Alkaline Sulfite Pulping of Wheat Straw

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This paper deals with the studies on alkaline sulfite pulping of wheat straw in comparision to conventional Soda pulping. The former has comparatively better delignification, besides significent increase in yield and b'ightness of unbleached pulp. The bleachability is better as the pulp can be bleached to a high level of brightness adopting H-H sequence. The strength properties are more or less comparable.

The cost of sodium sulfite is some-what higher as compared to caustic soda. However, considering the advantages. a partial substitution of sodium hydroxide by sodium sulfite to an extent of 30-40% is quite practicable, without affecting the processing system The increase in cost can very well be compensated with the various advantages by adopting this process.

Lignin can be made to swell in water and alkali by substituting polar groups like sulphonyl or carbonyl group, to make it more hydrophilic and thus accelerate its solubilization. Alkaline sulfite pulping ($NaOH+Na_2SO_3$) is reported to offer efficient solubilization of lignin by combining the phenol dissolving and depoly-merizing characteristics of kraft/soda pulping and the hydrophilic character of lignin sulphonate groups. It is anticipated that the lignin condensation is inhibited by the presence of strong nucleephilic groups like OH^- and SO_3^{--}(1,2).

At the same time, due to a lower alkalinity in the system as compared to alkaline pulping, degradation of carbohydrates and their dissolution may be lesser. Hence, both leading to an overall improvement in the yield and delignification. This study reports the findings of alkaline sulfite pulping in comparision with soda pulping of wheat straw.

EXPERIMENTAL :

Preliminary studies were carried out by varying the chemical percentage on as such basis i e NaOH and Na_2SO_3 ratio, temperature and time etc. The pulping conditions and the results are recorded in Table 1.

TABLE 1

PULPING OF WHEAT STRAW NaOH & Na_2SO_3

Particulars	C-1	C-2	C-3	C-4	C-5	C-6	C-7	C-8	C-9	C-10	C-11	C-12	C-13	C-14	C-15	C-16
NaO I added on O.D Straw, %	6.0	8.0	10.0	12.0	6.0	6.0	6 0	6.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Na_2SO_3 added on O.D. Straw, %	Nil	Nil	Nil	Nil	4.0	6.0	8.0	10.0	6.0	8.0	10.0	12.0	12.0	14.0	16.0	18.0
Total pulp yield, %	71.8	63.5	62.9	58.5	63.4	60.6	60.2	58.9	61.8	60.9	59.8	59.8	59.6	59.7	59.0	58.2
$KMnO_4$ (25 ml)	—	22.5	22.3	19.5	22.0	15.9	12.6	10.1	18.1	14.3	12.3	11.3	10 4	9.6	9 3	9.3
Brightness, % (Elrapho)	17.1	19.5	21.2	24.7	20.6	28.9	36.5	41.9	28.7	36.8	41.2	44.3	45.7	44.9	49.6	52 1
Initial freeness, SR	11	14	15	13	12	14	13	13	14	14	15	14	14	14	15	15

Note :—
1. Bath ratio = 1 : 4
2. Diluent = Water
3. Cooking schedule :
   C-1 to C.8 — 50 to 150°C = 1.75 hr. At 150°C = 2.00 hr.
   C-9 to C-16 — 50 to 160°C = 2.00 hr. At 160°C = 2.00 hr.

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These studies gave encouraging results in terms of increase in pulp yield and brightness of unbleached pulp and decrease in permanganate number. For further evaluation, three conditions were selected and large scale pulpings, in a 15 liters capacity electrically heated rotary digester, were carried out and given in Table 2.

TABLE–2
PULPING DATA

Particulars		Cook I	Cook II	Cook III
1. NaOH added,	%	10.0	6.0	4.0
2. Na_2SO_3 added,	%	—	6.0	6 0
3. Bath ratio		1 : 4	1 : 4	1 : 4
4. Time to temperature, hrs		2.0	2 0	2.0
5. Time at temperature, hrs		2.0	2.0	2 0
6. Maximum temperature, °C		150	150	150
7. Unbleached pulp yield, %		56.9	58.7	65.1
8. K. No		23.4	17.8	22 1
9. Brightness, % (Elrepho)		19.8	31.4	28.9
10. Ash in the pulp, *, %		12.7	15.5	14.2

*ash in the raw material = 9.0%

The characteristics of the black liquors obtained from these three cooks were determined for active alkali, COD, BOD_5 and total solids etc. and given in Table 3.

