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Roll of Feed water Heaters in 120 Mw Thermal Power Plant

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Abstract: *The purpose of present is to analyses the roll of feed water heaters that would have satisfactory thermal performance in 120MW thermal power plant. Here the performance of the feed water heaters are analyzed by finding the terminal temperature difference(TTD) drain cooling approach(DCA) and temperature rise of the heaters. Impact of by passing the feed water heaters, optimizing the cleaning of feed water heaters, placement of feed water heaters, reasons for failures of feed water heaters, investigations for effective design of feed water heaters, cycle performance impacts are analyzed in this project.*

The whole project is carried out in 120MW steam turbine thermal power plant in Kothagudem Thermal Power Station at Paloncha.

Keywords : *Turbine ,Feed pumps ,Water heaters , Deaerator ,Boliers*

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I. INTRODUCTION

Thermal Power plant

The basic principle based on which the thermal power plant as shown in fig works as law of conservation of energy which states the energy neither can be created nor destroyed but can be transformed from one form to other. Here in Thermal Power Plants chemical energy is converted to heat energy is converted to electrical energy.

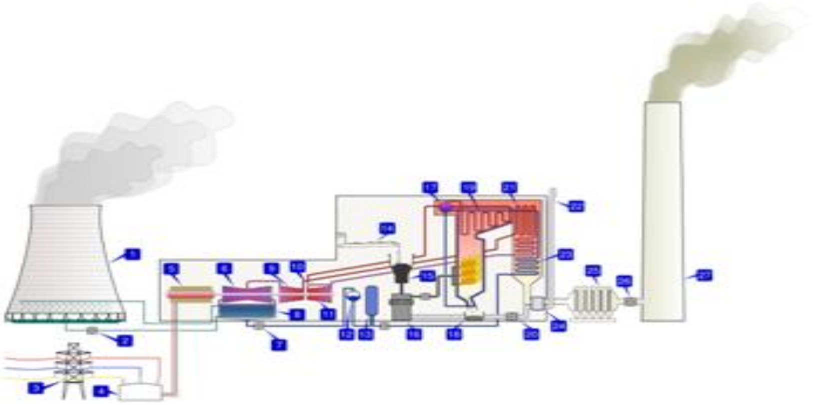

Fig: plant layout of thermal power plant

1.cooling tower 2.cooling water pump 3.Transmissionline(3-phase) 4.Unittransformer(3-phase)5.Electric generator(3-phase) 6.Low pressure turbine 7.Condensate extraction pump 8.Condenser 9.Intermediate pressure turbine 10.Steam governor value 11.High pressure turbine 12.Deaerator 13.Feed heater 14.Coal conveyor 15.Coal hopper 16.Pulverized fuel mill 17.Boiler drums 18.Ash hopper 19.Super heater 20.Forced draught fan 21.Reheater 22.Air intake 23.Economiser 24.Air preheated 25.Precipitator 26.Induced draught fan 27.Chimney Stack

Major elements in thermal power plant:

1. Boiler
2. Steam turbine
3. Condenser
4. Feed pump

5. Circulated watr system

Boiler:

In the boiler plant, the working fluid, water receives heat due to combustion of fuel and is converted into steam. Its efficiency is 90%.

Steam turbine:

In the steam turbine, the steam from the boiler expands (i.e., steam does work by reducing its pressure, temperature and heat constant) and thus perform mechanical work. It is a rotative dynamic machine. Its internal efficiency is about 80%.

Condenser:

In the steam condenser, the exhaust steam from the turbine gives up heat on condensation to the cooling water which cannot be converted to work and must be rejected to restore the initial condition of the working fluid. The condenser enables the exhaust steam to be used as the working fluid of the boiler again and again. It also increases the output of the turbine due to vacuum created inside the condenser. About 50% of the heat energy input is rejected in the condenser.

Feed pump:

It pumps the feed water coming out from the condenser to the boiler. It is either motor or turbine driven. It consumes about 2 to 2.5% of the power output.

Circulated water system:

It supplies cooling water to the turbine condenser and thus acts as a medium through which heat is rejected from the steam cycle to the environment. Cooling water can flow through the condenser in two methods.

