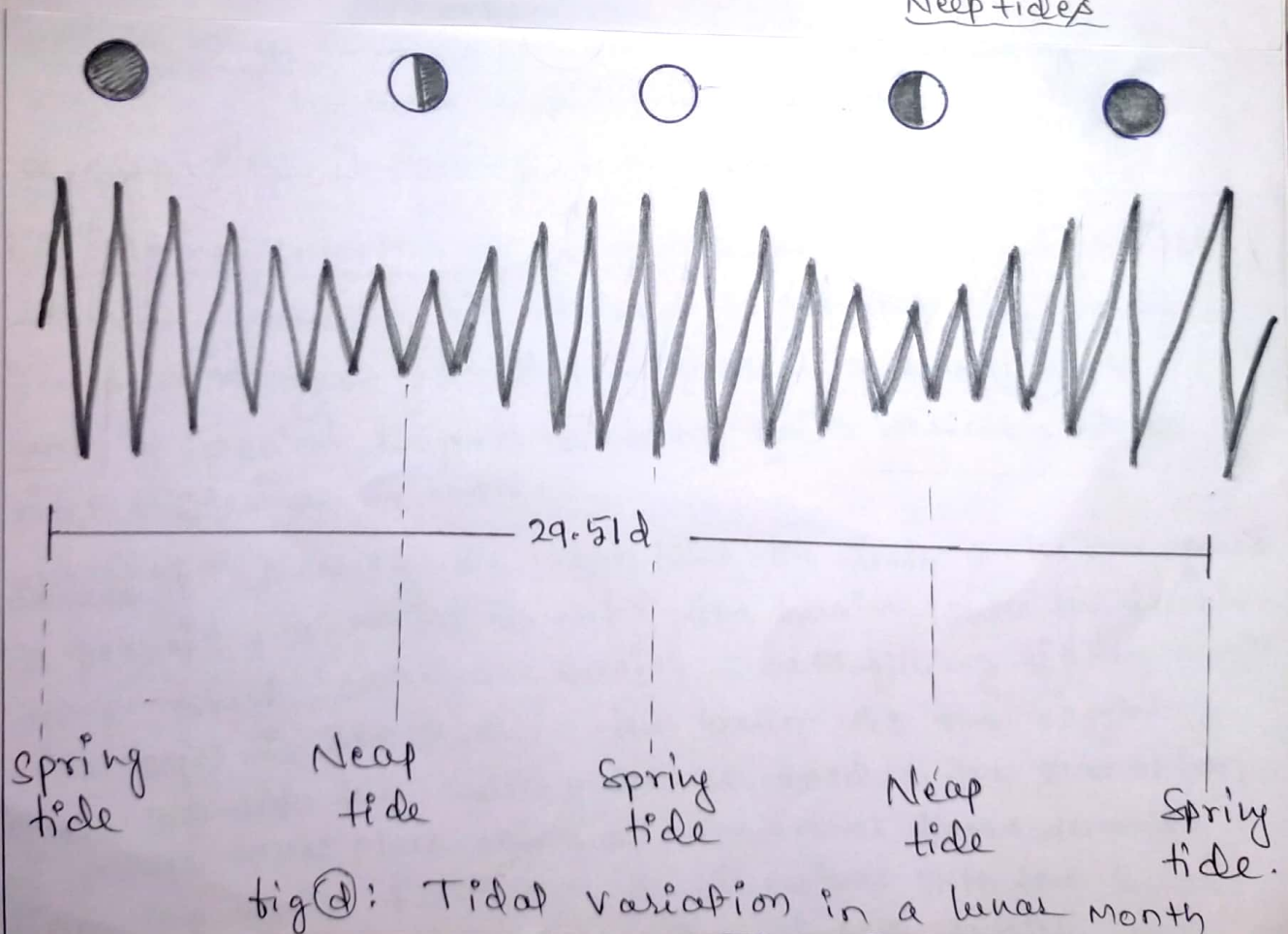
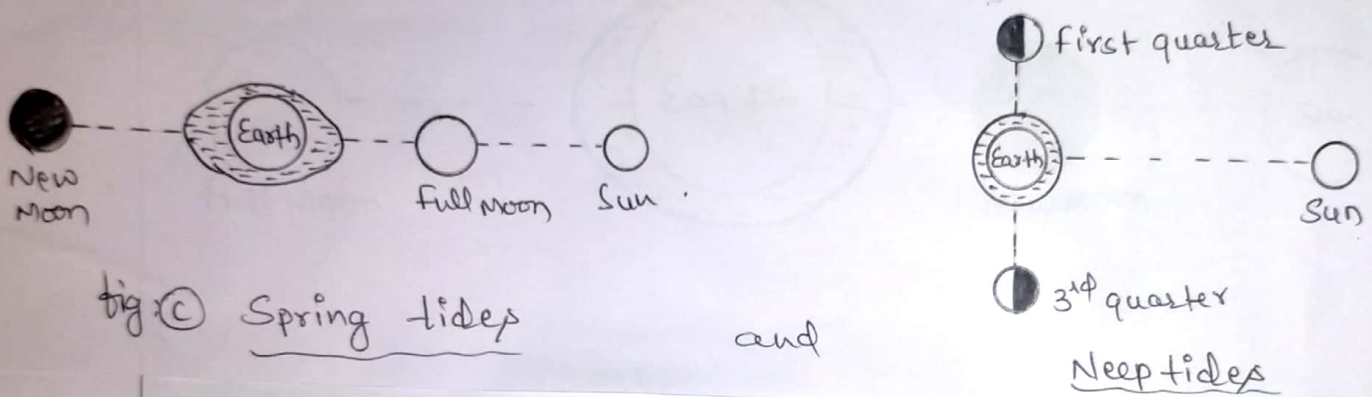