TABLE 3
BLACK LIQUR ANALYSIS

Particulars		COOK I	COOK II	COOK III
1. pH of Black liquor		10.2	8 2	8 9
2. Total solids,	%	10.5	9.8	11.2
3. Ash,	%	3 2	2 7	2.3
4. COD, mg/L		1,24,444	1,10,222	1,17,333
5. BOD_5, mg/L		12,500	9,000	11,000
6. Colour (Pt.Co. units)		1,55,583	71,250	37,350

The pulps after cooking, required defibration in a valley beater before bleaching. Bleaching experiments, on small scale, were carried out using HH sequence by varying the chlorine charge as shown in Table 4 Subsequent—large scale bleachings (500 g OD) were carried out by using 13% chlorine, in all, in H_1 & H_2 stages. The bleaching conditions are reported in Table 4.

TABLE 4
BLEACHING OF WHEAT STRAW PULPS

Cook No	I (10 % NaOH)						II (6% NaOH-6% Na_2SO_3)						III (4%NaOH-6%Na_2SO_3)					
	1	2	3	4	5	6*	1	2	3	4	5	6*	1	2	3	4	5	6*
Ist Stage Hypo																		
Cl_2 added,%	5.0	6.0	7.0	8 0	9.0	10.0	5.0	6.0	7.0	8.0	9.0	10 0	5.0	6.0	7.0	8.0	9.0	10.0
End pH	7.1	6.9	6.8	6.7	6 7	6.7	6.8	6.7	6.4	6 3	6.3	6.25	6.70	6.71	6.50	6.49	6 47	6 44
Cl_2 Consumption,%	5.0	6.0	7.0	8.0	9.0	10.0	5.0	6.0	6.5	7.8	8.8	9.5	5.0	6.0	7.0	7.8	8.8	9.5
2nd Stage Hypo																		
Cl_2 added,%	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3 0	3.0	3.0	3.0	3.0
End pH	7.11	7.29	7.06	6 95	6.16	6.96	7.00	7.03	6.85	6.96	6.97	6.96	6.27	6.45	6.35	6.34	6.45	6.28
Cl_2 consumed,%	3.0	2.8	2.9	2.5	2.5	2 4	2.6	2.4	2.3	2.0	2.10	2.10	2.70	2.70	2.70	2.70	2.80	2.80
Brightness (% El)	57.4	61.6	64.7	67.8	71.3	72.2	74.2	75.5	77.6	77.1	78 2	78.3	59.8	62.1	65.4	69.3	73.6	74 7

Constant Conditions :

Consistancy = 5%
Temperature = 40°C
Time in both I & II Stages Hypo–2.00 hrs.
*Conditions for large scale bleaching.

Unbleached and bleached pu'ps were, then beaten in a laboratory valley beater to varying freeness levels. Sheet making and testings were carried out as per ISI/TAPPI standard procedures.

The strength properties at 40° SR were obtained graphically by interpolatiag the beating curves obtained (fig. 1 to 6). The results at 40° SR are recorded in Table 5.

TABLE 5
STRENGTH PROPERTIES AT 40° SR

Particulars	Cook I (10 % Soda)		Cook II (6% NaOH-6% Na_2SO_3)		Cook III (4% NaOH-6%Na_2SO_3)	
	Unbleached	Bleached	Unbleached	Bleached	Unbleached	Bleached
Bulk, Cm³/g	1.76	1.62	1.84	1.58	1.91	1.70
Burst factor	19 00	21.60	17.20	18 80	16.80	18.65
Tear factor	27 60	27.80	28.80	22 70	25 20	28.00
Breaking length km.	5.60	4.24	4.80	3.64	4 90	3 72

RESULTS AND DISCUSSION :

The preliminary pulping experiments (Table 1) has given the idea that substitution of caustic soda by sodium sulfite gives definite advantage in terms of pulp yield and unbleached pulp brightness, It can be observed from Table 2, under the selected conditions of alkaline sulfite pulping, the pulp yield increased by 2 to 8% as compared to soda pulping (10% NaOH, cook I)– There is substantial decrease in permanganate number of pulp obtained with 6%, each, caustic soda and sodium sulfite (cook II). However, the pulp of same permanganate number is obtained with 4% caustic soda and 6% sodium sulfite (cook III) but the yield increased by 8% compared to cook 1.

