Consumption of furnace oil in recovery boilers

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SUMMARY

The poor combustion of black liquor solids, a frequent phenomena, in Recovery boilers is coped up with employing oil burners, resulting in high furnace oil consumption, the extent varying on the individual mill's conditions. This is undesirable in view of furnace oil becoming a rare commodity and expensive too, day-by-day.

The paper briefly describes a check list for the high consumption of furnace oil based on the study at the mills and also work done by others. Besides long storage, viscosity, velocity, turbidity and causticity, silica and organic content etc., of the black liquor have generally been found to be the possible check points. In addition, the green bamboo has also been found to increase the problem of poor combustion.

The poor combustion of black liquor solids in a recovery boiler is often encountered and to cope up with the situation, oil burners are usually employed. This results in high furnace oil consumption, the extent of which varies depending upon the problem faced. Furnace oil is slowly and slowly becoming a rare commodity and its supply is also becoming eratic, besides a huge increase in its cost. Therefore, utmost care must be exercised in its use.

The poor combustion of black liquor solids results in the following problems in the plant :—

a) The combustion in the furnace is not spontaneous.
b) Even after reaching the hearth, the black liquor remains wet. To be more precise, it is not sufficiently dried to support spontaneous combustion.
c) It burns slowly, sticks to the hearth and jams the ports resulting in furnace dullness and spout jamming.
d) Frequent nozzle choking and gun puncturing.

It was observed at the mills that, though, the oil consumption per ton of pulp remains in the range of 16 to 20 litres, it goes as much high as 40 to 45 litres during the months of April to July. This problem was observed minutely and analyses were carried out to study it during last few years. Our studies and other work done in this field indicate the following reasons, which could be considered as a check list for the problem, instead of each being a remedial measure.

STORAGE

When the liquor remains stagnant for long period and it is mixed with fresh liquor, it tends to deposit the solids due to lignin precipitation supplemented by fines, Calcium ions or carbonisation of various organic substances. This especially happens whenever the plant is shut for a longer duration, i.e. Annual Shut etc.

VISCOSITY

It is reported that the viscosity variation in the black liquor with total solids of 55% and above is

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very wide to the extent varying ±25%. Our experience have indicated that, some times, it goes even higher than ±25%. Naturally, it is very difficult to handle such an unpredictable variations in viscosity of black liquor to monitor its smooth firing in the furnace. The hemicelluloses and other low grade carbohydrates dissolved along with lignin during digestion are to a great extent responsible for the increase in black liquor viscosity especially at above concentrations, besides the role of temperature.

VELOCITY

The velocity of the liquor during firing, whenever high bore spray gun is used, is low leading to the formation of a thin coating of scale appearing on the inside surface of the spray nozzle and gun. This results in frequent puncturing of the gun as well as interruption in firing. One has to choose the optimum bore of the spray gun. For example, it is understood that Andhra Pradesh Paper Mills Ltd. could solve the problem by replacing 38 mm bore with 25 mm. At this mill, 25 mm is the usual bore used.

TURBIDITY & CAUSTICITY

The higher turbidity and lower causticity in white liquor increasing the inert material leads to a dead load in the system. This causes a harder chemical bed and primary port blackening.

SILICA

In bamboo, silica occurs both in soluble and insoluble forms and the resultant black liquor contains more silica than that of soft and hardwoods. After cooking, the total soluble and a part of insoluble silica go to the recovery plant along with the black liquor.

When the black liquor concentration is raised beyond 45%, the splitting tendency of Silica increases, being maximum when the free alkali content of black liquor is sufficiently low. To suppress the splitting of silica and precipitation of lignin, it is a common practice to add caustic soda in the evaporator section. It has been found that silica along with lignin precipitates even at a pH of 9.8 and hence the best way to prevent such splitting is to maintain the pH above 10. The precipitated silica appears at gun and nozzle coating causing flow restriction and improper spray etc.

INVERSE SOLUBILITY

The inorganics mainly responsible for scale formation are Sodium Sulfate, aluminium silicate and Calcium Carbonate, which follow inverse solubility phenomena, i.e. the solubility goes down when the temperature is increased beyond an optimum resulting in deposition in gun and nozzle.

ORGANIC CONTENT AND CALORIFIC VALUE

It is well known that the ratio of organic to inorganic in black liquor solids plays an important role in combustion. If and when, organic content goes down the problem may arise. The determination of calorific value, which is dependent upon the organics, can give an indication of this aspect.

The above reasons could explain the normal variations of 16 to 20 litres of oil consumption per ton of pulp at our mills. Depending upon the gravity of each of the above reasons, the problem faced with the black liquor cumbustion may vary.

