INCREASING THE EFFICIENCY OF SURFACE CONDENSER UNDER VARIOUS LOAD CLIMATIC CONDITIONS BY REDUCING SUBCCOLING

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Abstract-*Demand for Electrical power is increasing at rapid pace in our country. In order to meet the rapid increase in demand the installation of Thermal Power Station is an obvious choice.*

The Condenser is the most important component of the Turbine Cycle that affects. Turbine cycle heat rate. The function of the condenser is to condense the steam exhausted from the LP turbine by removing its heat of vaporization. The heat removed from the steam is transferred to the circulating water flowing inside the condenser tubes. The condenser vacuum plays an important role in the overall improvement of Turbine

The exhaust steam entering the shell from the top flows down over the tubes and gets condensed finally removed by an extraction pump. Due to the fact that steam flows in a right angle to the direction of flow of water. It is called cross-surface condenser. Low pressure is maintained by the vacuum created inside the condenser by Ejector device which pulls the steam from the low pressure turbine into the condenser.

This project deals with the study of the performance of condenser, the function of condenser, types of condenser, elements of condenser and also calculate the efficiency of condenser on various load climatic conditions.

Keywords: Condenser, subcooling, increasing efficiency

1. INTRODUCTION TO CONDENSER

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).

1.1. TYPES OF CONDENSER

- Jet condensers (mixing type condensers)
- Parallel flow jet condenser.
- Counter flow jet condenser (low level)
- Barometric or high level jet condenser.
- Ejector condenser.
- Surface condensers (non mixing type condensers)
- Down flow surface condenser.
- Central flow surface condenser.
- Regenerative surface condenser.
- Evaporative surface condenser.

1.2. SURFACE CONDENSER

In surface condenser there is no direct contact between the steam and cooling water and the condensate can be re-used in the boiler. In such a condenser even impure water can be need for cooling purpose where as 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 is 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;

- Down flow condenser
- Central flow condenser
- Evaporative condenser

2. FACTORS AFFECTING THE PERFORMANCE OF CONDENSERS

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

2.1. 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 give 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.

2.2. 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 cantilevered 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.

2.3. 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.

2.4. 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.

2.5. 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.

2.6. 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.

3. SUBCOOLING IN SURFACE CONDENSER

After the steam condenses, the saturated liquid continues to transfer heat to the cooling water as it falls to the bottom of the condenser, or hotwell. This is called subcooling, and a certain amount is desirable. A few degrees subcooling prevents condensate pump cavitation.

Condenser subcooling ensures that there is a liquid seal at the condenser's bottom so the liquid line or receiver will not be fed with vapors. This condition prevents any noncondensables, like refrigerant vapor or air, from leaving the condenser's bottom and entering the receiver or liquid line.

3.1. DEGREE OF SUBCOOLING

The degree of freedom temperature of subcooling (ATsub) is the difference between the temperature of saturation with subcooling fluid temperature before it enters the expansion valve is the difference between T3-T3'.

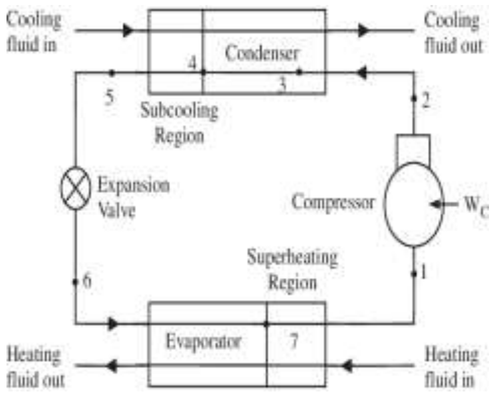

Fig.1

4. CONDENSER EFFICIENCY

It is defined as the ratio of difference between the outlet temperature and the inlet temperature of cooling water to the difference between the temperature corresponding to the vacuum in the condenser and inlet temperature of cooling water.

