Pulping of Whole Jute Plant (Corchorus Capsularies) by Soda-additive Methods

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ABSTRACT

Pulping of whole jute plant was done at 170 C in soda-HMTA and soda-NB processes. The influencing factors in these pulping processes were cooking time 1-4 hours, 0.05- 0.5% HMTA and 1-10% (on o.d. WJP) for soda-HMTA and soda-NB process respectively. The alkali concentration, material to liquor ratio were kept contant in both processes. The delignification rate was enhanced by the addition of 2% of nitrobenzene after that the delignification rate was retarded with the increase of nitrobenzene percentage in soda-NB process and in soda-HMTA process, the rate ws increased with the addition of HMTA. The physico-mechanical characteristics in soda-NB process were more improved than the soda and kraft process and soda-HMTA process showed higher properties than the soda and almost similar to kraft process.

INTRODUCTION

Jute is the bast fiber extracted from the stem of corchorus plant. It is characterized by a high cellulose, low lignin content (I), and quite long fiber length (2). The chemical and morphological properties therefore favour its use in making pulp.

Pulping of jute has been the subject of numerous studies for the last two decades both in home and abroad, by conventional processes (i.e., soda, kraft, sulphite either alone or combine with AQ) (3-10). But various problems are encountered in a mill trial in pulping of jute by the soda process (3) and also by the kraft process (11). The digester blowing, washing, screening and disintegration are difficult in this process. On the other hand, pulp produced by the alkaline processes was of inferior quality (12). They are degraded severely on bleaching (3,11). Thus it is imperative to search for other processes that can eliminate these problems and produce pulp of hiher yield and strength and also increase the rate of delignification.

The use of nitrogen containing to accelerate soda pulping in ligno-cellulosic raw materials has been the subject of renewed interest (13-21). This paper offers to rationalize the accelerating effect of delignification of whole jute plant and quality of pulps using mitrobenzene (NB) or hexamethylene tetramine (HMTA)as additive in soda liquor.

EXPERIMENTAL

Whole jute plant of corchorus Capsularies variety was used as the fibrous raw material. It was cut into small pieces about 3-4 cm in length . Whole jute plant was pulped in 20-liter capacity autoclave, electrically heated having automatic temperature control system. The cooking liquor created pressure. The rotation of the autoclave was 1 r.m. Each set of cooks with soda liquor containing HMTA and NB for soda -HMTA

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Table-1

Chemical characteristics of Soda-HMTA and soda-NB pulps (NaOH 18% on o.d. WJP, Material to liquor ratio 1:6 and Temperature 170°C

a) Soda-HMTA

Time Hrs.	HMTA % on o.d.WJP	Total yield	Screening reject %	Kappa No.	α-cellulose (%)	Pentosan (%)
1	0	53.6*	0	38.7	72.11	16.1
1	0.05	53.55*	0	38.5	72.21	16.13
1	0.1	53.61*	0	38.3	72.26	16.14
1	0.2	53.67*	0	38.3	72.33	16.19
1	0.3	53.66*	0	38.2	72.39	16.21
1	0.4	53.68*	0	38.1	72.43	16.31
1	0.5	53.67*	0	38.1	72.43	16.31
2	0	51.8*	0	34.8	74.24	16.37
2	0.05	51.86*	0	34.1	75.33	16.47
2	0.1	51.97	0	33.4	75.61	16.59
2	0.2	52.03	0	33.2	75.65	16.62
2	0.3	52.11	0	33	75.68	16.64
2	0.4	52.16	0	32.6	75.73	16.69
2	0.5	52.15	0	32.5	75.77	16.68
3	0	48.14	0	33.2	75.61	14.09
3	0.05	49.31	0	32.1	76.17	15.13
3	0.1	50.17	0	30.4	76.31	15.62
3	0.2	50.22	0	30.2	76.43	15.69
3	0.3	50.31	0	30.1	76.52	15.72
3	0.4	50.43	0	30.1	76.55	15.75
3	0.5	50.41	0	29.9	76.59	15.78
4	0	46.2	0	32.4	76.19	13.94
4	0.05	46.98	0	31.2	77.22	14.01
4	0.1	47.81	0	29.3	77.81	14.48
4	0.2	47.88	0	29.1	77.89	14.52
4	0.3	47.83	0	29.1	77.91	14.53
4	0.4	47.88	0	29.0	77.94	14.58
4	0.5	47.91	0	28.9	77.98	14.61

