Experiences In The Operation Of Chemical Recovery Boilers-A Case Study

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ABSTRACT

Successful operation of Chemical recovery boilers largely depends on the characteristics of spent liquor used, operating parameters employed and design features of the boiler. The present paper deals with the problems faced in the operation of a Recovery boiler with different liquor and under changed conditions and methodology adopted to overcome the same. A comparison of operation of Two boilers of different design using same spent liquor is drawn and possible reasons for the better performance of second boiler were highlighted. The impact of Chemical analysis of spent liquor and changes in fibrous raw material furnish on the performance were also dealt with.

INTRODUCTION

The Andhra Pradesh Paper Mills Ltd is equipped with Three Chemical recovery boilers viz.,

- A 127 TPD (Black liquor solids) firing capacity B&W Tomlinson Boiler supplied by Fives-Cail, France Commissioned in the year 1965.
- A B&W Type boiler with 270 TPD firing capacity supplied by M/s AVB, Durgapur in the year 1981.
- A CE Type 170 TPD capacity boiler supplied by BHEL, Tiruchi commissioned in 1994.

Among these No.1 boiler was kept as a stand by and the other two boilers are in continuous operation and the first boiler is to be dismantled after stabilising the other two. Since commissioning in 1981 the No.2 boiler gave satisfactory performance in steam generation with 2.85 T/Ton of BL solids on an average but the steam temperature was around 360 deg. C only instead of 420 deg. C as per design. This was attributed to the reduction in calorific value of black liquor with change in fibrous raw material furnish.

After a careful study by the supplier, modifications to the boiler were suggested viz., installation of additional super heater tubes in place of screen tubes for increasing the steam temperature to the designed 420 deg. C. With the installation of 10 MW congeneration TG set, increase in demand for steam of higher temperature necessiated the installation of Super heater coils. This no doubt increased the steam temperature but the interval of deposit clean out has come down significantly to as low as 28 days. Besides other disadvantages faced are-

1. Reduction of steam per Ton of BL Solids to 2.5 T from 3.0 T when the boiler was run at designed load of BL solids (270 tpd)
2. Boiler load has to be reduced to get required temperature and optimum steam per Ton of BL solids (3.0)
3. Boiler availability decreased to 90% from 95%.

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TABLE-1							
COMPARATIVE PERFORMANCE OF RECOVERY BOILERS NO. 2 & 3.							
S. NO.	PARTICULARS	BL SOLIDS TPD	STEAM TPD	STEAM, T/T OF BL SOLIDS TPD	CALORIFIC VALUE OF BL K Cal/Kg	TEMP deg. C	STEAM PRESSURE Kgs/sq. cm
1.	Designed	270	810	3	3500	420	34
2.	Best Achieved 17.12.87	272	830	3.05	3500	380	32
3.	Dec'92 (Average)	240	754	3.14	3138	365	34
4.	August '93 (Average)	263	702	2.67	2920	375	34
5.	94-95 (Average)	265	755	2.85	3365	365	34
	AFTER SUPER HEATER MODIFICATION						
6.	July '96 (Average)	228	691	3.03	3207	420	36
7.	October '96 (Average)	270	632	2.34	3120	420	36.5
8.	95-96	243	671	2.76	3186	420	36
	BOILER No. 3						
1.	Designed	170	491	2.89	3195	420	34
2.	Nov '95 (Average)	157	466	2.97	3206	420	36
3.	Jan '97 (Average)	197	465	2.36	3235	420	36.5
	95-96 (Average)	167	466	2.79	3186	420	36

4. Fuel oil consumption increased by 7-8 cu.m per month (on average) due to frequent stoppages of No. 2 boiler and running of age old No. 1 boiler.

5. Additional overtime expenditure for running No.1 boiler. Comparatively the performance of No. 3 boiler is quite consistent with the same spent liquor.

In this article an attempt was made to present various approaches tried to improve the performance of No.2 boiler inspite of change in fiber furnish. Reasons for the better performance of No. 2 boiler were also studied.

