

Effect of residual active alkali on viscosity of bagasse kraft black liquor in comparison to wood black liquors

Marimuthu P.*, Reddy K.P.*, Mohan Rao N.R.*

ABSTRACT

Black liquor characteristics like Residual Active Alkali (RAA), Viscosity, Swelling Volume Ratio (SVR), Inorganic content and Gross Calorific Value play a vital role in recovery operations. This paper highlights the bagasse black liquor properties in comparison to wood black liquors. Emphasis is drawn on the influence of Residual Active Alkali on viscosity at different concentrations in laboratory studies and in plant.

Introduction :

In the Kraft pulp mills black liquor is evaporated and burnt in the recovery furnace for the recovery of energy and chemicals. The black liquor characteristics are of paramount value to understand the dynamics of evaporation and pyrolysis in the furnace.

The important black liquor characteristics from operation perceives are viscosity, heating value and boiling point elevation(1). Among these, Viscosity plays the most important role because of its effects on evaporation rate, heat transfer rate and liquor spray size. Viscosity changes with composition, temperature and pulp mill operating conditions(2). Changes in the alkali content of the black liquor may possibly affect the viscosity (3). The viscosity of black liquor increases as the solid content increases or as the temperature decreases. The nature of organics, molecular weights and colloidal state are important factors in determining the viscosity of a particular liquor. These are affected by wood species and type, pulping conditions and subsequent processing conditions (1). Higher Heating value (HHV) is a measure of amount of heat released during burning. It has a large impact on steam generation rate and pulp production rate(3).

Approach to the Problem

Tamil Nadu Newsprint and Papers Ltd.,(TNPL) is a bagasse based paper mill producing newsprint out of

bagasse first time in the world. The mill also employs hard wood pulping as a reinforcement fibre to the bagasse fibre. TNPL utilises a wide variety of hard wood raw material such as Eucalyptus hybrid, Eucalyptus grandis, Karuvelam and wattle as per the availability and the Govt. allocations. The pulping conditions and the black liquor characteristics of these raw materials are vitally different. The key issue, as far as the evaporation in recovery is concerned is the variation of RAA. The heterogeneity in black liquor properties causes confusion and often leads to operational difficulties in the pulp mill and recovery section. To prevent this it is becoming increasingly necessary to understand the behaviour of different black liquors.

Results And Discussions:

Plant Observations

Bagasse is the main raw material in TNPL for paper production along with 20–25% of Eucalyptus wood. To get bleachable grade speck and shive free pulp, it is required to go for soft cook having Kappa number 10–12 in chemical bagasse pulping and medium cook having kappa number 20–22 in Eucalyptus wood pulping. The resultant weak Black Liquor (WBL) of these processes will be having 9–11 gpl and 3–5 gpl RAA as Na_2O at 200 gpl total solids for chemical bagasse and hard wood respectively.

*Tamil Nadu Newsprint and Papers Ltd.
Kagithapuram, Tamilnadu

The typical characteristics of WBL and Semi Concentrated Black Liquor (SCBL) from different sources from the plant is given in Table-1. The hard wood and chemical bagasse WBLs are mixed in the 30:70 volume ratio, in order to meet the recovery boiler design specification and to get satisfactory performance. This mixed WBL is concentrated in multiple effect evaporators and further concentrated in Cascade evaporators. The viscosity of SCBL after evaporators is 25–30 cps at 40–42% solids. The viscosity of cascade 1 outlet (50% solids) and cascade 2 outlet (60% solids) is in the range of 500 to 550 cps and 2500 to 3500 cps respectively.

Concentration studies of plant WBL were conducted in laboratory. The results indicate that the viscosity of bagasse black liquor with high RAA (12.8 gpl) is almost similar to that of hard wood black liquor with low RAA (5 gpl) at 60% solids. The viscosity at 80 °C at different concentrations are given in Table—2. It is also interesting to note that there is significant RAA reduction in the SCBL/CBL between evaporator to flow box. This reduction may be due to direct contact of flue gas with black liquor during cascade evaporation. The RAA results are given in Table—2.

