# Behaviour of mill bamboo, bamboo+mixed hard woods (70:30)%, bambo+mixed hard woods (50:50)% and mixed hard woods kraft black liquor on evaporation and addition of alkali

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## SUMMARY

Mill weak black liquor, Bomboo, Bamboo+mixed hard woods (70:30), Bamboo+mixed hard woods (50:50) and hard woods black liquor were evaporated to different total solid contents to see the behaviour of these liquor especially on black liquor viscosity and density It has been observed that mixed hard woods black liquor has higher viscosity as compard to Bamboo and with increase in hard wood percentage the viscosity of black liquor increase as we go on increasing the percentage of total solids. The black liquor viscosity of bamboo, Bamboo+mixed hard woods in different proportion and mixed hard woods can be reduced with increase in initial residual active alkali of the black liquor. This can help in reducing the Clogging of the evaporator tubes and better performance of the recovery

## INTRODUCTION

In view of the shortage of paper and paper products as expected, India has to increase its installed capacity of paper and board industry to 42.5 lakhs tonnes per year by 2000 A.D. from the present 18.26 lakhs tonnes. To meet this challenge 20 lakh A.D. tonnes of bamboo and 47 lakh tonnes of debarked wood will be required. Bamboo forests are depleting fast and the paper industry is under constant constraint to use more and more of hard woods to meet the pulp, paper and paper products demand in the coming decade.

To meet the paper shortages the only alternative left before the pulp and paper industries is to use maximum hard wood percentage but the problems in using hard woods are mainfold due the heterogenous nature of the available tropical woods. Black liquors from hard woods pose serious problems in the multiple effect evaporator due to high scaling and high viscosity[2].

Cooking of hard woods leaves cnsiderable quantity of fines in the black liquor resulting in aggravating the scaling property. Most of the hard wood black liquors as reported earlier[3] has granules forming tendency between 25-40% concentration.

(This granule formation may be attributed to kinos[4] a mix of various phenols) ellagic acid, ellagitannis present in the black liquor. Hillis and casle[5] mentioned that ellagic and salt make liquor excessively viscouse. During operation it is said to be responsible for gritty granules formation and cause of troubles in subsequent operation. Precipitation of inorganic components like $Na_2SO_4$, $Na_2CO_3$, $CaSO_4$ etc is also reported[6]. Hard woods black liquors are colloidally unstable. This instability may be due to salting out and instability of alkali lignin and its condensation products formed during pulping[7].

In our mill we are using 65-70% Bamboo and 30-35% mixed hard woods in the mixed digestion. Bamboo (Dendrocalamus strictus) and mixed hard woods composed of Sal (Shorea Robusta) Salai (Boswelia Serrata) forms 50% of the total hard woods and remaining hard wood species are Saza (Terminalia Tomentosa), Tendu (Diospyros melanoxylon), Harra (Terminalia Chebula), Haldu Adina C rdifolia) and Gunja Garuja Pinnata etc. It had been observed that with the increase in percentage of hard woods scaling or fouling of tubes takes place very often and it is difficult to concentrate

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the black liquor beyond 35% solids in multiple effect evaporator. Since the mill inception the black liquor from multiple effect evaporators is concentrated further by the forced circulation concentrator upto 40-45% total solids. The scaling problem still persists. Bamboo, Bamboo+mixed hard wood (70:30), Bamboo+mixed hard woods (50:50) and mixed hard woods (100%) black liqnors were studied on a laboratory scale for their behaviour during evaporation at various percentage of total solids and findings were compared with mill black liquor.

## EXPERIMENTAL

Screened Bamboo, Bamboo+mixed hard woods (70:30), Bamboo+mixed hard woods (50:50) and mixed hard woods (100%) chips (−29+10mm.) were digested with 16.0%, 18%, 18% and 18% alkali (Sulphidity 21.5%) respectively in a forced circulation electrically heated digester of 30 litre capacity and bath ratio was kept at 1:4. All the digestions were carried out for five hours (90 mts. hold time at 165°C). The resulting black liquors were collected, analysed and also concentrated in vacuum flash evaporator to different percentage of total solids. The viscosities of the liquors were determined at 90°C in a oil constant temperature bath using 200 and 300 No. Ostwald viscometers.