The unbleached pulp brightness in case of alkaline sulfite pulping (cook II and III) is significantly higher than the soda pulps. However, the unbleached pulp shows an increase in the ash content by about 20% over soda pulp (cook I).

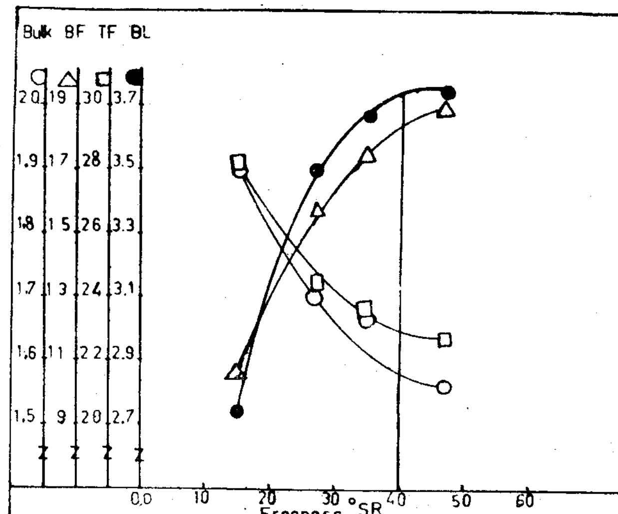

Fig 2 - Freeness Vs Strength Properties (Cook NO 2, Bleached)

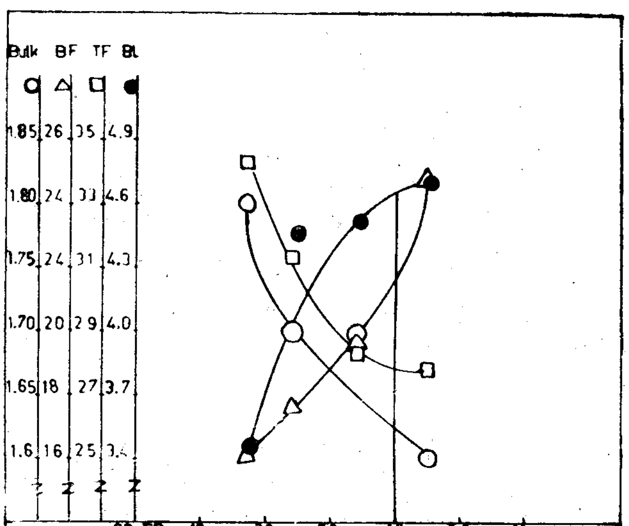

Fig-1 Freeness Vs Strength Properties (Cook NO 1, Bleached)

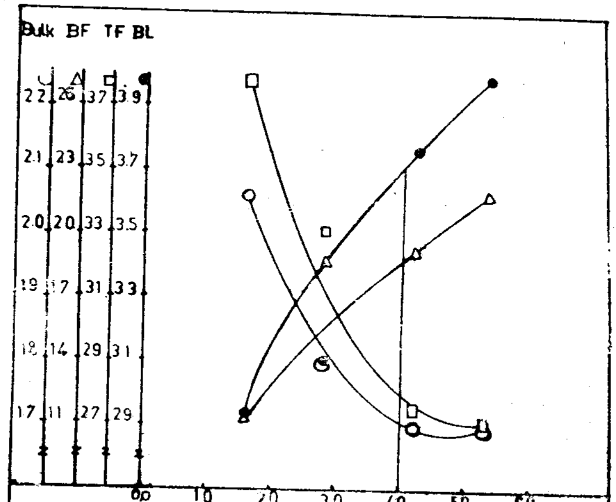

Fig 3-Freeness Vs Strength Properties (Cook NO 3 Bleached)

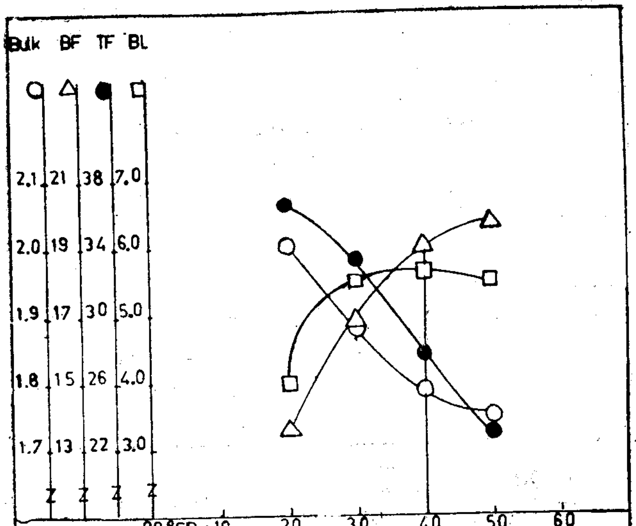

Fig 4 Freeness Vs Strength Properties (Cook NO 1, Unbleached)