4.1. CONDENSER EFFICIENCY

$$\text{Condenser Efficiency} = \frac{T_{out} - T_{in}}{T_{sat} - T_{in}}$$

4.2. CONDENSER DUTY

Condenser duty=(heat added MS+ heat added by SH attemperation+heat added CRH+heat added by BFP+ heat added by RH attemperation) -860(Pgen+Pgen losses + heat loss rad)

Where

Cond.duty=KJ/s

Heat added MS = Flow MS ×(h_{MS}-h_FW),KJ/s

Flow MS=(Flow main steam excluding SH attempt),kg/s.

h_{MS}=(enthalphy of main steam),kJ/kg

$h_{FW=}$(Enthalpy of feed water),kJ/kg

Heat added CRH=Flow CRH ×(h_{HRH} −h_{CRH}),kJ/s

Flow CRH = Flow cold reheat steam,kg/s

h_{HRH}=(enthalpy of cold reheat steam),kJ/kg

Heat added by BFP = flow FW×(h_{BFP} OUT – h_{BFP}IN),kJ/s

Flow FW = (Total FW flow) kg/s

h_{BFP}Out = (Enthalpy of FW at BFP Outlet),kJ/kg

h_{BFP} In = (Enthalpy of FW at BFP Inlet),kJ/kg

heat added by RH attemp = flow RH attemp × (h_{HRH} – h_{RHATT}) ,kJ/s

h_{SHATT} = (Enthalpy of SH Attemp), KJ/kg

Flow SH Attemp = Kg/s

Heat Loss rad= 0.1% of Pgen (Radiation Losses) kW

Pgen= (Gross GeneratorOutput), kW

Pgen Losses* = (Mech Losses + Iron Losses +Stator Current Losses), kW

* Values to be taken from Generator Loss Curve

5. EFFECTS OF SUBCOOLING

Subcooling Majorly affects the efficiency and the performance of the surface condenser. Its causes due to the atmospheric temperature reacts with the surface condenser inlet temperature. Outlet temperature should be reduced than the actual outlet temperature.

This condensed water directly sends to the boiler inlet its temperature is below than the boiler inlet temperature. So boiler and condenser needs extra fuel and time to increase and decrease the temperature.

By this process it actually reducing the efficiency and the performance of the boiler and surface condenser. In order to avoid this is to reduce the subcooling occurring in surface condenser.

6. DESIGN DIAGRAM

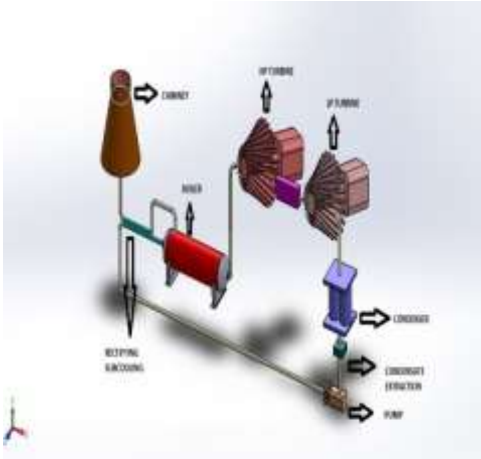

Fig.2

7. SOLUTION

In order to reduce subcooling is by making the parallel pipe connection of the condensate extraction pump outlet (to boiler inlet) and boiler outlet pipe (to chimney).

This parallel flow connection heat should to transferred from boiler outlet pipe (to chimney) to Condensate extraction pump outlet (to boiler inlet).

This action the subcooled condensate water temperature should increased to the actual temperature. By this method it should increases the efficiency and performance of the boiler and surface condenser.

8. CONCLUSION & SUGGESTION

This chapter includes the conclusion and suggestion of our project.

8.1. CONCLUSION

From the analysis it is found that, the condenser performance is satisfactory for the unit operating at rated capacity. But in various climatic conditions sub cooling is occurring in the condenser. Its affect the efficiency of the condenser and also the boiler. So in order to reduce that to make the parallel pipe connection of the condensate extraction pump outlet (to boiler inlet) and boiler outlet pipe (to chimney).

8.2. OVERVIEW OF THE ANALYSIS

Lower flow rate leads to increase the condenser pressure than design value poor heat transfer will occur.
Lower condenser pressure tends to decrease power output of turbine.
Lower the turbine output, higher the heat rate hence lowers the plant efficiency.
Subcooling occurring in the condenser also lowering the efficiency.

8.3. SUGGESTIONS

As the condenser performance is undoubtedly most important operation parameter on a unit. It is suggested that once in a week condenser back pressure may be watched during steady state condition and an ejector device must be installed and the back pressure must be monitored on hourly basis.

And also check the subcooling occurring in the condenser and rectifying the problem by parallel pipe connection of the condensate extraction pump outlet (to boiler inlet) and boiler outlet pipe (to chimney).

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