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Performance Analysis of Regenerative System and Improvement of Turbine Efficiency

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Abstract: *A thermal power station is a plant in which the prime mover is steam driven. Water is heated, turns into steam and spins a steam turbine which drives an electrical generator. After it passes through the turbine, then the steam is condensed in a condenser and it is recycled. The thermal efficiency is about 45% to 47%. The steam which enters the turbine is extracted to heaters. The extracted steam is used by heaters to heat the feed water. The heaters are connected by means of cascading system. But the cascading is separate for high pressure and low pressure heaters. So the drip after high pressure heater is sent to de aerator. This is the problem in this system. Due to this the efficiency of the turbine decreases and large amount of heat in the heater is wasted in the de aerator.If the cascading is done between high pressure and low pressure heater then the waste heat to de aerator can be carried to the low pressure heaters so the waste heat is utilized fully by the heaters. This will increase the efficiency of turbine system. And by analyzing the pressure reducing de superheating station near boiler will improve the efficiency. The maximum work done in the turbine will increase the efficiency and recovering the waste heat in the regenerative system helps to increase the temperature of the feed water. In thermodynamic power cycles, an improvement of even 0.5% in overall cycle efficiency is an important gain. In power plant, analysis of regenerative system is important.*

Index Terms: *high pressure heaters, deaerator, turbine, PRDS station.*

I. Introduction

The steam which is extracted from the turbine at various stages.There are about 21 stages of extraction in turbine. The steam from turbine enters into the heaters. There are about three HP heaters and four LP heaters two glance steam coolers, one de aerator in this system. These are placed in between the condenser and the economizer. The steam normally flows in the shell of the heaters, these heaters are nothing but a shell and tube heat exchangers in which feed water flows inside the tube the steam and the drip flows outside the tube. The water and the steam flows in a counter flow direction. Normally the steam after turbine enters into the condenser. The steam loses its heat in the condenser at 42^{o} C to increase the temperature of feed water to 245^{o} C in the boiler these heatersare used. To rise the temperature of feed water from 42 to 245^{o}C these heaters are used. By cascading system the temperature of feed water is increased.

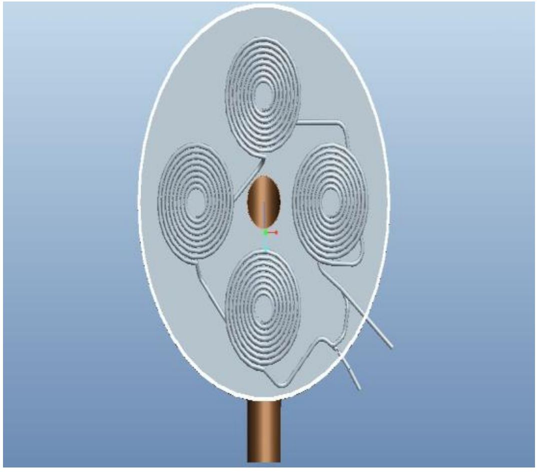
II. Working Of Heaters

The heaters in this system are normally connected by means of cascading system, cascading between HP heaters to de aerator and deaerator to LP heaters, but there is no cascading operation between HP heaters and LP heaters, so enormous amount of heat is wasted in de aerator. The steam loses its heat in each and every heater and forms as a drip. Finally these drip are commonly collected in the drip pump for recirculation. The feed water from condenser enters into these heaters to increase the temperature and pressure. The water after passing through four LP heaters enters into the HP heaters and then it enter in to economizer at a temperature of 245^{o} C.During this passage the feed water gains the heat from the heaters for boiler operation. Normally boiler converts the steam at a temperature of 540^{o} C and 130ksc of pressure. The heaters are used to boost up the temperature and pressure of the feed water before it enters into the turbine.

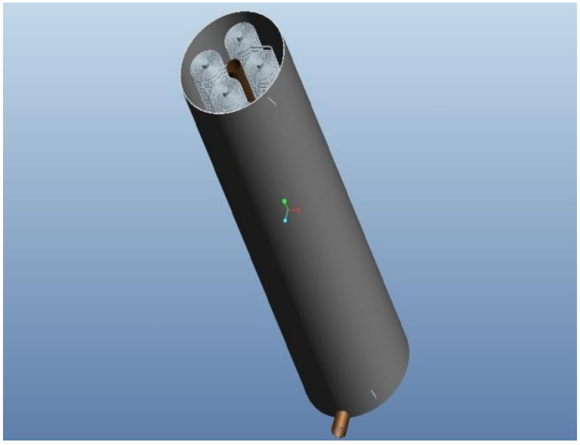
III. Modification

Cascading between the heaters helps to recover the waste heat, so redesign of HP heater will lead to cascading between heaters without de aerator. There is no cascading operation between heaters due to temperature difference. So by reducing the drip temperature in the HP heater the cascading will be possible. For that the heat in the drip must be fully utilized by the feed water. So the number of coils in the HP heater to be increased. By increasing the number of coils in the heater will increase the flow rate of water and drip and the time to travel in the heater also increased, so the drip loses its heat to feed water. This helps to have a cascade between the heaters.