Mill weak black liquor was also collected and evaporated to different percentage total solids and corresponding viscosities were determined. The results are tabulated in Table—1. The effect of evaporation of black liquor to different total solids viscosity is depicted in figure—1. Different alkali

### Table No.—1

Effect of Evoporation of mill weak black Liquor Viscosity

| S. No. | Tweddle at 60°C | Density at 60°C | Total Solids %W/W | Viscosity at 90°C CPS |
|--------|-----------------|-----------------|-------------------|------------------------|
| 1. | 13.5 | 1.080 | 16 0 | 1.21 |
| 2. | 18.0 | 1.109 | 19 9 | 1.38 |
| 3. | 22.5 | 1.131 | 25.0 | 1.48 |
| 4. | 37.5 | 1.203 | 39 5 | 1.70 |
| 5. | 42.0 | 1.231 | 44.5 | 3.10 |
| 6. | 45.0 | 1.248 | 49.0 | 5.80 |
| 7. | 50.0 | 1.273 | 51.2 | 12.80 |
| 8. | 54.0 | 1.280 | 52.0 | 16.70 |
| 9. | 56.0 | 1.298 | 53.0 | 2380 |
| 10. | 60.0 | 1.313 | 54.0 | 37 54 |

Note—Weak black Liquor taken for evaporation has R.A.A. 15.5 g/l Na$_2$O Same black Liquor was used throughout thu experimental work.

dosages were added in mill weak black liquor and the black liquor samples were concentrated to different total solids. The results are given in table—2 and the effect of evaporation of black liquor total solids versus viscosity is represented in Fig—2.

### Table No.—2

Effect of Evaporation of weak black Liquor on Viscosity

(Alkali dosages added before evaporation)

| S.No. | Black Liquor Concentrated (Tweddle at 60°C) | Density at 60°C | Total Solids%W/W | Viscosity at 90°C CPS |
|-------|----------------------------------------------|-----------------|------------------|------------------------|
| 1. | Black Liquor having R.A.A. 18.6 G/L as Na$_2$O | | | |
| 1. | 42.0 | 1.252 | 44.0 | 2.83 |
| 2. | 46.0 | 1.258 | 46.8 | 3.74 |
| 3. | 47.0 | 1.268 | 48.0 | 5.04 |
| 4. | 52.0 | 1.280 | 50.0 | 10.22 |
| 5. | 55.5 | 1.285 | 52.0 | 11.67 |
| 2. | Black Liquor having R.A.A. 20.0 G/L as Na$_2$O | | | |
| 1. | 38.0 | 1.231 | 39.5 | 1.70 |
| 2. | 49.0 | 1.272 | 51.0 | 8.50 |
| 3. | 57.0 | 1.290 | 54.0 | 11.00 |
| 4. | 65.0 | 1.340 | 60.0 | — |
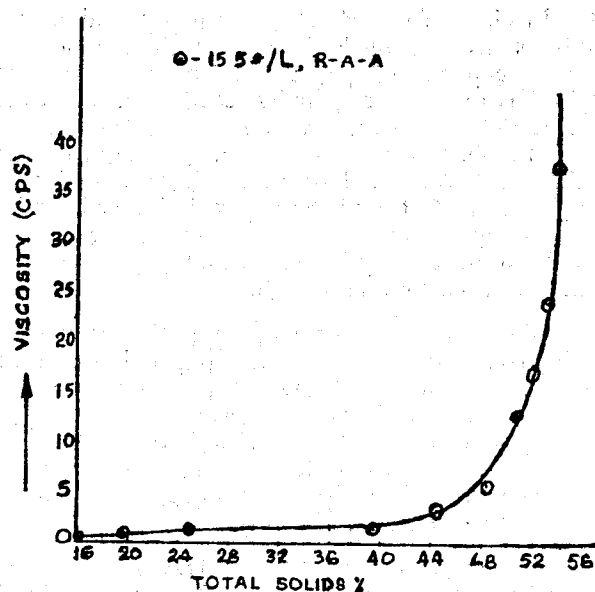