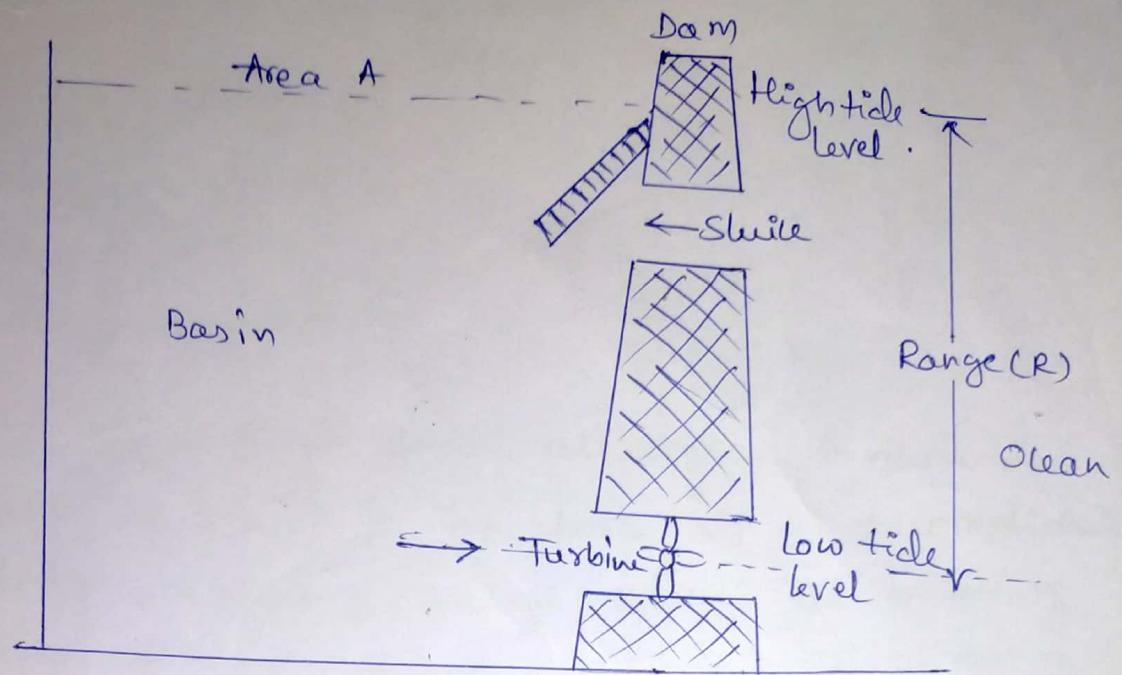


