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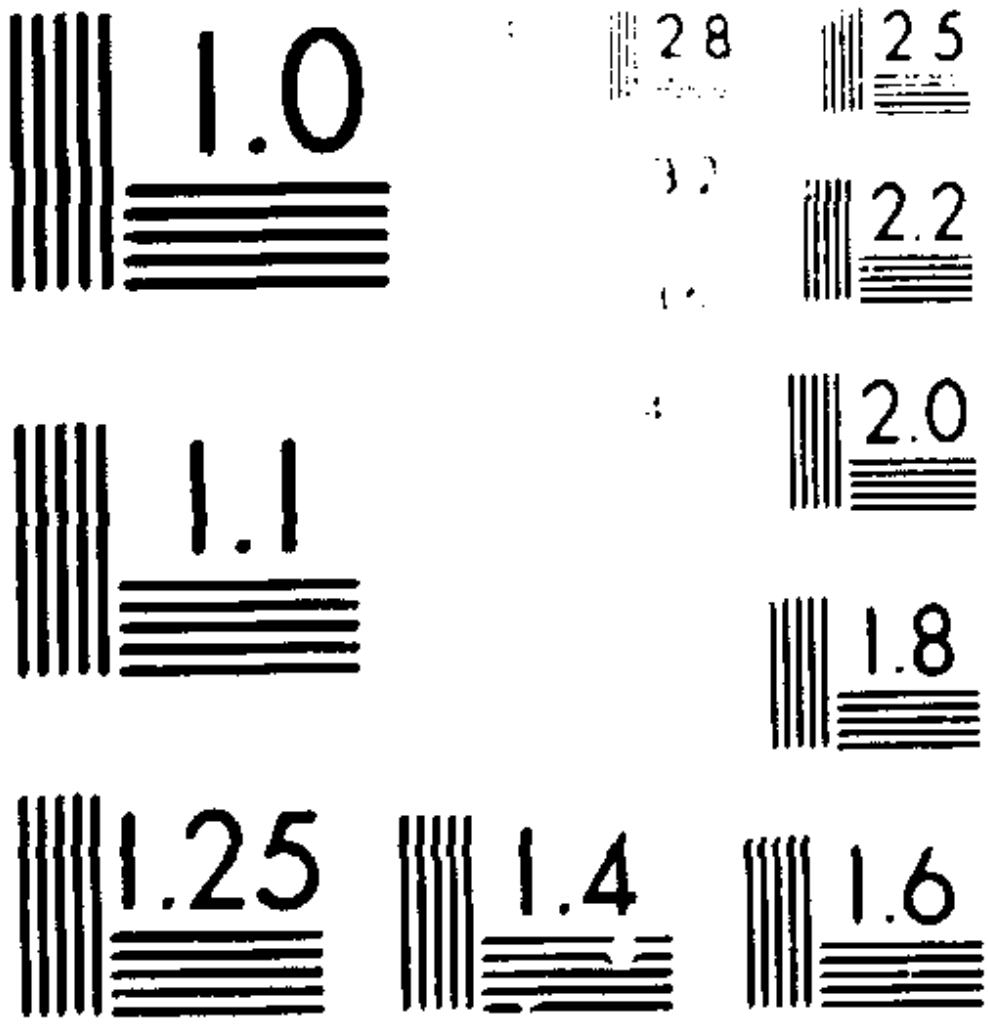
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THE UTILIZATION OF BAMBOO AS A PAPERMAKING MATERIAL*

by

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INTRODUCTION

The utilization of bamboo as a papermaking material in China dates back to the eighth century. For centuries, bamboo paper participated actively in prospering China's handmade paper industry. (1,2). Bamboo was first adopted by the machine-made paper industry of China in the early thirties of this century; the soda process and bisulphite process were the general methods employed in those days. It was not until after the founding of the People's Republic of China when bamboo was being extensively used in machine-made paper. The predominating cooking method has since then switched over to the sulfate process.

Bamboo exists essentially as a monocotyledon plant, belonging to the Bambusoideae family. Quite a number of different species of bamboo are found in the south and west parts of China, but only about thirty species are currently used in the pulp and paper industry. The most important ones are: Nan-Zhu (Phyllostachys edulis (Carrier) H. de Lehaie), Baijia-Zhu (Phyllostachys nigra var Henonis (Mitf.) Stapf et Rendle), Ci-Zhu (Sinocalamus affinis (Rendle) McClure) and others.