Fig 1—Total Solids V/S Viscosity of Mill Black Liquor. at Various Concentration (S/L)

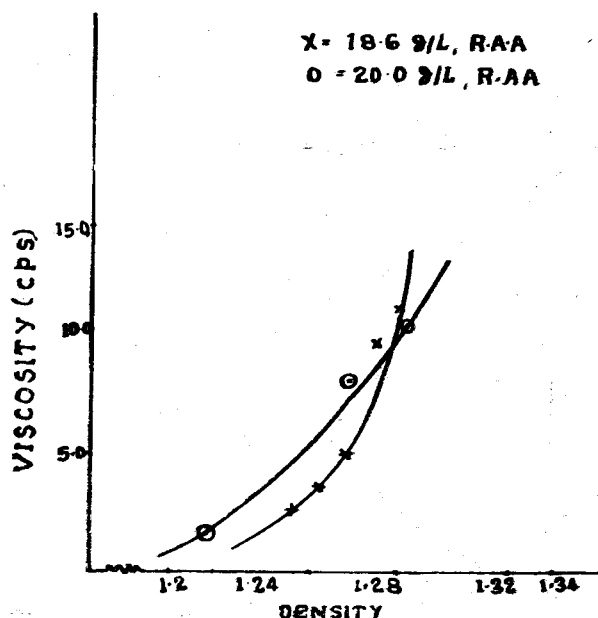X = 18·6 g/L, R·A·A
O = 20·0 g/L, R·AA

Fig. 2—Total Solids V/S Viscosity of Mill Weak Black Liquor at Various Concentration. (g/L)

Bamboo, Bamboo+mixed hard woods (70:30) Bamboo +mixed hard woods (50:50) and mixed hard woods (100%) black liquor from the digestions were evaporated to different total solids with and without addition of alkali dosages, The results are reported in table3,4,5 and 6 respectively. The effect of evaporation of different black liquor at different total solids versus viscosity is shown in Fig. No. 3,4,5 and 6 respectively.

Table—3

Effect of Concentration of Bamboo Black Liquor on Density, Total Solids, & Viscosity
(With & Without addition of alkali dosages)

| S.No. | R.A.A.of Bamboo Black Liquor | °TW at 60°C | Density at 60°C | Total Solids % | Viscosity at 90°C CPS |
|---|---|---|---|---|---|
| 1. | 18.6 gpl | 40.0 | 1.215 | 42 4 | 3.85 |
| | | 48 0 | 1 262 | 49.5 | 13.20 |
| | | 57 0 | 1.294 | 55.0 | 19.29 |
| 2. | 21.0 gpl | 45.0 | 1.254 | 49.2 | 9.34 |
| | | 54.0 | 1.284 | 52.3 | 11.96 |
| | | 62.0 | 1.313 | 58.3 | 22.00 |
| 3. | 23.25 gpl | 47.0 | 1 256 | 48.1 | 8.26 |
| | | 59.0 | 1.287 | 55.2 | 13.98 |
| | | 65.0 | 1.321 | 60.1 | 20 00 |

Table—4

Effect of Concentration of Bamboo + Mixed Hard Woods (70+30) Black Liquor on Density, Total Solids & Viscosity.