fig (d): Tidal variation in a lunar month

Basic working principle of tidal power plant



As shown in fig above the main components of a tidal plant is

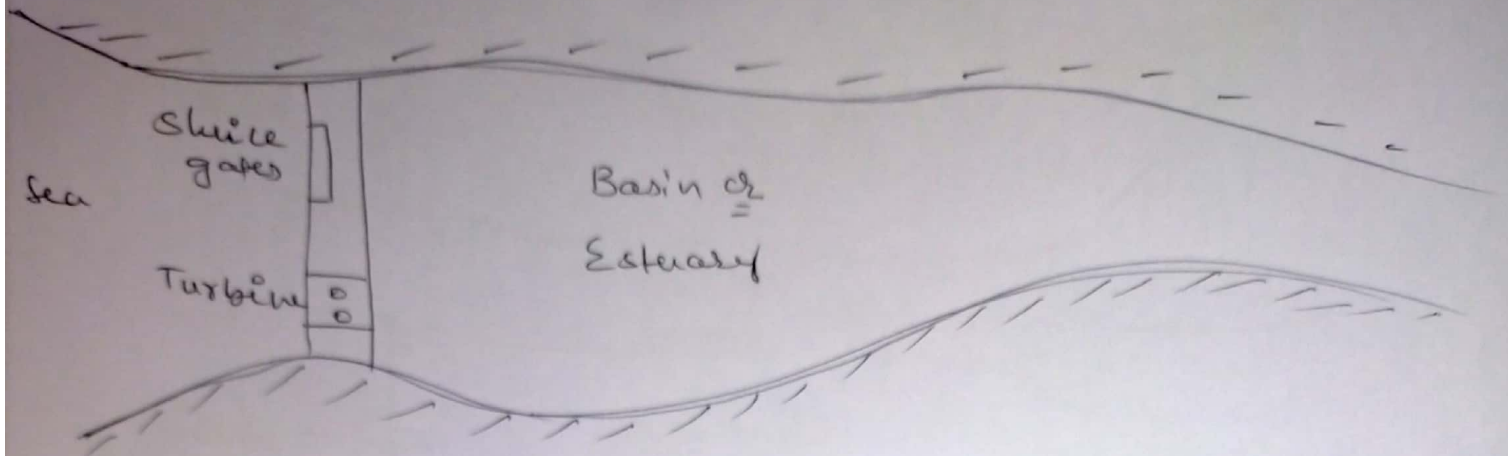
i) Dam :- It is a barrier constructed to hold water

ii) Sluice ways :- These are the rapid controlled gates used to fill basin during high tides & emptying it during low tides.

iii) Turbine generator set :- A special bulb type power turbine-generator set is used to generate electricity. The turbine-generator is placed in a steel shell and a special Kaplan turbine with variable blade pitch blades is used.

Working :- During the high tides the sluice gates are opened to permit sea-water to enter the basin while the turbine set is shut down. The basin starts filling till the max^m tide level is reached in the basin. At the beginning of the low tide the sluice gates are closed & the generation of power takes place when as the water flows through from the basin over the turbines into the lower level sea water.