However, this is not an attempt at declaring the superiority of one boiler deign over the other, but an attempt to highlight the difficulties in operating a boiler in different circumstances than those existing at the time of design. Salient data on comparative performance of two boilers is presented in **Table-1.** The data presented shows that for No.2 boiler at 263 TPD the steam generation is 2.67 T/T of solids against 3.0 T while at a lower loading at 240 TPD it is 3.14. Even after super heater modification at 270 TPD load the ratio is 2.34 only while at 228 TPD it is 3.03 T. This indicates that the designed performance of 270 TPD and 3.0 is not being achieved. A comparison of year average values for 95-96 and 94-95 also show that the loading and ratio are less after modification. For No. 3 boiler the difficulty is not present. Factors for the phenomena and trials to overcome the same are discussed hereunder.

1. BLACK LIQUOR CHARACTERISTICS

It is well documented in literature that Chemical reactions during pulping will change the composition of dissolved wood components in black liquor and are dependant on the fibrous raw materials and pulping conditions. These will result in change in elementary composition of the spent liquor dry solids and will affect the heat value. Also properties such as splitting of water from or absorption of

TABLE-2				
ELEMENTAL ANALYSIS OF BLACK LIQUOR FOR DESIGN CONSIDERATIONS				
S. No.	PARTICULARS		BOILER No.2	BOILER No.3
1.	CARBON	%	38.1	35.08
2.	SULPHUR	%	3.5	1.89
3.	HYDROGEN	%	3.2	4.77
4.	OXYGEN	%	34.9	32.57
5.	SODIUM	%	19.0	20.54
6.	POTASSIUM	%	---	3.04
7.	INERTS	%	1.3	2.11
8.	CALORIFIC VALUE,	Kcal/Kg	3500	3195

water by dry solids, formation of volatile compounds are affected. (1) A comparison of elemental analysis of black liquor at the time of designing of the No.2 and No.3 boilers is presented in Table-2. The data indicates a change in liquor characteristics considered in designing No. 3 boiler which may be due to change in fibrous raw material furnish and one of the reasons for the deterioration in the performance of No. 2 boiler.