1. once-through system
2. Closed loop system

Once-through system is used when there is a large source of water available. Water is taken from a natural body of water like a lake, river or ocean and pumped through the condenser, where it is heated, and then discharged back to the sources. In closed loop systems, warm water from the condenser is passed through a cooling device like a cooling tower or a spray pond and the cooled water is then pumped back for condenser circulation. However a natural body of water is still necessary near by to supply the makeup water to replace the loss due to evaporation. Blow down and so on. The once-through system though more efficient, cause thermal pollution. In addition, availability of gauge quantity of water is shrinking. Closed loop system are now almost universally preferred.

II. BASIC PRINCIPLES

The thermal power plant with steam turbines uses rankine cycle. Rankine cycle is a vapor power cycle having two basic characteristics:

1.The working fluid is a condensable vapor which is in liquid phase during part of the cycle and

2.The cycle consists of succession of steady flow processes, with each process carried out in a separated component specially designed for the purpose. Each constitute an open system, an all the components are connected in series so that as the fluid circulates through the power plant each fluid element passes through a cycle of mechanical and thermodynamics stages.

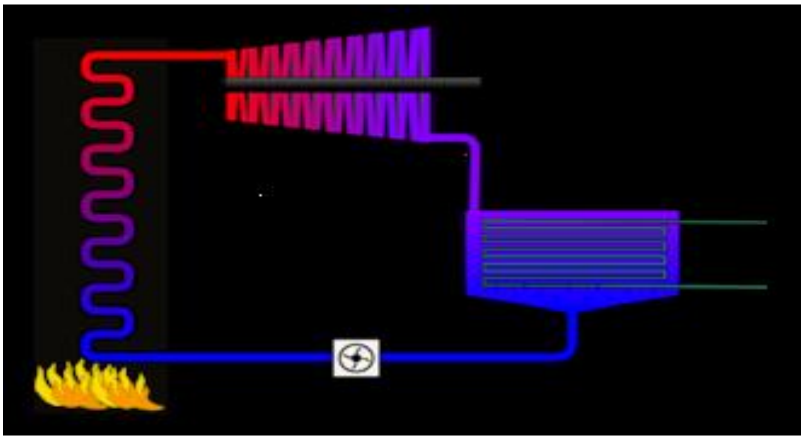

Fig : shows rankine cycle

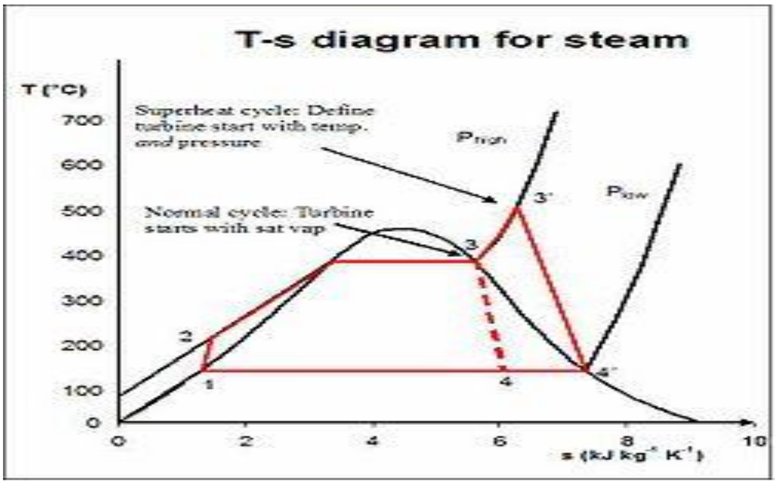

Fig : T-S diagram of rankine cycle

Working Principles:

When steam is allowed to expand through a narrow orifice, it assumes kinetic energy at the expense of enthalpy (heat energy). This kinetic energy of steam is changed into mechanical (rotational) energy through the impact(impulse) ore reaction of steam against the blades. It should be realized that the blade of the turbine obtains no motive force from the static pressure exerted as the result is normal to the blade surface at all points. The total motive force acting on the blade is thus the resultant of all the centrifugal forces plus the change of momentum. This causes the rotational motion of the blades.

