Effective Evaporator Maintenance Through Process Development

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Utilization of more and more hardwoods poses serious problems before Soda Recovery evaporarion units. Hardwood Black Liquors have a tendency to granules formation between 25–40% Total Solids which in its turn tend to plug the evaporator tubes and hamper the heat transmission rate and performance of the evaporators. This results in frequent boilouts, cleaning and maintenance shuts–which means loss of production and economy. Plugged material in the evaporator tube has been shown to be different than the scales formed in the high temperature effects. A novel method of mixing dilute MHW liquor with concentrated bamboo liquor has been developed through laboratory and plant efforts which subsides the intensity of granules formation, eases the operation and cuts down the maintenance time needed for tube cleaning, boilouts etc.

Among the many interesting problems surrounding the Soda Recovery operation, the outstanding one at present is adequate means of measuring the performance of a commercial evaporation unit in such terms that a systematic approach can be made to improve the unit as such or its method of operation. This is the fundamental area in evaporation practice, properly speaking; it is concerned mostly with the manner in which, and the extent to which, the Black Liquor components affect the evaporation and granulation characteristics, and then also what consequences these behaviours have had upon scaling, evaporator performance and downtime. As a rule water removing potentials depend upon how much we know in detail for each of the major Black Liquor components regarding these specific characteristics which they affect.

Historically, until a very few years ago, any operation had developed primarily through the skill and ingenuity of the operator himself with little assistance from the technical man. Development has been largely by trial and error. This has been true to the time, when the back history and the origin of the Black Liquor to be processed was more or less the same. But with the utilization of more and more hardwoods, a serious situation is posed before the soda recovery operations, due to different physico and physico-chemical characteristics of Black Liquors. Simultaneously a parallel development by the scientist has crept into the background to assist the plant personnel in his searches for advanced techniques.

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The maintenance and repair of equipment is a major item of cost and continuous service of the unit is vital for the sake of production. This in its term, not only details performance and costs but reveal areas of excessive repairs and downtime in proportion to production and permit prompt action to correct trouble areas.

Hardwood B. L. are a class of their own characterizing themselves with granule forming tendency between 25–40% concentration. With the evergrowing scarcity of fibrous raw materials, more and more local hardwoods are to be processed with higher and higher resultant load on soda recovery. Availability of various North Kanara Hardwoods is as given below :

Botanical name	Local name	Availability %
1. Xylia xylocarpa	Jamba	28.8
2. Terminalia tomentosa	Matti	16.8
3. Terminalia paniculata	Kindal	11.9
4. Anogeissus latifolia	Dindal	11.5
5. Lagerstromia lanceolata	Nandi	9.9
6. Kydia calycina	Bhendi	7.5
7. Grewia tiliaefolia	Dhaman	2.1
8 Dilleria pentagyna	Karmal	4.2
9. Careya arborea	Kumbai	4.0
10. Adina cordifolia	Heddi	1.7
11. Mitragyna parviflora	Kalam	1.2
12. Bombax melabarica	Bural	0.4

The problem encountered with JMK (Jamba, Matti and Kindal) are a matter and concern not to be overlooked. For every tonne of pulp from these three hardwoods about 2.2 tonnes of Total Solids go to recovery against (>2) tonnes for other light hardwoods and 1.5 tonnes for bamboo

Mixed evaporation of Bamboo, Euc. and MHW Black Liquors :

Accordingly the work was planned and as a preliminary study the granule forming tendency of various black liquors was studied in a Rotary Vacuum Flash Evaporator. Bamboo, Eucalyptus, MHW* and JMK* black liquors were taken for the purpose. Bamboo and eucalyptus black liquors did not pose any granulation problems except for higher viscosity of Eucalyptus black liquor. The black liquors from MHW and JMK showed granules even at 25% T.S. or less.

It is clear from above evaporation studies that there is an increased response for granulation with more than 20% hardwood black liquor. Below 20% the response for granulations suddenly decreases. When MHW is substituted by eucalyptus black liquor, the qualities are not affected except for an increas, in viscosity of the black liquor. When MHW was substituted by Eucalyptus, the response for granulation was substituted by Eucalyptus, the response for granulation was considerably decreased.

Table—I Mixed Evaporation

Bamboo	Eucalyptus	MHW	% conc. at which granulation starts	Characteristics of Concentrated Black Liquor			
				pH	Dyn. % solid	viscosity at 90°C cps	Nature
60	—	40	32 0	11.0	51.0	8.5	Heavy granules in 5%
60	10	30	34.0	11.0	48.0	7.3	-do-
60	20	20	36.5	11.0	49.8	9.5	Less granules
60	30	10	51.0	11.1	49.3	10.7	Concentrted liquor was clear. Slight granules at 56%

*MHW—A mixture of Nandi, Bhendi, Dhaman, Dindal, Ghoting, Heddi, Teak. Garjan, Poon, Kalam.

JMK– Jamba, Matti and Kindal

The above Laboratory data are further confirmed by the plant evaporation performance data (collected from January 1973 onwards for two years)

An analysis of the Plant Performance Data for two years leads to following observations:

i) Increasing the amount of Eucalyptus to as high as 25% along with bamboo does not create any significant variation in evaporator performance when compared with pure bamboo liquor processing.

ii) Hardwoods upto 10% along with bamboo (65%) and eucalyptus (25%) is not creating much trouble to evaporators.

iii) Hardwoods above 10% level seem to aggravate the situation towards bad performance, however the condition becomes worse around 20% or more of hardwood, (how so little eucalyptus may be) and resultant effect is plugging of tubes (high density effect); partial at about 15% and full at about 20% level.