Single basin single cycle system



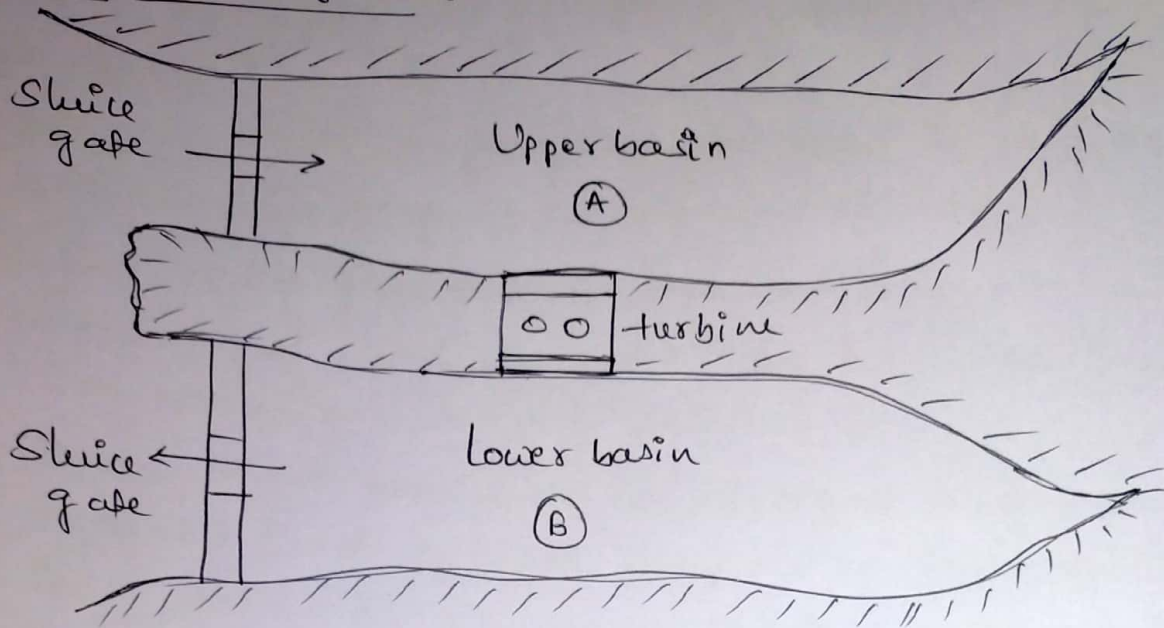
Construction :- In a single basin arrangement there is only one basin as shown in fig above. It is accomplished by constructing a dam or barrage across the mouth of a long narrow estuary. The dam consists of a number of sluice gates and a low head turbine sets.

Working :- The generation of power can be achieved ~~by the~~ during ebb cycle or tide cycle.

→ Ebb cycle system :- When the high tide comes, the sluice gates are opened to permit sea-water to enter the basin but while the turbine sets are shut. At the beginning of the low tide or ebb tide the sluice gates are closed and the generation of power takes place by making the water to flow to the sea through turbine.

→ Tide cycle system :- In a tide cycle system the generation takes place when the sea is at flood or high tide. The water of the sea is admitted into the basin over the turbines. As the flood-tide period is over and the sea level starts falling again, the generation is stopped. The basin is drained into the sea through the sluice ways.

Double basin system →



Construction → It requires two separate but adjacent basins. In one basin i.e; upper basin the water level is maintained above that of the other basin i.e; lower basin. In this system the turbines are located in between the two adjacent basins, while the sluice gates are embodied in the dam; & the dam is constructed across the mouths of the two estuaries.

Working → In this system the turbines are located in between the two adjacent basins while the sluice gates are embodied in the dam.

At the beginning of the flood tide, the turbines are shut down the gates of upper basin (A) are opened and the lower basin (B) are closed. The basin (A) is filled up while the basin (B) is remains empty. As soon as the rising water level in (A) provides sufficient difference of head between the two basins the turbines are started and the water flows from (A) to (B) through the turbines & generating power. At the end of the high tide when (A) is full its sluice gates are closed. When the low tide level gets lower than the water level in (B) its sluice gates are opened.

