Soda pulping of rice straw with low alkali

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ABSTRACT

In the light of existing trend of demand and availability of fibrous raw materials for the pulp and paper industry rice straw appears to be promising. Physical and chemical characteristics of straw indicate that it can be pulped even for bleachable grades with milder conditions of pulping. This paper deals with straw pulping with low causite soda of 4-6% and low temperature followed by optimisation of bleaching conditions to yield a pulp with a brightness of 7/-79% EL.

The pulp obtained with 4.0% alkali has necessarily to undergo mechanical treatment for defibration whereas in other cases, the pulp obtained is soft enough under all conditions of pulping. The bleaching of all the pulps can be carried out to a satisfactory level of brightness 71% El. The strength properties of unbleached and bleached pulps are higher with 5% alkali.

Bamboo was so far the main raw material for pulp and paper industry but now the supply is becoming dwindling. It may not be exaggeration to say that leave apart the expansion, to maintain the existing production of pulp and paper, some alternative fibrous raw materials has to be utilised. Many new small mills have also come into existance, based on agricultural residues as their basic raw materials.

Out of all the annual crops straw is most abundantly occuring as non wood plant material and huge quantity of this renewable material, which was successfully used for pulp and paper making though it was later substituted by other raw materials, is available. Under the present condition of availability of woody raw material, it has again gained the importance, particularly in the developing countries like Sri Lanka, India and Egypt etc.

As stated above, seeing the existance of many mills based on agricultural residues, particularly straw, it becomes essestial to study each and every aspect of its effective and efficient utilisation. Though, rice as well as wheat straw are considered under straw, the present investigation deals with rice straw only.

Relatively little work has been reported on pulping of rice straw. Inspite of inherent disadvantages like high silica, low fiber length it has got certain advantages like low lignin, openness of material and consequently easy pulping. The prominent research (1-8) reveal that a wide range of pulping condition were used to obtain the pulp from rice straw. The chemical used in pressure pulping ranged from 7 to 15 % NaOH and the temperature was as high as 180°c. The permanganate number obtained under these conditions ranged in betwee 5.5 to 13. For the bleachable grades of pulp most of the work carried out, using drastic conditions, i.e. high chemical and temperature, to obtain a pulp of very low permanganate number resulted in a very low yield.

Panda (9) reported that out of a total alkali charge of 15 % as Na₂0, only 5 % is used in dissolution of lignin and rest is comsumed by reactions with acids and hemicelluloses, in case of bamboo pulping. Thus it is imperative that the accessibility of lignin to the chemical is one of the main factor in pulping reaction. Further, when bleachable grads of pulp are being manufactured from wood and

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bamboo etc., in the permanganate number between 17 - 25, why should it not be possible to do the same thing in case of rice straw?

With the above background, an effort has been made to investigate the feasibility of rice straw pulping under milder conditions to obtain bleachable grade of pulp.

EXPERIMENTAL

Rice straw was collected from Rayagada (Orissa) region and chopped manually to around 4-5 cms. The proximate chemical analysis was carried out as per TAPPI standard and the results are recorded in Table 1.

The pulping was done in electrically heated rotary digester of 15 litres capacity. The conditions of pulping and results are shown in table 2. The pulps were bleached using a CEH sequence as per the constant conditions given below :

	Temp.°C	Time hr.	Consis- tency, %	
Chlorination (C)	Ambient	0.5	3.0	
Alkali Extraction (E	50	1.0	5. 0	
Hypochlorite (H)	40	2.0	5.0	

TABLE-1

PROXIMATE CHEMICAL ANALYLIS OF RICE STRAW.....

	Particulars, %	Results
1.	Moisture	6.7
2.	Ash	15.0
3.	Solubilities	
	a. Cold water	11.0
	b. Hot water	13.5
	c. 1.0% NaOH	44.3
	d. Alcohol-Benzene	5.9
4.	Holocellulose*	70.1
5.	Pentosans	20.0
6.	Klason lignin*	10.0

*Ash corrected

TABLE-2

Particulars	Cook-1*	Cook-2	Cook-3	Cook-4
Chemical added on O. D. Straw	· · ·		· · · · · · · · · · · · · · · · · · ·	
basis (as NaOH),%	4.0	4.0	5.0	6.0
Bath Ratio	1:4	1:4	1:4	1:4
Time to Max. Temp., (hrs)	1.0	1.0	1.0	1.0
Time at Max. Temp., (hrs)	1.5	1.5	1.5	1.5
Max. Temp., °C	140	150	140	140
Black liquor pH	9.0	8.8	9.1	9.3
Unbleached pulp yield, %	<u> </u>	63.0	61.7	59.4
$KMnO_4$ No. (40 ml)	·	18.1	16.0	12.1

