

3.1 Functions of Condensers:

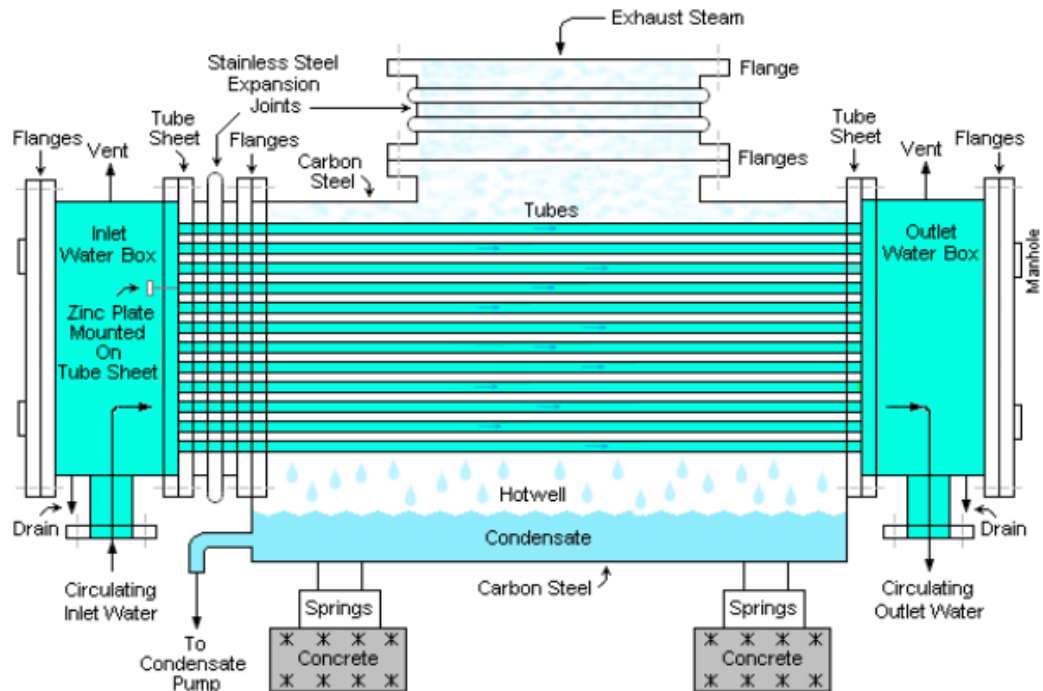
The main purposes of the condenser are to condense the exhaust steam from the turbine for reuse in the cycle and to maximize turbine efficiency by maintaining proper vacuum.

As the operating pressure of the condenser is lowered (vacuum is; increased), the enthalpy drop of the expanding steam in the turbine will also increase. This will increase the amount of available work from the turbine (electrical output). By lowering the condenser operating pressure, the following will occur:

1. Increased turbine output.
2. Increased plant efficiency.
3. Reduced steam flow (for a given plant output).

For best efficiency, the temperature in the condenser must be kept as low as practical in order to achieve the lowest possible pressure in the condensing steam. Since the condenser temperature can almost always be kept significantly below 100°C where the vapor pressure of water is much less than atmospheric pressure, the condenser generally works under vacuum. Thus leaks of non-condensable air into the closed loop must be prevented.

The condenser generally uses either circulating cooling water from a cooling tower to reject waste heat to the atmosphere, or once-through water from a river, lake or ocean.



Fig(3.1) Typical power plant condenser

Note: Tubes are brass, cupro nickel, titanium or stainless steel. The tubes are expanded or rolled and bell mouthed at the ends in the tube sheets.

The diagram depicts a typical water-cooled surface condenser as used in power stations to condense the exhaust steam from a steam turbine driving an electrical generator as well in other applications.

3.2 Condenser Components and their Functions:

3.2.1 Shell:

The shell is the condenser's outermost body and contains the heat exchanger tubes.

The shell is fabricated from carbon steel plates and is stiffened as needed to provide rigidity for the shell. When required by the selected design, intermediate plates are installed to serve as baffle plates that provide the desired flow path of the condensing steam. The plates also provide support that help prevent sagging of long tube lengths.

For most water-cooled surface condensers, the shell is under vacuum during normal operating conditions.

3.2.2 Hotwell:

At the bottom of the shell, where the condensate collects, an outlet is installed. In some designs, a sump (often referred to as the hotwell) is provided. Condensate is pumped from the outlet or the hotwell for reuse as boiler feed water. vacuum system for a steam ejector, the motive fluid is steam .For water-cooled surface condensers; the shell's internal vacuum is most commonly supplied by and maintained by an external steam jet ejector system.

