Effect of Nonfibrous Tissue on The Refining Behaviour of Bamboo Pulp

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ABSTRACT

Mechanical treatment to fibers alters fiber structure and influences the papermaking properties. Changes in pulps that are brought in this way may be useful or detrimental to the papermaking and product quality. Stock preparation refining significantly contributes to papermaking process by effecting the runnability of the of stock and quality of product. A correct approach towards refining treatment is very essential for energy savings and product with desired properties. Performance of a refined pulp in papermaking process is difficult to predict based on the beating data obtained in laboratory as the laboratory beaters are not representative of mill refiners. Aim of the present study is to optimise the process conditions and energy requirement for bamboo pulp and bamboo long fibre on refining under simulated mill conditions. The experiments help to establish the requirement of specific edge load for refining of pulp and long fraction and optimisation of energy requirement for achieving desired properties. The results from the set of experiments on the effect of consistency and specific edge load indicate that refining with 2000 ws/km specific edge load yielded pulp having improved drainage properties with relatively good strength properties provided the consistency of the pulp is maintained at 4%. Tensile index with this combination improved but with a marginal loss in tearing strength. The lower medium consistency (6%) refining gives pulp with improved tearing strength. As the lower medium consistency refining is not feasible in the existing facilities, refining at 4% consistency with 2000 ws/km refining intensity is recommended to obtain improved fibre quality.

INTRODUCTION

Properties of the fibres must be developed with minimum damage to the fibres. Aim of refining is to improve the bonding capacity of the fibres without loosing the intrinsic strength of the fibres and without effecting the drainage resistance of the pulp significantly. Properties of the fibres vary with the source of fibre, environmental conditions under which it is grown and the pulping processes etc. Because of the variables and further requirements set by various paper grades, the refining has to be controlled so that the desired fibre development is achieved.

As per specific edge load theory the amount of refining is described by evaluating the specific refining energy in kWh/t and the nature of refining by calculating specific edge load in ws/km. Refining impacts are generated when moving rotor bars travel over stationary stator bars and the number of these impacts is indicated by using the cutting speed (km/s or inch cuts/min.) (Fahey, 1970). The energy content of refining impacts is calculated by dividing the effective power load (kW) by the cutting speed (km/s).

The amount of refining is the result of these two factors. Given specific energy can be transferred to the fibre mass either by low energy content with higher number of impacts or by high energy content with lower number of impacts. So, the intensity of

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the refining (specific refining energy) impact depends on severity and length of impact. The nature of refining required for various pulp types in general are: a) Short and weak fibres require short and low intensity impacts; b) Longer and stronger fibres require longer and higher intensity impacts and c) Fibre cutting requires shorter and higher intensity impacts than for fibre fibrillation.

Bamboo pulp contains about 70% fibres which can be considered at par with softwood in terms of strength development. Bamboo pulp is used in India for producing high quality writing & printing papers and also used as long fibre furnish in newsprint that is made of hardwood pulp. The fibre has superior stretch values and fibrous portion of bamboo pulp can be used in producing specialty Kraft papers like sack Kraft. Considering these facts we have conducted the experiments on unbleached bamboo whole pulp and long fibre fraction to understand the effect of consistency and specific edge load on fibre development.

EXPERIMENTAL

The following pulps were studied for their strength potential:

1. Whole pulp (WP):

- i Effect of SEL (1000 and 2000 Ws/km at 4% consistency.
- ii. Effect of consistency (3% and 4%) at 1000 Ws/km SEL.
- iii. Effect of consistency (4% and 6%) at 2000 Ws/km SEL.

2. Long fibre (LF)

- i. Effect of specific edge load at 3% consistency.