Laboratory Studies

Bagasse Black Liquors Vs Wood Black Liquors :

Vacuum flash evaporation studies were conducted at different RAA levels for bagasse and other wood raw materials. The viscosity of different raw materials at different concentrations are given in Table-5. At all RAA levels, we observe bagasse black liquor has higher viscosity values than those of other wood black liquors. This may be due to presence of pith and more silica content of bagasse black liquor. In all the cases Viscosity of pine wood black liquor is found to be low followed by wattle, Karuvelam, Eucalyptus grandis etc. The trends of log viscosity Vs total solids for all the raw materials are given in figure-1

Effect of RAA in Bagasse Black Liquor :

The results show that higher the RAA, lower the viscosity at corresponding total solids. The strong dependence of viscosity on alkali content may be attributed to the colloidal suspension of lignin molecules in black liquor. The colloidal particles are stable at higher alk-

ali concentration. When alkali concentration is decreased the colloidal particles become unstable and the viscosity increases (1). The effect of RAA in bagasse black liquor is given in Table-6.

Effect of Pith on Bagasse Black Liquor Viscosity

To study the effect of pith on viscosity, black liquors were produced in laboratory with whole bagasse, depithed bagasse and pith under standard pulping conditions and evaporation studies were carried out. The results indicate that presence of pith in bagasse increases the viscosity of black liquor at corresponding total solids. This suggests that better depithing will have significant advantages in the kraft pulping and recovery process. The trends of log viscosity vs total solids are shown in fig.2 and the results are given in Table—7.

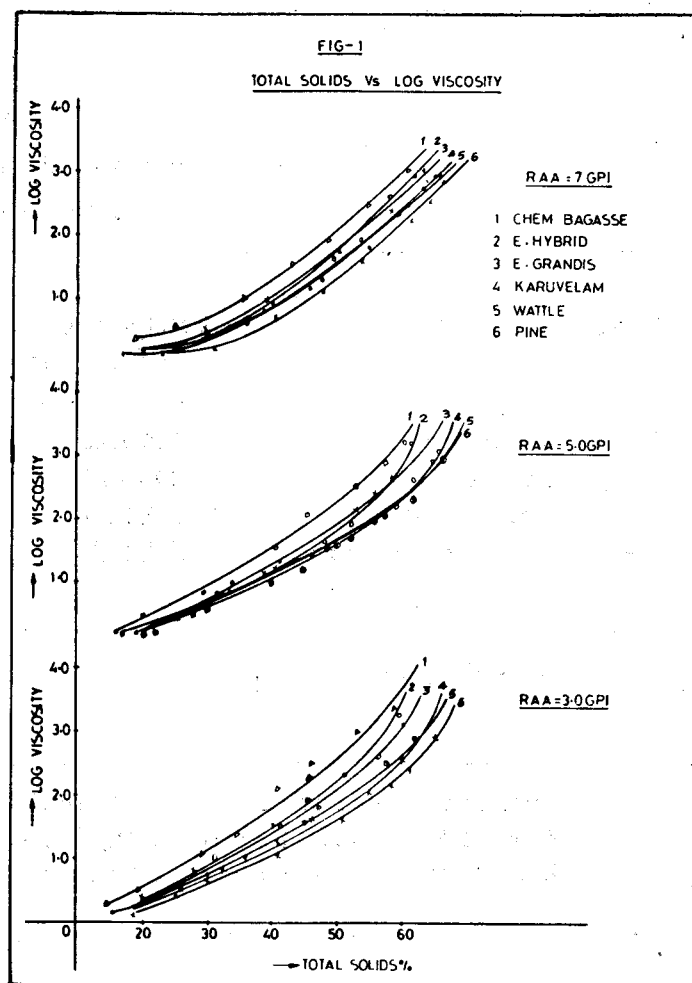


TABLE-1
 Characteristics of Black Liquors from Plant
 (Avg. Values)

S. No.	Black Liquor	Total Solids gpl/%	RAA as Na ₂ O gpl as such	Viscosity at 80°C cps as such	Silica as SiO ₂ gpl as such	Inorganics as NaOH % Total	GCV K.cal/kg Solid basis
1	Hardwood	151/14.2	2.71	2.2	0.35	33.4	3650
2	Bagasse	104/10.0	4.70	2.8	1.60	35.0	3380
3	Feed to evaporator	116/11.0	3.87	2.4	1.00	34.0	3460
4	SCBL	—/41.0	1.8%	25.0	—	34.5	3470