and soda-NB processes respectively were accompanied by conventional soda and kraft controls. HMTA and NB were from 0.05-0.5% and 1-10% for soda - HMTA and soda-NB process respectively. The cooking time was 1,2,3 and 4 hour at maximum 170°C. The following conditions were held constant; total alkali

b) Soda-NB pulps

Time Hrs.	NB % on o.d. WJP	Total yield	Screening reject (%)	Kappa No.	α-cellulose (%)	Pentosan (%)
1	0	53.6*	0	38.7	72.11	16.1
1	1	54.51*	0	38.2	72.28	16.34
1	2	54.84*	0	37.1	72.97	16.62
1	3	59.09*	0	37.9	72.37	15.87
1	4	56.45*	0	38.1	71.74	15.3
1	6	57.27*	0	40.7	66.48	14.81
1	10	57.5*	0	51.8	64.37	14.19
2	0	51.8*	0	34.8	74.24	16.37
2	1	51.84*	0	33.6	75.56	16.81
2	2	52.15	0	32.2	75.88	16.88
2	3	52.3	0	35.8	72.42	15.21
2	4	56.82	0	38.3	71.16	15.18
2	6	57.62*	0	42.2	67.05	14.66
2	10	58.6*	0	52.1	64.81	14.2
3	0	48.14	0	33.2	75.61	14.09
3	1	50.1	0	32.4	76.82	15.63
3	2	50.18	0	30.1	78.23	16.17
3	3	52.83	0	35.6	75.83	14.81
3	4	55.94*	0	38.4	72.21	14.21
3	6	57.14*	0	41.9	67.81	14.14
3	10	58.23	0	53.1	63.34	14.22
4	0	46.2	0	32.4	76.19	13.94
4	1	47.66	0	30.2	76.5	14.38
4	2	48.21	0	29.1	78.78	15.24
4	3	50.24	0	32.6	77.69	14.1
4	4	54.85	0	35.9	75.12	14.12
4	6	57.12*	0	42.4	69.81	14.15
4	10	58.32*	0	53.5	64.23	14.14

*** mechanically refined**

charge 18% on o.d. whole jute plant, liquor to jute ratio 6:1, charge of whole jute plant 250 gm (o.d), time to cooking temperature 90 min., sulphidity (in kraft controls) 25%

At the end of the cook, the pressure inside the digester was released. The waste liquor was drained off. The coked material was then washed thoroughly and, disintegrated. Hard cooked materials were defiberized in a Sprout Waldron Laboratory Refiner with 0.25 mm plate clearnce. Screening was done in a flat vibratory screen of 0.38 mm slots.

The screened pulp was then pressed to remove

excess water, weighed and sampled to determine the moisture content. The pulp yield and kappa number (T-236m60) was then determined.

The pulp was beaten in vally type laboratory beater to different SR value and hand sheets were made to determine the strength properties. The pulp strength properties were measured according to TAPPI standard methods.

RESULTS AND DISCUSSION

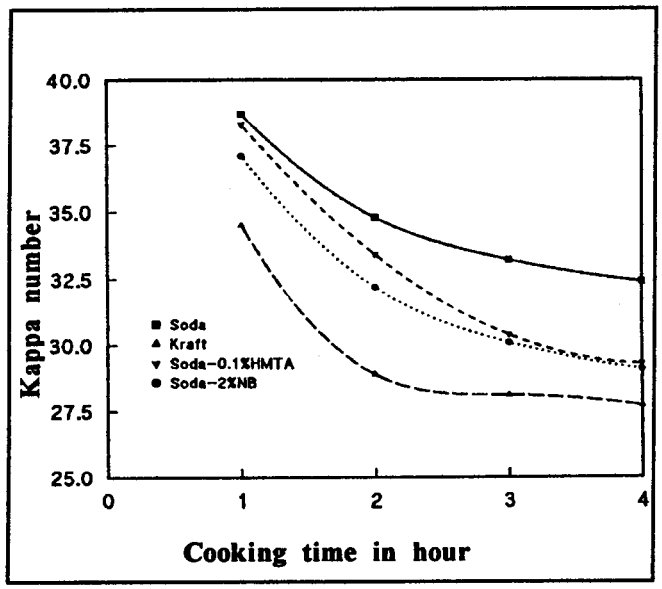
Chemical characteristics of soda-HMTA and soda-NB pulps are presented in Table-1 and 1b. It is seen from Table-1 that at the time of 1 hour of cooking there is no change in delignification with the addition of HMTA. At the time of 2,3 and 4 hours of cooking the delignification rate is increased with the addition of 0.1% on (o.d.WJP) HMTA after that there is no appreciable change in delignification with the increase of additive. Therefore 0.1% HMTA is used as an optimum concentration for soda-HMTA process at the time of 3 hours of cooking.

