A CASE OF BOILER FAILURE DUE TO OVERSIZING OF BOILER FEED PUMP

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THE FIRST VISIT

It was unbelievable that all the bank tubes were leaking at the joints within a month after the boiler was fired. The owner of the sugar mill requested me to make a visit and inspect the boiler to find out whether there was any thing wrong. The boiler was under shut and it was open when I visited. The boiler vendor had sent his people for re-expansion of all tubes. I checked with the operator whether there was low water level operation even for a short duration. He denied any such occurrence. I checked for any possibility for an overall circulation failure due to improper drum internal arrangement. The no of cyclone separators was adequate as per my calculation. As there was no drum level recorder, I could not ascertain the cause. The boiler engineers did not feel it was a serious issue. The boiler was planned for restart the next day. I returned the next day to see the boiler in operation as the owner requested me to come again.

THE DETAILS ABOUT THE BOILER

The boiler parameters were 35 TPH, 44-kg/cm2 g, 440 deg C. The boiler was fitted with pulsating grate to fire the bagasse from the sugar mill. The boiler was a bi drum type top supported design. The furnace was enclosed with loose tubes backed up by refractory tiles, insulation mattress and a leak proof casing attached to the buckstays. The boiler was provided with a three-element drum level control system. The Control panel had circular chart recorders for feed water flow, steam flow and CO_2 in flue gas. The boiler configuration is shown in figure 1.

WHAT I SAW NEXT DAY!

The boiler was on full fire when I came back the next day. I directly went up to see the water level. My first doubt was that the set point for NWL might be lower than what is required. But it was OK. I just watched for 5 minutes. There was a water level swing of nearly 120-mm but water level was within the gauge glass. The person stationed for drum level monitoring explained that the water level fluctuated but never it went down below the gage glass.

While coming down the platform, I observed the feed control station. The feed water flow control valve was hunting. The control valve remained closed for about 2 minutes. At times the valve went for full opening.

I came near the feed pumps at ground floor. The pump discharge pressure showed 80 kg/cm2g and I found the discharge valve was almost shut. For a boiler with main steam pressure of 44 kg/cm2g, this was too high. The hand operated minimum flow valve to Deaerator was fully open. By then, I learnt that Boiler vendor’s commissioning engineer had set the valves as such positions.

I went inside the boiler control room. There was no drum level recorder. Instead recorders were available only for feed water flow, steam flow & CO_2. I could not confirm that the water level had never gone down below the LWL. There was no tripping arrangement in the boiler on low water level. The steam flow chart did not show much of short time fluctuations. The steam load on the boiler was about 25 TPH since the old boilers were also in operation. The feed flow chart indicated that the closure of the feed control valve very often. I reviewed all the daily charts on water level. Almost all the charts since the boiler was commissioned indicated the feed water flow fluctuation.

I had a look at the boiler pressure part arrangement. There were no positive downcomers to ensure the positive circulation of water to the lower drum when the water flow would be cut off. I discussed with the Plant in charge. I explained that the boiler feed pump is oversized. The feed control valve design pressure drop seemed small and hence the feed control valve was working as on / off valve instead of regulating the feed flow.

I explained that the heat pick up in the boiler was expected to be more as there was economiser and airheater down the flue gas path. Due to this, the rear set of bank tubes which are to act as downcomers suffer reverse flow. When cold water is not added to the drum, the water level appears swollen. Since the drum level remains increased for more time until the water hold up in the evaporator comes down due to continued steam drawal. I explained the possibility of excess steaming of bank tubes due to reduced circulation. The Plant in charge confirmed that some tubes were found distorted inside the boiler bank. Then I recommended that the feed pump motor is provided with the Variable frequency drive. Alternately the control valve should be changed to suit the available excess head at the discharge of the pump. We discussed the possibility of killing the excess pressure drop by means of series of orifice plates. I gave a sketch and left the plant.

THREE MONTHS LATER

The Plant in Charge called up over phone to inform me that the whole boiler tubes were found to be distorted. The crushing season was over and the boiler was in open for cleaning. No measures were taken during the season to attend the water flow fluctuation.

The steam generating tubes in the furnace were found completely distorted. There was mild swelling of tubes in several places. Since the tubes were tied together at the level of buckstays, in all other locations the tubes were found elongated and distorted. It was clear that the inside the tubes nucleate boiling would have been disrupted. Steam blanketing must have occurred leading to overheating of tubes and abnormal thermal expansion of the tubes. It was observed that the furnace refractory walls caved inside because of the thrust from the downward expansion of the tubes. It was clear that the feed water flow and drum level fluctuation must have caused the reduced flow in the steam generating tubes. During the season the boiler had run at near full load. Hence the firing rate was more. Since the furnace tubes pick up more heat at increased firing rate, the tubes had to distort. Yet I had to check the circulation calculations for the heated downcomers (rear set of bank tubes). The circulation calculations confirmed that adequate velocity in the steam generating tubes.

