Papermaking Properties of Nonwood Fiber Pulps

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1. BACKGROUND

World paper and board production from non-wood fibers in 1990 was 28.3 million tons, which accounted for about 10% of total production. China produced 17.5 million tons of paper and board in 1992, 75% of which was made from non-wood fibers, such as straw, reed, bagasse and bamboo (Figs 1 and 2).

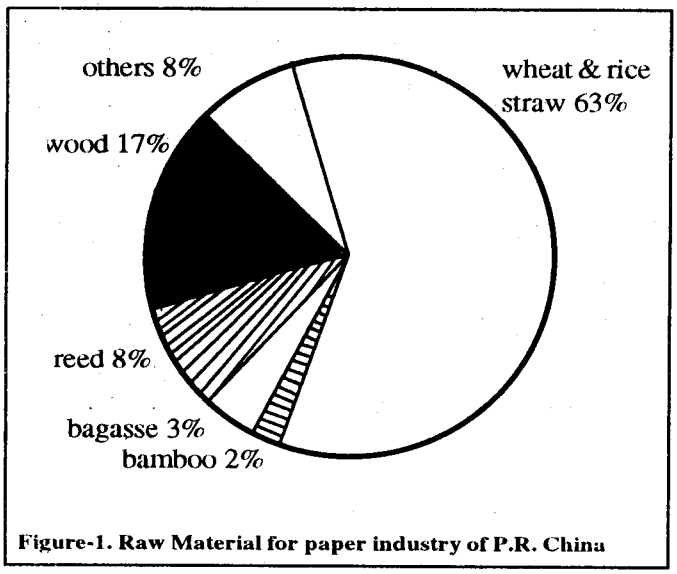

Figure-1. Raw Material for paper industry of P.R. China

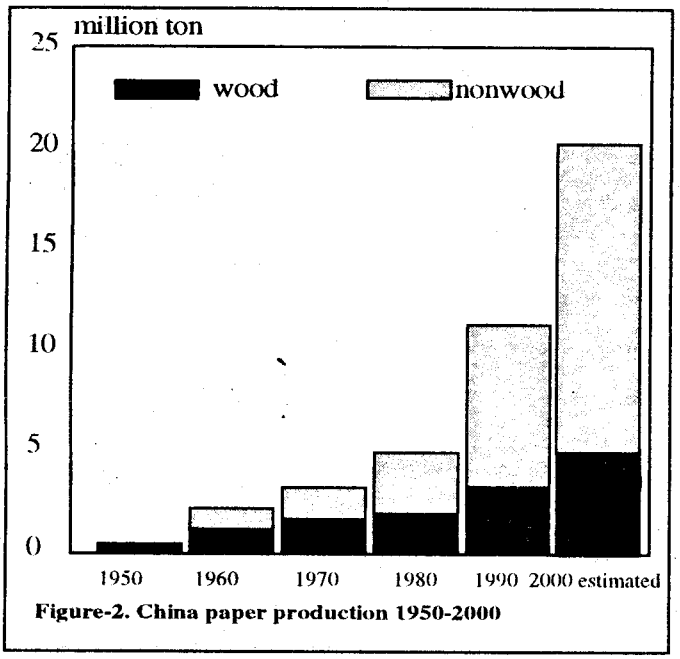

Figure-2. China paper production 1950-2000

Compared with wood pulp, non-wood fiber pulps have the problems of poor drainability, poor response to retention aid, poor wet web strength, high stickiness to roll surface, poor dimensional stability and so on. However, very little research work has been done concerning the papermaking properties of these non-wood fibers, especially on their wet end behavior.

Therefore it is of great importance to have a thorough understanding of papermaking properties of different nonwood fiber pulps in order to develop new design of paper machine which is more suitable to non-wood fiber pulp furnishes and to maintain good operation of existing paper machines.

Based on the financial and technical supports from Finland side: Ministry of Trade and Industry, Valmet Paper Machinery Inc., Valmet-Tampella, and Laboratory of Paper Technology, Helsinki University of Technology and from China side: Ministry of Light Industry, Valmet-Xian, Paper Industrial Research Institute of China, Hubei Institute of Technology and Northwest Institute of Light Industry, the two years project for research on papermaking properties of nonwood fiber pulps started from May 1993.