TABLE-2
 Viscosity of Black Liquors From Plant
 (Evaporated in laboratory)

S. No.	Black Liquor	Total Solids gpl/%	RAA as Na ₂ O		Viscosity CPS		@80°C@	
			gpl as such/200 gpl	TS	30% TS	40% TS	50% TS	60% TS
1	Hardwood	146/13.8	3.60	4.93	2.8	8.8	50	1260
2	Bagasse	116/10.5	7.44	12.8	8.0	32.0	150	960
3	HW 30 : CB 70	132/12.0	4.71	7.98	5.0	20.0	100	1000
4	Feed to evaporator	118/10.9	6.57	6.57	6.3	25.0	110	1000

Black Liquor From Plant	RAA as Na ₂ O % on TS basis	Viscosity at 80°C cps
Semi Concentrated Black Liquor (40% Solids)	— 4.8—6.0	25—30
Cascade Evaporator—1 outlet (50% Solids)	— 3.0—4.0	500—550
Cascade Evaporator—2 outlet (60% Solids)	— 1.8—2.5	2500—3500

TABLE—3
Kraft Pulping Conditions

S. No.			Chemicals As Na ₂ O %	Total Pulp Yield%	Kappa No.	*RAA as Na ₂ O gpl	*TTA as gpl Na ₂ O
1	Bagasse* (Depithed Bag)	a)	10.0	61.0	18.8	3.03	22.9
		b)	12.0	56.2	15.2	5.23	25.4
		c)	14.0	52.2	12.8	7.72	29.3
2	Eucalyptus Hybrid	a)	13.0	47.0	28.0	2.92	27.9
		b)	15.0	45.4	26.0	4.83	32.9
		c)	17.0	45.0	23.0	6.83	38.4
3	Eucalyptus Grandis	a)	11.0	56.8	24.2	2.92	24.9
		b)	13.0	53.4	22.3	5.43	29.2
		c)	15.0	53.1	20.0	6.76	33.8
4	Karuvelam	a)	13.0	59.2	26.6	3.32	25.8
		b)	15.0	54.0	22.8	5.31	29.8
		c)	17.0	52.0	20.6	7.10	32.7
5	Wattle	a)	11.0	58.2	27.0	3.10	20.5
		b)	13.0	53.6	24.1	4.78	26.8
		c)	15.0	52.0	21.4	6.70	31.0
6	Pine	a)	15.0	47.7	36.8	3.44	24.8
		b)	17.0	44.7	29.2	5.85	27.3
		c)	19.0	42.1	24.5	7.82	32.2

* TTA and RAA results expressed as Na₂O at 200 gpl Total Solids basis.

* Fibre to Pith Ratio of Whole Bagasse — 1.80 : 1
 Fibre to Pith Ratio of Depithed Bagasse — 2.40 : 1
 Fibre to Pith Ratio of Pith — 0.32 : 1

TABLE—4
Properties of Black Liquors

S.No.	Black Liquor		Chemicals as Na ₂ O %	pH	*TTA as Na ₂ O gpl	*RAA as Na ₂ O gpl	Inorg. as NaOH %	SVR ml/g	G.C.V K.Cal/Kg. on TS basis
1	Bagasse	a)	10.0	11.2	22.9	3.03	28.2	14	3850
		b)	12.0	11.8	25.4	5.23	30.6	13	3480
		c)	14.0	12.6	29.3	7.72	32.2	13	3200
2	Eucalyptus Hybrid	a)	13.0	11.8	27.9	2.92	28.2	20	3910
		b)	15.0	12.2	32.9	4.83	29.8	18	3730
		c)	17.0	12.6	38.4	6.87	31.4	18	3520
3	Eucalyptus Grandis	a)	11.0	11.9	24.9	2.92	29.6	20	3970
		b)	13.0	12.4	29.2	5.43	30.9	20	3810
		c)	15.0	12.8	33.8	6.76	32.7	22	3570
4	Karuvelam	a)	13.0	12.0	25.8	3.32	30.1	65	3780
		b)	15.0	12.5	29.8	5.31	31.8	63	3660
		c)	17.0	13.2	32.7	7.10	33.3	65	3570
5	Wattle	a)	11.0	11.0	20.5	3.10	28.2	70	3830
		b)	13.0	12.1	26.8	4.78	29.4	65	3700
		c)	15.0	12.9	31.0	6.70	31.4	65	3550
6	Pine	a)	15.0	12.8	24.8	3.44	30.1	80	3810
		b)	17.0	13.1	27.3	5.85	32.1	80	3660
		c)	19.0	13.3	32.2	7.82	33.8	80	3370

