1.5 TURBINES

Steam turbine is a heat engine which uses the heat energy stored in steam and performs work. The main parts of s steam turbine are as follows:

A rotor on the circumference of which a series of blades or buckets are attached. To a great extent of performance of the turbine depends upon the design and construction of blades. The blades should be so designed that they are able to withstand the action of steam and the centrifugal force caused by high speed.

As the steam pressure drops the length and size of blades should be increased in order to accommodate the increase in volume. The various materials used for the construction of blades materials used for the construction of blades depend upon the conditions under which they operated steel or alloys are the materials generally used.

(i) Bearing to support the shaft.

(ii) Metallic casing which surrounds blades, nozzles, rotor etc.

(iii) Governor to control the speed.

(iv) Lubricating oil system.

Steam from nozzles is directed against blades thus causing the rotation. The steam attains high velocity during its expansion in nozzles and this velocity energy of the steam is converted into mechanical energy by the turbine.

As a thermal prime mover, the thermal efficiency of turbine is the usual work energy appearing as shaft power presented as a percentage of the heat energy available.

High pressure steam is sent in through the throttle valve of the turbine. From it comes torque energy at the shaft, exhaust steam, extracted steam, mechanical friction and radiation.

Depending upon the methods of using steam arrangement and construction of blades, nozzle and steam passages, the steam turbines can be classified as follows:

1. According to the action of steam
   (i) Impulse turbine
   (ii) Reaction turbine
   (iii) Impulse and reaction turbine.

In impulse turbine the steam expands in the stationary nozzles and attains high velocity. The resulting high velocity steam impinges against the blades which alter the direction of steam jet thus changing the momentum of jet and causing impulsive force on the blades.

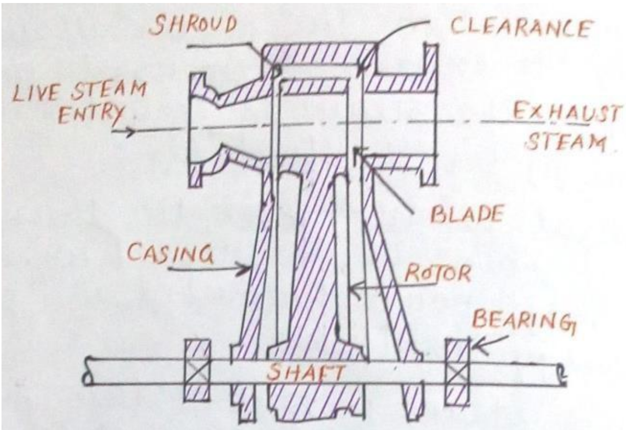

Figure 1.5.1 Impulse Turbine
[Source: "power plant Engineering" by by Anup Goel ,Laxmikant D.jathar,Siddu :3page:27]

In reaction turbine steam enters the fast moving blades on the rotor from stationary nozzles. Further expansion of steam through nozzles shaped blades changes the momentum of steam and causes a reaction force on the blades.

Commercial turbines make use of combination of impulse and reaction forces because steam can be used efficiently by using the impulse and reaction blading on the same shaft. Figure shows impulsed reaction turbine.

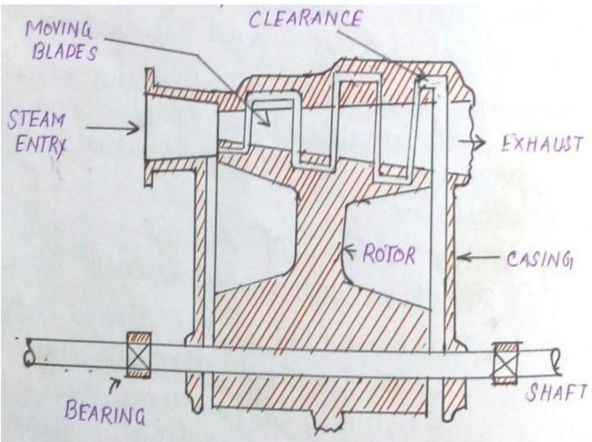

Figure 1.5.2 Reaction turbine

[Source: "power plant Engineering" by P.K.Nag page:28]

2. According to the direction of steam flow
   (i) Axial
   (ii) Radial
   (iii) Mixed
3. According to pressure of exhaust
   (i) Condensing
   (ii) Non-condensing
   (iii) Bleeder
4. According to pressure of entering steam
   (i) Low pressure
   (ii) High pressure
   (iii) Mixed pressure

5. According to step reduction

   (i) Single stage

   (ii) Multi-stage

6. According to method of drive such as

   (i) Direct connected

   (ii) Geared

CONDENSERS

The thermal efficiency of a closed cycle power developing system using steam as working fluid and working on carnot cycle is given by an expression $(T_1-T_2)/T_1$. This expression of efficiency shows that the efficiency increases with an increase in temperature T_1 and decrease in temperature T_2.The maximum temperature T_2(temperature at which heat is rejected) can be reduced to the atmospheric temperature if the exhaust of the steam takes place below atmospheric pressure. If the exhaust is at atmospheric pressure, the heat rejection is at 100˚C.