The objective of this research project is to study the basic papermaking properties of non-wood fiber pulps and their influences on papermaking processes and papermachine design. The laboratory research work is focused on the characteristics of non-wood fiber pulps at the paper machine wet end and their impact on retention, drainage and formation and will provide theoretical understanding of this process.

2. BASIC PROPERTIES OF NON-WOOD FIBERS

The characteristics of non-wood fibers are quite different from those of wood fibers, the most problems

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in non-wood fibers pulping and papermaking are resulted from the following properties--

* Short fiber length

The fiber length of most non-wood fibers is quite short, average about 1.0 mm. (Fig.-3).

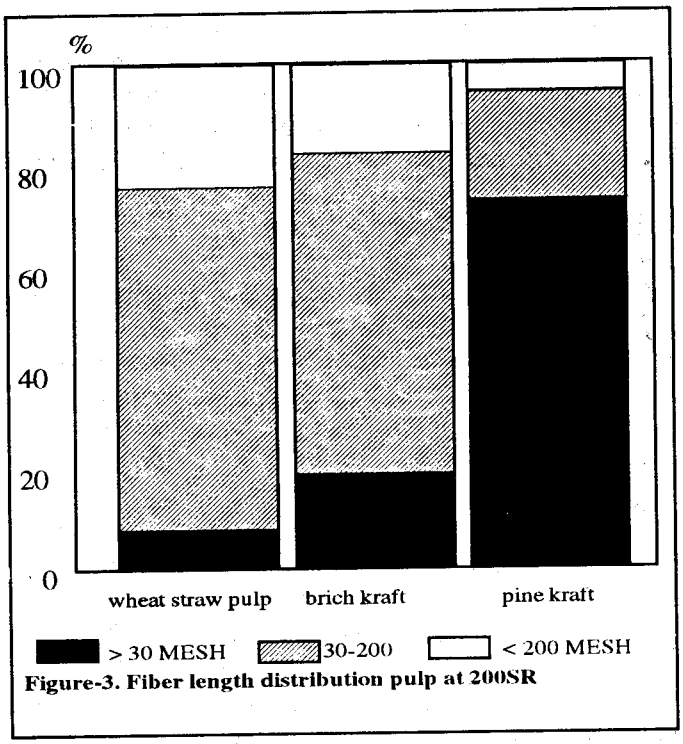


Figure-3. Fiber length distribution pulp at 200SR

* High non-fiber cell content

Most of non-wood fibers have 15-45% of non-fiber cells, such as parenchyma (thin wall cell), epidermic (surface cell), vessel, silicon cell, etc. (Fig.-4)

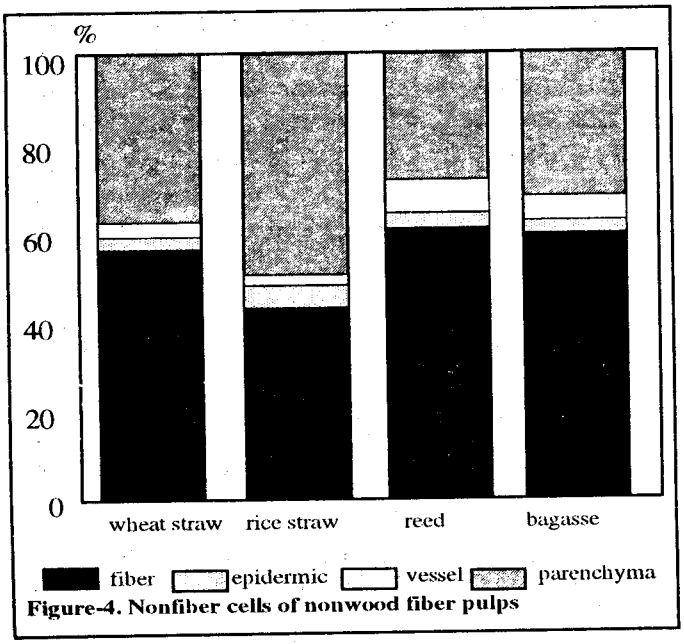


Figure-4. Nonfiber cells of nonwood fiber pulps

* Special chemical composition

Compared with soft wood, non-wood fibers generally are with lower lignin (15-20%), lower cellulose (about 40%), higher hemi-cellulose (20-25%) and higher ash content (4-10%). (Fig.-5).

