

Effect of Consistency on Refining of Rice Straw Pulp

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ABSTRACT

India is the second largest producer of straws and bagasse in the world. These agricultural residues are a potential source of raw materials for papermaking. However, the factors mitigating their use in the paper industry is the collection and transport costs due to high bulk. The technical disadvantages of the straw pulps are their high nonfibrous content which leads to unusual pulping chemical requirement in spite of their low lignin content and their high silica content. Rice straw chemical pulp which has very high nonfibrous content cause severe drainage problems. This inherent disadvantage of the pulpmakes it difficult to refine straw pulp. The present experiments suggest that the pulp consistency plays an important role in developing the fibers under inherent unfavorable conditions of the straw pulps. Rice straw pulp require low intensity refining (specific edge load). Pulp can be developed in low consistency refining but at the cost of excess energy. Ideal pulp properties are obtained when the pulp is refined at 6% consistency with 25 Kwh/t of net specific energy. Medium consistency (9%) refining of rice straw pulp lead to severe drainage problems.

Introduction :

Mechanical treatment to fibers alters fiber structure, thereby influences the papermaking properties. Changes in pulps that are brought in this way may be useful or detrimental to the papermaking and/or product quality. Refining of straws is a tricky problem because to improve product quality the fibers are to be treated mechanically but this treatment leads to break down of the non-fibrous tissue to individual cells (Subrahmanyam & Roy, 1992) creating severe problems in the drainage (Roy et al., 1992) of the pulp. The question is how to selectively treat fibers in a highly heterogeneous straw pulp which contains both fibrous and non-fibrous tissue.

Performance of a post refined pulp in papermaking process is very difficult to predict based on the beating data obtained in laboratory. This is due to the greater number of variables present in a process line. Where as the laboratory studies are carried out in ideal conditions. The aim of the present study is to understand the behavior of straw pulp on refining under simulated commercial process conditions. Rice straw

pulp is being studied for its refining responses in Escher Wyss Laborefiner. The most important difference between Escher Wyss Laborefiner and a commercial refiner is that it is multipass refiner whereas it is single pass refining in a commercial refiner.

Consistency plays an important role in developing fiber. Medium consistency to high consistency refining of the chemical pulps from woods found to be best to treat fibers (Fahey, 1970). The present study is to understand the effect of consistency on fiber structure and properties of rice straw pulp. The consistency (csy) chosen in the experiment range from low to medium level i.e. about 3%, 4%, 6% and 9%.

Methodology :

Rice straw was cooked in pilot plant using 12% NaOH, washed and dewatered in belt press. Straw pulp was then screened in laboratory on 'Serla' screen using 0.3mm slot size. Dewatered pulp was shredded

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and air dried. Refining experiments were carried out on Escher Wyss laboratory refiner using disc fillings. Specific edge length was 1.24 m/s at given rpm of the disc. Samples were drawn from the same lot to conduct all the four sets of experiments. 25 liters of stock was used in all the experiments. Refined samples in the experiments were collected at different net specific energy levels. Fiber length analysis was carried out using Kajaani FS-100, and the cells <.2mm length are considered the fines.

The conditions of refining are as follows :

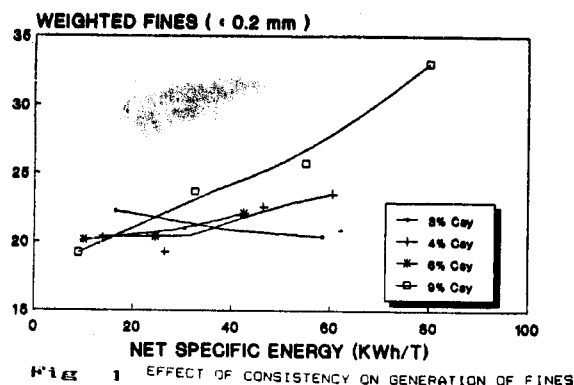
1. Consistencies : 3%, 4%, 6%, 9%
2. Specific edge load : 270 ws/km
3. Peripheral speed : 3093 FT/min or 943 m/min
4. Stock flow : 100 lit/min
5. Net sp. energy : 0, 20, 40, 60, 80 Kwh/t applied

Results and Discussion :

The present study is made using a low specific edge load as it is felt that the mild treatment would improve the pulp properties without damaging the fiber. We have analysed the data to evaluate the effect of consistency at various net specific energy levels on the strength properties of the pulp.

