Solution for the Problem of Loud Knocking Sound in LPH 3 at 2 x 250 MW Paras TPS, MSEB, Maharashtra

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Abstract

In a Thermal Power Plant, importance of Feedwater Heaters in the Power Plant cycle cannot be gainsaid. In a typical 250 MW Thermal Power Plant, if one Low Pressure Feedwater Heater is taken out of service, then it would cost power producer, the loss of about 7.5 lacs per day. Hence, it is imperative for all Feedwater Heaters to work efficiently and properly for its longer and enduring life and low operational cost of Power Plant. Whenever, there is any malfunction in Feedwater Heaters, then it has to be analyzed in-situ i.e. while it is in operation, as it requires a lot of effort to take out the Heater from operation and also the problem would have to be fixed fast because even if one Heater is taken out of service, then there is substantial loss of efficiency in Power Plant operation. Additionally, valuable Customer's delight is a by-product of one's ability to quick-fix the problem. Therefore, it becomes very essential that there is proper knowledge of Heater manufacturing details and its implications. More importantly, there has to be complete understanding of systems associated with the Heater. The problem discussed in this paper had occurred for the first time. This paper discusses the how the solution was reached in theory first, then was worked upon and was found to be successful in the very first attempt.

Key Words - Rankine Cycle, Shell side, Drain, Knocking.

Introduction

Power Plant runs on thermodynamic Rankine Cycle. A typical Rankine Cycle has efficiency of 38-40% (Chen *et al*., 2010). To increase the efficiency of Power Plant Cycle, modified Rankine cycle (Wiser *et al*., 2000) was envisaged in which feed waters were introduced between the Condenser and Boiler of a typical Rankine Cycle. These Feedwaters are known as Low Pressure Feed water Heater and High Pressure Feedwater Heater. In these Feedwater Heaters are used to heat the Condensate from Condenser to higher temperature so that less amount heat requirement in Boiler. Though there is loss of work done in the Turbine, but the net result of reduction of heat supplied in Boiler and reduction of work in Turbine is positive and hence increases the efficiency of the Power Plant Cycle (Sonntag *et al*., 2008). In Low Pressure Feedwater Heaters, condensate temperature is increased by way transferring heat from steam extracted from the Low Pressure Turbine. In a typical Power Plant, there are 3 nos. of Low Pressure Feedwater Heaters. All these 3 nos. of Low Pressure Feedwater Heaters combined, increases the Power Plant efficiency by 1-1.3% with contribution from LPH-3 i.e. Low Pressure Feed Water Heater-3, being maximum (Douglass *et al.*, 1991; Stultz *et al*., 2005). In a typical 250 MW Power Plant, 1 % increase in Power Plant efficiency leads to about Rs 10-12 crores of annual saving. In this perpective, there is a important role of LPHs i.e Low pressure Feed Water Heaters in Power Plant operational cost and efficiency.

Features of L P Heaters

L P Heater is a shell and tube type heat exchanger in which there is extracted steam is in the shell side and condensate in the tube side. LP Heater Tubes are 'U' type tubes, hence there is only one Tube Plate in L P Heaters.

Functionally, LPHs are of two types

- Condensing Types: In these heaters, extracted steam is only condensed and only latent heat of Condensed Steam is transferred to the Condensate.
- Condensing plus Sub Cooling type: In these heaters, apart from condensation of extracted steam, further cooling of condensate is done. There is an additional sub-cooler inside the L P Heater. This sub-cooling zone is also called Drain Cooling Zone and this type of heaters is also known as Heaters with integral Drain Cooler. In these types of Heaters, latent heat of extracted Steam is transferred in Condensing Zone of the Heater and sensible heat of Condensed Steam is transferred in the Sub-Cooling zone of the Heater.

Below is a typical longitudinal section of the Heater which is having a integral Drain Cooling Zone.