Such an ejector system uses steam as the motive fluid to remove any non condensable gases that may be present in the surface condenser. The venturi effect, which is a particular case of Bernoulli's principle, applies to the operation of steam jet ejectors.

Motor driven mechanical vacuum pumps, such as the liquid ring type, are also popular for this service.

3.2.3 Tube Sheets:

At each end of the shell, a sheet of sufficient thickness usually made of stainless steel is provided, with holes for the tubes to be inserted and rolled. The inlet end of each tube is also bell mouthed for streamlined entry of water. This is to avoid eddies at the inlet of each tube giving rise to erosion and to reduce flow friction.

Some makers also recommend plastic inserts at the entry of tubes to avoid eddies and eroding the inlet end. In smaller units some manufacturers use ferrules to seal the tube ends instead of rolling. To take care of length wise expansion of tubes some designs have expansion joint

between the shell and the tube sheet allowing the latter to move longitudinally. In smaller units some sag is given to the tubes to take care of tube expansion with both end water boxes fixed rigidly to the shell.

3.2.4 Tubes:

Generally the tubes are made of stainless steel, copper alloys such as brass or bronze, cupro nickel or titanium depending on several selection criteria. The use of copper bearing alloys such as brass or cupro nickel is rare in new plants, due to environmental concerns of toxic copper alloys. Also depending on the steam cycle water treatment for the boiler, it may be desirable to avoid tube materials containing copper.

Titanium condenser tubes are usually the best technical choice; however the use of titanium condenser tubes has been virtually eliminated by the sharp increases in the costs for this material.

The tube lengths range to about 17 m for modern power plants, depending on the size of the condenser. The size chosen is based on transportability from the manufacturers' site and ease of erection at the installation site".

3.2.5 Water boxes:

The tube sheet at each end with tube ends rolled, for each end of the condenser is closed by a fabricated box cover known as a water box, with flanged connection to the tube sheet or condenser shell. The water box is usually provided with many holes on hinged covers to allow inspection and cleaning.

These water boxes on inlet side will also have flanged connections for cooling water inlet butterfly valves, small vent pipe with hand valve for air venting at higher level, and hand operated drain valve

at bottom to drain the water box for maintenance. Similarly on the outlet water box the cooling water connection will have large flanges, butterfly valves, vent connection also at higher level and drain connections at lower level. Similarly thermometer pockets are located at inlet and outlet pipes for local measurements of cooling water temperature.

3.2.6 Baffles:

Baffles are used to direct the side and tube side flow so that the fluid velocity is increased to obtain higher heat transfer rate and reduce fouling deposits. In horizontal units baffle are used to provide support against sagging and vibration damage. There are different types of baffles:

1. Segmental.
2. Disc and doughnut.
3. Orifice.
4. Rod type.
5. Nest type.
6. Longitudinal.
7. Impingement.

3.2.7 Air Pump:

The main function which an air pump performs is that it maintains vacuum in the condenser as nearly as possible equal to that corresponding to the exhaust steam temperature by removing air from the condenser. It may also remove condensate together with air from the condenser. An air pump which removes both air condensates is called a wet air pump.

Type of air pumps:

1. Reciprocating piston or bucket pumps.
2. Rotary pumps.
3. Steam jet air pump.

3.2.7.1 Steam Jet Air Ejector:

The operation of a steam-driven air ejector uses the viscous drag of a high-velocity steam jet for the ejection of air and other non-condensable from a condenser compartment. The steam jet flows through a chamber where it entrains the air and any gases adjacent to the surface of the jet. The kinetic energy of the resulting mixture is then converted to pressure energy by being passed through a diverging cone or diffuser. The resulting increase in pressure enables the mixture to be discharged against a pressure that is higher than that of the entraining chamber. The main stream is throttled and connected to the nozzle that is on the same axis as the mixing section and diffuser.