Advantages and Disadvantages of Tidal power generation

→ Advantages : →

- The biggest advantage of the tidal power is its inexhaustible and independent of rain and uncertainty.
- Tidal power generation is free from pollution as it doesn't use any fuel and also not produce any unhealthy waste like gases, ash, atomic residues.
- These power plants do not demand large area of valuable land because they are on the bays (sea shore).
- Peak power demand can be effectively met when it works in combination with thermal & hydroelectric system.

→ Disadvantages & Limitations : →

- The fundamental drawback to all methods of generating tidal power is the variability in output caused by the variations in the tidal range.
- The tidal ranges is highly variable and thus the turbines have to work on a wide range of head variation. This affects the efficiency of the plant.
- Since the tidal power generation depends upon the level difference in the sea and the basin hence the operation and generation is intermittent; Its not continuous.
- The tidal range is limited to a few meters. Thus the bulb turbine technology is not well developed, use of conventional kaplan runners was the only alternative.
- The time of occurrence tidal power cycle is not constant; it keeps on changing due to which difficulties occurs in the planning of the load sharing every day in a grid.
- Sea water is corrosive hence there is a fear of machinery to get corrosion.
- Construction in sea is very difficult & the cost is also more.

OTEC $\Rightarrow$ Ocean Thermal Electric Conversion System

In this method indirect form of solar energy at sea is used. The surface water of the sea is a infinite heat storage. Here the temperature difference between the warm surface water of the tropical oceans and the colder water in the depths is utilized to generate electricity.

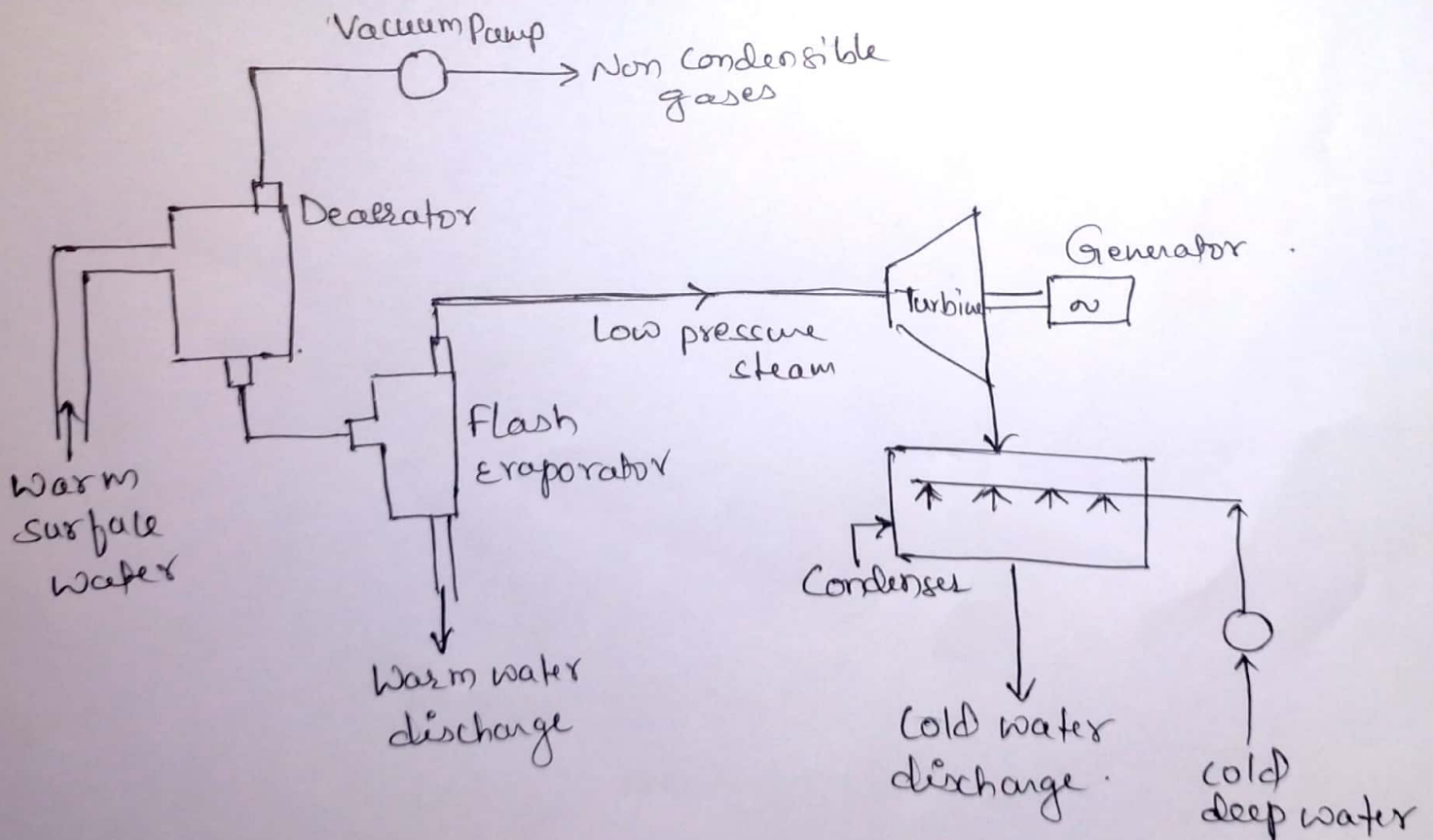
Warm surface water could be used to heat some low boiling organic fluid, the vapour of which would run a heat engine. The exit vapour would be condensed by pumping cold water from the deeper regions ($20-25^{\circ}\text{K}$).