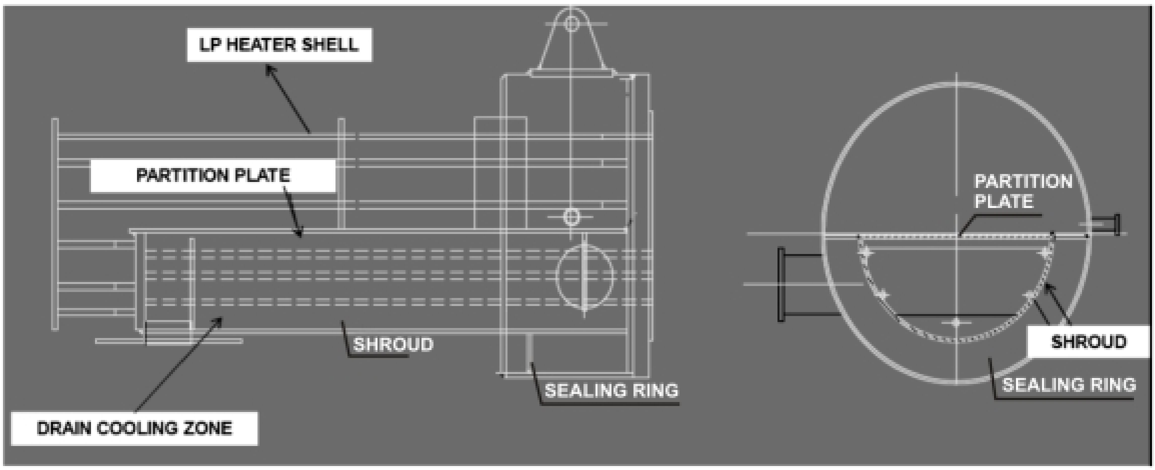

Figure 1: L.P. Heater with integral Drain Cooler

Drain Cooling Zone is near the tube sheet end and is in lower half of the shell. Typically, it's length is about 1.4 M to 1.6 M. Curved boundary of Drain Cooling Zone (DC Zone) is separated from shell by 12 mm thick shroud of Carbon Steel and there is a partition plate on the top.

There is exchange of sensible heat in Drain Cooler from hot fluid (condensate of extracted steam) to cold fluid (condensate from Power Plant Condenser). Drain cooling zone is completely filled with condensate (on shell side). Hence, there is liquid as fluid on both hot and cold side.

In modified Rankine cycle, drain from downstream heater is cascaded to upstream heater (Moran *et al.*, 2004). These cascading connections in Heaters are known as Drain Inlet / Drain Outlet connection.

Since, condensate (shell side) side goes to DC Zone of the heater, Drain Outlet connection is on the downstream of DC Zone i.e. is in the shell side of DC Zone .

Characteristics of Problem in 250 MW Paras, MSEB LPH-3

In 2 x 250 MW Paras TPP, there was a loud, continuous knocking / cluttering sound emanating from inside of LP Heater.

LPH-3 supplied in 2 x 250 MW Paras has following features

- Heater has integral drain cooling section
- Drain outlet pipe Size is of NB 100 where as in earlier 250 MW sets it was NB 150
- Unlike earlier projects, 'direct drain cooling' by-pass was not provided

Characteristics of Problem

- There was no sound when Power Plant operated at partial load of 100 MW or less.
- Continuous knocking sound / cluttering sound seemed to be coming from Tube Plate side of the Shell.
- Knocking sound ceased when water level in heater was raised up to center line of the heater (Drain Cooling Zone fully submerged).
- Pressure drop in Drain Cooling zone was within limits.
- At normal level conditions, steam was coming out of stub at drain outlet nozzle.