This time again the feed water recorder charts showed quite lot of hunting. I explained to client that the loss of available head for circulation must have lead to poor circulation rate and thus the DNB (Departure from nucleate boiling) must have occurred.

The plant in charge decided to replace all the furnace tubes and to go in for my recommendations for VFD for boiler feed pump. The cause for the entire episode was definitely the oversizing of feed pump. The plant in charge explained that in sugar mills it is a practice to go in for 130 % margin on normal head and 130 % margin on flow. It was obvious that the feed pump was oversized leading to high discharge pressures at normal flow rate. The feed control valve had to operate like open / close valve because of oversizing of the boiler feed pump.

4 MONTHS LATER

I visited the plant to check how the VFD was working in the system. The feed control valve was disconnected from the control loop. It was kept full open. The Feed pump rpm was now controlled through VFD by the Drum level control loop. The feed flow chart indicated that the feed flow is now steady. Further as advised by me the CO_2 recorder available in the panel was now connected for indicating the drum level. Drum level chart indicated no fluctuation in level.

CONCLUSIONS

The feed pump selection should be proper and more care is to be taken for the control valve selection. Oversizing of the pump has led to a unusual failure. A worksheet showing the method for selection of boiler feed pump is presented in this article.

It is appropriate to narrate a similar failure pattern in boilers offered by a leading Indian Boiler Manufacturer. The figure 2 shows the boiler configuration adopted by the manufacturer. The boiler is offered with FBC furnace for firing many fuels. The boiler is designed to produce saturated steam at low pressures (max 17.5 kg/cm2g). The boiler is designed for switching on / off based on low & high-pressure switches. Also the feedpump is designed switching on / off based on Mobrey level controller. The bank tubes are often found distorted / sagged. Many users retube the boiler and yet experience the same failure. Only distortions occur but not tube failure. As such in this boiler, the head available for circulation is very less. If the pump is oversized or if the boiler steam drawal is less, the boiler feed pump is likely to be off for more period. This will disturb the circulation rate through the bank tubes. The firing rate being always constant in this boiler, the available head reduces when the pump is in the off mode. My request to these users is to operate the pump on continuous basis.

SAFETY VALVE SET PRESSURE & RELIEVING CAP.CALCULATIONS

PROJECT : **M/S ABC Limited**

INPUTS

Steam generation rate Nett =	35000	kg/h
Saturated steam flow for deaerator =	400	kg/h
Main steam pressure =	44	kg/cm2 g
Calculated Pressure drop across SH & DESH =	3.5	
Calculated Economiser pressure drop =	1.5	kg/cm2 g
Control valve pressure drop assumed =	2	kg/cm2 g
Calculated Feed line pressure drop =	1	kg/cm2 g
Margin on BFP flow =	15	%

SAFETY VALVE RELIEVING CAPACITY CALCULATIONS

Maximum steam generation capacity of boiler	= 35000 kg/h
Peak generation capacity	= 1.1 x 35000 kg/h
	= 38500 kg/h
MSSV relieving capacity	= 0.4 x 38500 = 15400 kg/h
Saturated steam flow for deaerator	= 400 kg/h
Drum SV 1 relieving capacity	=(0.3 x 38500) +(0.5 x 400) = 11750 l
Drum SV 2 relieving capacity	=(0.3 x 38500) +(0.5 x 400) = 11750 l

SAFETY VALVE SET PRESSURE & FEED PUMP DISCHARGE PRESSURE

Main steam pressure	= 44 kg/cm2 g
MSSV set pressure	= 44 / 0.95 kg/cm2 g
	= 46.316 kg/cm2 g
MSSV set pressure	= say, 46.5 kg/cm2 g
Calculated SH press. Drop	= 3.5 kg / cm2
Drum pressure when MSSV floats	= 46.5 + 3.5 = 50 kg/cm2 g
Margin	= 1 kg/cm2 g
Selected pressure	= 50 + 1 = 51 kg/cm2 g
Drum I SV set pressure	= 51 / 0.95 kg/cm2 g
Drum I SV set pressure	= 53.7 kg/cm2 g
Say, Drum I safety valve set pressure	= 54 kg/cm2 g
Difference between drum I & II SV set pressures	= 1 kg/cm2 g
Drum II SV set pressure	= 54+1 = 55 kg/cm2 g
Economiser pressure drop	= 1.5 kg/cm2g
Control valve pressure drop	= 2 kg/cm2g
Feed line pressure drop	= 1 kg/cm2g