The net specific energy consumption is reduced with increase in consistency in general with the exception of medium consistency (9%) treatment, where the net sp. energy is high. The freeness (CSF) of the pulp started increasing as a function of increase in csy as well as net sp. energy. This is due to improper fiber mat formation in the freeness tester leading to false freeness. So this parameter has to be disregarded for evaluating the pulp properties as it would lead to erroneous conclusions. Pulp in the present experiment are characterised based on the net specific energy.

All these pulps are studied for fiber length distribution and generation of fines on Kajaani Fiber Length Analyser FS-100. The generation of fines (<.2mm) is not drastically different in 3%, 4% and 6% csy (Fig 1). The weighted fines content increased dramatically from 23% in 4% csy to 33% in 9% csy maximum refined pulp (fig. 1).



Microscopic observation reveal that the fibers are excessively fibrillated in 9% csy in addition breakdown of parenchyma cells to minute fragments to form debris. This debris results in increased (<.2mm) fines in 9% csy refining (Fig. 1). This pulp has very poor drainage. Fibers are more intact in csy ranging from 3% to 6% at similar net sp. energy levels. Formation of debris from parenchyma and excessive fibrillation of fibers in medium (9%) consistency refining resulted mainly due to fragility of the rice straw fibers (Roy et al., 1992 ; 1993) and the excessive frictional forces within the pulp.

Tensile strength improved with increased net specific energy consumption at csy ranging from 3% to 6% (Fig.2). Increase in tensile strength is more rapid in 6% csy compared to 3% and 4%. Maximum tensile is developed in csy 4% but it is highly energy intensive to attain this level (Fig.2). The tensile curve has its peak at 25 Kwh/t net sp. energy consumption and further energy input has no positive effect on the tensile strength. Refining with 6% csy at about 25 Kwh/t net sp. energy appears to be ideal for rice straw pulp (Table. 1), since a maximum improvement in tensile is achieved at this level of refining (Table. 1).

Tear strength is almost similar in all consistency levels and loss in tear strength is noticed above 30 Kwh/t net refining energy level. (Fig.3). It suggests that the refining above this level has negative influence on the fiber development as well as the fragile nature of the rice straw fibers.

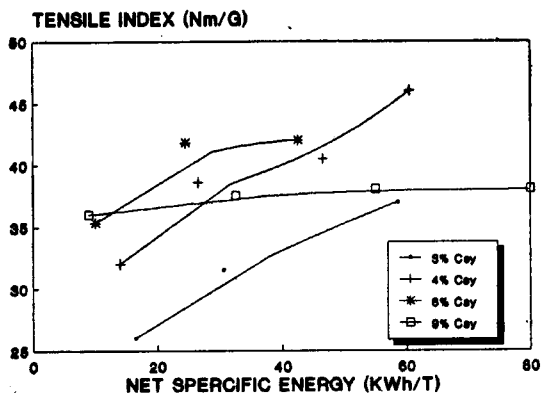


Fig. 2 EFFECT OF CONSISTENCY ON DEVELOPMENT OF TENSILE STRENGTH

Table-1

Effect of Consistency on % Improvement of physical properties of rice straw pulp at 25 kwh/t net specific energy

Sl. No.	Strength Properties	Consistency			
		3%	4%	6%	9%
1	Tensile	100	27	42	27
2	Stretch	100	25	33	-29
3	Burst	100	25	56	12
4	Fold	100	43	86	57
5	Porosity	100	-42	-74	-79

Values at 3% csy are considered as base values.

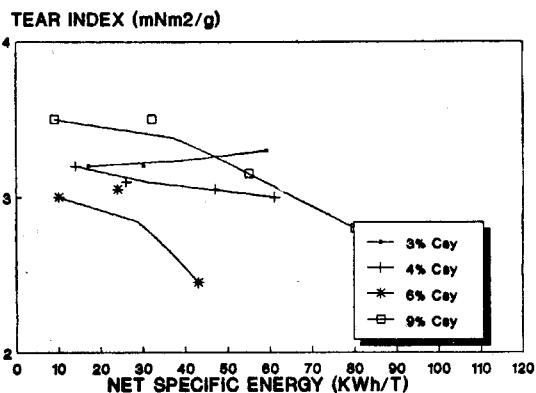


Fig. 3 EFFECT OF CONSISTENCY ON DEVELOPMENT OF TEAR INDEX

Stretch is best developed in csy 6% and lost in 9% csy with increasing net sp. energy (Fig 4). In 3% and 4% csy the stretch is more or less stable. Loss in stretch in 9% csy (Table 1) is due to excessive fibrillation which forms excessive net work and restrict the structural reorganization with in fibers (to make use of available microcompressions and curl) under tension

before failure. Higher stretch in csy 6% appear to be due to moderate inter fiber friction during refining leading to inducement of fiber curl and micro-compressions.