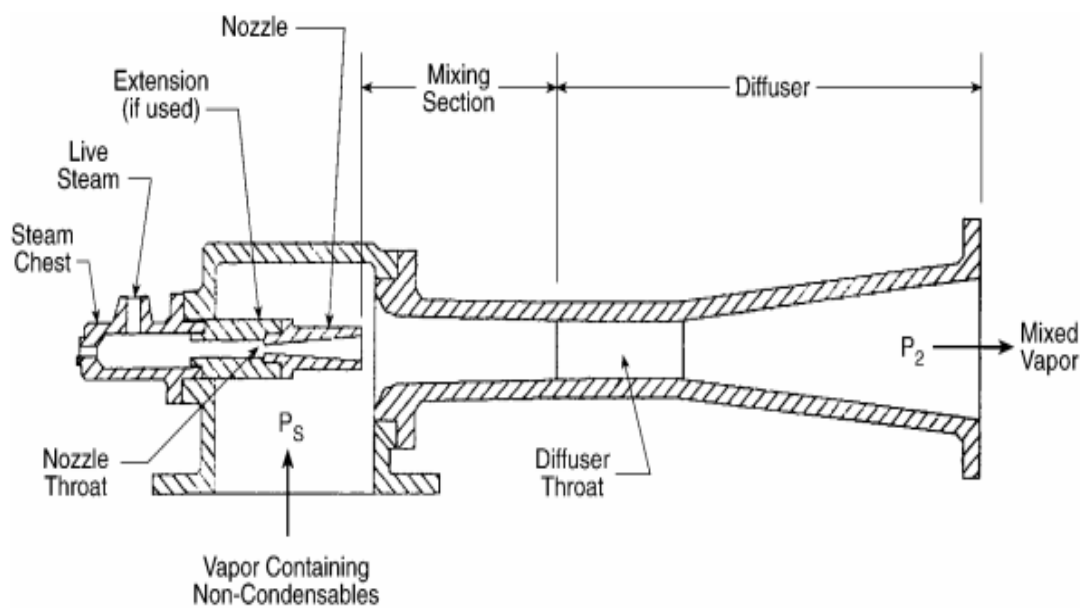


Fig (3.2) Typical Steam Jet Air Ejector

A variety of air ejector system configurations exist.

Some of the configurations are single element, single stage, condensing or single element, two stage condensing or non-condensing, two element, two stage non-condensing and parallel train. It might be necessary to use two or three ejectors in series to obtain the desired vacuum. In the condensing designs, an intercooler is located between the ejectors to condense the steam leaving the preceding ejector. These coolers lower the temperature of the steam leaving the ejector stage and reduce the volume before entering the next stage. The after cooler is used to condense the steam before leaving to the vent system.

3.2.7.2 Vacuum Pump:

Liquid ring vacuum pumps are the most common form of mechanical pump used in air-removal systems for steam surface condensers. The liquid ring vacuum pump is a rotary, positive displacement pump using a liquid as the principal element in gas compression. It is not unusual for more than one liquid ring vacuum pump system connected in parallel to be used. This allows the air-removal capacity to be adjusted, especially during low load operation or low condenser circulating water inlet temperatures. It also permits maintenance to be conducted without taking the unit out of service. See Figure (3.4) for an illustration of a liquid ring vacuum pump.



Fig (3.3) show the vacuum pump for BAHRI STATION PHASE III

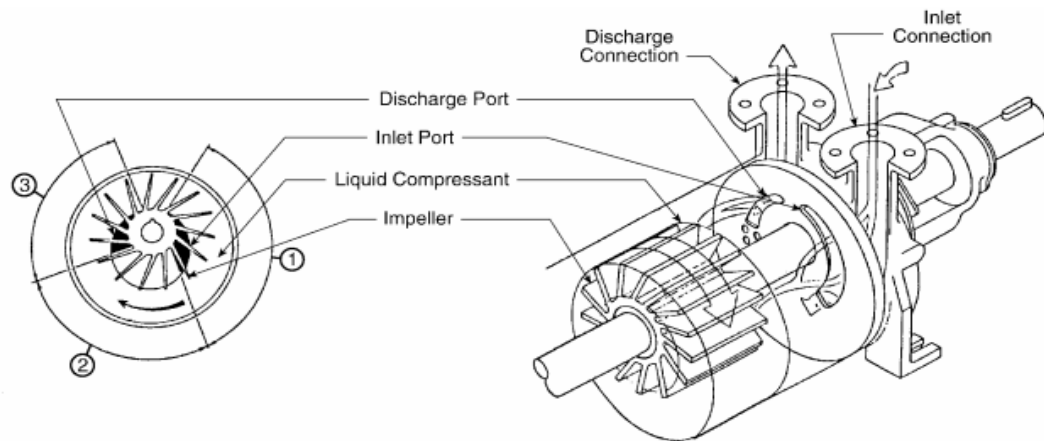


Fig (3.4) Flat Port Type Liquid Ring Vacuum Pump

3.3 Condensate Pumps:

Condensate pumps are those kinds of pumps that are used to collect and transport condensate back into a steam system for reheating and reuse, or to remove unwanted condensate.

Condensate pumps have a tank in which condensate can accumulate. The tank size varies depending on the application. The accumulating liquid raises a float switch which energizes the pump. The pump then runs until the level of liquid in the tank is substantially

lowered. Some pumps contain a two-stage switch.