Pump duty Point 1

Pump head required during drum SV II floating	= 55+1.5+2+1+1.5 kg/cm2g
Pump head at duty point 1	= 61 kg/cm2g
Flow at duty point 1(MCR Flow)	= 35000 + 400 = 35400 kg/h

Pump duty point 2

Pump head at duty point 2	= 44+3.5+1.5+2+1+1.5 kg/cm2g
	= 53.5 kg/cm2g
MCR flow	= 35400 kg/h
Flow margin	= 15 %
Flow required at duty point 2	= 35400x (100 + 15) /100 kg/h
	= 40710 kg/h

Summary

SH safety valve set pressure	**= 46.5 kg/cm2g**
Drum safety valve set pressure 1	**= 54 kg/cm2g**
Drum safety valve set pressure 2	**= 55 kg/cm2g**
Min relieving capacity of SH safety valve	**= 15400 kg/h**
Min relieving capacity of Drum 1 safety valve	**= 11750 kg/h**
Min relieving capacity of Drum 2 safety valve	**= 11750 kg/h**
Feedpump flow at duty point 1	**= 35400 kg/h**
Pump head at duty point 1	**= 61 kg/cm2g**
Feedpump flow at duty point 2	**= 40710 kg/h**

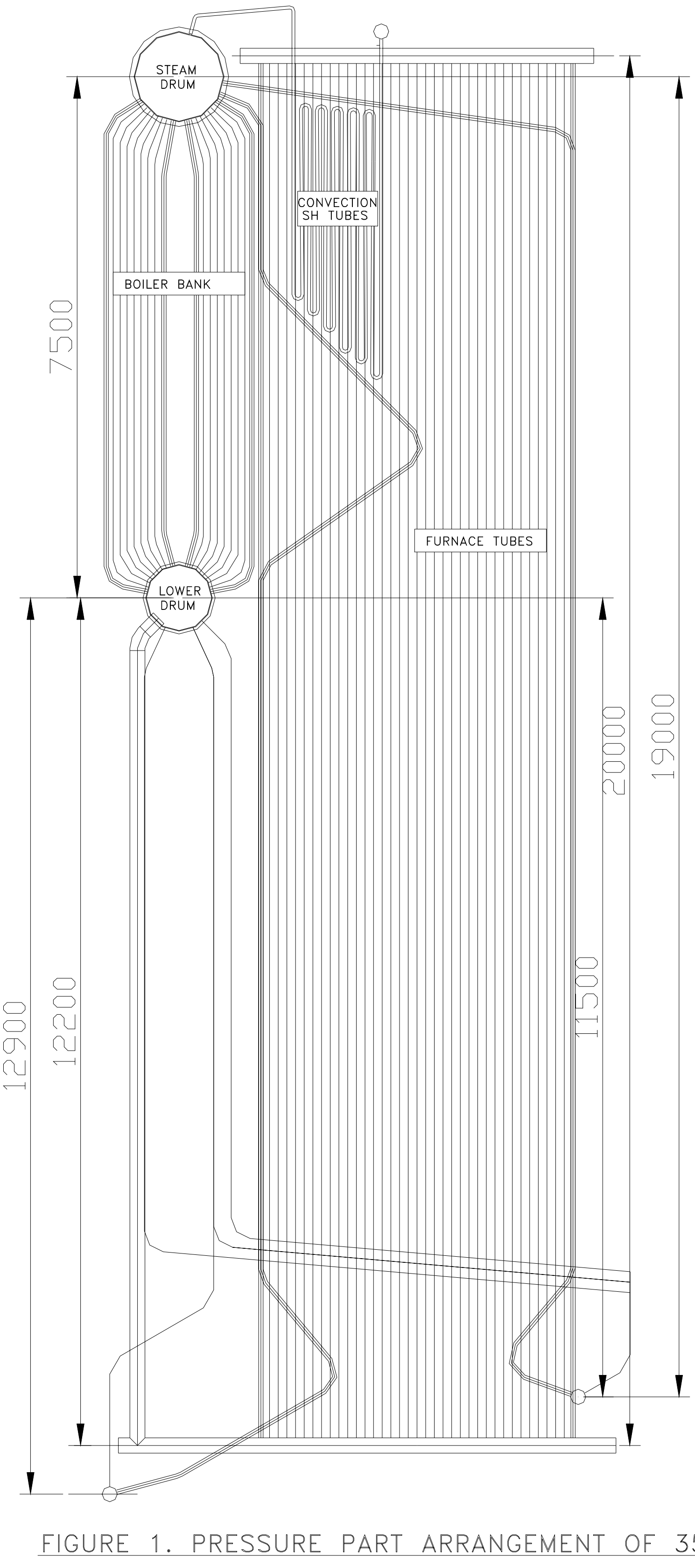

FIGURE 1. PRESSURE PART ARRANGEMENT OF 35 TPH BOILER

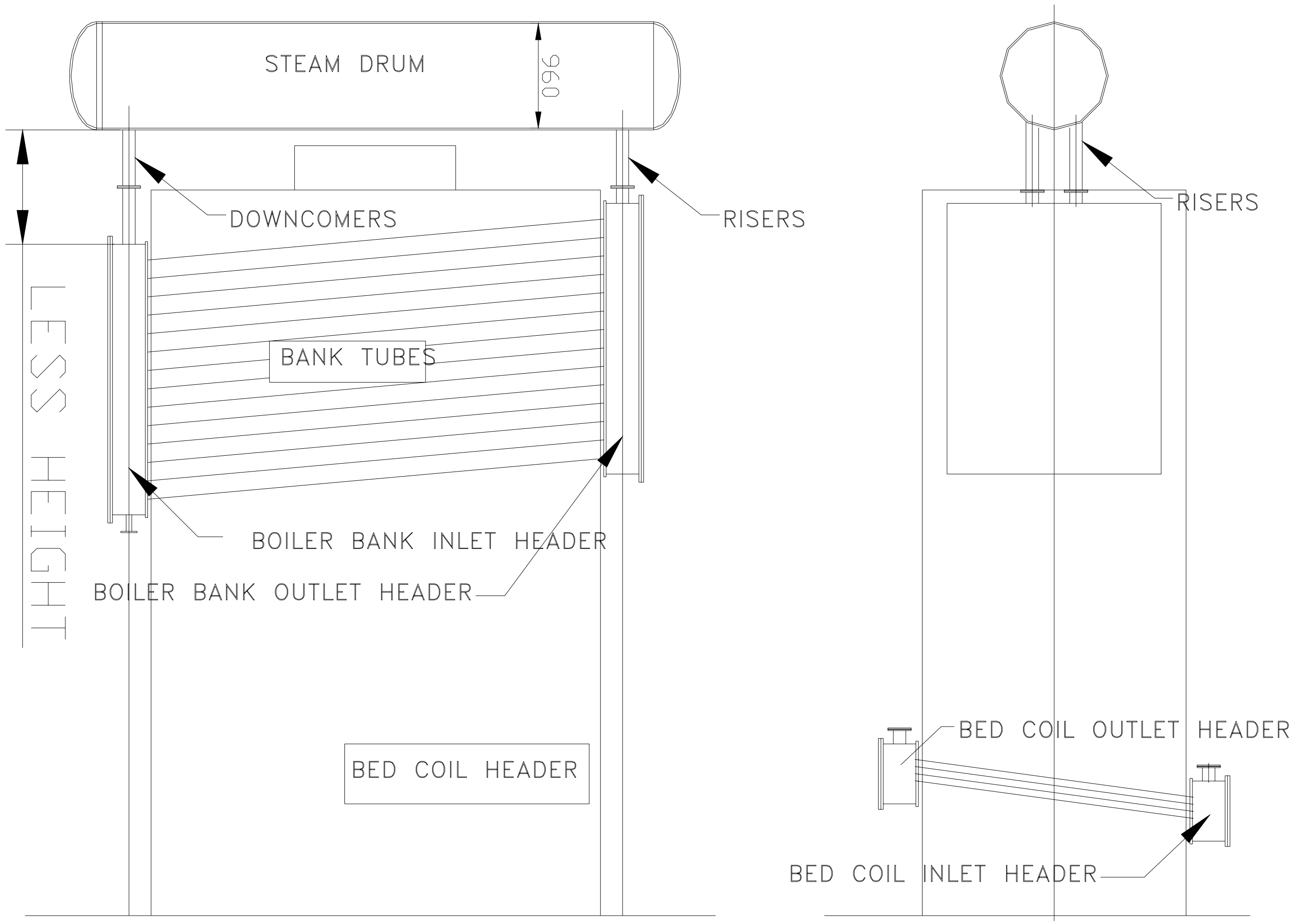

FIGURE 2 : TUBE DISTORTION IN SINGLE DRUM BOILER