An approach on capacity upgradation of old chemical recovery boilers in paper mills

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Introduction :

Chemical recovery boilers are designed for a particular solids handling based on the paper mill size. Many times a 30% oversizing is also done. But still the mill capacity is increased over years and a need comes to upgrade the chemical recovery boiler. Many exercises were done by BHEL for both upgradation of chemical recovery boilers solid handling capacity and also for revamping these boilers. This article presents the limitations and experience in such proposals for capacity upgradation.

Performance Review/Analysis :

In all cases of upgradation, it is required to understand the present operating performance of the boiler, along with detailed black liquor analysis. With these data collected the performance is fully re-predicted for new duty conditions. The main limitation seen here is the bank inlet flue gas temperature which limits the solid handling capacity. The reason for such limitation is seen to be due to the presence of low melting salts like NaCl. In many of the earlier designed boilers the furnace selection on hearth heat loading is seen to be quite stringent.

Major Areas of Analysis :

The major areas that require detailed analysis are :

(i) Drum

(ii) Furnace

(iii) Air and flue gas system

(iv) Black and green liquor system

(v) Feed water and steam system

(vi) Variations in input parameters

Drum :

This requires to be checked for relieving capacity, the operating pressure to design pressure margin. The minimum resource required is 5%. The limitation in this area has been the increase in drum operating pressure due to increased dP across superheaters.

Furnace :

The increased heat input to the furnace due to upgradation increases the hearth loading and also the gas temperature entering the bank tubes. This results in a need to find out whether screen can be provided in the existing arrangements. It also calls for increased soot blowers in various sections before bank. In all old boilers the waterwalls are of tangent tube or skin case type. This needs to be changed to membrane wall in order to have a better enclosure and higher surface area.

Air and Gas System :

Due to increase in the total black liquor to be burnt, flue gas quantity to be handled increases. Accordingly the FD and ID fans have to be checked for adequate resource in head and flow. Generally it is found that the ID fans need a change due to higher suction load to be handled. In certain cases where air system is totally changed, addition of FD fan is needed.

Black Liquor and Green Liquor System :

Higher flow of black liquor warrants a total relook in the total system based on piping layout,

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liquor characteristics, etc. In many cases, this has not been a constraint. The liquor firing system however will need a change.

Feed Water and Steam System :

The superheater outlet pressure has to be checked with the design and operating pressure. This has to be reviewed based on the operating conditions. Any reduction in this will lead to increase in steam flow thus higher capacity of solids handling for the same heating value of the black liquor. The changes in feed water temperature and other conditions have also to be taken into consideration while making the proposal for revamp/upgradation.

Variation in input Parameters :

The black liquor properties depends on the types of cellulosic raw material used for pulp making. The changes in these affect the heating value of the dry solids. This poses a problem in the capacity to handle steam generated. The variation in concentration of the black liquor is an important factor to be evaluated. This results in limitation on capacity upgradation of a chemical recovery boiler already built.

Pressure Parts Condition Assessment :

In many cases the boilers have operated for more than 15-20 years. This brings in a need to assess the suitability of pressure parts to take up the duty condition.

Hence a full fledged condition assessment study has to be done. It is also equally important to check the condition of the various non-pressure parts like ducts, hangers, structurals etc. The total package of changes suggested should include this apart from the need due to capacity upgradation alone.

Case Study :

A typical case study of engineering analysis for capacity upgradation of a 574 TPD day solids chemical recovery boiler to a higher capacity of 667 TPD/709 TPD is given here.

This Engineering Analysis for capacity upgradation of a suspension firing type chemical recovery boiler is for increasing the capacity from 574 TPD to 667 TPD/709 TPD. These two capacities are considered due to the changes in the dry solids concentrations and calorific values. Based on the operating feedback, it could be predicted that during operation at overloads, carry over and gas side fouling of heat transfer surfaces are bound to increase. Such foulings can be minimised to a certain extent but cannot be totally eliminated.

In order to minimise the gas side fouling, this engineering analysis envisages following changes in the existing design of the chemical recovery boiler.

1. Additional furnace screens ahead of superheaters.
2. Revised counter flow superheater design.
3. Additional soot blowers in SH and boiler bank region.

Combination of furnace screens and counter flow SH design has restricted the gas temperature at boiler bank inlet to a safer value. But it has not been possible to bring down the gas temperature to desired optimum level due to the restriction in the present furnace size.