2. INLET LIQUOR CONCENTRATION

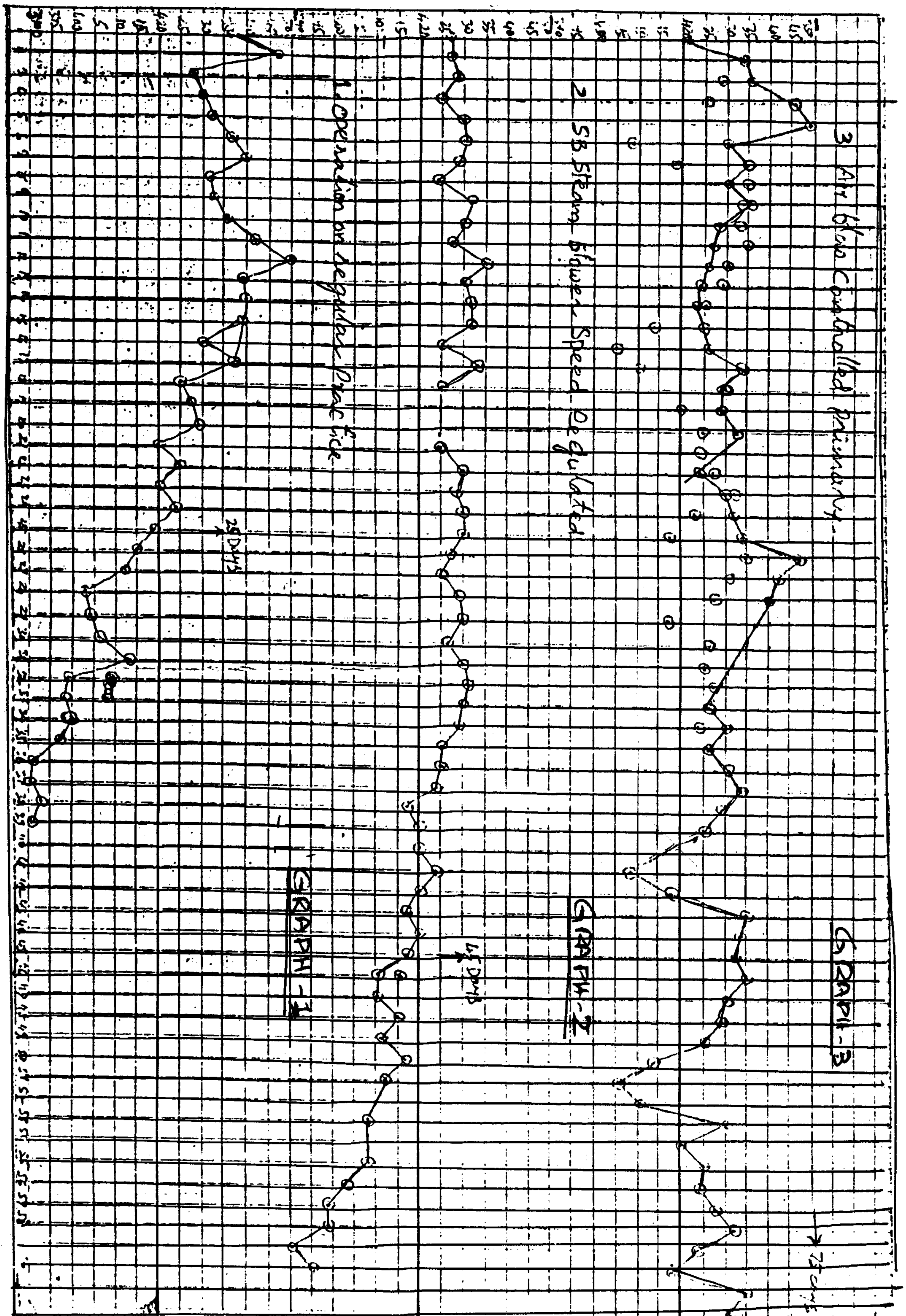
The firing liquor concentration is 2 to 3% more in No. 3 boiler which can be traced to higher DCE inlet flue gas temperature viz., 340 deg. C resulting in effective evaporation. In case of No. 2 boiler it is 325 deg. C initially and later dropped to as low as 280 deg. C gradually with change in liquor quality and after modification of super heater. The higher temperatures can be traced to better design of heat transfer surfaces and distribution of air for suitable turbulence and mixing in No. 3 boiler. Hence it is contemplated to supply 2% more concentrated liquor to DCE from MEE without much adverse effect of heat transfer surfaces of evaporators. This is possible due to reduction in viscosities of present liquor compared to that of earlier liquor.