(With & Without addition of Alkali dosages)

| S.No. | R.A A.of Bamboo+ Mixed Hard woods (70+30) Black Liquor | OTW at 60°C | Density at 60°C | Total Solids % | Viscosity at 90°C CPS |
|---|---|---|---|---|---|
| 1. | 18.0 gpl | 38 | 1.207 | 40 0 | 7.49 |
| | | 51 | 1.279 | 50.0 | 15 89 |
| | | 56 | 1.288 | 52.8 | 20.86 |
| 2. | 21.7 gpl | 49.5 | 1.260 | 50.8 | 7.09 |
| | | 58.5 | 1.282 | 55.0 | 12.50 |
| | | 65.0 | 1.308 | 59.9 | 21.93 |
| 3. | 23.25 gpl | 42.0 | 1.235 | 44.2 | 4 60 |
| | | 54.0 | 1.287 | 52.3 | 9.50 |
| | | 58.0 | 1.320 | 60 4 | 24.00 |

Table—5

Effect of Concentration of Bamboo + Mixed Hard wood (50+50) Black Liquor on Density, Total solids, and Viscosity.

(With & Without addition of Alkali dosages)

| S.No. | R.A.A. of Bamboo+ Mixed Hardwoods BlackLiquor | OTW at 60°C | Density Solids % | Total Solids % | Viscosity at 90°C CPS |
|---|---|---|---|---|---|
| 1. | 18 6 gpl | 40.0 | 1.228 | 42.5 | 7.5 |
| | | 52.0 | 1.271 | 51.0 | 16.67 |
| | | 57.0 | 1.304 | 53.8 | 24.00 |
| 2. | 21.7 gpl | 45.0 | 1.247 | 46.5 | 7.00 |
| | | 54.5 | 1.280 | 52.0 | 12.71 |
| | | 60.0 | 1.315 | 54.4 | 20.41 |
| 3. | 24.0 gpl | 46.0 | 1.255 | 47.1 | 5.00 |
| | | 50.0 | 1.279 | 51.0 | 10.09 |
| | | 64.0 | 1.336 | 59.5 | 26.00 |

## Table—6

Effect of Concentration of Mixed Hardwoods Black Liquor on Density, Total Solids, and Viscosity.

(With & Without addition of Alkali dosages)

| S. No. | R.A.A. of Mixed Hardwoods Black Liquor | OTW at 60°C | Density at 60°C | Total Solids % | Viscosity at 90°C CPS |
|--------|------|------|------|------|------|
| 1. | 21.7 gpl | 48.0 | 1.265 | 49.0 | 14.05 |
|  |  | 51.0 | 1.269 | 50.0 | 15.59 |
|  |  | 59.0 | 1.287 | 54.5 | 23.98 |
|  |  | 69.0 | 1.341 | 60.0 | 33.00 |
| 2. | 24.0 gpl | 42.0 | 1.229 | 44.3 | 5.34 |
|  |  | 50.0 | 1.267 | 51.3 | 12.00 |
|  |  | 60.0 | 1.314 | 55.0 | 19.00 |

Fig 4—Total Solids V/S Viscosity of Bamboo+ Mixed Hard Woods (70:30) at Various Concentration (g/L)

Fig.3—Total Solids V/S Viscosity of Bamboo (100%) Black Liquor at Various Concentration (g/L)
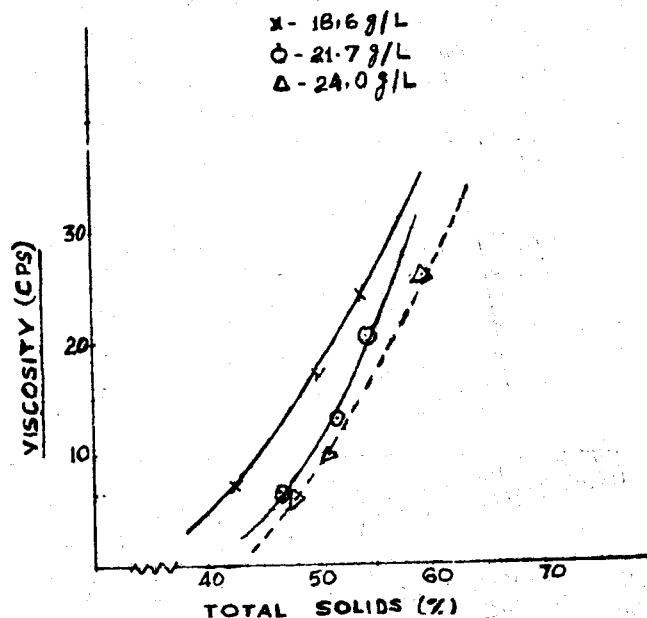
Fig. 5—Total Solids V/S Viscosity of Bamboo+ Mixed Hard Woods (50:50) at Various Concentration (g/L)

