# Recovery Boiler Superheater Modification for Increased Output at the West Coast Paper Mills

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SUMMARY

In this article, the importance of a good design of the Superheater of a Recovery boiler is discussed. It will be essential to go into deeper aspects of Superheater design in order to increase the availability of the unit. From time to time, as the mill working conditions change with respect to the furnish of pulping raw materials, a fresh approach will have to be made for solving the problems in the Chemical Recovery Plant.

## INTRODUCTION

In many paper mills in our country Recovery Boilers are in operation, with the main purpose of obtaining a higher Chemical Recovery efficiency. Some mills have installed low pressure Recovery Boilers and some mills have installed high pressure Recovery Boilers, to take the double advantage of steam and power generation.

High pressure Recovery Boilers where Superheaters are incorporated usually meet with difficulties in in operation. At West Coast Paper Mills we have experienced many difficulties and in the last 18 years several modifications have been made. The major modifications have been made in the year 1975. This article deals with the details of the changes effected in the Superheater of the boiler from time to time.

## DESCRIPTION OF THE RECOVERY BOILER UNIT AT THE WEST COAST PAPER MILLS LTD.

The Recovery Boiler at the West Coast Paper Mills Ltd. is designed, for the input of 120 tonnes Black liquor solids per day with a steam generation 15 t/hr. at MCR (at 40 kg/cm$^2$). The boiler is provided with a Superheater and economiser. The unit was commissioned in the year 1959.

The boiler has been originally designed for the Superheater steam temperature of 390°C, which was shooting up to 440–500°C even at the rated capacity of the boiler. In addition to this high temperature, the plugging of Superheater tubes on the outer surface was also severe resulting in the frequent boiler shut odwns.

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## DESCRIPTION OF THE ORIGINAL SUPERHEATER OF THE BOILER

The Superheater originally provided was of pendant type (nondrainable). Totally 19 tubes with 2½" O.D. were arranged in 6 loops - 9 tubes in the first pass in counterflow direction and 10 tubes in second pass in parallel flow direction. The mean effective length of each tube was 167 ft, and the total heating surface provided was 2075 sq. ft. The 19 tubes were arranged at the side spacing of 5" only. After the three loops a chamber has been provided for the operation of soot blower as per the general practice.

The above design of Superheater was giving a higher steam temperature even at normal loading of black liquor solids. The temperature used to shoot up to 440–500°C. Apart from this the Superheater passage used to get plugged with carried over material as the spacing of tubes was very close. (The spacing was 5" only, where as in modern boilers it has been increased 10") In order to avoid this trouble of higher superheater steam temperature, the manufacturers suggested to take away 1½ loop of the Superheater thereby reducing the area of the Superheater to 1615 sq. ft.

In this modification carried out in August 1961, the effective length of the tube was reduced to 129'10". This modification no doubt decreased the superheater outlet temperature to around 420–440°C but the problems of plugging the passage and subsequent cleaning became more difficult.

In August 1964, the Superheater loops were cut by 9" in the vertical direction in order to give more gap between the nose baffle tube surface and the bottom of the Superheater tube bends. This was necessary to clean the plugged material during inter-

mediate shut downs and cold shut downs. Finally the effective length of the tube became 123'–10" with total area of 1535 sq. ft. With this change in the area of the superheater the superheater outlet steam temperature remained at 410–420°C even at higher input of black liquor solids. (170–180 T. per day.)

After finding out a reasonable solution of higher superheater outlet steam temperature, the basic problem of superheater passage plugging remained unchanged and the shut down periods became longer. With great difficulty the availability of the Recovery Boiler for liquor firing purposes used to be 310–315 days per year. Apart from the intermediate shuts (to be arranged once in 9–10 days) the boiler was to be totally shut for a period of 3 days after running the same for about 3 months. This was essential to thoroughly clean the plugged material from the boiler passes including the superheater regions.

At this stage, when the production of paper was to be increased, there was great pressure on the Recovery Plant for higher overloading of black liquor solids. A fresh approach to the problems of boiler passes fouling was thought of based on the following comments in the book "Steam its' generation and use-pp 20–29) published by Babcock & Wilcox Co. USA.