Design parameters

Base design data considered for analysis :

—Dry solids fired		: 574 TPD
—Elemental analysis of Dry solids (% weight basis)		
—Carbon		: 39.4
—Sodium		: 21.2
—Oxygen		: 31.4
—Hydrogen		: 3.6
—Sulphur		: 3.4
—Inerts		: 1.0
—HHV	Kcal/Kg	: 3600
—BL temp to unit	Deg.C	: 100
—BL Conc. to unit	% DS	: 64
—Salt cake makeup	Kg/Kg DS	: 0.033

—H_2O in Salt cake	%	: 0.2
—Smelt reduction	% Tappi	: 90
—Smelt sulphidity	% Tappi	: 23
—Steam flow	% T/Hr.	; 90
—Steam pr. at SHO	Kg/cm² (g)	: 65
—Steam temp at SHO	Deg.C	; 482
—Feedwater at Eco. inlet	Deg. C	: 144
—Drum operating pr.	Kg/cm² (g)	: 69.9
—Drum design pressure	Kg/cm² (g)	: 77.3
—Gas temp. leaving Eco.	Deg.C	: 204
—Excess air at Eco outlet	%	: 15
—Air temp to unit	Deg.C	: 149
—Ambient temp.	Deg.C	: 32

With these basic parameters the boiler was checked for overloading. The following areas were analysed in detail.

(a) Drum
(b) Furnace
(c) Air and gas system
(d) Black and green liquor system and
(e) Feedwater and steam system.

All the above analyses revealed that the drum design pressure was the limitation for further increase in capacity. This was seen to be for a steam flow of 115 T/Hr. Hence all the analyses were restricted to a point when the steam generation became 115 T/Hr.

Design Parameters for upgraded capacity :

1.	Black liquor dry solids, TPD	:	667	709
2.	Black liquor Conc. to salt cake mixing tank, %	:	70	65
3.	Black liquor temp to saltcake mixing tank, Deg.C	:	110	110
4.	Smelt sulphidity, % Tappi	:	28	28
5.	Smelt reduction, % Tappi	:	92	92
6.	Steam generated, T/Hr.	:	115	115
7.	SH outlet steam pr., Kg/cm² (g)	:	65	65
8.	SH steam temp., Deg.C	:	482	482
9.	Feedwater temp Entering Boiler, Deg C	:	144	144
10.	Drum design pr., Kg/cm² (g)	:	77.34	77.34
11.	BL dry solids elemental analysis (% Weight basis)			
	Carbon, %	:	37.74	37.74
	Sodium, %	:	18.40	18.40
	Oxygen, %	:	36.81	36.81
	Hydrogen, %	:	4.10	4.10
	Sulphur, %	:	2.50	2.50
	Inerts, %	;	0.45	0.45
	Higher Heating Value, Kcal/Kg	:	3800	3700
12.	BL viscosity at 70% Conc. and 110 deg. c, Centi poise	:	570	570
13.	BL viscosity at 65% Conc. and 110 deg. c, Centi poise	:	126	126
14.	Ambient temp. deg c	:	30	30
15.	RH, %	:	90	90

Findings of Analyses and Recommendation :

1. It is possible to go to higher solid handling capacity when we have lower calorific value and lower concentration (above minimum value required for firing) of black liquor.
2. Furnace screen is to be added.
3. Superheater assemblies are to be replaced with three stage system along with desuperheater.
4. Addition of soot blowers in superheater and bank-tube area is required.
5. One FD and ID fan each to handle additional air and gas flow is required.
6. Resized SCAPH.
7. Resized Air and flue gas ducts.
8. Resized EP to handle additional salts.
9. Resized Green liquor pumps and motors.

10. Resized primary air nozzles.

11. Waterwall bends for installation of additional air nozzles and soot blowers.

With all the changes as envisaged above the capacity upgradation could be achieved.

Conclusion

Capacity upgradation of chemical recovery boilers in many cases might call for changes like introduction oi screens or additional screens etc. Hence it may be appropriate to carry out such upgradation when a major revamp and modernisation is crrried out in boilers. During this period the boiler will be down for longer duration and if needed even furnace size increase can be thought of by properly altering the water walls. The limitaations posed by NaCI in black liquor is also to be considered so that capacity upgradation in chemical recovery boilers can be achieved with optimal conditions. BHEL, having a long term experience on various types of boiler, including chemical recovery boiler, has done many renovation and modernisation in both BHEL and non BHEL boilers and hence would like to work further to share their experience.