From boiler the amount of the steam is not fully enters into the turbine for PRDS flow about 15T/hr of steam is taken at the boiler outlet, so the work done in the turbine is decreased. In order to have maximum work done the PRDS must be taken at the HP turbine outlet, so the maximum work done is done in HP turbine it will helps to increase the turbine efficiency.



Top view of high pressure heater



Isometric view of high pressure heater

PRDS vs CRH.(667T/hr)
PRDS flow=15T enthalpy=2790.9KJ/kg
Temp=200^{o}C pressure=14.5kg/cm^{2}
CRH flow=652T/hr enthalpy=3140KJ/kg
Temp=330^{o}C pressure=26.04kg/cm^{2}
Heat loss=15*(3140-2790.9)
=5236.5*10^{3}KJ/hr

Work Done In Hpt
MS flow=667T/hr (without PRDS flow)
=MS flow*(MS enthalpy-HPH7 E.S enthalpy)*10^{3}+(MS flow-HPH7 E.S flow)* (HPH7 E.S enthalpy-CRH enthalpy)= 667*(3500-3210)+(667-33.5)*(3210-3140)
Work done in HPT=238645*10^{3}KJ.
Excess Work done by HPT with 667T=238645-193676.10(existing)
=44968.9*10^{3}KJ

Turbine Efficiency
Work done in HPT (without PRDS flow)=238645
Work done in IPT =125212.2
Work done in LPT =421807.57
Total work done in turbine =785664.79*10^{3}KJ

TURBINE EFFICIENCY =785664.79/1775020.16=44.26%**=44.26%**
EXISTING EFFICIENCY=**41.72%**

IV. Estimation

Estimation for increasing the number of coils in the heater depends on the amount of heat gained by feed water. For cascading the outlet of feed water is about 194.2^{o}C in HP heater 5 so the cascading is done between HPH to LPH. And the drip temperature is to be at 110^{o}C.

So the amount of heat gained by feed water at an outlet temperature of about 194.2^{o}C can be calculated
Drip temp=110^{o}C enthalpy of steam=3420KJ/kg
=((211*4.184*0.05)+(211*4.184*0.06)+(3420*4.184*0.02))+707.9=((110*4.184*0.05)+(110*4.184*0.06)+(110*4.184*0.02))+x
=44.14+52.96+68.4+707.09=23.01+27.61+9.20+x
=872.59=59.82+x
X=812.77/4.184(enthalpy of feed water oulet)
X=194.2^{o}c (outlet temp)

HPH 5 FOR DRIP OUTLET 110deg.Cqty =670T/hr.
Feed water inlet=169deg.c feed water outlet=194.2^{o}C
Qty of ES 5=13.4T/hr drip qty=(40.2+33.5)
FS temp=458deg.c drip temp=110deg.c
Pre=11.92kg/cm^2 enthalpy=461.3KJ/kg
Enthalpy=3400KJ/kg drip enthalpy of 6=920.6KJ/kg
Heat gained by water=670*4.184*(194.2-169) =70082.1*10^{3}KJ/hr
Heat loss by ES=qty*enthalpy=13.4*(3420-461.3)=39378.58*10^{3}KJ/kg
Heat loss by drip=73.7*(920.6-461.3)=33850.41*10^{3}KJ/kg
Heat loss by drip and steam at 110deg.c =(39378.58+33850.41)=73228.99*10^{3}KJ/hr
Heat loss by drip and steam at 188deg.C=43374.94*10^{3}KJ/hr
Heat gained by water=(73228.99-43374.97)=29854.02*10^{3}KJ/hr

Benefits

By increasing the number the coils in the heaters the heat is recovered, so there is no additional supply of the heat By changing the flow of PRDS the efficiency of turbine is increased to 3%. So the overall thermal efficiency of the plant is increased.

V. Results

By this we came to know clearly that if the cascading system between the heaters is perfectly done, the efficiency of the turbine and the heater can be increased.And the waste heat is utilized properly in the heaters. And analyzing the PRDS flow at the turbine inlet will give better flow rate of steam and this will helps to increase the overall thermal efficiency of the plant.

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