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 causitc soda of 4-6% and low temperature followed by optimisation of bleaching conditions to yield a pulp with a brightness of 77-79% 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 77% 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 Na_2O, 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 betwen 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.	Consistency, %
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

PULPING OF RICE STRAW

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, %	—	63.0	61.7	59.4
$KMnO_4$ No. (40 ml)	—	18.1	16.0	12.1

*Pulp cold not be Defibrated in valley beater

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.

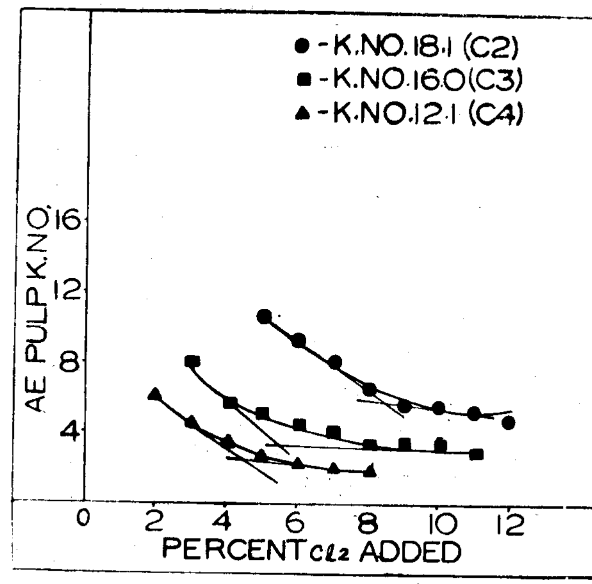

FIG.1 PERCENT Cl_2 ADDED (C-STAGE) Vs A.E PULP K.NO.

TABLE—3

OPTIMIZATION OF CHLORINATION OF C. E. H. SEQUENCE

Unbleached Pulp $KMnO_4$ No. 18.1 (C–2)

Particulars	1	2	3	4	5	6	7	8
CHLORINATION								
Cl_2 added, %	5.0	6 0	7.0	8.0	9.0	10.0	11.0	12.0
Cl_2 consumed, %	4.97	5.92	6.85	7.10	7.90	8.75	6.69	10.50
Final pH	1.7	1.6	1.5	1.3	1.2	1.0	0.9	0.8
ALKALI EXTRACTION								
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 % Cl_2 is taken as optimum

OPTIMIZATION OF 'E' STAGE OF THE ABOVE

Particulars	1	2	3*	4	5
HYPO STAGE					
Cl_2 added, %	1.0	2.0	3.0	4.0	5.0
Cl_2 consumed, %	0.99	1.96	2.72	3.64	4.20
Final pH	6.4	6.1	6.2	6.0	6 0
Brightness (Elrepho), %	52.8	67.2	77.0	78.7	81.0
P.C. Number	—	—	9.4	—	—
Shrinkage, %	—	—	24.0	—	—
Viscosity, cp (CED)	—	—	4.2	—	—

*Taken as optimum

TABLE—4

OPTIMIZATION OF CHLORINATION OF C.E.H. SEQUENCE

(Unbleached $KMnO_4$ No. 16.1 (C-3))

Particulars	1	2	3	4	5	6	7	8	9
CHLORINATION									
Cl_2 added, %	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0
Cl_2 consumed, %	2.98	3.98	4.38	5.75	6.72	7.60	8.54	9.44	10.40
Final pH	2·3	2.0	2.0	1.9	1.8	1.8	1.8	1.7	1.6
ALKALI EXTRACTION									
NaOH added, %	1.0	1.2	1.2	1.2	1.3	1.3	1.4	1.5	1.6
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. Pulp	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 optimum

OPTIMIZATION OF 'H' STAGE OF THE ABOVE

Particulars	1	2*	3	4	5	6
HYPO STAGE						
Cl_2 added, %	1.0	2.0	3.0	4.0	5.0	6.0
Cl_2 consumed, %	0.9	1.8	2.7	3.5	4.2	5.0
Final pH	7.1	6.6	6.4	6.2	6.1	6.0
Brightness (Elrepho), %	73.5	80.9	81.4	82.8	83.0	83.3
P. C. Number	—	8.0	—	—	—	—
Shrinkage, %	—	20.0	—	—	—	—
Viscosity, cp (CED)	—	6.3	—	—	—	—

*Taken as optimum.

TABLE—5

OPTIMIZATION OF CHLORINATION OF C. E. H. SEQUENCE

(Unbleached Pulp $KMnO_4$ No. 12.1 (C-4))

Particulrrs	1	2	3	4	5	6
Cl_2 added, %	2.0	3.0	4.0	5.0	6.0	7.0
Cl_2 conumed, %	1.98	2.96	3.81	4.40	4.65	5.44
ALKALI EXTRACTION						
NaOH added, %	0.6	0.8	1.0	1.3	1.5	1.7
Final pH	9.0	9.1	9.3	9.5	9.8	9.9
$KMnO_4$ No. after extraction	6.3	4.6	3.6	2.9	2.4	2.4

*4.5 % Cl_2 is taken as optimum

OPTIMIZATION OF 'H' STAGE OF THE ABOVE

Particulars	1	2	3	4	5	6
HYPO STAGE						
Cl_2 added, %	0.5	1.0	1.5	2.0	2.5	3.0
Cl_2 consumed, %	0.50	0.95	1.27	1.64	2.15	2.60
Final pH	7.1	7.2	7.4	7.3	7.1	7.1
Brightness, % (Elrepho)	71.3	76 8	78.3	79.3	80.4	80.8
P.C. Number	—	5.1	—	—	—	—
Shrinkage, %	—	20.0	—	—	—	—
Viscosity, cp (CED)	—	6.2	—	—	—	—

*Taken as optimum

TABLE—6

Particulars	Cook-2		Cook-3		Cook-4	
	Unbleached	Bleached	Unbleached	Bleached	Unbleached	Bleached
Bulk, cm^3/g	2.13	1.80	1.79	1.67	1.79	1.61
Burst factor	21.0	26.9	24.2	29.6	25.5	24.0
Tear factor	33.0	27.1	33.1	38.6	25.6	32.0
Breaking length, M	3986	4713	4015	4589	4113	3900
Double folds, No.	5	4	9	12	4	15

PULPING :

Pulping with 4 % NaOH (Table 2) at a temperatureof 140°C (C-1) results in a pulp which was 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%.

BLEACHING

CEH 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 chlorination 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 oxidation 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 that the bulk of bleached pulp was lower than unbleached pulp. The other properties were more or less similar in all the cases, however, the pulp of C-3 ie. 5%NaOH was having slightly higher strength properties.

CONCLUSION:

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 pulping is having slightly higher strength properties.

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