3. AIR DISTRIBUTION

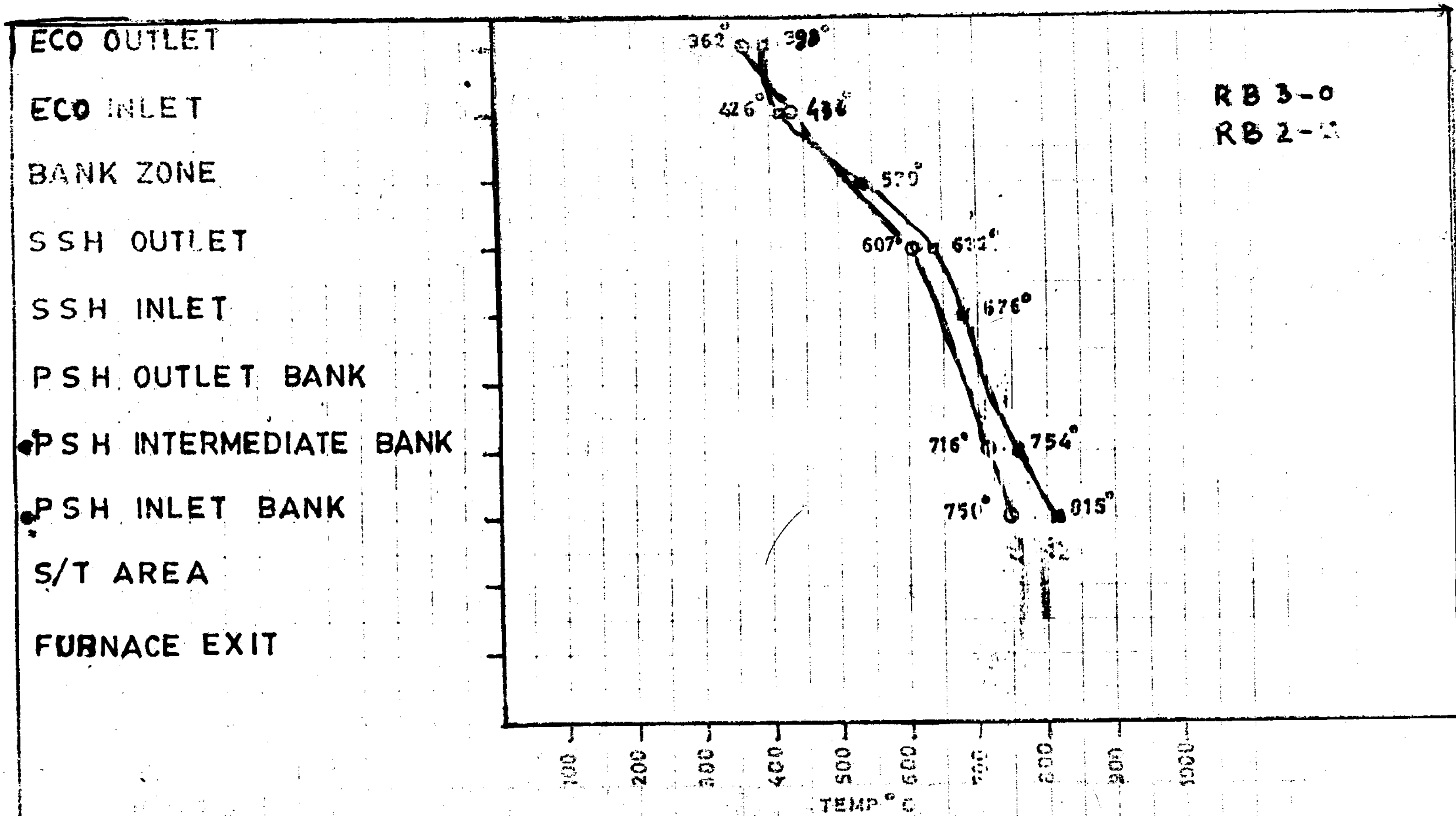
Liquor spray techniques and Air distribution systems are some of the means for improving the performance of boiler. Also it is acknowledged that the interval of deposit cleanout can be significantly prolonged by changing the primary air quantity. (2)