Feed Water Heaters

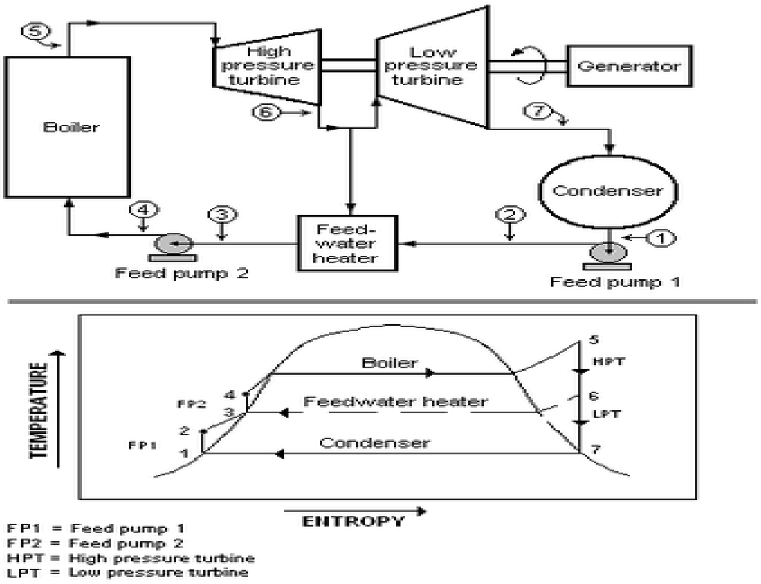

fig : water heater cycle

A feed water heater is a power plant component used to pre-heat water delivered to a steam generating boiler. Preheating the feed water reduces the irreversibility's involved in steam generation and therefore improves the thermodynamic efficiency of the system. This reduces plant operation costs and also helps to avoid thermal shock to the boiler metal when In a steam power plant (usually modeled as a modified Rankine cycle) feed water heaters allow the feed water to be brought up to the saturation temperature very gradually. This minimizes the inevitable irreversibility's associated with heat transfer to the working fluid (water).

H.P Heaters and Steam Power Plants:

In steam power plants high pressure heaters are used to heat feed water. A portion of steam called bleed steam, that extracted from turbine is used in high pressure heaters to heat feed water, latent heat of this bleed steam is utilized otherwise it will lost in condenser with cooling water. Hence over all cycle efficiency of the plant increased. In power plants H.P Heaters are connected in feed water line (Line between boiler feed pump and economizer)

H.P Heaters and Steam Power Plants:

Basically for feed water heating, normally takes steam from initial stages of a turbine. One thing that might be of interest is you can estimate the amount of energy available by looking at the non return valves associated with the particular heater, if it has two non returns in series there is a sufficient amount of power involved to cause a destructive over speed condition.

L.P&H.P Heater

The low pressure and high pressure heater in steam power plant is used to increase the efficiency of boiler. The condensate water from the condenser get heated in L.P heater by steam which is extracted from L.P Turbines. The water after BFP get heated by H.P heater by steam which is extracted from H.P & I.P turbines.

Types :

1.Low pressure feed heater
2.Surface feed heater

Deaerator

Functions :

The pressure of certain gases like Oxygen, Carbondioxide and ammonia, disselved in water is harmful because of their corrosive attack on metals, particularly at elevated, temperatures. Thus in modern high pressure boiler, to prevent internal corrosion, the feed water should be free, as far as practicable of all dissolved gases especially oxygen. This is achieved by embodying into the freed system a decreasing unit. A part from this a deaerator also serves the following functions.

1) Heating incoming feed water.
2) To act as a reservoir to provide a sudden or instantaneous demand.

Principle of Deaeration:

a) The solubility of any gas dissolved in a liquid is directly proportional to the partial pressure of the gas. This holds within close limits for any gas which does not react chemically with the solvent.
b) Solubility of gases decrease with increase in solution temperature and or decrease in pressure.

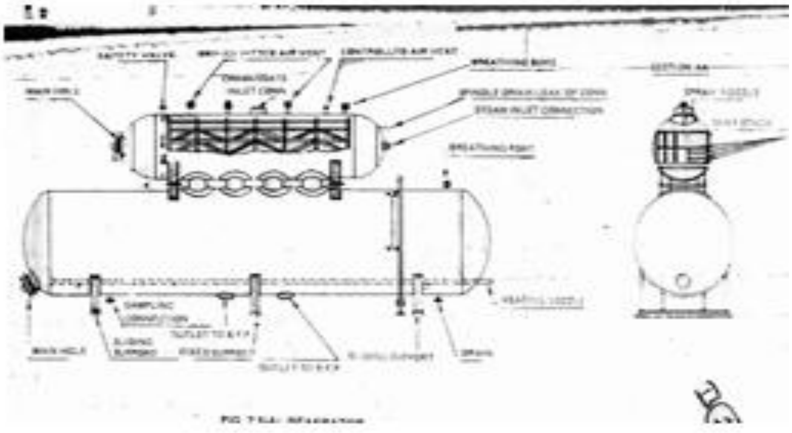

Fig : shows working of Deaeration

4. Effect of turbine heater rate & efficiency by removing the H.P heaters at various loads (execution of the project)

Calculation :