*TTA and RAA results expressed as Na₂O at 200 gpl Total Solids basis

TABLE-5

Viscosity of Different Black Liquors @ Different Solids (RAA- 3.0 gpl)

Sr. No.	Black Liquor	RAA as Na ₂ O gpl	Viscosity at 80°C (cps) @			
			30% TS	40% TS	50% TS	60% TS
1	Chem. Bagasse	3.03	13.0	56.0	355.0	3160
2	Eucalyptus hybrid	2.92	8.0	28.0	250.0	1990
3	Eucalyptus grandis	2.92	7.0	25.0	160.0	1120
4	Karuvelam	3.32	5.0	14.0	56.0	400
5	Wattle	3.10	5.6	18.0	70.0	445
6	Pine	3.44	4.0	11.0	40.0	200

Viscosity of Different Black Liquors @ Different Solids (RAA-5.0 gpl)

1	Chem. bagasse	5.23	8.0	32.0	160.0	1410
2	Eucalyptus hybrid	4.83	5.0	16.0	63.0	800
3	Eucalyptus grandis	5.43	5.0	18.0	70.00	500
4	Karuvelam	5.31	5.0	14.0	50.0	230
5	Wattle	4.78	4.5	14.0	45.0	200
6	Pine	5.85	4.5	13.0	40.0	200

Viscosity of Different Black Liquors @ Different Solids (RAA-7.0 gpl)

1	Chem. bagasse	7.72	5.0	18.0	110.0	900
2	Eucalyptus hybrid	6.87	3.0	10.0	56.0	560
3	Eucalyptus grandis	6.76	2.5	9.0	56.0	400
4	Karuvelam	7.10	2.5	7.1	35.0	250
5	Wattle	6.70	2.2	6.3	32.0	200
6	Pine	7.82	2.0	5.0	20.0	160

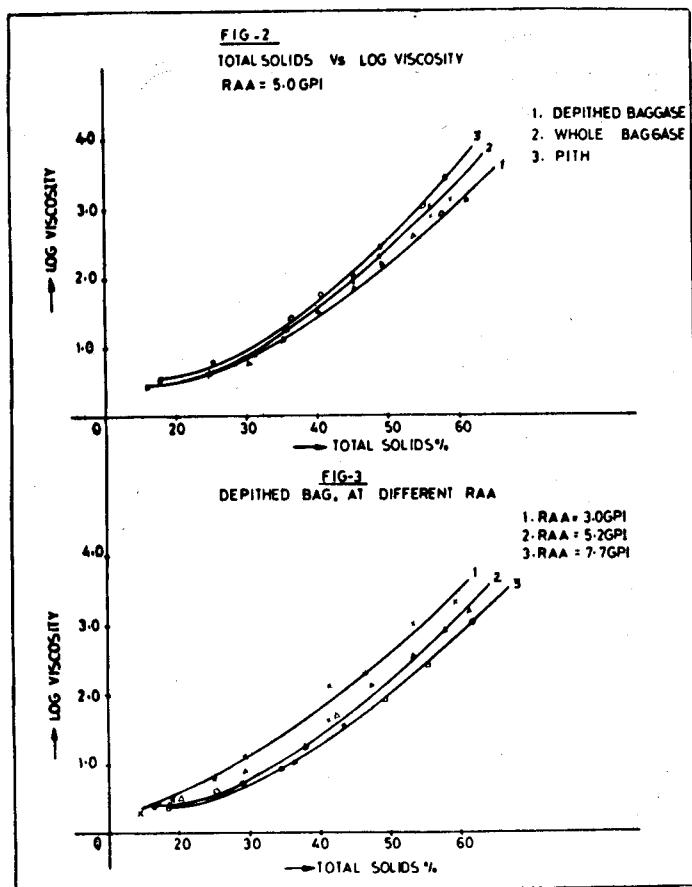
*RAA results expressed as Na₂O at 200 gpl Total solids basis

