Effect of Stepwise Removal of Hemicellulose on the Quality of Eucalyptus hybrid Pulps

S. P. Singh
J. S. Negi
S. R. D. Guha

The pulps were prepared by sulphite and semi-chemical process from Eucalyptus tereticornis (so called 'hybrid'). These pulps were bleached with sodium chlorite to minimise the degradation and subsequent removal of hemicellulose and other carbohydrates. The bleached pulps were extracted by increasing concentration of alkali to obtain pulps of varying pentosan content. The results showed that the strength properties decreased and beating time increased with removal of pentosans while presence of hemicelluloses tend to yellow the pulp on aging.

Introduction

It is already a established fact that hemicellulose (both pentosans and hexosans) have decisive effect on the strength properties and beating qualities of pulps. It is assumed that the effect is due to the hydrophilous nature and short chainlength of the hemicelluloses as compared to cellulose. The hydrophilous nature of hamicelluloses has been accounted as due to their amorphous nature. Young and Rowland[1] showed that 2.5% pentosans of coniferous pulp correspond to 42% swelling, whereas with the rise in pentosans to 12.6%, the swelling rose to 96%. According to Giertz[2], the effect of hemicellulose is more physical then chemical in improving the properties of paper. The hemicelluloses most probably act like glue. The process of drying brings the hydroxyl groups close to each other and they become bound to cellulose chain by means of hydrogen bond.

The effect of hemicelluloses has been found more advantageous when these are added in the pulp in isolated form. Jonas and Reith[3] studied the effect of mannans and xylans and mixture of the two on spruce pulp. They found that mannan rich hemicelluloses were more effective than xylan. Jayme[4] studied the effect of removal of hemicelluloses from Mitscherlish pulp and found that breaking length and double fold values were reduced. When isolated hemicelluloses were added to the pulp, the strength improved to almost to the original level. A similar study was made by Guha and co-workers[5,6] on bamboo pulp. They prepared bamboo sulphate pulp and studied the effect of addition of isolated xylan and step-wise removal of xylan from bamboo sulphate pulp. They found that the strength properties of the paper made from pulps having different xylan content increased or decreased depending upon the amount of pentosan contant of pulp. Many investigators [7–12] found that high hemicellulose pulps hydrate rapidly and produce stronger papers. However the strength of paper reaches a maximum at a certain optimum hemicellulose content and then gradually begins to fall.

In the present study an effort is made to correlate the strength properties of different pulps from which hemicellulose were removed by increasing concentration of alkali. A study was also made on brightness reversion on accelerated heat aging.

In this investigation two entirely different methods of approach were made.

1. Pulps from different methods that contain varying amount of hemicelluloses were prepared.
2. A pulp of high hemicellulose content may be subjected to stepwise alkaline extractions, thus producing a series of pulps residues with widely varying hemicellulose contants.

The amount of hemicelluloses in pulps or papers was estimated as pentosans, as it has already been established that *Eucalyptus hybrid* contains only pentose type of hemicelluloses with about 20 percent glucuronic acid in it.

Experimental

Air dry logs of *Eucalyptus tereticor-*

S. P. Singh, J. S. Negi and S. R. D. Guha,
Cellulose and Paper Branch, Forest Research Institute, Dehra Dun.

nis (hybrid) raised in plantations in Lalkua U. P. State were received from the Silviculturist, Sal Region, Lalkua, U.P. The logs wers converted into chips in the pilot plant chipper. The chips were milled in the laboratory disintegrator to produce dust. The dust passing through 60 mesh, but retained on 80 mesh was used for analysis.

(a) Preparation of different pulps from Eucalyptus hybrid

Production of sulphate pulps:–200 g. chips were digested by the sulphate process (NaOH : Na_2S : : 3:1) in a three litre stationary stainless steel digester using chips to liquor ratio 1:4. The quantity of chemicals used was 18% on the oven dry weight of the chips and the digestion was carried out at 162°C for 4 hours including 1 hour to raise the temperature to the maximum cooking temperature from the room temperature. After the digestion the pulp was thoroughly washed with water. The yield of the pulp was 49.7 percent, The pulp was prepared in large quantity.