The turbine cycles heat rate is defined as the net heat supplied to the cycle divided by power output from the generator. TCHR =

$m_{LS}(h_{LS}-h_{fw})+m_{hrh}(h_{hrh}h_{crh})+m_{SWPR}(h_{crh}-h_{fw})P_{gen}$

Where

TCHR : Turbine Cycle Heat Rate
m_{LS} : Main steam flwo kg/hr
h_{LS} : Enthalpy of steam of steam entering H.P turbine
h_{fw} : Enthalpy of feed water at H.P Heater Outlet k.Cal/kg-
m_{hrh} : Hot reheat steam flow in kg/hr
h_{hrh} : Enthalpy of steam entering MP turbine K.Cal/kg
h_{crh} : Enthalpy of steam leaving H.P turbine (cold reheat) k.Cal/kg
M_{SWPR} : Mass flow rate of spray water
Pgen : Electrical power out put at the generator terminals in KW

Turbine Heat Rate With H.P Heaters(At 120mw)
With H.P Heaters :

m_{LS} : 360×10^3 kg/hr
h_{LS} : 819.8 Kcal/kg
h_{fw} : 247.3 K.Cal/kg
m_{HRH} : 321.705 kg/hr
h_{crh} : 844.1 K.Cal/kg
h_{crh} : 741.2 K.Cal/kg
M_{swpr} : 2×10^3 kg/hr
P_{gen} : 120×10^3 Kw

$$\text{TCHR} = \text{TCHR} = \frac{m_{LS}(h_{LS}-h_{FW}) + m_{hrh}(h_{hrh}-h_{crh}) + m_{SWPR}(h_{crh}-h_{fw})}{P_{gen}}$$

$$= \frac{360 \text{ X } 10^3 (819.8-247.3)+321.705 \text{x} 10^3(844.1-741.1)+2\text{x}10^3(741.2-247.3)}{120\text{x}10^3}$$

$$=2000.7 \text{ k.cal/Kwh}$$

$$\acute{\eta} \text{ therml} = \frac{860}{2000.7} \text{ x } 100$$

$$\acute{\eta} \text{ therml} = 43\%$$

Guarateed value is 1993.53 K.Cal/Kwh. The duration is due to consideration of closed extraction E6 as 500 KW and taking the attemparation spray as 210 tones per hour instead of ‘0’

Without H.P heaters :

m_{LS} : 360×10^3 kg/hr
h_{LS} : 819.8 K.Cal/Kg
h_{fw} ; 164.2 K.Cal/Kg
m_{hrh} : 321.705 Kg/hr
h_{hrh} : 844.1 K.Cal/Kg
h_{crh} : 741.2 K.Cal/Kg
m_{SWPR} : 2×10^3 Kg/hr
P_{gen} : 120×10^3 KW

$$\text{TCHR} = \text{TCHR} = \underline{m_{LS}(h_{LS}-h_{FW}) + m_{hrh}(h_{hrh}-h_{crh}) + m_{SWPR}(h_{crh}-h_{fw})} \; P_{gen}$$

$$= \frac{360 \text{ X } 10^3 (819.8-164.2)+321.705 \text{x} 10^3(844.1-741.1)+2\text{x}10^3(741.2-164.2)}{120\text{x}10^3}$$

$$= 2250.25 \text{ K.cal/Kwh}$$

$$\acute{\eta} \text{ therml} = \frac{860}{2252.25} \text{ x } 100$$

$$\acute{\eta} \text{ therml} = 38.1\%$$

$$\text{Difference} = 2252.25 - 2000.75$$

$$= 251.5 \text{ K.cal/Kwh}$$

$$\%\text{ Change in heat rate} = \frac{251.5}{2000.75} \text{ x } 100$$

$$= 12.75\% \text{ rise}$$

Observations made on 2o/06/2011 in 7th unit of k.t.p.s.c. With hp heaters (7th unit)

Parameters	7th Unit With H.P Heaters
Load	104 Mw
Main Steam Flow	324 T/Hr
Main Steam Pr. At Turbine Inlet	122 Kg/Cm^2
Main Steam Temp..	545°C
Cold Reheat Pr.	31 Kg/Cm^2
Re Heat Temp..	525°C
Attemparation Flow	23 T/Hr
Feed Flow	315 T/Hr
H.Ph-I Extraction Pr. &Temp.	16 Kg/Cm^2 & 162°C
H.Ph-Ii Extraction Pr. & Temp..	29 Kg/Cm^2 & 223°C