From Table 1 b it is observed that at the time of 1 hour of cooking whole jute plant is not digested by soda-NB process. By the addition of nitrobenzene to the alkaline liquor there is an unexplainable reverse effect isx observed. At the time of 3 hour of cooking, the delignification rate is slightly increased up to 2% of nitrobenzene (on o.d. WJP) after that there is a reverse effect and whole jute plant remained undigested with increase of nitrobenzene. But at he time of 3 and 4 hours of cooking the delignification rate is significantly increased up to 2% of nitrobenzene after that the kappa number is rapidly increased. The reverse effect is more pronounced with the increase of cooking time. So it is considered that 2% is optimum dose of NB for soda-NB process at time of 3 hours of cooking.

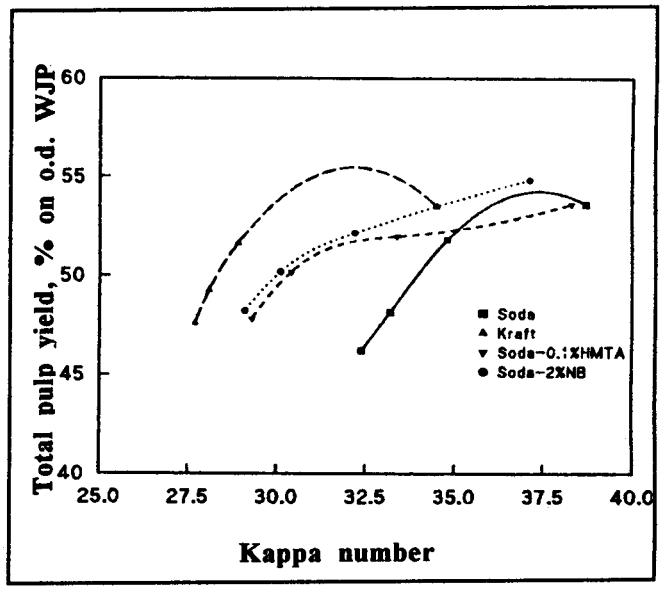
Figure-1 shows that the whole jute plant is delignified faster in soda-HMTA and soda-NB process compared to soda process. Between these two processessoda - NB exhibited the greater increase in pulping rate. But both these processes can not exceed the kraft-pulping rate.

It is also evident from Table-1 that an increased in pulp yield is observed by the addition of HMTA at the time of 2, 3 and 4 hours of cooking. This is caused by the stabilization of carbohydrate fraction. After 0-.1% of HMTA addition appreciable pulp yield gain is not evident. The percentage of cellulose and pentosan are increased in soda-HMTA process.

It is seen from table-1 that the pulp yield is increased with the increase of NB addition, but cellulose ad pentosan in pulp are increased by the addition of NB up to 2% Figure-2 shows the relationship between kappa number and total pulp yield. At any given kappa nnumber the yield of soda-NB pulps, no matter has prepared is higher than that of corresponding soda pulp. The same is true for



Fog.-1 Delignification of WJP during soda-HMTA & Soda-NB pulping with respect to time.



Fog.-2 The relation between kappa number and total pulp yield of sodaHMTA & soda-NB pulping of WJP.