TABLE-6
Viscosity of Depithed Bagasse Black Liquor at Different RAA

S. NO	RAA as Na ₂ O gpl at 200 gpl T.S	Viscosity at 80°C (cps) @			
		30% TS	40% TS	50% TS	60% TS
1	3.00	13.0	56.0	355	3550
2	5.20	8.0	32.0	160	1410
3	7.70	5.0	18.0	110	900

TABLE-7
Effect of Pith Content on Black Liquor Viscosity at Similar RAA (5.0 GPL)

S. NO	Black Liquor	RAA as Na ₂ O gpl 200gpl	Viscosity at 80°C (cps) @			
			30% TS	40% TS	50% TS	60% TS
1	Whole bagasse	5.12	7.0	32.0	250	2000
2	Depithed bagasse	5.20	8.0	32.0	160	1410
3	pith	4.73	9.0	45.0	280	2510



Heating Value

Heating value is a measure of amount of heat released, and it varies when organic content changes. However the heating values of black liquors with different chemical dosages at given cooking conditions fall within limits (3300 to 3800 K.Cal/Kg.). Therefore, the utilisation of raw materials with regard to heating value will depend on the requirement of the mill. Heating value and swelling volume ratio (SVR) values of black liquors obtained under this study are given in table-4. SVR is a semi quantitative measure of degree of pyrolysis. It is interesting to note that there is significant difference in the SVR among different black liquors. From the results it is evident that pine black liquor contains significantly high SVR (80 ml/g). Although Eucalyptus hybrid and eucalyptus grandis have low SVR (18-20). The SVR of bagasse black liquor (13 ml/g) is observed to be the least in the series.

Experimental : Kraft Pulping

Different kraft pulping experiments were carried out in laboratory using an electrically heated rotating digester

with Bagasse, Eucalyptus hybrid, Eucalyptus grandis, karuvelam, wattle and pine with different alkali charge to produce black liquors of approximately similar RAA levels (three groups of RAA levels of each raw material is tried). These are designated as low RAA (3 gpl), medium RAA (5 gpl) and high RAA (7 gpl). The pulping results are shown in Table-3.

Evaporation And Viscosity.

Evaporation was carried out in laboratory using Vacuum Flash evaporator to get black liquors of different solids. The viscosity measurements are conducted using LVTD modle Brooke Field Digital viscometer at 80 °C with small sample adapter for all black liquors.

Observations.

1. Viscosity of bagasse black liquor is high compared to wood black liquors at all RAA levels.
2. The viscosity of bagasse black liquor with high RAA (12.8 gpl) is similar to that of hard wood black liquor with lower RAA (5 0 gpl) at 60 % solids.
3. The viscosity of feed WBL evaporated in laboratory to 60 % Total Solids is around 1000 cps (low) against 2500–3500 cps of plant CBL sample. This may be due to RAA reduction across the cascade evaporation with flue gas.
4. Pine black liquor is having SVR 80 ml/g (high) followed by wattle and Karuvelam (65 ml/g), Eucalyptus varieties (18 to 20 ml/g). The SVR of bagasse black liquor is the least (13 ml/g).
5. The viscosity of the Bagasse black liquor increases as the presence of pith increases in the raw material.

Acknowledgement.

The authors thank the TNPL management for granting permission to present this paper in the IPPTA zonal seminar at Hyderabad.

References.

1. W.J Frederick 'TAPPI PROCEEDINGS', orlando 22–27, 1989 kraft Recovery Seminar.
2. W.J Frederick 'TAPPI PROCEEDINGS' Orlando 11–16 1987 Kraft Recovery Seminar 1992.
3. E.Milanova and G.M.Dorris –Journal of JPPS 16, 3, 1990.