Higher temperatures in lower furnace result in better thermal efficiency and lower temperatures at the furnace exit and a consequent reduction in the rate of formation of fire side deposits on pendant heat transfer surfaces which is desirable for continuous boiler operation. Recovery boiler No. 3 is in accordance with this theory necessiating soot blowing once in every 8 hours and continuous operation for more than 6 months before stoppage for deposit clean out. For No. 2 boiler the air port openings are provided for 60 % primary and 20 % each in secondary and tertiary stages. In our trials with No. 2 boiler we have tried to increase the interval of cleanouts by changing the Liquor and Air distribution ratios. In No. 3 boiler the liquor spray is in the form of droplets with conical spray in the boiler which allows the burned out mass to fall on the hearth while in the No. 2 boiler it is sprayed on the opposite wall with splash sheet spray and falls on hearth as a deposit resulting in non uniform burning. Soot blowing is carried out once in 4 hours but this also has not proved effective in controlling the rate of deposit formation. Secondly the larger amount of Primary air (50%) in No. 2 boiler carries the unburnt and volatile materials to exit of boiler and promotes formation of deposits on the fireside of superheater coils and a drop in super heated steam temperature resulting in frequent cleanouts. A graph indicating the average steam temperatures day wise is plotted in the course of normal run (graph-1). This showed that a clean out became necessary after 25 days only. After studying the phenomena, the SB steam blower speed is regulated and temperatures plotted daywise (graph-2). This shows that the clean out required after 45 days, longer than normal run. Encouraged by this another trial by reducing the primary air was conducted. The graph-3 indicates that the time interval increased to 75 days before cleanout. Thus graphs 1,2,3 indicate that cleanout intervals increased by changing operating parameters.

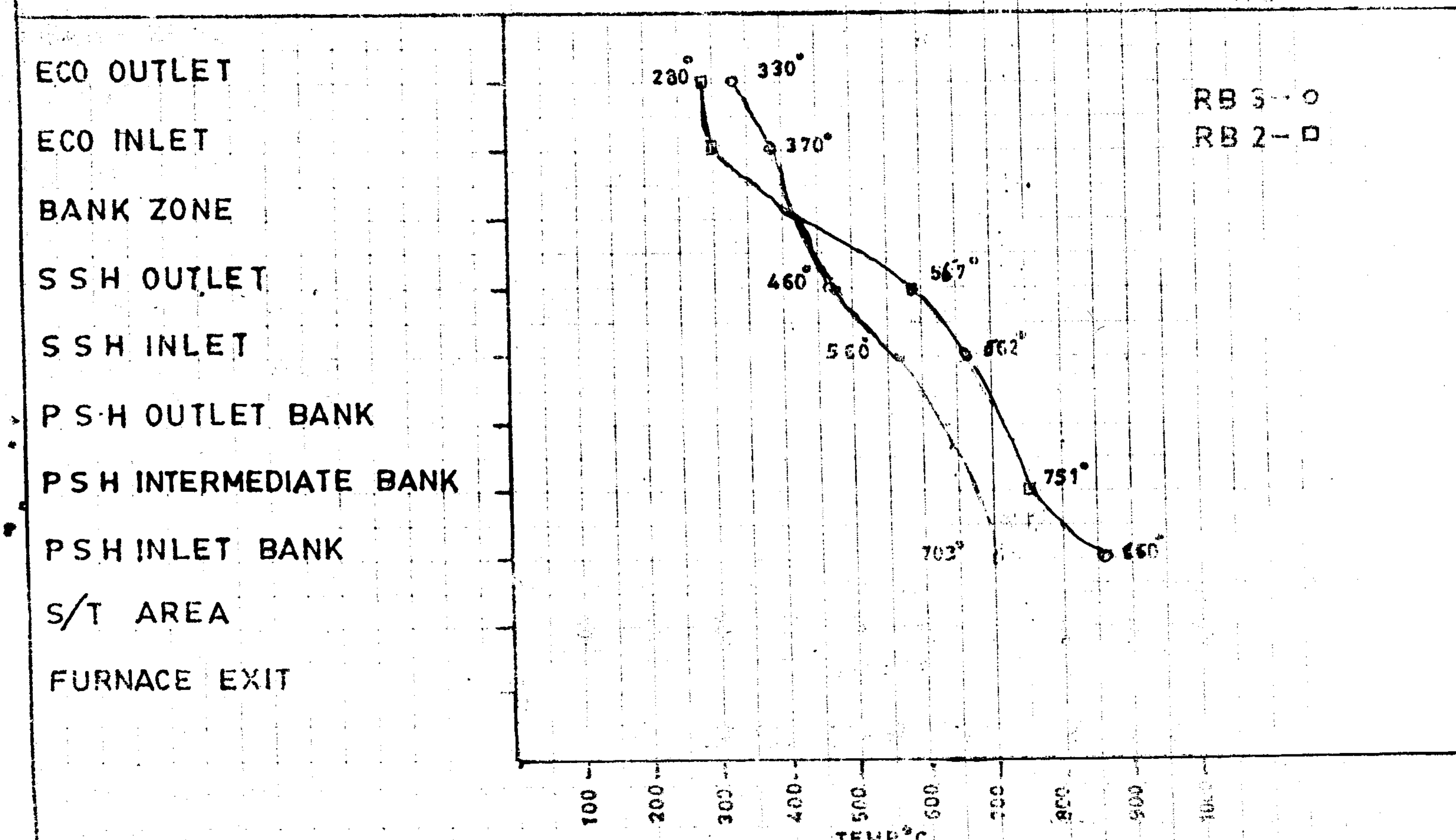
Further trials were conducted to control this deposition by (1) stopping combustion air preheating (2) Stoppage of tertiary air and (3) supply of more amount of primary and secondary air for complete