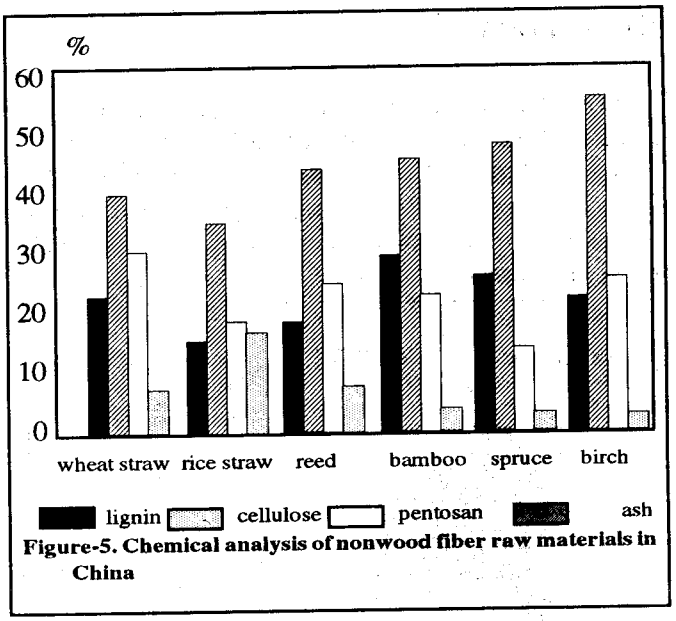


Figure-5. Chemical analysis of nonwood fiber raw materials in China

3. MAIN PROBLEMS AND SOME RESEARCH RESULTS IN NONWOOD FIBERS PAPERMAKING

3.1 Slow drainage

The poor drainability is one of most influential shortcomings of nonwood fiber pulps, which influence pulp washing operation, wire, vacuum dewatering and press section dewatering.

Slow drainage of nonwood fiber pulps is resulting from short fiber with large specific surface area (Figs 6 and 7), and from highly swollen properties of the pulps (Table-1).

Table-1.

Water retention value of wheat straw

Strawpulp unbeaten total		Straw pulp unbeaten fraction < 100 mesh,	> 100 mesh	Pine kraft beaten
WRV %	176	192	156	141
SR	34	46	20.5	30