There are two different methods for harnessing ocean thermal differences.

*> Open cycle also known as Claude cycle

*> Closed cycle also known as Anderson cycle.

Open Cycle OTEC System



As shown in fig the sea water is flash ~~evap~~ used as working fluid; the sea water is flash evaporated under a partial vacuum. The low pressure steam is passed through a turbine, which extracts energy from it, and then the spent vapour is cooled in a condenser. called condensate and in open cycle OTEC system the condensate is mixed with the cooling water and the mixture is discharged back into the ocean.

Wave Energy :-

The wave energy derives from wind energy and the wind is from solar energy.

Wave energy is most active and more concentrated than the solar energy.

Devices that convert energy from waves can therefore produce much higher power density than solar devices.

Advantages of wave energy

- *> The wave energy has the advantage over wind & solar that the energy is naturally concentrated.
- *> It is free and renewable energy source.
- *> Wave power devices do not use up large land masses.
- *> These devices are relatively pollution free and because they remove energy from the waves and leave the water in a calm state.

Disadvantages of wave energy

- *> The major disadvantage of wave energy is that the energy is available on the ocean; hence the extraction equipment must operate in a marine environment.
- *> The energy may have to be transported a greater distance to shore.
- *> Wave energy converters must be capable of withstanding very severe peak stresses in storms.
- *> Wave energy devices are relatively complicated.
- *> Installation cost, maintenance cost, repair & replacement costs are more.

Principle and working of wave energy

Wave motion is primarily horizontal but the motion of the water is primarily vertical. Mechanical power is obtained by floats making use of the motion of water. The concept uses a large float that is driven up and down by the water within relatively stationary guides. This reciprocating motion is converted to mechanical and then electrical power is generated.

The system based on this principle is shown in fig (a) below.