The Superheater (of a Recovery Boiler) is arranged for parallel flow of gas and steam. Saturated steam enters the front tubes of Superheater in contact with the hot gas and flows through successive loops so that the final steam with the hottest steam is in contact with cooler gas. There is a dual advantage with this arrangement. First cooling of the gas is most rapid at the front of the Superheater where the need for cooling the ash is the greatest. Second, the parallel flow arrangement results in lower average tube metal temperature. This is particularly desirable in Recovery units, designed for steam temperatures above 370°C, design temperature of the flue gases across the Superheater zone.(1)

In a Recovery boiler the area of the furnace is well manipulated to get the following temperatures in the gas path.

Normal temperature at the inlet to the slag screen tubes is around 870°C. The outlet gas temperature of screen tubes (or inlet to the Superheater zone) is around 788°C. The Superheater outlet gas temperature should be around 590°C to 700°C, when the carried over chemical will not be sticky or tacky.(2)

It is evident that the above temperatures will shoot up when we start overloading the boiler.

As the rate of input black liquor solids increases in a Recovery boiler and if enough air is provided for efficient burning the gas temperature in the furnace and entering the slag screen increases. The optimum capacity of the furnace of a modern Recovery unit is said to have been exceeded when the maximum temperature of the flue gas entering the screen is so high that fouling of the screen and Superheater cannot be controlled with mechanical soot blowers. It may also be said that the peak capacity for a particular furnace has been exceeded when the gas temperature reaches a level where the fouling of the screen and superheater cannot be controlled with moderate amount of hand lancing in addition to mechanical soot blowing.(3,4)

Further it is also established regarding the spacing of the tubes that the spacing of slag screen tubes as well as superheater tubes should be at 10" centres across the boiler and the back spacing may be around 5". It is also advisable to have larger bends for the Ist, 2nd and preferably 3rd loop of the superheater elements.

Based on the above data available and after studying the design of some of the boilers in our country the following modification on the superheater of the boiler was carried out, which resulted in many advantages.

## DETAILS OF THE SUPERHEATER MODIFICATION CARRIED OUT IN JANUARY, 1975

Basically the mixed flow design has been modified to a single pass parallel system.

Out of the 19 elements originally provided the 4th, 8th, 12th and 16th elements were removed and the corresponding holes in the Superheater headers were plugged with certified tube plugs. The original intermediate superheater header was converted to the inlet header after connecting the saturated steam lines from the boiler steam drum. The outlet header was retained as the same after the removal of the diaphragm at the centre. Proper precautions were taken to see that the welding connections on the header were made with utmost care.

With the above re-arrangement of the Superheater the area got reduced to 1208 ft². Subsequently after one year, the lower bend radius of the front half loop elements No. 2, 5, 8, 11 and 14 were enlarged from 3" to 9" for easy dislodging of chemical deposits.

## PRESENT PERFORMANCE OF BOILER OPERATION AFTER THE MAJOR MODIFICATION

After the modification jobs, the temperature of the flue gases before and after the superheater zones were measured. At the inlet the temperature varied from 765°C and at the outlet it varied from 610°C to 635°C. This indicated that the temperature ranges were well with in the design range stated earlier and hence we expected better performance, from the modification.

The Recovery boiler availability for liquor firing purposes used to be 310–315 days per year. This has been increased to 325 to 330 days per year.

(with increased rate of solids input to the furnace) The increased availability has also resulted in extra salt-cake make-up, (to maintain higher sulphidity in the white liquor) extra steam generation etc.

Before the last modification the intermediate shuts used to be for a longer period ranging from 12 to 16 hours, which has now reduced to 8–12 hours. Cold shuts of boiler which used to take place once in 3 months for a period of 3 days are not very essential now-a-days. The corresponding reduction in the fuel oil saving is also experienced.

## OBSERVATIONS OF PLUGGING IN THE BOILER PASSES AFTER THE SUPERHEATER

At the time of modifying the superheater tubes, it was feared that the passage plugging problems might increase, in the Ist and 2nd pass of the boiler. As the temperatures remained well within the range the "plugging" problems were not severe. We have been observing only a bit more of chemical collection at the boiler hopper. This has not posed any serious problem for the smooth operation of the boiler. Lesser frequency of leakages from the Expansion joints to the Superheater tubes with the header.

