Analysis on Performance of Condenser in Thermal Power Plant

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Abstract : **Demand for Electrical power is increasing at a rapid pace in our country. In order to meet the rapid increase in demand, the installation of Thermal Power Station is on obvious choice. In Thermal Power Station condenser plays a vital role for having good efficiency.**

The function of a condenser in thermal cycle is to maintain the exit pressure of the turbine lower than the atmosphere pressure. It appreciably increases the work done per kg of steam. i.e. some extra work is obtain from steam. This improves in efficiency of the plant.

Energy efficiency of any power plant strongly depends on its turbine- condenser system operation mode. Operating the condenser at optimum circulation water flow rate is essentially important to ensure maximum efficiency and minimum operating cost of the plant. Hence in this work, the condenser variables like cooling water flow rate, condenser pressure, condenser temperature which are having vital importance on entire plant performance has been controlled and study was done with various parameters.

INTRODUCTION:

In a Thermal Power Station, the efficient operation of a turbine depends upon the effective performance of the condenser. Fouling and scaling in the condenser tubes reduce the heat transfer rate and hence the vacuum in the condenser tends to be poor.

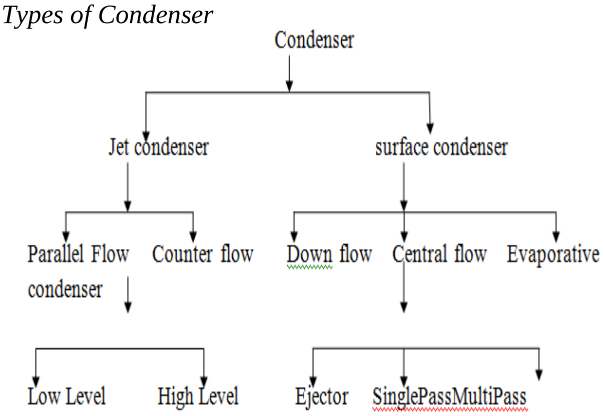
After the steam has surrendered its useful heat to the turbine, it passes to the condenser. The work obtained by the turbine from the steam will increase as the back pressure is reduced, so it is always desirable to operate at the minimum economic back pressure, i.e. the condensate temperature should be as low as possible. If the condensing surface were infinite, the condensing temperature would equal the temperature of the inlet cooling water (CW).

However, there is a practical limit and in practice the average temperature of the condensate is about 15°C above the inlet temperature, but even so the size of condensing plant is considerable. For example, a 660 MW unit the condenser may have 20,000X 25mm dia. Tubes, each 20 meters long. The reason for such a massive heat-transfer surface is apparent when it is realized that for a generator output of 660 MW about 780 MW of energy will be surrendered to the cooling water.

The Two Objectives of aSteam Condenser

The main objective is to maintain low pressure (below atmospheric pressure). Some extra work is obtained due to exhaust at a pressure lower than that of the atmosphere. This improves the efficiency of the plant. Air inside the condenser should be pumped out continuously in order to maintain the vacuum. The condensation of steam occurs in the range of 25°C to 38°C.

Types of Condenser



Jet Condenser

In a jet condenser, the steam to be condensed and the cooling water come in direct contact and the temperature of the condensate is the same as that of the cooling water leaving the condenser. For jet condensers the recovery of the condensate for reuse as boiler feed water is not possible.

Depending upon the arrangement of the removal of condensate, the jet condensers are sub-divided into the following categories.

- Low level counter flow jet condenser
- High level (or) barometric jet condenser
- Ejector condenser

1. Low level counter flow jet Condenser

In low level jet condenser the condensate is pumped by means of a condensate pump into the hot level.

2. High level (or) barometric jet Condenser

In high level jet condenser the condensate falls to the hot well by the barometric leg provided in the condenser.