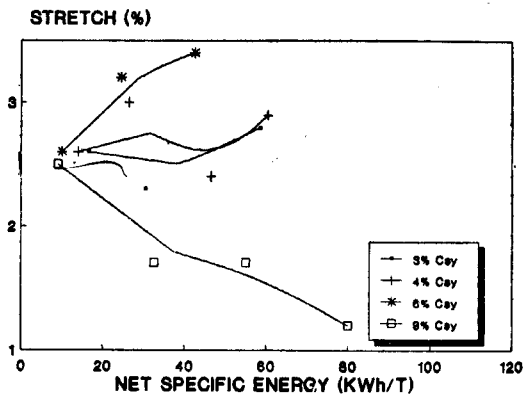


Fig. 4 EFFECT OF CONSISTENCY ON DEVELOPMENT OF STRETCH

Burst strength also developed better in 6% csy compared to 3% and 4% csy. Burst strength develop more rapidly in 6% csy upto 25 kwh/t net sp. energy whereas to develop the fiber to similar strength in 4% csy it consumes double the energy (Fig 5). Refining at 9% csy appear to be of no use since there is no improvement in burst strength with net sp. energy input upto 80 Kwh/t. Burst strength is retained because of the compensation of intrinsic fiber strength with the net work formed by fibrillation. Improvement of folding endurance also is superior in 6% at any given net sp. energy consumption (Fig. 6).

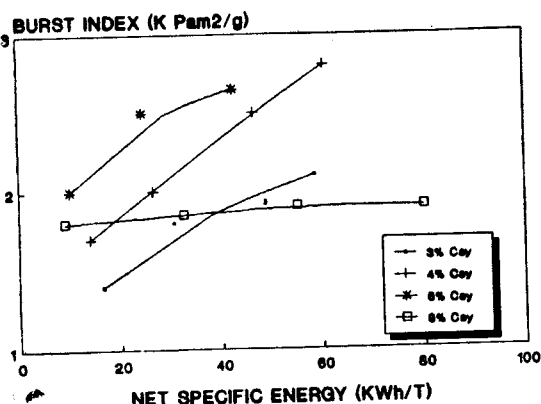
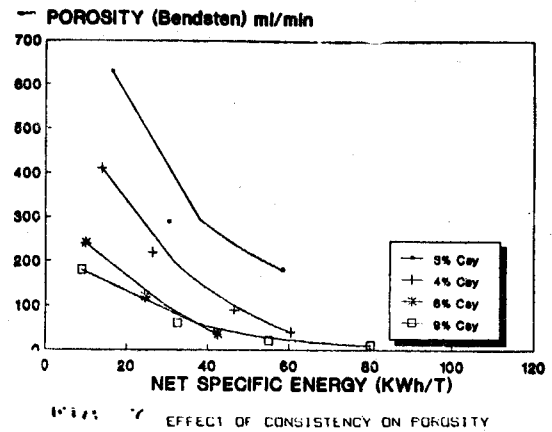
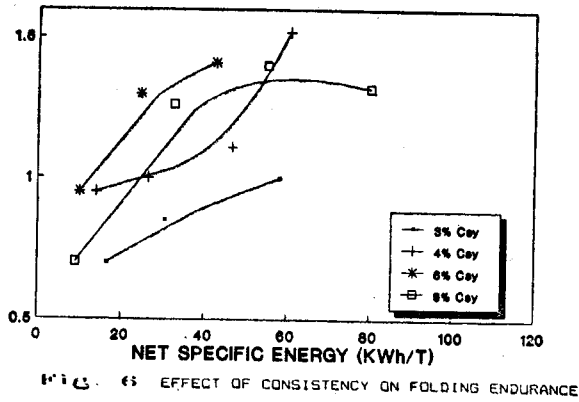


Fig. 5 EFFECT OF CONSISTENCY ON DEVELOPMENT OF BURST STRENGTH

Porosity is low in csy 3% followed by 4%, 6% and 9% csy. At 25 kwh/t of net specific energy level the porosity value is 100 ml/min for the pulp refined at 6% csy (Fig 7.)



Conclusions :

Overall observation on the effect of consistency on pulp properties of rice straw pulp suggest the following :

1. Low consistency refining is energy intensive to develop the fiber to optimal level.
2. Consistency around 9% and above leads to excessive fibrillation and fragmentation of parenchyma cells causing no improvement and/or loss of strength properties along with severe drainage problem.
3. Consistency around 6% at 25 kwh/t net specific energy appear to be ideal to achieve optimal strength properties for rice straw pulp.

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