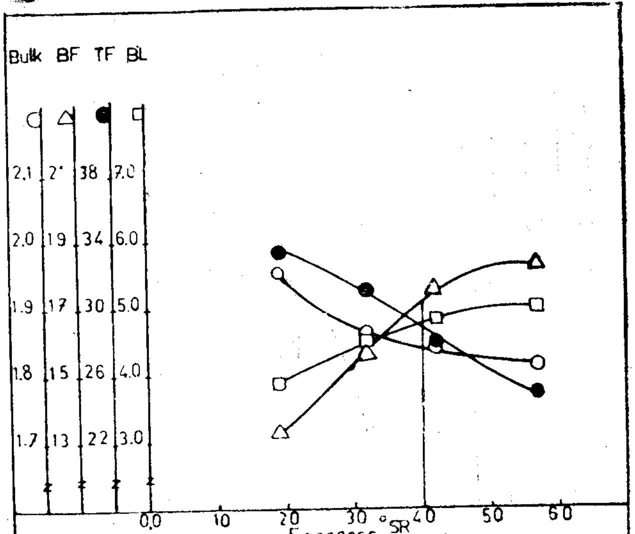

Fig. 5-Freeness Vs Strength Properties (Cook NO 2, Unbleached)

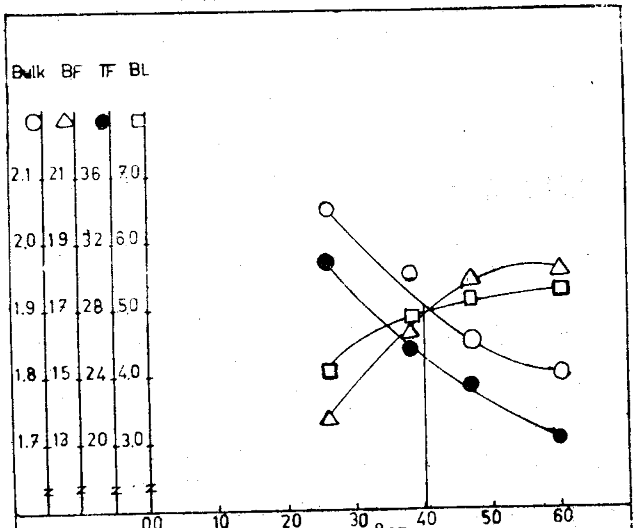

Fig 6- Freeness Vs Strength Properties (Cook NO 3, Unbleached)

The black liquor pH is understandably lower in cook II and III than in cook I. COD is slightly lower in case of alkaline sulfite black liquor as compared to soda black liquor, but BOD_5 is significantly lower indicating the less dissolution of carbohydrate in case of alkaline sulfite process. Colour of black liquor is considerably lighter for alkaline sulfite (cook II and III) compared to soda process.

Both soda and alkaline sulfite pulps could be bleached by using HH sequence but the brightness of soda pulp is only 72.2% compared to 78.5% for alkaline sulfite pulp. Though permanganate number of unbleached pulp (cook III) is nearly the same as that of soda pulp (cook I) it could attain a higher brightness under similar conditions of bleaching.

The strength properties at 40° SR (Table 5) reveal that the bulk in case of alkaline sulfite pulps (unbleached and bleached) is slightly higher than the soda pulps. Burst factor and tear factor for both of the bleached and unbleached pulps are more or less comparable. However, breaking length for alkaline sulfite pulp is marginally lower.

CONCLUSION

It can be concluded that alkaline sulfite pulping of wheat straw has shown definite advantages over normal soda pulping with the same percentage of chemicals. Alkaline sulfite pulping gives higher pulp yield and pulp brightness as compared to normal soda pulping at equivalent permanganate number. The alkaline sulfite pulp can be bleached by using HH sequence to a higher level of brightness than soda pulps. The black liquor obtained from alkaline sulfite pulping of wheat straw has lower BOD_5 and lighter colour compared to soda black liquor.

ACKNOWLEDGEMENT

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