Analysis of Problem

a) As LPHs of same design were operating with-out any problem on other sites at 2 x 250 MW Korba (E) and 2 x 250 MW New Parli , hence it's concluded that there was no design problem in the Heater. The problem could either be operational or there could be a manufacturing defect

b) Sound from LPH could be because of following reasons

1. Small mechanical objects like splinters / scales inside the heater which could be colliding with each other / heater shell.
2. Smaller Size of Drain Pipe to upstream Heater: Layout designer of the Power Plant had reduced the size of cascading connection (between LPHs) from NB 150 to NB 100. Because of reduction in pipe size, there shall be higher velocity of Drain inside the pipe which could lead to higher pressure drop, thereby making the temperature of drain (liquid) more than the saturation temperature , hence boiling and subsequent cavitaion.
3. Steam in the Drain Cooling Zone: Since, there was continuous cluttering sound from the tube side end of the heater, this could be sound of the cavitation in the heater, As, there is pure steam in the condensing zone of the heater, hence cavitation could take place only in DC zone of the heater. As explained above , shell side of DC zone is completely filled with water, therefore , if there is leakage of steam into the shell side of DC zone, then this could lead to the interaction between steam and water (condensate) in the DC zone. Whenever, there is interaction between Steam and Water, then there are bubbles formation and collapse (implosion) of bubbles. The sound of bubbles implosion could have lead to the continous cavitations like sound (Elliott *et al*., 1997).
4. Steam in the Drain Pipe: For the same reason as explained above.

Action Plan

It was decided to eliminate the above possible reasons one by one. Thus, following action plan was carried out.

In view of the above conclusion, it was decided to inspect the welding of the above mentioned area and following action plans were chalked out,

- Cleaning of Shell: It was decided to clean the shell by putting water inside the shell through start-up vent connection at the top of Heater Shell and taking the water out from shell drain connection in bottom on the other end. This helped in cleaning the heater from inside. But there was no reduction in the knocking sound.
- Alternate Drain Path: Since the drain pipe line size was changed to NB 100 from NB 150, it was apprehended that due to increase in velocity inside the pipe, there could higher pressure drop in the flowing drain which could have lead to the vaporization of the drain resulting in steam formation inside the pipe which may be finding it's way inside to the heater. Hence, it was decided to alter the flow of drain to alternate pipe line directly to flash tank by-passing LPH-2 and LPH-1. However, this also did not result in any reduction of sound.
- Possibility of Steam inside the Drain Cooling Zone of Heater

As observed earlier, there was no sound when Power Plant operated at part load. These could be explained, steam being in lesser amount and having lesser energy, there would be no bubble formation and subsequent implosion. Hence, it was concluded that there could be leakage or presence of steam inside the DC zone of the heater.

There could be following ways by which steam may enter the Drain Cooling(DC) zone and remain entrapped there

i) Pressure Drop in Drain Cooling Zone

ii) Gap between Partition plate and Shroud

iii) Welding defect in the area joining Shroud / Partition Plate / Tube Plate

i) Since the flow of the Condensate through the integral Drain Cooler to the upstream LP Heaters / Flash tank is by way of siphon, it is no possible for the drain cooling zone of the Heater to remain partial filled unless there is substantial pressure drop of the condensate in the drain cooling zone. It was observed from the data obtained that there was not much pressure drop in the drain cooling zone, hence conjecture (a) as above was ruled out.

ii) / iii) Since , there was no knocking sound coming from inside the heater when condensate level was increased up to the centerline of the heater, hence, there was strong possibility that there might be some defect along the weld edge between shroud and the partition plate. This weld edge / line is about 1200 mm in length. Hence, it was decided to see this weld edge with-out cutting the shell.

To observe any manufacturing / welding defect following approach was adopted

a) It was decided to cut the vent pipe on one side of the shell and and gas-cut a hole on the other side of the shell. After gas-cutting, attempt was made to see the defect.