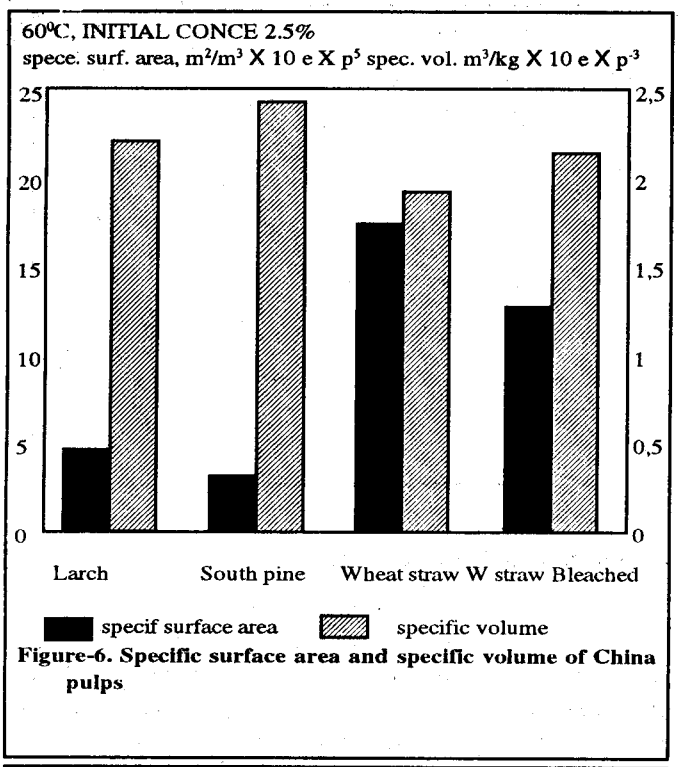


Figure-6. Specific surface area and specific volume of China pulps

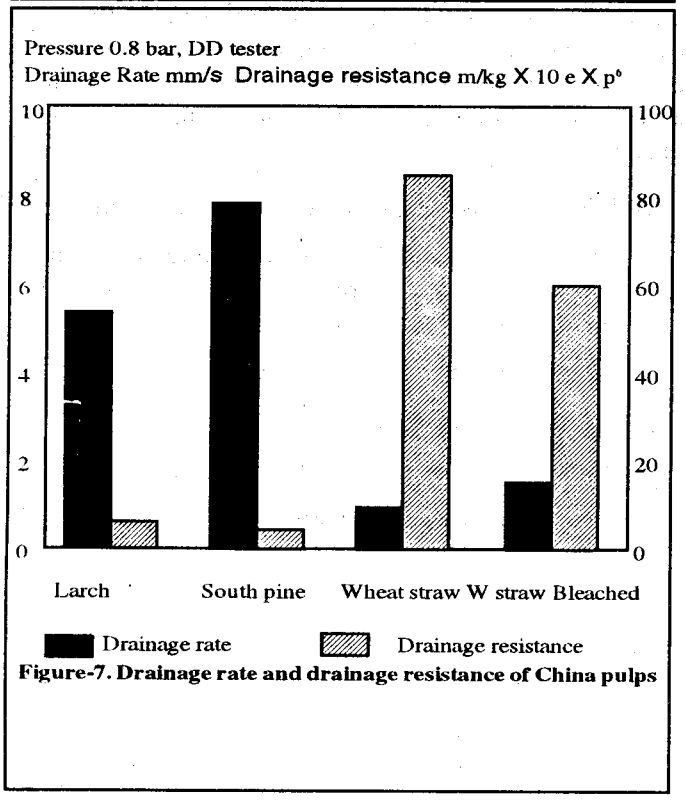
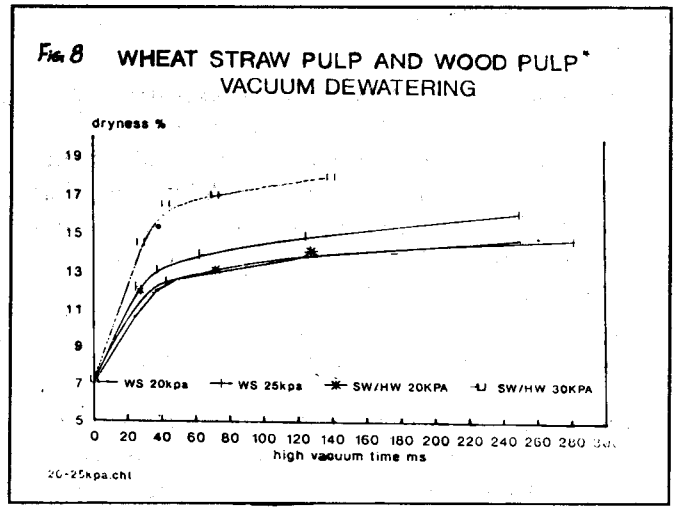


Figure-7. Drainage rate and drainage resistance of China pulps

The vacuum dewatering of nonwood fiber pulps is also slower than wood pulp (Fig.-8) measured on Moving Belt Drainage Tester.



3.2 Strong anionic furnishes

One of the problems using retention/ drainage aids in nonwood fiber furnishes is that lower efficiency of the retention-/ drainage chemical aids than in wood pulp furnishes. This is closely related to the pulp properties and chemical environment. With higher acid groups in the nonwood fiber pulp, the pulp (wheat straw) shows a higher cationic demand (Table-2).