1. Operation on regular practice
2 SB Steam blower speed regulated
3 Air flow controlled primarily
GRAPH-1
GRAPH-2
GRAPH-3
25 DAYS
45 DAYS



DESIGNER PREDICTION



APRIL-95 AFTER S/H MODIFICATION

ACTUAL PERFORMANCE

burnout in the lower furnace.However, these resulted in reduced combustion efficiency which is undesirable.

Injection of cold air in the tertiary was thought of but could not be carried out as suitable blower was not available. Even for the two level air supply (only Primary and Secondary), control has become a problem with the existing arrangement.

TABLE-3		
THERMAL PROPERTIES OF DEPOSIT SAMPLE		
	Sample-1	Sample-2
1. STICKY TEMPERATURE deg. C	780	650
2. SMELT FORMATION TEMPERATURE, deg. C	808	685
3. SMELTING TEMPERATURE, deg. C	838	745

4. FIRE SIDE DEPOSIT FORMATION

To findout the reasons for the formation of fireside deposits in No. 2 boiler, deposits were collected and got analysed for individual constituents and for thermal properties on two occasions and the results are presented in Table-3. They show that deposit sticky temperatures are around 750 deg.C. Hence to understand the temperature of deposition an attempt was made to determine the temperature profiles of No.2 & 3 boilers and the results are compared to the values predicted at the time of design. These are presented in graphs 4 and 5. A study of the graphs reveal that the temperature profiles recorded are comparable to those at the time of design for both boilers with minor variations. Howerer, it is interesting to note that high temperatures were avoided in the design of No. 3 boiler in the region where deposits are likely to give problem.

As No. 2 boiler gave better performance earlier with the same temperature profile, the recent cause of deposit formation may be traced to the change in the liquor composition and burning characteristics compared to those at the time of design.

5. OXYGEN CONTENT

In general to achieve complete combustion 2-3% excess Oxygen content is recommended for any boiler. This is true for No. 3 boiler where as for No. 2 boiler the oxygen content is to be maintained at higher levels i.e., 5-6% to get required steam after modification. This is an indication of inadequate mixing and turbulence of air and fuel in No. 2 boiler. Also the liquor temperature is to be maintained on higher side viz. 122 deg. C compared to 115 deg. C normallly maintained in No. 3 boiler.

Thus by modifying operating parameters, the interval of cleanout could be increased to about 100 days. However to further increase the interval detailed studies are to be takenup.

Experts and consultants in the field are being contacted for a comprehensive study on No. 2 boiler and suggest any modifications required for improved performance for longer periods.

CONCLUSION

The reduced performance of a boiler can be improved by changing the operating conditions to some extent. However, to achieve the designed performance with fuel of different composition and burning characteristics a detailed study is needed. Deposit formation can also be reduced if proper understanding of it's nature is understood.

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