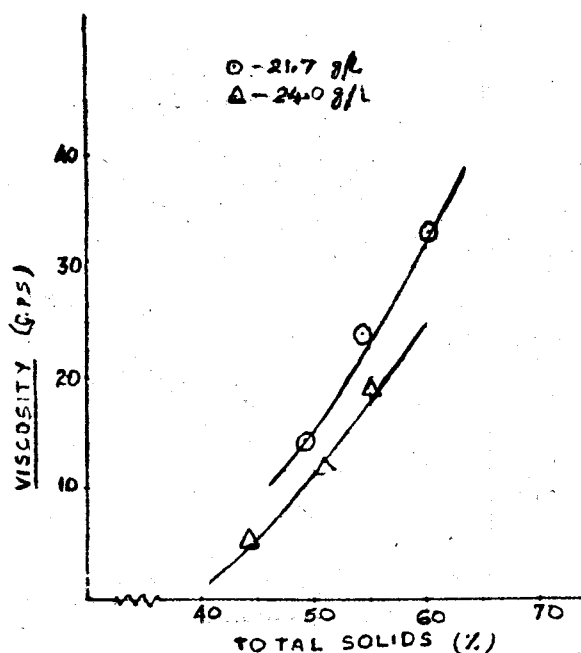Fig 6—Total Solids V/S Viscosity of Mixed Hard
Woods at Various Concentration g/L)



Lig. 7—Density V/S Viscosity of Mill Weak Black
Liquor at Different Concn.

Mill weak black liquor evaporated to different total solids with and without alkali dosages was analysed for desnsities. The effect of density versus viscosity is plotted in Fig—7 and 8 respectively. Bamboo, Bamboo+mixed hard woods (70:30) Bamboo+mixed hard woods (50:50) and mixed hard woods black liquors evaporated to different total solids with and without alkali dosages and analysed for densities. The effect of density versus viscosity is plotted in Fig. 9, 10, 11 and 12 respectively.

## RETULTS & DISCUSSION

A perusal of table-1 shows that as the mill weak is evaporated the viscosity of black liquor rises gradually upto 45°TW and appreciably onwards upto 60°TW as evident from Fig. 1. In another set of experiments mill weak black liquor initial (R.A.A. 15.5 g/l) was increased upto 18.6 g/l and 20.0 g/l and as $Na_2O$ and evaporated to different°TW. The results recorded in table-2 shows that with increase in initial R.A.A. the viscosity of the concentrated liquor can be reduced appreciably. The rise in viscosity versus total solids as shown in Fig. 2 clearly indicatcs that the black liquor having initial higher R.A.A. 20.0 g/l as $Na_2O$ has considerably lower viscosity as compared to black liquors having initial R.A.A. 15.5 g/l and 18 6 g/l as $Na_2O$ On evaporation to different total solids.
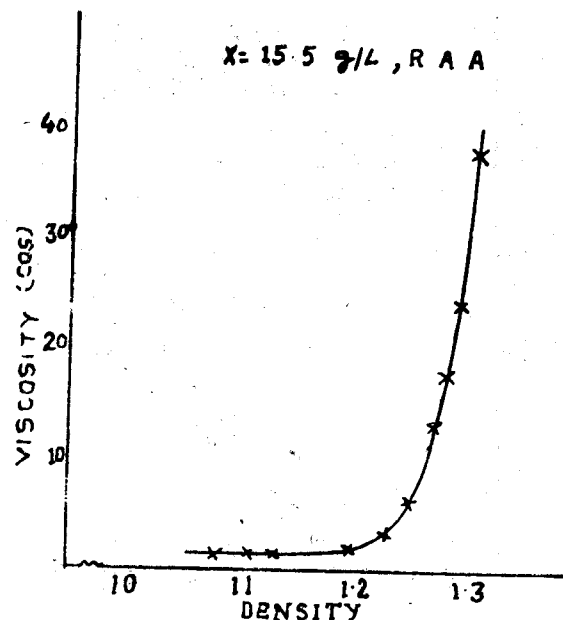