Table-2.

Some Properties of Wheat Straw Soda-AQ and Pine Kraft Pulps

	R100	P100	Wheat straw Bleached Soda-AQ Pulp	Pine Bleached Karft Pulp
Acid group meq/100 g	11.9	11.5	11.7	6.7
Specific surface area m^2/g (N_2)	11.5	29.0	14.3	3.8
Specific hydrodynimic surface area m^2/g	1.5	2.7	1.9	--
Classification ratio %	47	42	100	--
Cationic demand meq/g	0.116	0.195	0.133	--

And a unknown amount of dissolved and colloidal substances in the pulp also contribute to the strong anionic nature. The investigation on it is under way.

3.3 Low wet web strength

The runnability of paper machine depends mainly on machinery factor and pulp factor. Nonwood fiber pulps normally give more frequent web breaks at the wet end of paper machine than wood pulp at the similar running condition, thus causing poor runnability in paper making. These problems are usually ascribed to low wet strength and higher adhesion to the press rolls of webs containing nonwood fiber pulps. These problems become worse when paper machine speed is higher.

The earlier study in Paper Industrial Research Institute of China shows that, at a given dryness, wheat straw pulp has unexpectedly a higher wet strength than pine kraft pulp (Fig.-9), but at a given press pressure, the wet strength of wheat straw pulp is lower than that of wood pulp (Fig.-10). The poor runnability of stock containing wheat straw pulp is due not to the inferior wet web strength of the straw pulp but to the poor drainability of the wheat straw pulp. To obtain better machine runnability the drainability of the straw pulp must therefore be improved.

Fig. 9 Tensile index of wheat straw soda-AQ pulp and pine kraft pulp

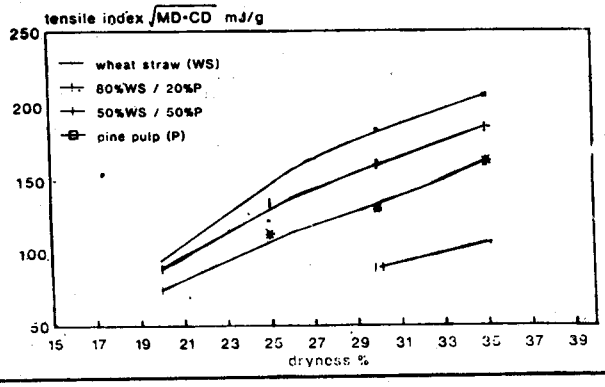
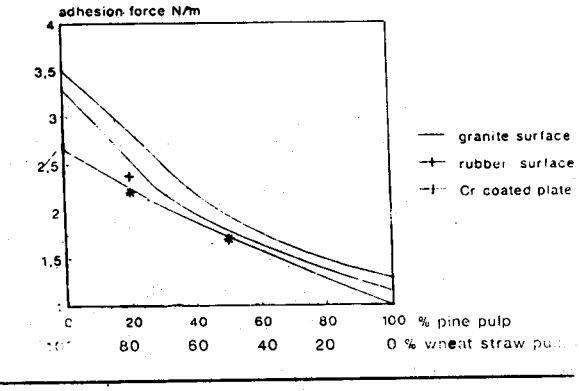


Fig. 10 ADHESION FORCE VS. SURFACE wheat straw soda-AQ and pine kraft pulps



3.4 High sticking forces to rolls

The factors affecting the adhesion of the wheat straw pulp to press roll materials were investigated in Paper Industrial Research Institute of China. Laboratory measurements of the adhesion to various press roll materials of wet web containing wheat straw pulp indicated that the adhesion of wheat straw pulp is much higher than that of wood pulp (Fig.-11). And the following measures will diminish the adhesion and thus improve runnability--

* addition of wood or cotton pulp to the straw pulp.
* removal of hemicellulose or epidermic or parenchyma cells from the straw pulp. Removal of the hemicellulose has the largest effect.
* making the paper in an acidic environment.
* not beating the straw pulp.
* addition of filler such as $CaCO_3$.
* addition of some chemical aids.