Table-2

Physical characteristics of Soda-HMTA and soda-NB pulps (NaOH 18% on o.d. WJP, Material to liquor ratio 1:6 and Temperature 170°C

a) Soda-HMTA

Time in hour	% of HMTA On o.d. WJP	Breaking Lenght in meter		Burst factor		Tear factor		Double fold No.		Apparent Density Kg/m²	
		30°SR	40°SR	30°SR	40°SR	30°SR	40°SR	30°SR	40°SR	30°SR	40°SR
1	0	5211	6516	52.6	65.8	96	101	179	398	481.4	517.9
1	0.05	5319	6529	52.4	66.1	97	104	184	382	491.1	518.4
1	0.1	5322	6534	52.8	66.3	99	104	188	393	491.6	519.2
1	0.2	5334	6551	53.2	66.3	100	102	191	397	490.8	519.3
1	0.3	5342	6562	53.5	66.2	101	103	195	395	491.1	519.6
1	0.4	5349	6567	53.8	66.4	101	104	193	398	489.7	518.8
1	0.5	5351	6572	53.7	66.3	102	105	199	397	489.9	519.1
2	0	6022	6676	59.6	66.1	107	105	237	457	496.7	533.2
2	0.05	6108	6728	60.5	67.9	107	107	251	471	497.8	534.2
2	0.1	6189	6784	62.5	68.7	111	110	266	491	500.2	535.1
2	0.2	6192	6793	62.4	68.8	112	110	254	497	500.7	535.7
2	0.3	6193	6809	62.7	68.8	114	111	267	496	500.6	535.9
2	0.4	6121	6822	62.9	69.1	113	112	269	501	501.1	535.7
2	0.5	6218	6831	62.1	69.3	115	113	271	510	501.5	535.9
3	0	6123	6865	62.1	68.2	109	106	252	488	530.1	569.4
3	0.05	6193	6933	62.9	69.3	110	108	266	499	533.4	571.4
3	0.1	6328	7019	63.6	69.7	113	110	278	521	535.2	572.3
3	0.2	6387	7111	63.8	69.8	113	111	281	511	534.3	571.8
3	0.3	6391	7129	68.7	69.8	114	113	275	508	534.9	573.2
3	0.4	6397	7134	68.9	69.6	115	112	272	501	535.1	573.7
3	0.5	6389	7149	68.8	70.1	114	110	261	498	534.9	574.1
4	0	6128	6887	60.7	66.7	105	103	267	492	549.5	563.8
4	0.05	6124	7026	60.8	69.4	108	106	259	498	550.6	564.5
4	0.1	6008	6927	60.5	69.7	110	108	263	511	551.2	565.3
4	0.2	6001	6921	60	68.2	107	105	265	503	551.1	565.1
4	0.3	5924	6867	58.8	67.5	106	105	263	500	551.8	565.2
4	0.4	5886	6824	58.1	66.5	105	104	268	491	551.4	564.8
4	0.5	5861	6803	57.6	65.2	105	103	264	488	551.2	564.4

soda-HMTA pulp, the kapld raton appaches, andn exceed thaof the soda pulp. In soda-HMTa process, the yield is lower than the soda process at highest kappa number and yield is increased with the decrease of kappa number.

Physical characteristics of soda-HMTA and soda-NB pulps are presented in Table 2a and 2b. It is seen from Table-2 a that the addition of HMTA in soda liquor improves the physico-mechanical properties of the pulps at the time of 2 ,3a nd 4 hours of cooking.