Fig 8—Density V S Viscosity of Mill Weak Black
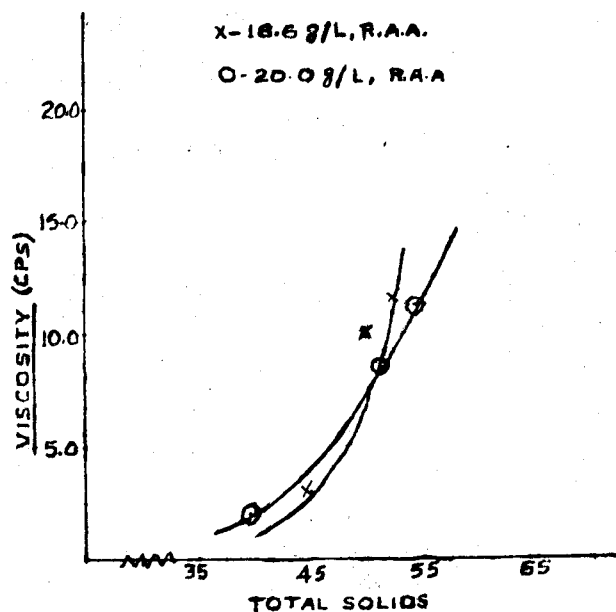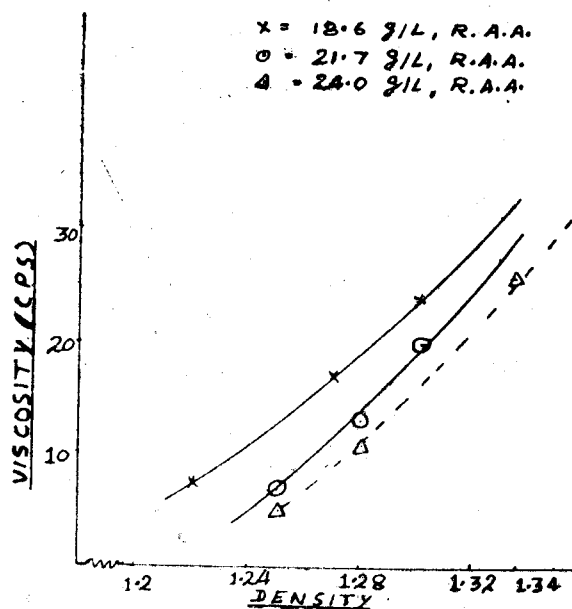Liquor at Various Concentrations (g L)

X = 18.6 g/L, R.A.A
θ = 21.0 g/L, R.A.A
Δ = 23.25 g/L, R.A.A

VISCOSITY (CPS)
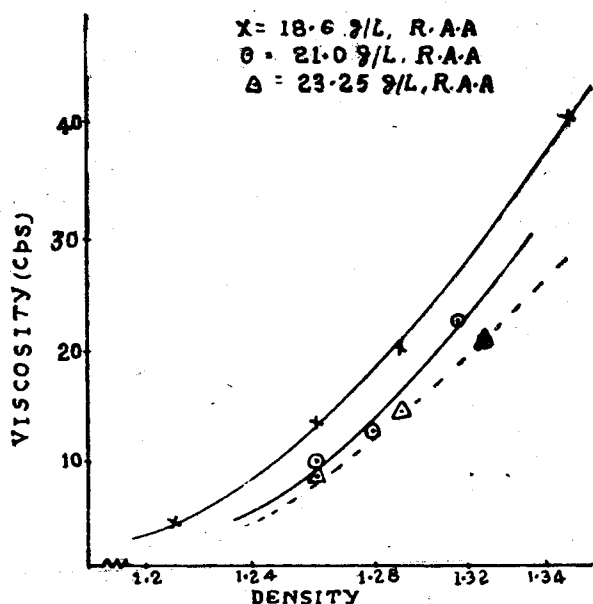
DENSITY

Fig. 9—Density V/S Viscosity of Bamboo Black Liquor at Various Concn (g/L).