Calculation:-

For 7th unit, Turbine cycle heat rate is

$$TCHR = \frac{m_{LS}(h_{LS}-h_{FW}) + m_{hrh}(h_{hrh}-h_{crh})+m_{SWPR}(h_{crh}-h_{fw}) \text{ K cal/ kw}}{P_{gen}} \text{ hr}$$

From the above table values h_{Ls},h_{fw},h_{hrh},h_{crh} values taken from the steam table as below

h_{Ls}=869.4k cal,h_{fw}=218.75k cal,h_{hrh}=892k cal,h_{crh}=764k cal

$$TCHR = \frac{324\times10^3(869.4-218.75)+320\times10^3(892.5-764)+23\times(764-218.75)}{104\times10^3}$$

$$TCHR = \frac{324(650.65)+320(128.5)+23(545.25)}{104}$$

$$TCHR = \frac{264471.35}{104} = 2542.99 \text{ K cal/ kw hr}$$

$$ή \text{ therml} = \frac{860}{2543} \times 100$$

$$ή \text{ therml} = 33.81\%$$

Effect of bypassing the feed water heaters on boiler heat rate and thermal Efficiency of the power plant

The below values are taken from 120 MW steam turbine plant (KTPS ‘C’ Station-7th Unit) on 20.06.2011 when the H.P heaters are bypassed.

No.of Units generated = 2.292 MU
Coal consumption = 2365 MT
L.O. Consumption = 0.165 KL
F.O Consumption = 4.55 KL

Heat rate of the boiler = Coal consumption x G.C.V. + F.O x 0.983 x 1000+L.OX
0.8264x 19800 No.of Units Generated

= 2365x3582+4.55x0.9837x1000+0.165x0.8264x19800
2292
= 583861.61
2292
2610 K.Cal/Kwh

Thermal Efficiency = nth
= 860 / 2610
= 32.94%

The below values are taken from 120MW steam turbine plant (KTPS’C’ Station-7th Unit) on 20-06-2011 with H.P heaters.

No.of Units generated = 2809 MU
Coal consumption = 1947 MT
L.O. Consumption = 0.1832 KT
F.O Consumption = 1.165 KL

$$\text{Heat rate of the boiler} = \frac{\text{Coal consumption x G.C.V.} + \text{F.O x } 0.98 \text{ x}1000 + \text{L.Ox}0.8264\text{x } 19800}{\text{No.of Units Generated}}$$

$$= \frac{1947\text{x}3582 + 1.165\text{x}0.9837\text{x}1000 + 0.0832\text{x}0.8264\text{x}19800}{2809}$$

$$= \frac{6986975}{2809}$$

2487 K.Cal/Kwh

Thermal Efficiency = nth

= 860 / 2487

= 0.3457 x 100

= 34.57%

$$\text{\% Change in heat rate} = \frac{2610-2480}{2480}$$

$$= \frac{130}{2480}$$

= **0.0524% increase**

RESULTS

Table 1:

Load	With H.P Heaters		With Out H.P Heaters		
	Heat Rate	Ή%	Heat Rate	Ή%	% Change In Heat Rate
At 120 Mw	2007.7	43%	2250.25	38.1%	12.75%

Discussions & Conclusion

1) As seen from the calculations, it is clearly shows that when H.P heaters are in service (at 120MW), the heat rate is about 2007.7 and when H.P heaters are in out of service the heat rate is about 2250.7. At 95MW, When H.P heaters are in service, the heat rate is about 2434.33 and when the heaters in out of service the heat rate is about 2856.84

   It shows that the heat rate is increased when the heaters are out of service ie; The efficiency is getting decreased. The increased heat rate effects the boiler performance . ie; Boiler heat load also increased to achieve the design power out put.
2) AS seen in the plant, more leakage flanges are present in the feed water side and steam side in H.P heaters and also poor drain level maintenance which caused a negative DCAT. Hence the H.P heaters should be replaced the proposed R&M with U-tube H.P. heaters.
3) More connection has to be paid for optimizing the cleaning of feed water heaters the condenser periodically.
4) A steam or condensate leak has to be arrested on top priority to improve heat rate.

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