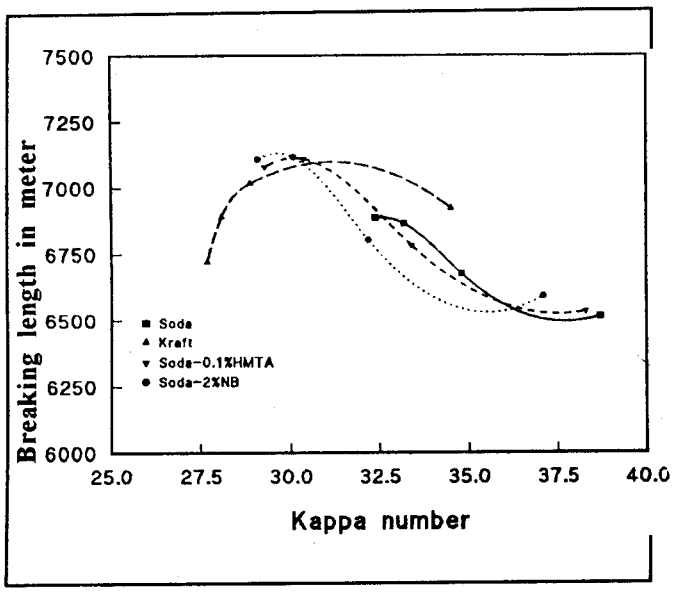
b) Soda-NB

Time in hour	% of NB On o.d. WJP	Breaking Lenght in meter		Burst factor		Tear factor		Double fold No.		Apparent Density Kg/m²	
		30°SR	40°SR	30°SR	40°SR	30°SR	40°SR	30°SR	40°SR	30°SR	40°SR
1	0	5311	6516	52.6	65.8	96	101	179	398	481.4	517.9
1	1	5332	6538	53.2	66.4	99	102	187	396	482.2	518.5
1	2	5384	6591	53.8	66.8	100	105	198	411	482.7	519.3
1	3	5287	6478	52.1	64.1	100	106	185	378	481.5	517.2
1	4	5202	6382	51.7	62.3	98	101	178	312	480.2	516.3
1	6	5111	61.09	50.3	60.8	96	98	179	266	472.3	512.4
1	10	4322	5121	43.8	52.5	89	91	154	205	470.1	510.1
2	0	6022	6676	59.6	67.1	107	105	237	457	496.7	533.2
2	1	6128	6713	60.8	67.9	108	109	246	483	497.3	535.6
2	2	6242	68.4	61.4	68.3	109	11	294	513	497.9	536.8
2	3	6106	6389	56.4	64.5	101	105	275	397	492.4	531.5
2	4	6087	6296	53.2	61.4	99	102	246	302	490.7	528.2
2	6	5621	6077	50.8	60.6	96	99	171	254	470.5	516.4
2	10	4752	5103	44.1	51.7	88	95	162	197	470.1	509.7
3	0	6123	6865	62.1	68.2	109	106	252	488	530.1	569.4
3	1	6309	6921	63.2	68.7	111	108	266	514	531.6	569.4
3	2	6395	7116	64.4	70.5	124	118	284	545	532.5	571.2
3	3	6187	6408	55.9	63.5	105	104	274	387	501.4	556.3
3	4	6011	6221	53.3	61.8	99	101	239	314	491.3	529.5
3	6	5547	6021	50.1	60.3	91	94	174	266	471.2	518.4
3	10	4672	5109	43.6	51.5	88	90	161	186	470.2	510.2
4	0	6128	6887	60.7	66.7	105	103	267	492	549.5	563.8
4	1	6235	7007	61.8	68.8	107	105	291	518	551.2	565.2
4	2	6364	7108	635	70.9	109	112	308	551	552.4	565.9
4	3	5912	6512	58.7	63.8	101	103	234	393	531.4	514.2
4	4	5511	6134	54.3	61.5	100	100	212	375	528.7	507.4
4	6	5067	5939	50.1	60.1	95	98	197	254	472.1	504.7
4	10	4313	5411	43.1	52.1	88	92	188	198	461.5	502.1

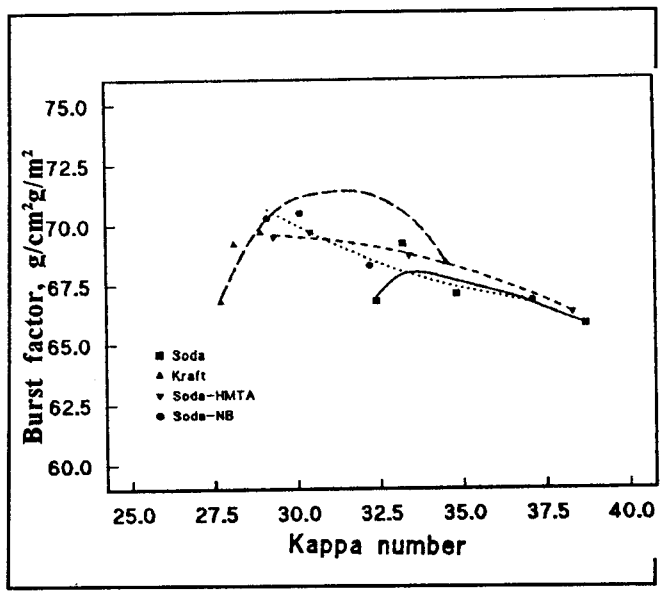
This effect is prominent up to 0.1% HMTA and afte that concentration effects are very slow. Table 13 b shows the physico-mechanical characteristics of pulps are increased with the addition o nitrobenzene up to 2%. The characteristics are decreased with the increased of nitrobenzene addition after 2%.