Bamboo is closely structured, but porous in nature. Its pores run vertically throughout the whole culm. The pores are filled with sap when green, and with air when dry. Air thus entrapped is hard to expel. The nodes, large and hard, are highly liguified. There are also quite some silica scattered inside the nodes. Bamboo

noces and the reinforcing diaphragms existing inside the hollow sections at the sheath nodes, if not properly handled, will be a source of dirt specks in the final pulp and paper. The average length of most Chinese bamboo species lies within the range of 0.92-2.76 millimeters, regardless of the age of growth of the bamboo. The length-to-width ratio is somewhere around 120-140. It is beyond any doubt, therefore, that bamboo would serve as a good papermaking material.

PULPING AND PAPERMAKING

Both green bamboo and mature bamboo are being used in China. When green bamboos are used, they are generally pre-processed 'in situ' before shipment. Usually, they are split into halves or fours, air-dried, leached with water, and then air-dried again. Leaching renders the green bamboos less susceptible to deterioration and insect pests, making them better prepared for transportation and storage. Pre-processing is not necessary for mature bamboo. However, it is advisable to have mature bamboo mechanically crushed before digestion in order to loosen the nodes and the culms and to destroy the reinforcing diaphragms. Such pretreatment helps to enhance penetration of cooking liquors into bamboo chips, thus assuring a uniform cook. (3,4).

Overhead digestion is presently practised, both for green and mature bamboo. Pilot plant studies and actual commercial practices have proved that with an alkali charge of not more than 16-17 % Na_2O, a pulp of $KMnO_4$ 12-15 can be obtained. Such a pulp can be bleached to the desired brightness without much difficulty. (4,5)

There is a tendency for bleached bamboo pulp to reverse in

color. The cause of such a color reversion is not totally disclosed. Carbonyl groups in the cellulosic constituents of bleached bamboo pulp may possibly be a predominating source causing color reversion. The best way to combat color reversion, apparently, is to resort to multistage bleaching. Using a CEH three-stage sequence, the brightness of the resulting bamboo pulp may reach around 82%, which drops off to 78-79 % on aging. Pulp strength improvement is also attained through multistage bleaching.

Sulfate bamboo fibers, with comparatively high contents of hemicellulose (8-15 % pentosan), are slender and flexible. (4,5). It can be predicted, therefore, that greater bonding surface is available at the superficial regions of the fibers, benefiting their surface activity. Such fibers tend to swell with ease. From Figure 1, taken from work done by Zhongqing Paper Mill, it can be seen that the developing trend in physical strength of bamboo pulp is much similar to that of woodpulp, with the exception that tear factor tends to drop off much faster. It is also noted that bamboo fibers are less susceptible to cutting. (See Figure 2). Full comprehension of such fiber characteristics should be attended to during stock preparation. .

Relief printings and writing papers made from 100 % bamboo pulp have successfully made their way into the market. Offset printings of about 80 % bleached bamboo furnish is comparable in quality with sulfite woodpulp grades. Using a furnish of over 70% bleached bamboo pulp, typewriting paper of competitive quality can be manufactured. All these bamboo papers are of close structure and of good ink receptivity. Furthermore, they do not tend to lint.

The manufacture of kraft wrapping and kraft sack paper from

unbleached bamboo pulp is nothing new in China. The grades thus produced, are somewhat inferior in tearing strength when compared with those from woodpulp. However, if not more than 30-40 % unbleached kraft bamboo pulp (hard cook) is used as part of the furnish, acceptable kraft sacks can be made.

Studies on making qualitative filter paper, electrolytic condenser paper, impregnated insulating paper, viscous grade pulp and various other grades have been conducted. Experimental results have disclosed good prospects for these products. It is expected that chemi-mechanical bamboo pulp may serve as a furnish for newsprints. Work along this line is to be undertaken.

It may be of interest to say a few words about the utilization of bamboo-shoot hulls in typewriting papers and cigarette tissues. Up to 20-30 % bamboo-shoot hull pulp has been currently used with success as a furnish for the said grades. Collecting hulls in rural countries is not an easy task ; this problem hinders the extensive application of bamboo-shoot hulls.

CONCLUSIONS

Bamboo fibers are long and slender, with lengths midway between those of coniferous and deciduous woods. Without doubt, bamboo is a good papermaking material. Furtnermore, bamboo is a rapidly growing plant. Once seeded, clumps of bamboo will develop into groves within 4-6 years. The average annual crop of a well-developed bamboo grove may reach as much as 500 kilograms (bone dry) per mou, equivalent to 7500 kilograms per hectre. Cultivation of bamboo groves to serve as a supply base for papermaking fibers can be carried out without much difficulty. As a matter of fact, in recent years, bamboo-growing provinces in China have begun to take measures for salvaging, recovering and reconstructing bamboo groves,

to back up the paper industry. It is hoped that within 3-5 years, more and more mature bamboo will be available for papermaking.