As the liquid rises to the trigger point of the first stage, the pump starts working. If the liquid continues to rise, the second stage will be triggered. This stage may switch off the HVAC equipment, which is preventing the production of further condensate, trigger an alarm or both.

3.4 Types of Condensate Pump:

3.4.1 Boiler Feed Pump:

This pump closes the boiler, steam and condensate loop by returning the Condensate back into the system for re use.



Fig(3.5) Boiler Feed Pump BAHRI STATION PHASE III

3.4.2 Sump Pump:

This pump is installed in compartments to remove the unwanted build-up of water.

In a steam power plant, the condensate pump is normally located adjacent to the main condenser hotwell often directly below it this pump sends the water to a make-up tank closer to the steam generator or

boiler, if the tank is also designed to remove dissolved oxygen from the condensate, it is known as a De aerating feed tank (DFT). The output of the DFT supplies the feed booster pump which, in turn, supplies the feed pump (feed water pump) which returns the feed water to the boiler so the cycle can start over.

Two pumps in succession are used to provide sufficient net positive suction head to prevent cavitation and the subsequent damage associated with it.

3.4.3 Circulating Pumps:

Condenser circulating pumps are used to pump cooling water through the condenser. The source of the cooling water can be the sea, lake and river or a cooling tower. Low speed –horizontal-double suction-volute centrifugal pumps are used for this application. This pump has a simple but rugged design that allows ready access to interior for examination and rapid dismantling if repairs are required.

3.5 Atmospheric Relief Valves:

Atmospheric relief valves provide automatic protection of costly condenser equipment. These valves are as important as trip throttle valves, over speed governors and other devices for power plant protection. Atmospheric relief valves are designed and manufactured with the finest materials and the highest quality workmanship.

Atmospheric relief valves open and close automatically. Each valve needs to be installed vertically and properly leveled for smooth operation. Special ring seals and a water seal is provided for zero leakage in full vacuum conditions. Each valve opens immediately when pressure increases slightly above atmospheric pressure, higher than

atmospheric set pressures can be provided with internally spring loaded discs. During regular maintenance and as many times as possible, each atmospheric valve should be opened by turning the hand wheel clockwise then closing the valves by turning counter clockwise. This process ensures non binding and self-cleaning valve action.

3.6 Cooling Tower:

Cooling tower is similar to evaporative condenser where water used for cooling is being cooled effectively. Water used for cooling becomes hotter after extracting heat from condenser steam and needs to be cooled down if it is to be recycled. Cooling towers are preferably used where the water supply is limited and cooling water has to be recirculated without being thrown out.

Cooling tower is such an arrangement made of wood or metal structure having baffles inside to facilitate better heat exchange between hot water falling down and atmospheric air blowing across it.

Generally, hot water is admitted from top and is broken into small size (atomized) while falling down. Air enters tower at bottom and flows upward either due to natural draught or forced draught as the case may be.

Air picks up heat by intimate contact with hot water particles and leaves cooling tower from exit passage at top. Cooled water falls down and is collected in a tank at bottom of cooling tower. The heat transfer from hot water to air occurs due to evaporative cooling of water and convective heating of air both. The effectiveness of cooling tower diminishes in humid weather conditions due to reduced capacity of air.

Dry air shall offer better cooling effectiveness as compared to moist air. During cooling there occurs some loss of water as it is

carried away by air. This water loss may be from (1-4)% due to evaporation and drift losses.