Figure 3 shows the breaking length with respect to kappa number at 40 °SR of both soda-HMTA and soda-NB pulps with control soda and kraft pulps. The breaking length of soda-HMTA and soda-NB are superior to those of kraft pulps at the targeted kappa number 30. Below kappa number 30.5, breaking length is inferior to the control kraft pulp. The soda-NB pulp is slightly inferior at kappa number range 30.5.36 than the soda-HMTA pulp.

Figure 4 shows that burst factor of soda-HMTA pulp is superior at any kappa number compared to soda pulp but inferior to kraft pulp. The soda-NB pulp



Fog.-3 The relation between kappa number and breaking length of soda-HMTA & Soda-NB pulping of WJP at 40°SR.

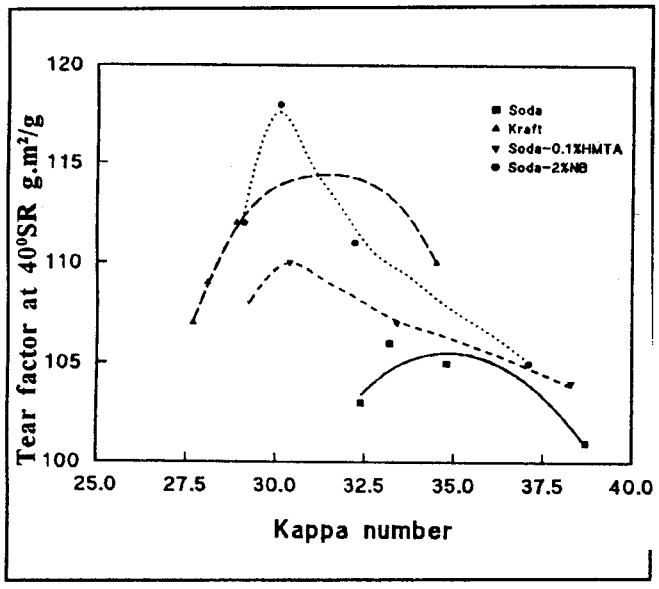


Fog.-4 The relation between kappa number and burst factor ofsoda-HMTA & soda-NB pulping of WJP at 40°SR.

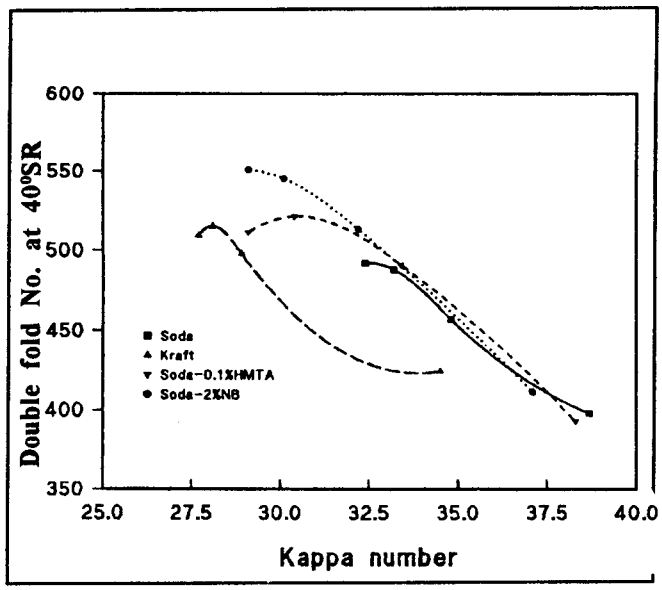
is inferio to the soda and kraft pulps in the kappa number range 33-37. The soda-NB pulp exceed the soda-HMTA pulp after kappa numbers 30.5 and almost equivalent to kraft pulp.