It goes without saying that the general trend is to use mature bamboos other than green ones in the paper industry. To meet such a developing trend, problems such as fiber morphology (micro-structure in particular), behaviour of bamboo fibers during the beating process, mechanism of color reversion and methods to overcome it etc., still await more extensive and systematic studies to reveal the secrets therein.

Acknowledgement

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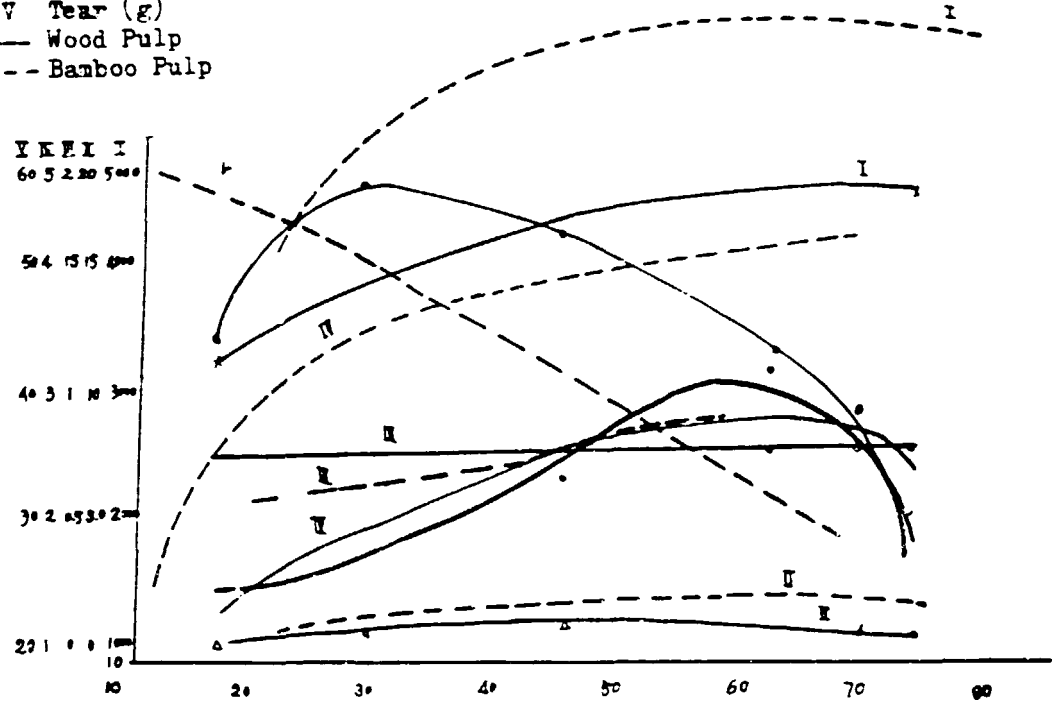
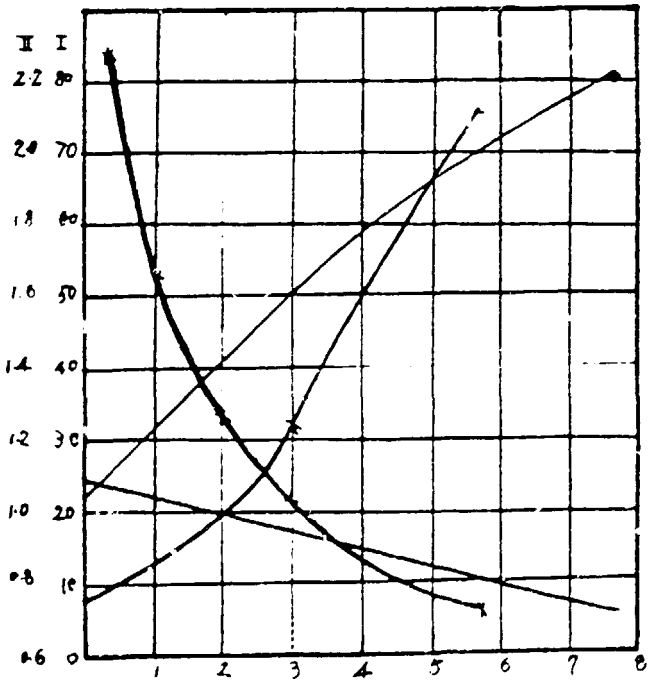
I Breaking Length (m)
II Folding Ratio
III Density (g/cm^3)
IV Burat (kg/cm^2)
V Tear (g)
—— Wood Pulp
- - - Bamboo Pulp



Beating Degree

Figure 2: Strength Development of Bamboo Pulp



I Ascending Curve: Beating Degree

II Descending Curve: Fibre Length

Time of beating (in hrs)

Figure 3: Fibre Length versus Beating Degree