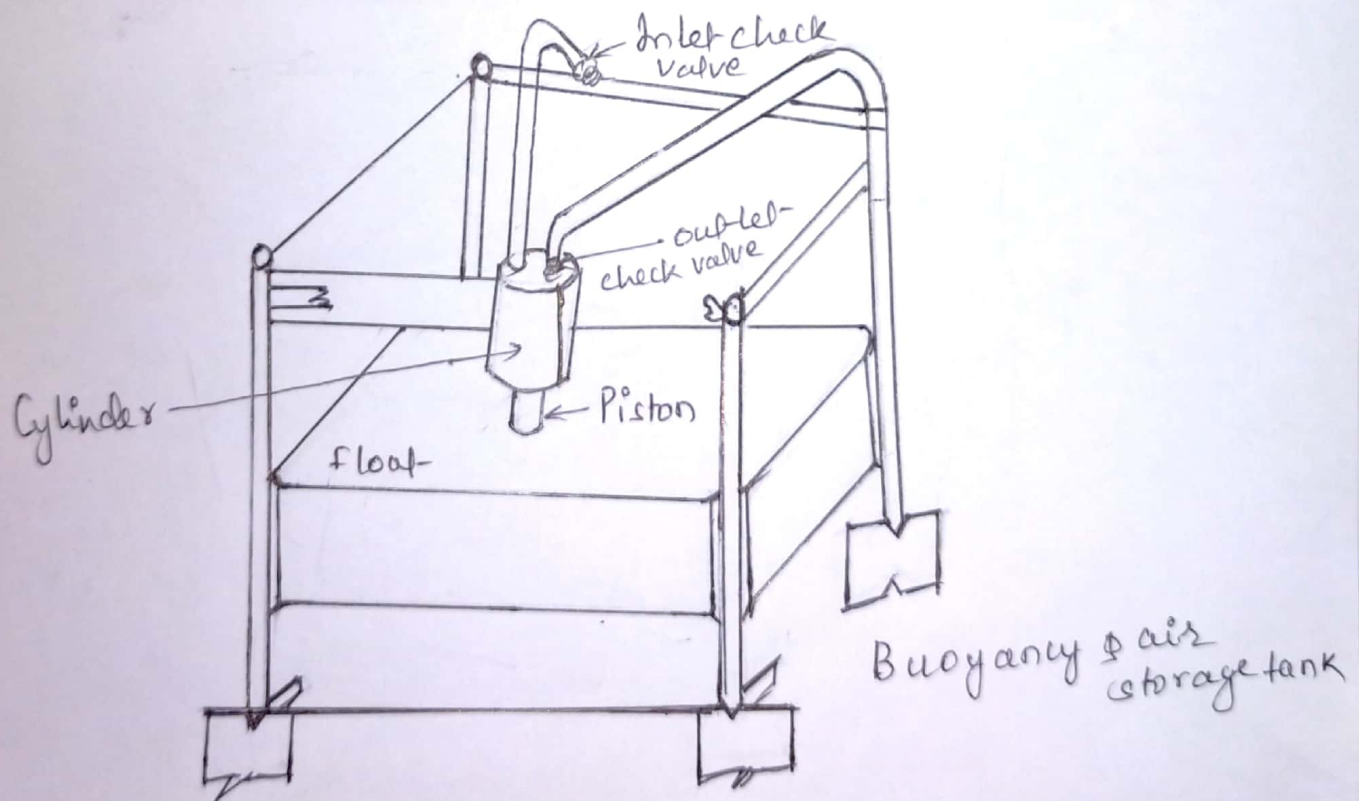


fig (a): Schematic diagram of float-wave-power conversion device.

Construction

In this system a square float moves up and down with the water. There are four large underwater floatation tanks which stabilize the platform. Platform is supported by buoyancy forces and hence the platform is made stationary in space.

A piston which is attached to float moves up and down inside a cylinder. The cylinder is attached to platform & hence it is also stationary.

The piston and cylinder arrangement is used as a reciprocating compressor.

Working

The downward motion of the piston draws air into the cylinder via an inlet check valve. This air is compressed by upward motion of the piston and is supplied to the four under-water floatation tanks; through an outlet check valve. In this way the four floatation tanks serve the dual purpose of ~~buoyancy~~ buoyancy - storage tanks & stabilize the platform.

An air turbine is run by the compressed air and drives the generator which produces electrical energy. ~~work~~
This generated electricity is transmitted to the shore via an under-water cable.