With frequent shut downs coupled with severe passage plugging problems as mentioned earlier, the strain on the S/H tubes increases specially when more physical force is applied for dislodging carried over material. This has resulted in the leakages of expansion joints of S/H tubes with the respective header. These troubles have practically disappeared when the plugging problems are reduced to a great extent.

## STEAM GENERATING EFFICIENCY OF THE BOILER, BEFORE AND AFTER THE SUPERHEATER MODIFICATION

It is evident to assume a higher flue gas temperature after the Superheater zone specially when the area of the same has been cut down. This increase in heat of flue gases was proportionately absorbed more in the boiler passes resulting in almost the same boiler outlet gas temperature before and after the modification. It is to be noted here that with better spacing of Superheater tubes and efficient soot blowing arrangement, plugging of gas passages beyond superheater zone will be very much less.

## ADVANTAGES OF LOWER SUPERHEATER STEAM TEMPERATURE AT THE POWER HOUSE OF THE MILL

The mill has three high pressure boilers for the generation of power (2 Nos. coal fired boilers and one Recovery boiler of equal steam generation capacity). The coal fired boilers have the attemperator for adjusting the super heater steam temperature, whereas the Recovery Boiler does not have the attemperator. With this arrangement it was very difficult to control the combined steam temperature of all the boilers going to the Turbo Generator. The specified steam temperature entering the Turbo Generator is 390°C, whereas in practice it used to go beyond 420°C. After the modification of the Superheater at the Recovery boiler this problem has practically disappeared and the control of steam temperature at the Turbo Generator has become easy.

The following data shows the working results of the Recovery boiler, before and after the modification

| | 1969–70 | 70–71 | 71–72 | 72–73* | 73–74 | 74–75 | 75–76 | 76–77** |
|---|---|---|---|---|---|---|---|---|
| Availability of Recovery Boiler, days | 315 | 307.5 | 305 | 271 | 286.5 | 308.5 | 330 | 324 |
| Consumption of thick liquor, $M^3$ | 79308 | 76588 | 74306 | 71255 | 80929 | 78069 | 93082 | 90719 |
| Makeup salt cake used, Tonnes | 2261 | 2527 | 2523 | 2767 | 2671 | 3520 | 4677 | 4343 |
| Fuel oil consumption, K. Lit. | 1005.23 | 869.39 | 902.44 | 1249.2 | 1567.1 | 1464.95 | 976.89 | 1292.9 |
| Steam generated, Tonnes | 108969 | 104279 | 103010 | 110522 | 123999 | 135123 | 145105 | 139723 |

* General strike of the mill for 49 days.

** General strike of the mill for 6 days.

## ADVANTAGES OF UNIFORM QUALITY OF COOKING LIQUOR TO THE DIGESTER HOUSE

It is well known that the continuous running of the Recovery unit gives uniform quality of cooking white liquor as needed by the Digester house. Prior to 1975, when we had to longer shuts, fresh caustic input to the chemical system had to be increased all of a sudden affecting the sulphidity of the white liquor. Presently with better running of the Recovery unit we are in a position to maintain uniform quality of cooking liquor. Fresh Caustic Soda required as a make up chemical is added in a uniform fashion thereby maintaining uniform % Sulphidity. Further with more availability of the Recovery boiler caustic soda inventories are controlled better.

## EFFECTS OF CHANGES IN THE RAW MATERIAL FURNISH ON THE OPERATION OF THE RECOVERY BOILER

With the increasing shortage of bamboo in the mill, the use of mixed hardwoods and eucalyptus have increased. This mill which was using 100% bamboo, had to switch over to hardwoods and the percentage use of bamboo out of the total furnish came down to 58-60% in the years 1974, 75 and 76. The increased proportion of wood have given plenty of troubles at the multiple effect evaporation stage. But after this point we have not experienced any serious difficulty at the Cyclone Evaporator or the Recovery Furnace. Hardwood liquors are more viscous in nature at higher concentration which need a higher temperature for pumping purposes.

At the screen tube and Superheater zones of the Recovery Boiler, we have some times observed harder deposits possibly due to the change in the melting point of the entectic mixture of the sublimited compounds.

## ACKNOWLEDGEMENT

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