X = 18.6 g/L, R.A.A.
θ = 21.7 g/L, R.A.A.
Δ = 24.0 g/L, R.A.A.

VISCOSITY (CPS)

DENSITY

Fig. 11—Density V/S Viscosity of Bamboo + Mixed Hard Woods (50:50) at Various Concentration (g/L)



X = 18.0 g/L, R.A.A
O = 21.7 g/L, R.A.A
Δ = 23.2 g/L, R.A.A

VISCOSITY (CPS)
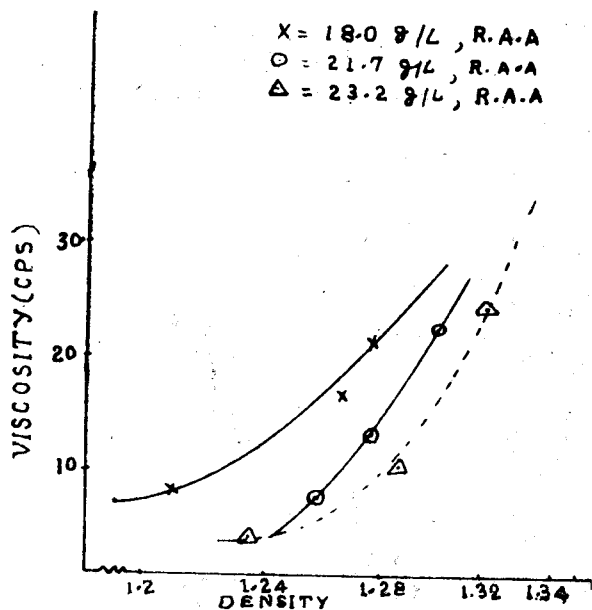
DENSITY

Fig. 10—Density V/S Viscosity of Bamboo + Mixed Hard Waods (70:30) Black Liquor Various Concentration (g/L)



θ = 21.7 g/L, R.A.A.
Δ = 24.0 g/L, R.A.A.
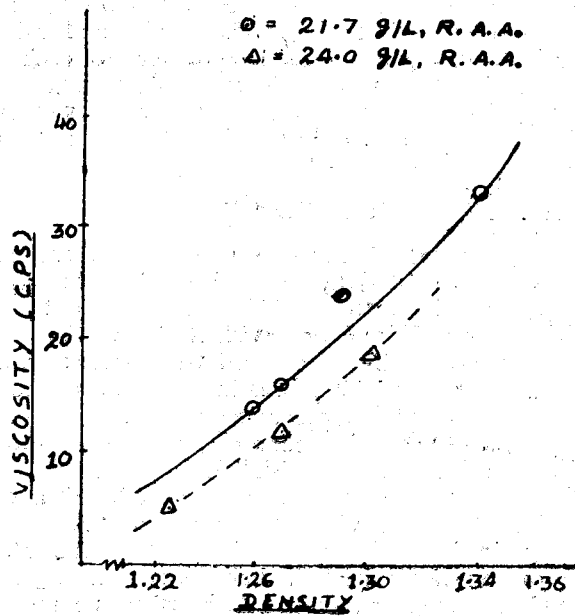
VISCOSITY (CPS)

DENSITY

Fig. 12—Density V/S Viscosity of Mixed Hard Woods.

Bamboo black liquor collected from Bamboo digestion having initial R.A.A. 18.6 g/l as $Na_2O$ was evaporated to different total solids and corresponding viscosities were determined (table-3). The initial R.A.A. of black liquor was increased upto 21.0 g/l and 23.25 g/l as $Na_2O$ and the liquor samples were evaporated to different total solids concentrations and corresponding viscosities were determined. It is evident from table-3 and the graphical representation (Fig. 3) that the viscosity of 18.5 g/l black liquor is higher as compared to 21.0 g/l and 23.25 g/l respectively on evaporation to different total solids.