Granule Formation, Scaling and Developed Evaporation Technique

Formation of granules may be attributed to Kinos[1] (a mix of various Polyphenols) ellagic acid, ellagitannins present in Black Liquor, as mentioned by Hillis and Carle[2] Ellagic acids and salts have been mentioned to make liquors excessively viscous. During evaporation, it is said to be responsible for gritty granules formation and cause of troubles in subsequent operations. Precipitation of inorganic components like Na_2SO_4, Na_2CO_3. $CaSO_4$ etc. is also a mention[3]. The system Na_2CO_3–Na_2S–H_2O is also not to be overlooked as equilibrium relationships predict a zone of phase separation[4]. Such conditions singly or in combination may give rise to such phenomenon as granulation, phase separation and scaling etc. Conc. of such granules vary from 4 to 11 gpl in SCBL (55° Tw at 104° C.). Such tendencies diminish rate of heat transfer, foul the evaporator tubes and above all hamper production.

Scale formation is one of the non-controlled factors, which affect the rate of evaporation. We generally come across two types of scales in our mill practices: (a) Hard scale, generally encountered in the last but one effect. (b) Soft material plugging the tube in the last effect. Some of the scales and plugged materials collected on various dates were analysed for various components. The results are given in Table 2 (I and II).

Hard scales were observed in high density and high temperature effects. In all the hard scales fibrous material was also present. Plugged material in the tubes seems to originate from granules as the composition of granules and the granular mass collected from high density effect was nearly the same (See table 3 (I & II) and table 2 II.

These granules may be filtered out and the resulting black liquor may be mixed with bamboo liquor and evaporated further. By such a method further granulation is subsided.

Developed Evaporation Technique

A developed evaporation technique for hardwood black liquor was tried on Laboratory scale, where weak black liquor from hardwood is mixed with concentrated black liquor from bamboo and subjected to further evaporation. The results shown in the table below, show better evaporator performance. As is clear, black liquor may be added at a stage of about 40% concentration. The relevent data are presented below.

Expt. No.	1	2	3	4	5
*Bamboo %	70	60	50	70	30
*MHW %	30	40	50	30	30
N B.					
Conc. of bamboo liq. at which MHW WBL added	50.0	50.0	50.0	40.0	18.2
% Conc. at which granulation starts	53.5	48.5	46.0	50.0	34.0

*Black liquors are mixed on total dry solid basis.

The higher viscosity of Bamboo BL at higher conc. seems to hamper ppm and granule formation of MHW liquor.

Table 2

I) Composition of Evaporator Hard scales:

Components	% in scale of effect No. 1st 14.1.75	1st 1.2.75
Ash	81.4	86.0
HCl insolubles	63.0	59.0
Silica as SiO_2	50.5	58.5
R_2O_3	Traces	2.8
CaO	Traces	12.5
13% caustic solubles	—	11.5
Hot water insolubles	91.0	—
Undetermined	—	12.2

II) Composition of Evaporator Plugged Materials

Components	% in plugged material of effect No. IInd 15.11.74	IInd 13.12.74	IInd 15.1.75	IIIrd 7.2.75
Inorganics as NaOH	65.5	49.0	60.7	47.0
Organics	34.5	51.0	39.3	53.0
Na_2CO_3 as NaOH	35.6	48.5	—	44.5
Na_2SO_4	2.6	2.18	3 15	3.04
SiO_2	2.85	1.44	3.7	—
R_2O_3	0.284	0.215	—	—
CaO	0.24	0.23	—	—

Table 3

I) Concentration of Granules in the SCBL

Date & Time	Temp. °C	°Tw	% Solids	*Granules gpl
5.2.1975, 3.00 pm	102	55	50.5	4.0
6.2.1975, 11.00 pm	104	55	50.8	7.0
6.2.1975, 4.00 pm	103	56	51.0	11.0
15.2.1975, 11.00 pm	103	54	48.7	4.0

*Granules grams per litre of SCBL.

II) Composition of granular mass collected

Expt No.	1	2	3
Inorganics as NaOH, %	45.5	40.0	42.0
Organics as NaOH, %	54.5	60.0	58.0
**Na_2CO_3, %	42.5	38.0	39.6
Na_2SO_4, %	3.8	3.08	3.25

**Na_2CO_3 is determined in ash.

Mixed Hardwood B.L. seem to contain substantial amount of high polymers originating from high hemicellulose content. Furthermore, the solids being relatively unstable may undergo such processes as volatilization, oxidation, polymerization etc. even on standing at Room temperature and show 'thixotropic behaviour' i.e., the liquor becomes a gel upon standing and resumes flow upon stirring. The thixotropic behaviour of a B.L. may be represented by following relationship :

$$\mu = \mu^{\circ} + \frac{\theta}{\partial}$$

where

μ = apparent viscosity

∂ = rate of shear

μ° = residual viscosity

θ = coeff. of thixotropy

Concentration problems due to high viscosity and plugging tendency can be solved by utilization of forced circulation evaporators. The flow behaviour through the evaporator tubes is governed by Grashof group $\frac{D^3P^2g\ \beta \triangle t}{\mu^2}$, with very viscous liquors there is no alternative but to use forced circulation evaporators. Also the tendency to form scales or deposit of salts is overcome by the use of high velocities obtainable by the use of circulating pumps.

Lastly, whether the problems be one of replacing unreliable and inefficient equipment or providing for the development of new process, the plan and project should be based on a through, fundamental study by the company's engineers. Development of such processes for modernizing the evaporation unit should begin with a thorough study of present and future production and recovery load accordingly. Without a basic understanding of these, the desirability of new unit cannot be properly judged and the effective maintenance of evaporation unit will only be a dream.

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