PULPING OF RICE STRAW

*Pulp cold not be Defibrated in valley beater

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The chlorine charge was optimised by varying the chlorine dose and optimised charge was taken out by plotting a graph between chlorine charge against permanganate number of alkali extracted pulp, as shown in figer 1. After optimum chlorination, extraction was done and then hypochlorite charge was optimized to get desired level of brightness. The bleaching conditions and results are recorded in Table 3-5. Unbleached and bleached pulps were beaten in valley beater sheets were made on British handsheet making machine and after conditioning, those were tested for physical strength properties data at 45° SR are recorded in Table 6.

RESULTS AND DISCUSSION PROXIMATE CHEMICAL ANALYSIS:

The proximate chemical analysis data reveal (Table 1) that the lignin content is low, while ash and pentosan are very high compared to conventional raw material. Holocellulose content is more or less similar to other conventional raw materials.

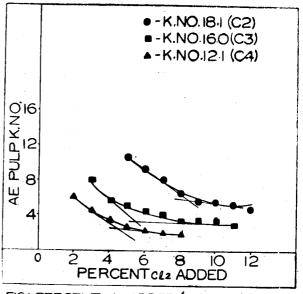




TABLE-3 OPTIMIZATION OF CHLORINATION OF C. E. H. SEQUENCE Unbleached Pulp KMnO₄ No. 18.1 (C-2)

Particulars	1	2	3	4	5	6	7	
CHLORINATION		· · · · · · · · · · · · · · · · · · ·				0		8
Cl_2 added, % Cl_2 consumed, %	5.0 4.97	6 0 5.92	7.0 6.85	8.0 7.10	9.0 7.90	10.0 8.75	11 . 0 6.69	12.0 10.50
Final pH ALKALI EXFRACTION	1.7	1.6	1.5	1.3	1.2	1.0	0.9	0.8
NaOH added, %	1.6	1.6	1.8	1.8	2.0	2.0	2.2	2.4
Final pH	9.6	9.5	8.9	8.5	8.6	8.5	9.0	9.3
KMnO ₄ No. of A.E. Pulp	10.6	9.5	8.3	6.6	5.7	5.7	5.4	4.7

*8.5 % Cl₂ is taken as optimum

OPTIMIZATION OF 'E' STAGE OF THE ABOVE

1	2	3*	4	
1.0	2.0	3.0	40	5.0
0.99	1.96			4.20
6.4	6.1	6.2		60
52.8	67.2	77.0	78.7	81.0
	¹	9.4		
	· <u> </u>	24.0		_
		4.2		· •
	6.4	0.99 1.96 6.4 6.1	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$