Production of semi–chemical pulps : 200 g. chips were first partially digested by the sulphate process (NaOH:Na_2S : : 3:1) in a three litre stationary stainless steel digester using chips to liquor 1:4. The quantity of chemicals used was 8 percent on oven–dry weight of the chips and the digestion was carried out at 153°C for 4 hour including 1 hour to raise the temperature to the maximum cooking temperature. After the digestion, the partially cooked chips were passed through refiner (10, 5, 0 mills) to get the pulp. The pulp was thoroughly washed with water. The yield of the pulp was 70 percent.

(b) **Bleaching of the different pulps :** One portion of each pulp was bleached with sodium chlorite in presence of acetic acid at 100 °C at 3 percent consistancy for 1 hour by the method of Wise and co–workers[13]. In case of sulphate pulps one treatment of sodium chlorite was sufficient, while in case of semi-chemical pulps, three such treatments were required. After the bleaching, the pulps were washed thooughly with water and the yield of the bleached pulps was determined.

(c) **Extraction of the pulps with alkali** : 50 g. portions of each sulphate and semi–chemical bleached pulps were extracted with 5%, 12% and 24% potassium hydroxide solution separately at 3 percent consistency for 2 hours. The pulps were then filtered and washed with water thoroughly. The yield of the extracted pulps was also determined.

(d) **Analysis of different pulps** :– Lignin content[14] of the unbleached sulphate and semi–chemical pulps and pentosan content[15] of the different pulps, were estimated by Tappi standard methods.

(e) **Preparation of standard sheets and testing of their strength properties** :–28 g. of each pulp was beaten in the Lampen Mill to 250 ml. (C. S. F.) freeness at 4 percent consistency and after beating, the consistency was changed to 0.31 per cent and standard sheets of 60 g. s. m. basis weight were made. The sheets were pressed at 50 lbs/sq. inch pressure for 5 minutes and then air dried with the help of rings and plates. Then the strength properties of paper were determined at 65 per cent R. H. and 25±2°C.

(f) **Effect of aging on the brightness of the pulp** :–Standard sheeets of bleached pulps were kept in oven at 120°C for 96 hours and the brightness of the sheets was determined by 'Eel' Reflectance spectrophotometer (MgO=100).

Discussion

The results in Table I show that the yield of the unbleached sulphate pulps is 49.7 percent, while it is 70 percent in case of semi–chemical pulps. The very high yield in case of semi–chemical pulps may be due to the very low removal of lignin and hemicelluloses (pentosans) in these pulps. The lignin content of the unbleached semi–chemical pulp is 23.1 percent as compared to 7.2 percent in case of sulphate pulps.

The extraction of the different bleached pulps with increasing concentration of alkali reduced the pentosan content of the pulps gradually and with gradual removal of pentosans from the pulps, the strength properties of paper i. e. breaking length, burst factor, tear factor and folding endurance reduced considerabely. (Fig. 1). By reducing the amount of pentosans by alkali extraction of the pulps, the beating time increased considerabely from 80 minutes to 240 minutes in case of bleached sulphate pulps and from 45 to 245 minutes in case of bleached semi–chemical pulps.

The semi–chemical pulps beat more rapidly than sulphate pulps which is due to the retention of more hemicelluloses during semi–chemical pulping process.

The results of brightness testing showed that on accelerated aging, the drop in brightness was more in

TABLE–1

Effect of stepwise removal of hemicelluloses on the quality of different pulps. (% expressed on the oven-dry weight of the material)