Low exhaust pressure is necessary to obtain low exhaust temperature. But the steam cannot be exhausted to the atmosphere if it is expanded in the engine or turbine to a pressure lower than the atmospheric pressure. Under this condition, the steam is exhausted into a vessel known as condenser where the pressure is maintained below the atmosphere by continuously condensing the steam by means of circulating cold water at atmospheric temperature.

A closed vessel in which steam is condensed by abstracting the heat and where the pressure is maintained below atmospheric pressure is known as a condenser. The efficiency of the steam plant is considerably increased by the use of a condenser. In large turbine plants, the condensate recovery becomes very important and this is also made possible by the use of condenser.

The steam condenser is one of the essential components of all modern steam power plants. Steam condensers are of two types:

1. Surface condenser
   (a) Down flow type
   (b) Central flow condenser
   (c) Evaporation condenser
2. Jet condenser
   (a) Low level jet condensers (parallel flow type)
   (b) High level or barometric condenser
   (c) Ejector condenser

Surface condensers

In surface condensers there is no direct contact between the steam and cooling water and the condensate can be re-used in the boiler. In such condenser even impure water can be used for cooling purpose whereas the cooling water must be pure in jet condensers.

Although the capital cost and the space needed is more in surface condensers but it is justified by the saving in running cost and increase in efficiency of plant achieved by using this condenser. Depending upon the position of condensate extraction pump, flow of condensate and arrangement of tubes the surface condensers may be classified as follows:

(a) Down flow type

Figure shows a sectional view of down flow condenser. Steam enters at the top and flows downward. The water flowing through the tubes in one direction lower half comes out in the opposite direction in the upper half. figure shows a longitudinal section of a two pass down- flow condenser.

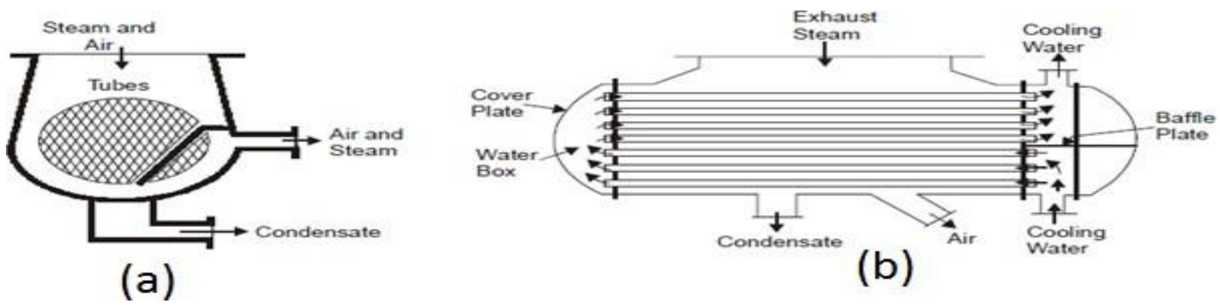

Figure 1.5.3 Surface condenser

[Source: "power plant Engineering" by by Anup Goel ,Laxmikant D.jathar,Siddu :3page:35]

(b) Central flow condenser

Figure shows a central flow condenser. In this condenser the steam passages are all around the periphery of the shell. Air is pumped away from the center of the condenser.

The condensate moves radially towards the center of tube nest. Some of the exhaust steam which moves towards the center meets the undercooling condensate and pre-heats it thus reducing under cooling.

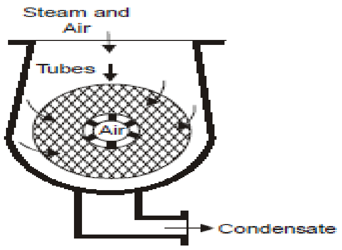

Figure 1.5.4 Down flow condenser

[Source: "power plant Engineering" by by Anup Goel ,Laxmikant D.jathar,Siddu :3page:35]

(c) Evaporation condenser.

In this condenser Figure steam to be condensed in passed through a series of tubes and the cooling water falls over these tubes in the form of spray. A steam of air flows over the tubes to increase evaporation of cooling water which further increases the condensation of steam.

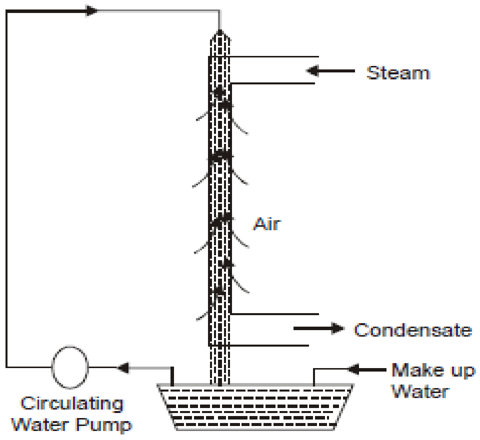

Figure 1.5.5 Evaporation condenser

[Source: "power plant Engineering" by by Anup Goel ,Laxmikant D.jathar,Siddu :3page:35]

Advantages

(i) The condensate can be used as boiler feed water.