Taken as optimum

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CHLORINATION	3.0 4	.0 5:0	- 10 107 05 107 56 6 5 107 6	្រសាទ ន ៀមមាន (10.0
Cl ₂ added, % Cl ₂ consumed, %		98 4.38	18.75 au 6.72	7.60	8.54 9.44 10.40
Final pH		0 2.0 cm	199/213181	as tis zelievi	18 HOLL 1 7 16
ALKALI EXTRACTION		S. A. States	une sniebu	ti Mattalatio	real tests in induces.
NaOH added, %		.2 1.2	1.2 1.3	1.3°, 576	1.5
Final pH	9.5 9	.5 9.4	9.2 9.0	9.5	9.3 9.2 9.4
KMnO ₄ No. of A. E. Palp	* 8.0 5	.9 5.0	4.5 4.4	3.5	3.5 3.5 3.1
• 5.5% Cl ₂ is taken as OPTIM	optimum ZATION O	F 'H' STAGE	OF THE		RESULTS AND DIS PROSEMATE CHEN
Particulars 1	21	t de la companya de l	3	4 Hu Jasimod	5
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C_{12} added, $\frac{1}{2}$	2.0		y _{ess} a bead	Quere algorit y	5.0 556 6.0
Cl ₂ consumed %) (300 0.9	· · · · · · · · · · · ·	≩,⊜≊≊ _{26 0} 2,	An 2 1121013	.9 9993881899998 .9 99938	412 Horoten 510 Horot - 611 des et 12.01610 et al
Final pH Brightness (Elfepho), % 73.5	6. 80.9				83.0 83.3
P. C. Number -	8.0			-	
Shrinkage 0/	20.0	Laine 2197	UID 10-7	ENTZSIKT	1940 <u>—</u>
Viscosity, cp (CED) 223002	6.	VI. CHEVIA	us Eschurd (f	; ` !	,,
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	Inbleached P	$ulp KMnO_4 N$	lo. 12.1 (C-4	I. SEQUEN	
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Cl conumed %	1 00		4.0 0-3.81	5.0 4.40	6.0 7.0 M
ALKALI EXTRACTION	1994 -				4.65 5.44
	-9.X 7.3			42 B.	
NaOH added. %	0.6		1.0	- e ₽ - \\\\	TAKE WARANA
NaÖH added, % Final pH	0.6	0.8	1.0 9.3		
NaOH added, % Final pH KMnO ₄ No: after extraction	0.6	0.8	1.0 9.3	0.01 .3 409	9.8 9.9
Final pH KMnO ₄ No. after extraction	0.6 9.0 6.3	0.8 9.1 4.6	1.0 9.3 Into 43 16 410	0.011.3qte4 9.5 21.5 2.9 7.4	9.8 9.9
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Final pH KMnO4 No: after extraction *4.5 % Cl ₂ is it OPTIMI Particulars HYPO STAGE Cl ₂ added, %	0.6 9.0 6.3 aken as optin ZATION OF 1 0.5	0.8 9.1 4.6 mbm/ 1 5 'H' STAGE 2	1.0 9.3 10) (1.3q) (1 9.5 21 (2.9) 7.4 12.1 (1) ABOVE	9.8 9.9 2.4 2.4 5 100 100 100 100 100 100 100 100 100 10
Final pH KMnO4 No. after extraction *4.5 % Ct ₂ is it OPTIMI Particulars HYPO STAGE Cl ₂ added, % Cl ₂ consumed, %	0.6 9.0 6.3 aken as optimization of 1 0.5 0.50	0.8 9.1 4.6 mbm/ T 4 7 'H' STAGE 2 1.0 0.95	1.0 9.3 9.3 10) 011.3q1 9 9.5 2.9 123 TOO ABOVE 4	9.8 9.9 2.4 2.4 3.4 2.4
Final pH KMnO4 No. after extraction *4.5 % C42 is a OPTIMI Particulars HYPO STAGE Cl2 added, % Cl2 consumed, % Final pH	0.6 9.0 6.3 aken as optimization of 1 0.5 0.50 7.1	0.8 9.1 4.6 mbm ² T	1.0 9.3 9.3 10	<u>9 001.3 000000000000000000000000000000000</u>	9.8 9.9 2.4 2.4 2.4 2.4 2.4 2.4 2.5 3.0
Final pH KMnO ₄ No. after extraction *4.5 % Ch ₂ is it OPTIMI Particulars HYPO STAGE Cl ₂ added, % Cl ₂ consumed, % Final pH Brightness, % (Elrepho) P C Mumber	0.6 9.0 6.3 (aken as optin ZATION OF 1 0.5 0.50 7.1 0.71.3	0.8 9.1 4.6 mbm/ F 'H' STAGE 2 10 1.0 0.95 7.2 76 8	1.0 9.3 9.3 10	0 011.3 cm 9.5 2.9 ABOVE 4 2.0 1.64	9.8 9.9 2.4 2.4 2.4 9.9 9.9 9.9 2.4 2.4 2.4 2.4 2.4 2.4 2.4 2.4
Final pH KMnO ₄ No. after extraction *4.5 % Ck is it OPTIMI Particulars HYPO STAGE Cl ₂ added, % Cl ₂ consumed, % Final pH Brightness, % (Elrepho) P.C. Number	0.6 9.0 6.3 aken as optimization of 1 0.5 0.50 7.1	0.8 9.1 4.6 mtm F 'H' STAGE 2 2 10 10 1.0 0.95 7.2 76 8 5.1	1.0 9.3 9.3 10	<u>9 001.3 000000000000000000000000000000000</u>	9.8 9.9 2.4 2.4 2.4 3.0 2.5 3.0 2.15 2.60 4.1 2.5 3.0 2.15 4.1 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0
Final pH KMnO4 No. after extraction *4.5 % C42 is at OPTIMI Particulars HYPO STAGE Cl2 added, % Cl2 consumed, % Final pH Brightness, % (Elrepho) P.C. Number Shrinkage, %	0.6 9.0 6.3 (aken as optin ZATION OF 1 0.5 0.50 7.1 0.71.3	0.8 9.1 4.6 mtm/ T H' STAGE 2 2 10 10 0.95 7.2 76 8 5.1 20.0	1.0 9.3 9.3 10	<u>9 001.3 000000000000000000000000000000000</u>	9.8 9.9 2.4 2.4 2.4 2.4 2.4 2.4 2.5 3.0 2.15 2.5 3.0 2.15 2.5 3.0 2.15 2.60 4.7.1 2.60 4.7.1 2.4 2.4
Final pH KMnO4 No. after extraction *4.5 % C42 is it OPTIMI Particulars HYPO STAGE Cl2 added, % Cl2 consumed, % Final pH Brightness, % (Elrepho) P.C. Number Shrinkage, % Viscosity, cp (CED)	0.6 9.0 6.3 (aken as optin ZATION OF 1 0.5 0.50 7.1 0.5 7.1 0.5 7.1 0.5 7.1	0.8 9.1 4.6 mtm/ T 'H' STAGE 2 2 10 10 1.0 0.95 7.2 76 8 5.1	1.0 9.3 9.3 9.3 9.3 9.3 9.3 0 0 7.4 7.4 78.3 	<u>9 001.3 000000000000000000000000000000000</u>	9.8 9.9 2.4 2.4 5 2.5 3.0 2.15 12.60 4.7.1 2.60 4.7.1 2.60 5.7.1 2.50 5.7.1 2.50 5.7.50 5.7.50 5.7.50 5.7.50 5.7.50 5.7.50 5.7.50 5.