Bamboo+mixed hard woods (70:30) black liquor having initial R.A.A. 18.8 g/l as $Na_2O$ was increased to 21.7 g/l and 23.25 g/l by addition of alkali and evaporated to different total solids. The corresponding viscosities against total solids depicted in Fig. 4 and the results recorded in table-4 shows that the liquor viscosities has similar trend with increase in R.A.A. as was observed with Bamboo liquor on evaporation to different total solids. It is interesting to note that the Bamboo+mixed hard wood (70:30) has higher black liquor viscosity 7 49 Cps as compared to Bamboo (3.8 Cps) at total solids 40.0% and 42.4% respectively when initial R.A.A. of these two liquors were almost the same.

Bamboo+mixed hard woods (50:50) black liquor having initial R.A.A. 18.6 g/l as $Na_2O$ was increased to 21.7 g/l and 24.0 g/l by addition of alkali. The corresponding viscosities against total solids on evaporation to different total solids depicted in Fig. 5 and the results recorded in table-5 shows that the liquor viscosities has similar trend with increase in R.A.A. as was observed with bamboo and Bamboo+mixed hard woods (70:30) black liquor on evaporation to different total solids. The results indicate that Bamboo+mixed hard woods (50:50) black liquor initial R.A.A. 18.6 g/l has higher viscosity (24.0 Cps) at 53 81% total solids as compared to Bamboa+mixed hard wonds (70:30) and Bamboo which has viscosities 20.86 Cps, and 19 29 Cps respectively at 52.8% and 55.0% total solids respectively.

Mixed hard wood black liquor having initial R.A.A. 21.7 g/l as $Na_2O$ was increased to 24.0 g/l by addition of alkali. The corresponding viscosities against total solids on evaporation to different total solids depicted in Fig-6 and the results recorded in Table-6 shows that the liquor viscosities has similar trend with increase in R.A.A. as was observed with Bamboo, Bamboo+mixed hard woods (70:30) and Bamboo+mixed hard woods (50:50). The viscosities of the liquors fall down with incre-

ase in initial R.A.A. in all the experiments. Mixed hard woods black liquor having initial R.A.A. 21.7 g/l has higher viscosity 23.98 Cps at 54.5% total solids as compared to viscosities of Bamboo, Bamboo+mixed hard woods (70:30) and Bamboo+mixed hard woods (50:50) which are 11 9 Cps. 12.5 Cps 20.4 Cps respectively at 52.3%, 55.0%, and 54.4% total solids. It was interesting observation that the mill black liquor (initial R.A.A. 20.0 g/l) has 11.0 Cps viscosity at 54.0% total solids which is also lower than mixed hard woods black liquor.

The viscosity of mill black liquor, Bamboo, Bamboo+mixed hard woods (70:30), Bamboo+mixed hard woods 50:50) and mixed hard woods liquors against density has been shown in Figs. 7, 8, 9, 10, 11 and 12 with and without addition of alkali. More or less same pattern of viscosity against density was observed as against total solids.

## Conclusion

With the increase in residual active alkali (RAA), value the viscosity is lower for a fixed solid content in all the cases. The lowering of viscosity will help in efficient burning and will choke the evaporator tubes to a lower extent, thereby reducing the shut down time.

Mixed hard woods black liquor has higher viscosity than Bamboo black liquor. This can be reduced by increasing residual active alkali with increase in percentage of hard woods the viscosity increases but the increase is not pronounced upto 30% hard woods. This latter effect may be due to the small amount of extractives leached out which do not cause salting effect at that concentration. As the percentage of hard woods increase the amount of extractives from them proportionately increases causing salting effect resulting in a higher viscosity. Residual—active alkali can be increased either by cooking the material with higher conc. of chemicals or by adding dreg weak wash to the black liquor.

## ACKNOWLEDGEMENT

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