The Figure 5 represents the relation between kappa number and tear factor at 40 SR. The pulps made by soda-HMTA and soda-NB processes exhibited higher tear strength than the soda pulp. The strength obtained by soda-NB process exceeds that obtained by soda-HMTA process. Maximum tear value is obtained at kappa number 30 in both processes. At kappa number 30, soda-NB pulp made tear value 3.5% higher than the kraft pulp.

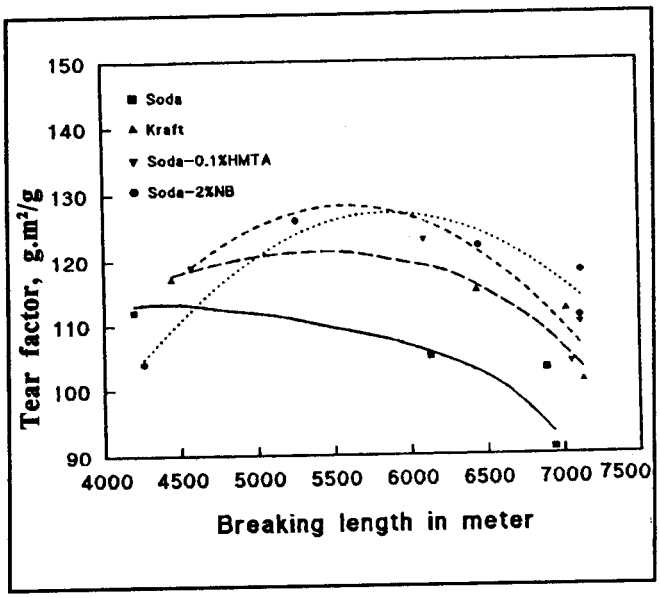
The double fold number of soda-HMTA and soda-NB pulps with control at a particular SR is given in the Figure 6. The pulps produced in soda-HMTA



Fog.-5 The relation between kappa number and tear factor of soda-HMTA & Soda-NB pulping of WJP at 40°SR.



Fog.-6 The relation between kappa number and double fold No. of soda-HMTA & Soda-NB pulping of WJP at 40°SR.



Fog.-7 The relation between tensile and tar of soda-HMTA & soda-NB pulps at almost similar degree of cooking.

and soda-NB processes are superior at any point of kappa number than the kraft pulp. The double fold number shows almost same value in both processes up to kappa number 32. 5 after that soda-NB exceed the soda-HMTA pulp At targeted kappa nr 30, doubl fold number is ieased about 1% for so-HMTA a16.9% for soda-NB pros than the kraft pulp.

The tensile-tear diagrams for soda-HMTA and soda-NB with control at almost similar degree of pulping are shown in Figure 7. The strength properties of soda-HMTA and soda-NB pulps are hardly different at the breaking length 6000 meter. The soda-HMTA pulp exhibited superior tear strength at any breaking length compared to kraft pulp. At the intial stage, the tear value is lower for soda-NB pulp and the value increased sharply with the increase of breaking length and even exceeds the soda-HMTA pulp after breaking length 6000 meter. At breaking length 6000 meter, these two pulps show about 7.5% higher tear value.

According to the results, the additive favour the physico-mechanical characteristics up to some limit, which is most likely due to a plasticizing effect of the additive on the lignin of the fibrous materials (21).

CONCLUSION

The folowing conclusion may be made from these investigation:

- The addition of HMTA up to 0.01% or NB up to 2% on o.d. WJP in soda liquor increased the pulping rate but both these additive cannot exceed the control kraft rate. Higher percentage of NB decreased the pulping rate.

-Pulp yield is slightly increased with the addition of HMTA or NB in soda liquor. NB is comparably better than the HMTA in respect to pulp yield and delignification.

- The physical strength characteristics of soda-NB and soda-HMTA pulp are considerably better than the soda pulp and almost same to kraft pulp.

ACKNOLEDGEMENT

The authors' wishes to thank Sk Abdullah for his valuable suggestion rega rding our experiments. Thanks are due to Dr. Nurul Islam, Director, BCSIR Laboratories, Dhaka for providing fund for performing these works.

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Table 2: Physical Characteristics of soda-HMTA and soda-NB pulps (NaOH 18%, material to liquor ratio 1:6 and temperature 170°C).

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