(ii) Cooling water of even poor quality can be used because the cooling water does not come in direct contact with steam.

(iii) High vacuum (about 73.5 of Hg) can be obtained in the surface condenser. This increasing the thermal efficiency of the plant.

Disadvantages

(i) The capital cost is more

(ii) The maintenance cost and running cost this condenser is high

(iii) It is bulky and requires more space.

Jet condensers

In jet condensers the exhaust steam and cooling water come in direct contact with each other. The temperature of cooling water and the condensate is same when leaving the condensers.

Elements of the jet condenser are as follows:

(i) Nozzles or distributors for the condensing water.

(ii) Steam inlet

(iii) Mixing chambers: They may be (a) Parallel flow type (b) Counter flow type depending on whether the steam and water move in the same direction before condensation or whether the flows are opposite

(iv) Hot well

In jet condensers the condensing water is called injection water.

(a) Low level jet condensers (Parallel flow type)

In this condenser Figure water is sprayed through jets and it mixes with steam.

The air is removed at the top by an air pump.

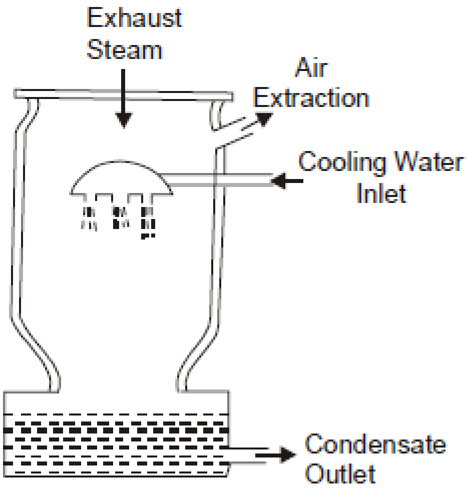

Fig.14

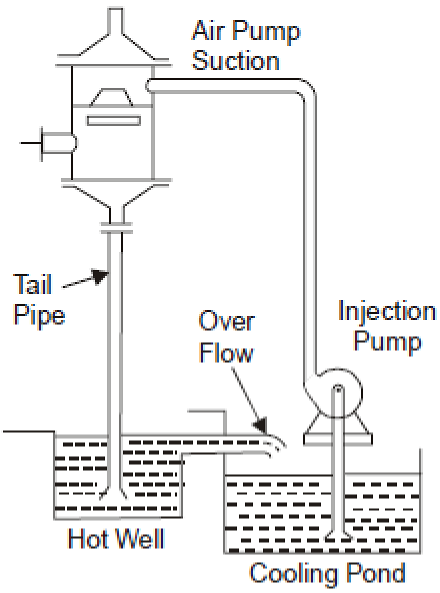

Fig.15

Figure 1.5.6 Low level and High level Jet condenser

[Source: "power plant Engineering" by by Anup Goel ,Laxmikant D.jathar,Siddu :page:36]

High level or Barometric condenser

Figure shows a high level jet condenser. The condenser shell is place at a height of 10.33m (barometric height) above the hot well. As compared to low level jet condenser this condenser does not flood the engine if the water extraction pumps facts. A separate air pump is used to remove the air.

Ejector condenser

Figure shows an ejector condenser. In this condenser cold water is discharged under a head of about 5 to 6m through a series of convergent nozzles. The steam and air enter the condenser through a non-return valve.

Steam gets condensed by mixing with water. Pressure energy is partly converted into kinetic energy at the converging cones. In the diverging cone the kinetic energy is partly converted into pressure energy and a pressure higher that atmospheric pressure is achieved so as to discharge the condensate to the hot well.

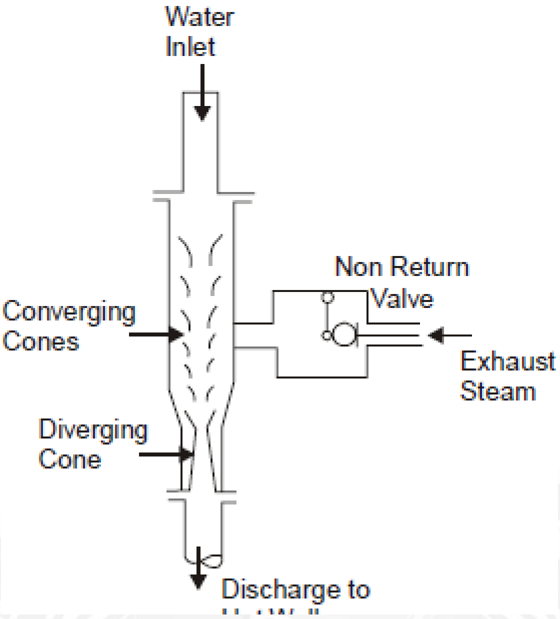

Figure 1.5.7 Ejector Condenser

[Source: "power plant Engineering" by by Anup Goel ,Laxmikant D.jathar,Siddu :page:36]