Surface Condenser

In surface condenser there is no direct contact between the steam and cooling water and the condensate can be reused in the boiler. In such a condenser even impure water can be used for cooling purpose whereas the cooling water must be pure in jet condenser. Although the capital cost and the space needed is more in surface condenser but it is justified by the savings in running cost and increase in efficiency of plant achieved by using this condenser. Depending upon the position of condensate and arrangement of tubes the surface condenser may be classified as follows;

1. Down flow condenser
2. Central flow condenser
3. Evaporative condenser

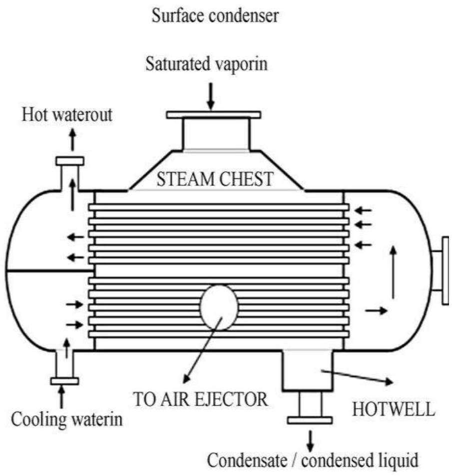


Figure: Shows the Down flow Condenser

Rankine Cycle

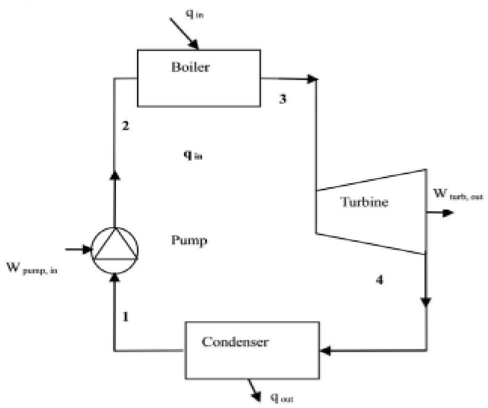
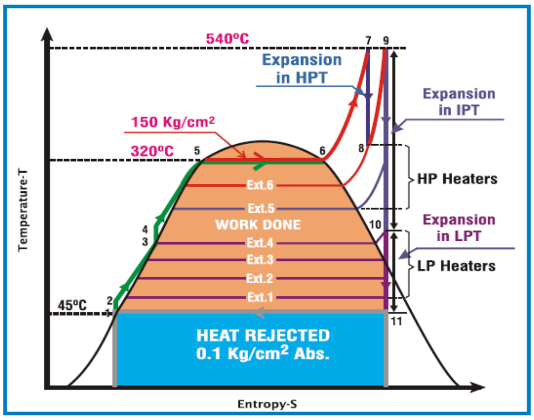


Figure : Rankine cycle

T-S Diagram



Factors Affecting The Performance of Condensers

This chapter discuss about the factors affecting the performance of condensers.

Cw Inlet Temperature

The CW inlet temperature is reasonably uniform across the supply pipe. Therefore, a single measuring point in each CW inlet pipe normally gives the required accuracy. If thermometer pockets are used, they should project at least 150mm into the pipes and should be partially filled with oil to improve the thermal conductivity.

4.2 Cw Outlet Temperature

The cooling water temperature at the condenser outlet is stratified because of spatial variations of the rate of condensation within the condenser. It is therefore necessary either to measure the temperature after sufficient length of pipe to ensure adequate mixing has taken place or to provide an averaging temperature measuring system such as:

- A continuous sample which may be withdrawn using either cantilevered multi-hole probes. The cantilever type is preferred because, by the use of a gland and valve system, it can be inserted or removed while the unit is on- load.
- Thermistors located at area- weighted radial positions.
- Long resistance elements positioned on chordal paths.

The mean water temperature may be weighted by the chordal path length and by the mean path water velocity, if known.

The probes are subjected to considerable buffering by the water, so care must be taken to ensure that they are adequately protected and supported. In systems arranged for symphonic operation, the condenser CW outlet may be below atmospheric pressure. When using multi-hole probes with this arrangement, it may be necessary to incorporate a suitable extraction device to ensure an adequate water flow over the temperature sensing elements.

Condensate Outlet Temperature

Condensate outlet temperature is measured at the exit from the condenser shell, irrespective of whether the hot well is integral with, or external to, the condenser.

Condenser Pressure

The most important pressure is that at the condenser steam inlet.

The same plane should be used for measuring both condenser pressure and turbine back pressure. With under slung condensers, the plane can be readily identified; but for other types the pressure should be measured at the plane or planes as near as practicable to the condenser tube nests.