	Total chemicals %	Time of cooking hrs.	Temp. of cooking °C	Unbleached pulp yield %	Bleached pulp yield %	Lignin %	Pentosans %	Time of beating	Breaking length metres	Burst factor	Tear factor	Folding endurance double folds	Brightness MgO =100	Brightness after aging for 96 hours at 120°C
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Semi-Chemical pulp unbleached	8	4	153	70.0	48.0	23.1	9.9	50 min.	4284	24	68	44	—	—
Semi-chemical pulp bleached	8	4	153	—	48.4	—	9.5	45 min.	8370	66	115	above 1000	69	62
Bleached semichemical pulp extracted with 5% KOH	8	4	153	—	39.2	—	6.8	1.15 hrs.	5120	30	55	36	78	75
Bleached semi-chemical pulp extracted with 12% KOH	8	4	153	—	35.2	—	2.3	4 hrs.	3540	17	31	16	80	78
Bleached semi-chemical pulp extracted with 24% KOH	8	4	153	—	32.4	—	0.8	4 hrs.	3524	18	25	6	80	79
Sulphate pulp unbleached	18	4	162	49.7	46.4	7.2	6.5	1.13 hrs.	6325	51	86	628	—	—
Sulphate pulp bleached	18	4	162	—	46.4	—	6.3	1.20 hrs.	6534	39	101	524	73	68
Bleached sulphate pulp extracted with 5% KOH	18	4	162	—	—	—	2.8	4 hrs.	3826	26	46	28	79	76
Bleached sulphate pulp extracted with 12% KOH	18	4	162	—	42.4	—	1.8	4 hrs.	3648	21	—	24	79	77
Bleached sulphate pulp extracted with 24% KOH	18	4	162	—	37.7	—	0.6	4 hrs.	3328	18	30	14	79	77

A BREAKING LENGTH (METRES)

B BURST FACTOR

C TEAR FACTOR

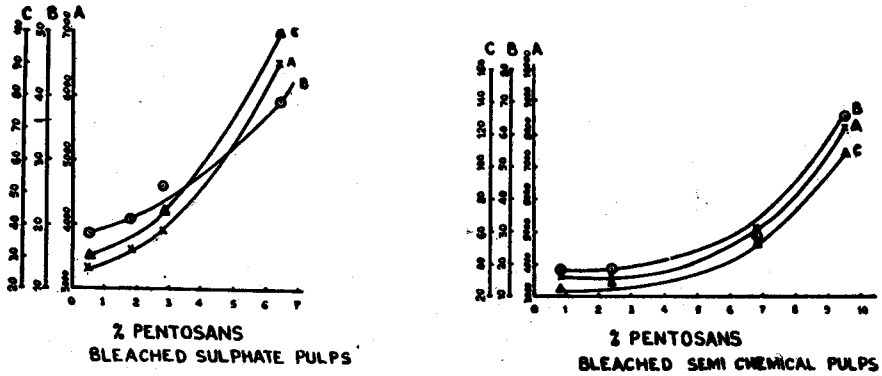

Fig. 1. Relation Between Pentosan Content and Strength Properties of Paper.

case of semi-chemical pulps. This difference may be accounted for by the presence of more hemicelluloses in semi-chemical pulps, which tend to yellow on accelerated aging.

References

1. Young, G. H. and Rowland, *Paper Trade J., 97,* 178 (1938).
2. Giertz, H. V., British Paper Board Makers Assoc. (London) Proc. Tech. Sec. *33,* 483, (1952)
3. Jonas, K. G. and Reith, E., *Wochbl. Papierfabr, 64,* 8 (1953).
4. Jayme, G. *Wochbl. Papierfabr,* 295 (1944).
5. Guha, S. R. D. and Pant, P. C., *Indian Pulp and Paper XXV,* 1–6, (1970).
6. Negi, J. S., *Indian Pulp and Paper, XXIV,* 8–12, (1970.)
7. Hajny, G. J. and Ritter, G. J., *Paper Trade J., III,* 22, 131 (1940).
8. Klingstedt, F. W., *Svensk Paperstidn,* 40, 412 (1937).
9. Saarnio, J., Wathen. K., and Gustafsson, F., *Papperijapu, 36,* 209 (1954).
10. Richter, G. A., *Tappi,* 40, 429 (1957).
11. Peterson, H. R. and Bray, *Paper Trade J.,* 121, 2 (1945).
12. March, R. E., *Tech. Assoc. Papers, 31,* 240 (1948).
13. Wise, L. E., Murphy, M. and D' Addieco, A., *Paper Trade J., 122,* 2, 35 (1946).
14. Lignin in wood *Official Standard T 13m-54, Tech. Assoc. Pulp and Paper Ind.,* New York (1945).
15. Pentosans in wood. *Tentative standard T 19m-50 Tech. Assoc. Pulp and Paper Ind.,* New York (1934).