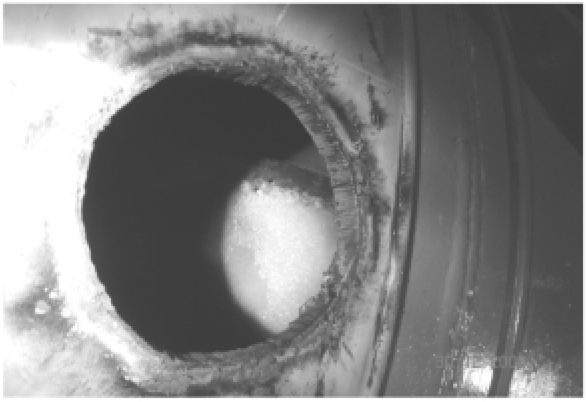

Figure 2: Holes cut on the either side of the LP Heater shell to see the welding between Drain cooling Zone shroud / Partition Plate / Sealing Ring

a) Following picture was taken while doing the inspection

c) As it was not possible to have the view of the complete weld edge of Shroud with Partition plate, it was decided to put a light source through the drain outlet by cutting the drain outlet connection

There is cut out in the shroud of the DC Zone for the exit of the Drains through Drain Outlet connection. As Drain Outlet connection was cut, which paved the way of entry of light source inside the DC Zone. Since the light source was put inside the DC Zone , therefore, if there was any passage for steam to enter the DC Zone , then the light would come out from the same passage.

It is clear from the photograph (Fig. 4) that there were enough gaps / weld holes between the shroud and the partition plate.

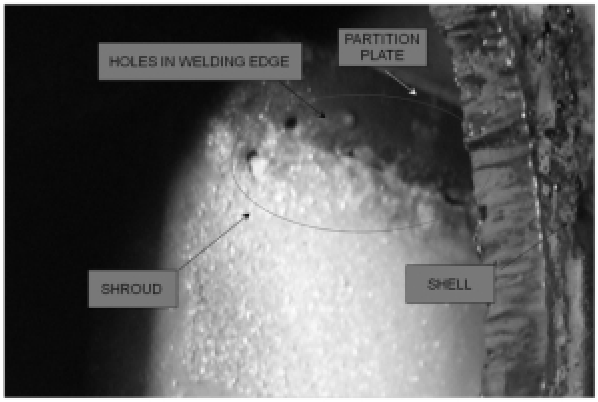

Figure 3: Weld edge between shroud and Partition Plate is having holes from where live-steam was leaking into Drain Cooling zone enclosed with-in shroud.

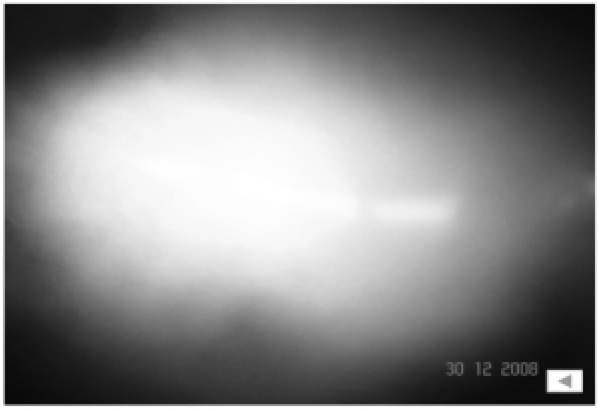

Figure 4: Torch Light was put inside the shroud through Drain Outlet. Light was seen across through the weld edge from the other side (air-vent connection), proving that there were weld defects .

Solution

a) Heater was taken out of service, the extraction valve was fully throttled and heater was isolated from extraction steam by cutting the connection between steam nozzle and steam extraction line.

b) Heater was cut from shell cutting line and shell was taken out by the distance so that complete edge of shroud and partition plate welding was seen.

c) Welding defects were corrected as below

d) Heater was re-assembled and cut holes were blanked.

e) On operation, Heater was found to be working satisfactorily.

Figure 5: Photograph taken after the welding, showing no weld gaps/holes.

Figure 6: Holes made on the LPH shell were blanked.

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