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Particulars	çinə	Unbleached		Unbleached			d Bleached
Bulk, cm ³ /g		2.13	1.80	1.79	1.67 0%	1.79:1	MAUTAH
Burst factor		21.0	26.9	22412 AVA	296HB	- 0258 T3	YATAAD
Tear factor		33.0	27.1	33.1	38.6	25.6	32.0
Breaking length, N	ſ	3986	4713	4015 MMU	4589	4113	3900
Double folds, No.	婚姻 接近限	liter matterion as	on of all an	It efforts a R. to be	s jal2and te	e alema (4 alemana) - alema (terratural) -	selecter15

PULPING:

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not defibrated even after long mechanical treatment in a valley beater. When the temperature, under the same condition (C-2), was raised to 150° C the resulting pulp has to be defibrated but the process is easier with 5-6% NaOH at 140°C, gave sufficiently soft pulps which needed no further defibration. However, the permanganate, number reduced from 18 to 12 with a decrease in pulp yield 63% to 59%. (wat have)

BLEACHING

id the anglithnes arisens of t

aluq cen sequence was followed for bleaching as the permanganate number of unbleached pulp was considerably high (8). The optimization of bleaching stages were also carried out. It can be seen from > table 3-5 that during chloringtion with the increase in the charge of chlorine the end pH decreases. The decrease in pH was very sharp in case of pulp of high permanganate number due to formation of more acidic compounds. In the extraction stage in order to maintain pH around 9, with increasing chlorine charge increased amount of NaOH was required. The addition of varied amount of hypo; in optimised chlorinated and extracted pulp has given the optimum hypo charged to get the desired. level of brightness.

The shrinkage during bleaching was higher in case of higher permanganate number pulp. The post colour number of bleached pulp, obtained from, unbleached pulp of higher permanganate number, was high. This may be due to more exidation of cellulose since higer percentage of chlorine was applied at the same time more fractions of lignin molecules were left over, after bleaching, with the pulp. The physical strength properties (table6) at 45°SR for unbleached and bleached pulps revealed

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Pulping with 4 % NaOH (Table 2) at a temp- less similar in all the cases, however, the pulp of erature of 140°C (C-1) results in a pulp which was C-3 ie. 5% NaOH was having slightly higher strength properties. onalling in our number of the

CONCLUSION: An Asidow And Andread And State

The present study reveals that the pulp of satisfactory quality can be obtained even by using lower chemical in cooking and at the same time it will give higher pulp yield. The bleaching of these high permanganate number pulps can be done to a desired level of brightness by using CEH sequence. The physical strength properties are more or less same in all cases, however, the pulp obtained with 5% NaOH pulcing is baving slightly higher strength properties. The have 电自己的 机酸盐 的人的

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