To study the abnormal increase in oil consumption during a particular period from April to July, a special study was made as per the detail in the foregoing paragraphs.

Though, no quantitative assessment could be made, it was found that the green bamboos, i.e. freshly felled and without seasoning were consumed in a very high and widely varying proportion during the said period. The study indicated that there is not much difference in other process variables during this period when compared to the months of normal consumption of oil, except the use of green bamboo. The day-to-day consumption of furnace oil varies in wide range from 16 to 45 litres per ton of pulp and the quantity of green bamboo too, varies in wide range.

In view of the above context, the detailed analytical work on green as well as dry bamboo was carried out as per the following details :—

Detailed proximate analysis of screened samples of dry and green bamboo chips was carried out. Cooking experiments under similar conditions stimulating the plant were also carried out and the resultant black liquor was concentrated in laboratory flash evaporator to a density of 66 °TW and analysed. The average results given in the table, lead to the following inferences :—

(i) The average pH of the extracts of old and green bamboo were found to be 7.50 and 5.35 respectively. The low pH of green bamboo is indicative of the presence of higher content of fatty acids and resineous matter. This is further corroborated by the Al-benzsolubility values, which in case of green bamboo is 5.93%

EXPERIMENTAL RESULTS

Sl. No.	Particulars	Unit	100% dry bamboo		100% green bamboo	
(1)	(2)	(3)	(4)		(5)	
1.	**Chips classification**					
	Retention on +32	%	7.3		1.8	
	−32+25	%	8.4	29.6	18.2	46.2
	−25+22	%	5.3		9.5	
	−22+19	%	8.6		10.4	
	−19+16	%	13.2		15.8	
	−16+13	%	17.5		16.0	
	−13+6	%	34.9		19.4	
	− 6+3	%	4.8		2 6	
2.	**Proximate analysis**					
	Alcohol solubility	%	3.27		5.93	
	Benzene					
	Lignin	%	24.84		26.00	
	Silica	%	1.08		2.11	
	pH (1% extract)	—	7.50		5.35	
3.	**Cooking conditions**					
	Moisture	%	6.6		10 0	
	Alkali as Na_2O in B.D. bamboo	%	17.5		17.5	
	Sulfidity	%	19.0		19.0	
	Steam ng to 160°C	Minute	120		120	
	at 160°C	"	120		120	
	Pressure	kg/cm²	5.5		5.5	
	Bath ratio		1:1.27		1:1.27	
	K. No.	—	19.1		20.5	
4.	**Weak Black liquor analysis**					
	Density	°TW	26		25	
	Temp.	°C	35		37	
	Free alkali	g/l	12.8		12.0	
	pH	—	10.55		10 40	
	Total solids	%	24 26		22.09	
	Organic	%	53.77		52.74	
	Inorganic	%	46.23		47.26	
	(on Inorganic basis)					
	$NaOH + Na_2S$	%	14.04		11.77	
	Na_2CO_3	%	65.08		62.40	
	Na_2O	%	48.95		45.62	
	NaCl	%	2.57		2.87	
	$Na\ SO_4$	%	5.15		5.88	
	Acid insolubles	%	11.4		9.35	
	Silica	%	7.95		6.17	
	R_2O_3	%	1.95		2.05	
	CaO	%	1.31		2.05	
	Viscosity of black liquor °TW —spindle 4 and speed 20 RPM	cps (Brook field) (RVT model)	190		395	

against 3.27% of dry bamboo. The excessive fatty acids and resinous matter may increase black liquor viscosity when it is concentrated in the evaporators Viscosity of green and dry bamboo thick liquor has been 395 cps, 190 cps respectively. It is quite likely that due to comparatively higher viscosity, the size distribution of green bamboo black liquor during spray is badly affected and the drops are not easily entrained by the furnace gases. The result is that the black liquor reaches the furnace hearth in a relatively wet state and burns very slowly. Howevr, as per our practical experience, the increase in furnace air temperature has been found to reduce the problem to some extent.

(ii) The packing chips in the digester is not uniform due to the presence of higher percentage of slivers from green bamboo. The chip classification indicates that fractions retained over + 19 mesh in case of green bamboo is 46.2% and 29.6% for old bamboo. The higher slivers content in case of green bamboos results in increased number of re-blows. This enhances the severity of treatment and probably increases the dissolution of degradable carbohydrates and hemicelluloses in the black liquor deteriorating its quality.

The above facts lead to the conclusion that the use of green bamboo is quite detrimental for the black liquor quality with regard to its combustion. One solution could be to season the green bamboo before its use. However, its practical aspects have to be further studied.

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