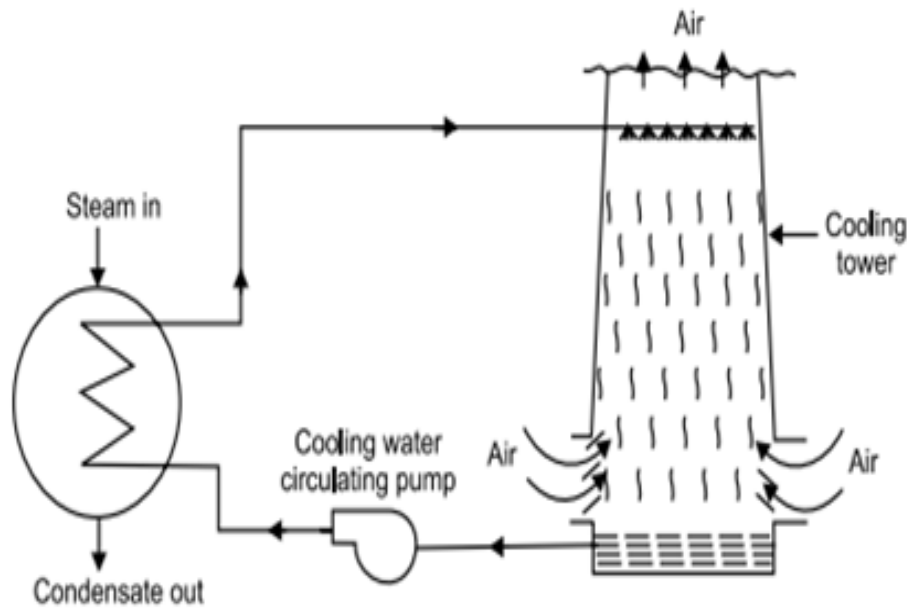


Fig (3.6) Schematic of cooling tower

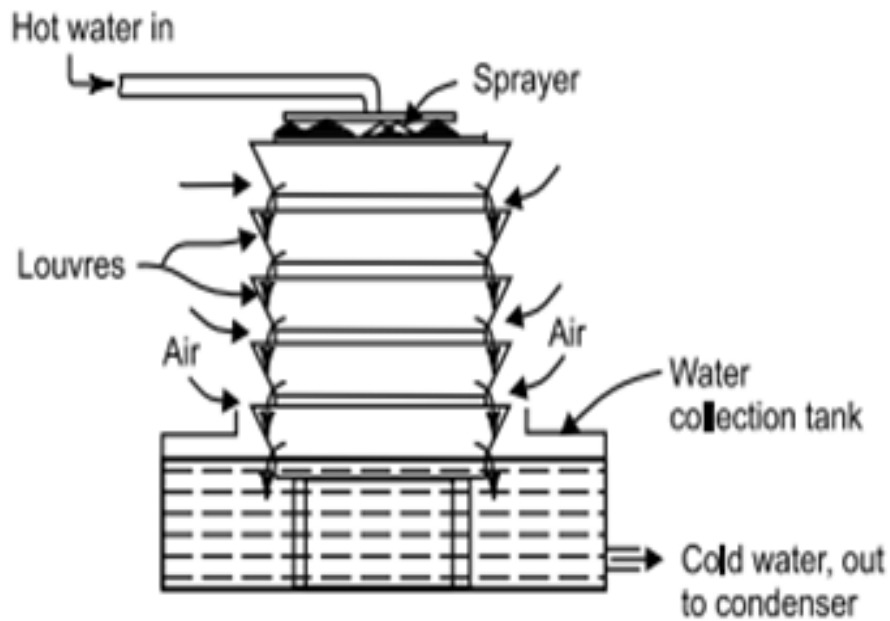


Fig (3.7) Atmospheric cooling tower

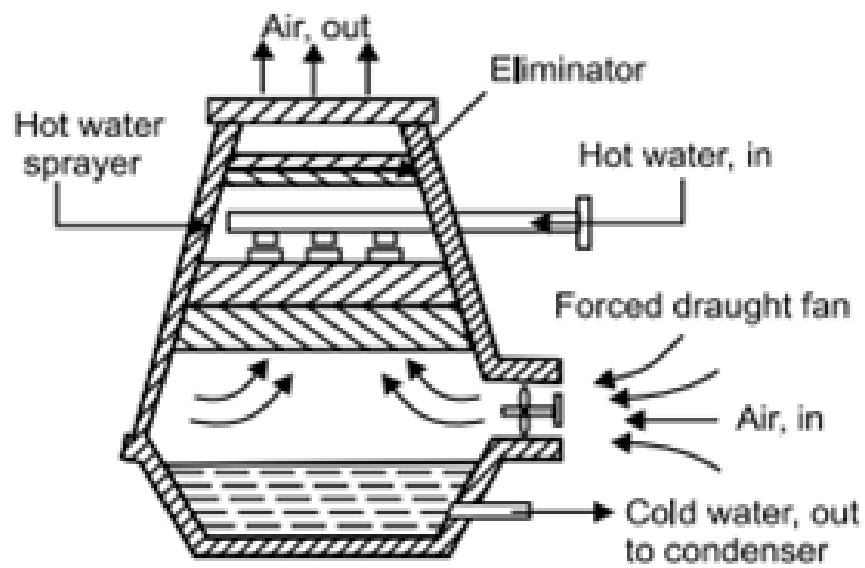


Fig (3.8) Mechanical draught (forced) cooling tower

The performance of cooling tower depends largely upon the duration of contact between water particle and air, surface area of contact between water particle and air, humidity of air and relative velocity of air and water flow etc.