Considerable variations in static pressure occur across the condenser inlet so that it is necessary to make provision for measuring the mean by providing for measuring the mean by providing numerous points for pressure sampling. Flush wall tapings are preferred and the holes should be 10mm diameter where possible, but never less than 6mm. They should be drilled normal to the wall, with burrs removed and a wide area around the hole cleaned and coated with anti-corrosive paint. Each condenser inlet duct should have wall tapings on all four sides, or on two opposite sides if access to all sides is impossible. The tapings are distributed as evenly as possible and there should be at least eight for each LP cylinder.

Should the flow at the tapings not be parallel to the wall, measurement errors may occur. Two ways to overcome this are:

- Fit guide plates about 300mm square parallel to the wall surface containing the pressure – sensing holes at a distance of about 50mm.
- Install an array of pressure – sensing tubes consisting of a series of closed tubes with rounded ends facing the steam flow and parallel to the expected flow direction with a series of small holes drilled around each tube about three diameters from the closed end.

Commonly the back pressure is displayed in the control room on an instrument such as a Kenotomers or a Vacuumeter. They are very good for this purpose, but suffer from two disadvantages:

- The instrument must be zeroed by adjusting the scale, judging the correct position by eye. This is a subjective assessment which may be in error.
- The instrument is connected to the condenser tapings by small- bore pipe work. The pipe should be run such that moisture cannot accumulate in it, but if some supports should fail it may permit the pipe to dip and from a 'valley'. This slows moisture to collect and the instrument will give a wrong indication. Alternatively, air may get into the pipe at a defective joint and again wrong indication will be given.

An alternative to these instruments is to install back pressure transducers near the condenser, connected electrically to a digital readout in the Control Room.

Heat Transfer in Condensers

Heat-transfer coefficient (U) is defined as the average rate or heat transfer from the steam to the cooling water per unit area per degree of logarithmic mean temperature difference.

Tube Cleanliness

The tube cleanliness factor (Fc) is the ratio of the average heat- transfer coefficient of tubes in the condenser to that of a new, acid – cleaned tube. Obviously, this is a very important parameter, particularly with tubes which are prone to fouling, either on the outside or inside.

Analysis of Design & Test Parameters of Condenser

S. no	DESCRIPTION	DESIGN VALUE	ACTUAL VALUE
1	Condenser Pressure	0.101 (Bar)	0.0981
2	Condensate Temperature at HotWell	46.03°C	46.15°C
3	Circulating Water Flow	29500 (m3/hr)	31282.151 (m3/hr)
4	Tube Clearliness Factor	85%	75%
5	Circulating Water Inlet Temp.	35°C	33.64°C
6	Circulating Water Outlet Temp.	43.29°C	41.00°C
7	Water Velocity Through Tube	1.508 (m/s)	1.628 (m/s)
8	Total Number of Tubes	21444	21444
9	Tube Length	10037 (mm)	10000 (mm)
10	Tube diameter	25.4(mm)	25.4(mm)

PERFORMANCE ANALYSIS OF DUAL PRESSURE CONDENSER

If cooling water is supplied to condenser in series flow arrangement, the performance of condenser can be: Let as assume that basis construction of both the condensers are same.

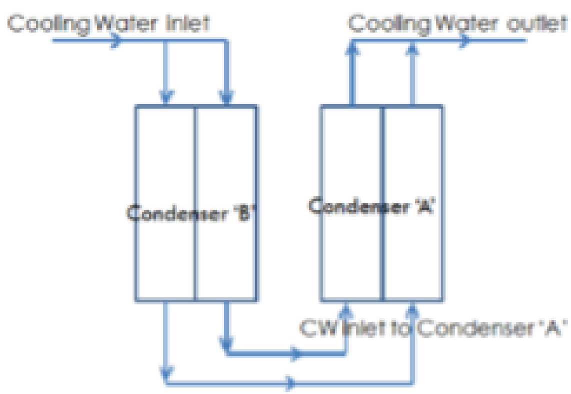


Figure : Cooling Water Flow in Dual Pressure Condenser

CONCLUSION

In this paper, the causes which are effecting the performance of condenser are found to be having deviation due to cooling water inlet temperature, water flow rate and condenser pressure. Eventually the total efficiency of a power plant is found to be reduced by 2.7% due to these deviations in the condenser. And it is concluded that, by overcoming these three factors, the performance of power plant can be improved with a good level.

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