Process conditions:

Air dried samples were used in the experiments. Moisture for these air dried samples were determined in duplicate. No load power was determined using water and I mm plate clearance by operating the calibration routine just prior to each experiment. Refining experiment with pulp was carried out under the same conditions that were used in the calibration. Each experiment was carried out using normally 1000g pulp (on bone dry basis). The air dried pulps were slushed in 25 liters of water to obtain 4% consistency and given about 7 to 10 min. pulping time. Following general conditions were used in all experiments:

Disc refiner	Single disc refiner
Disc pattern	3-1.12-60
Disc diameter	6 inch
RPM	2000
Peripheral speed	943 m/min.
Edge length	1.12 km/s
Specific edge load	1000 or 1500 or 2000 Ws/km
Consistency	4 or 6%
Flow rate	100 ml/min.
Net specific energy applied	0, 25, 50, 100, 150, 200 kWh/t
Sample collected	1 liter

Hand sheets of 60 gsm were made on British sheet former as per ISO DP 5269. Strength properties for the hand sheets were determined using standard ISO methods. Fibre length analysis was carried out for the pulps on Kajaani FS-100 Fibre Length Analyser.

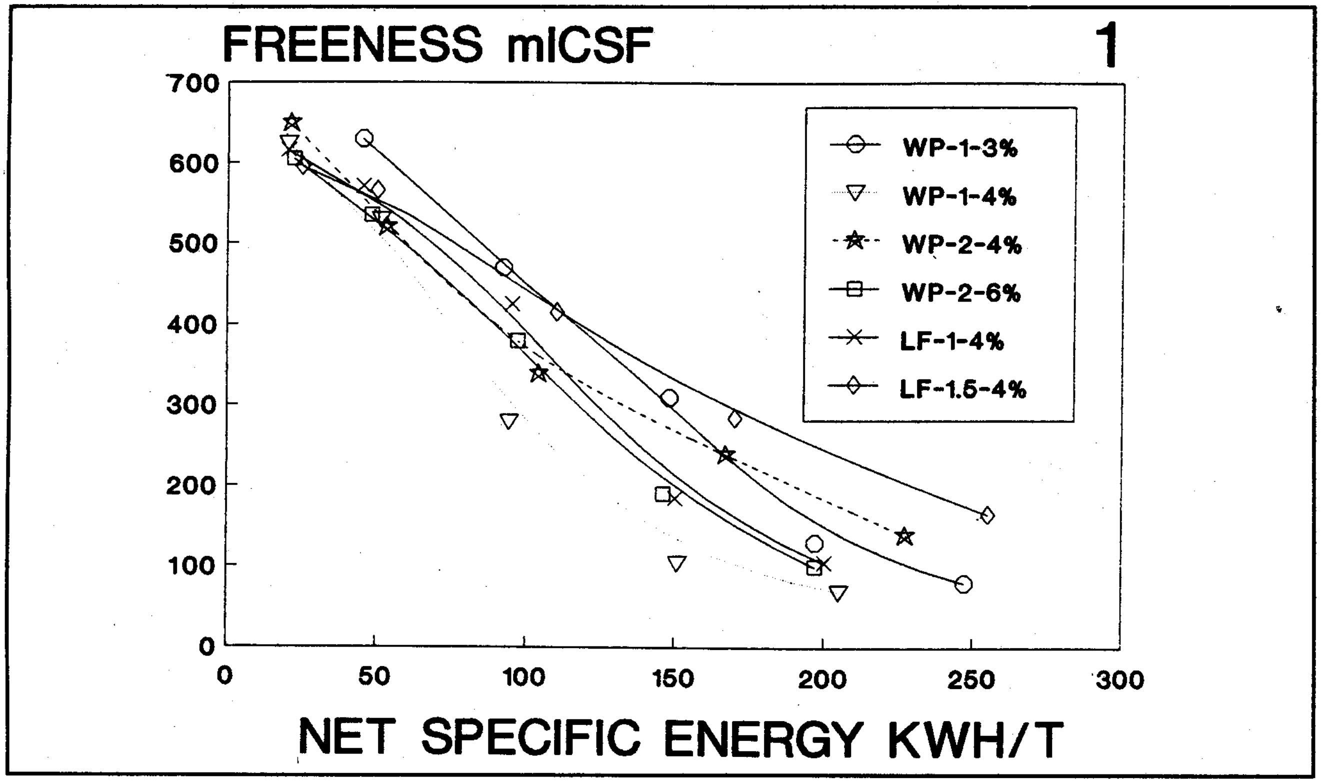
RESULTS AND DISCUSSION

The results being discussed in the following text are the results for the dried and rewetted pulps. Strength properties for the undried virgin pulps will be superior compared to the dried and rewetted pulps.

1. UNBLEACHED WHOLE PULP (WP)

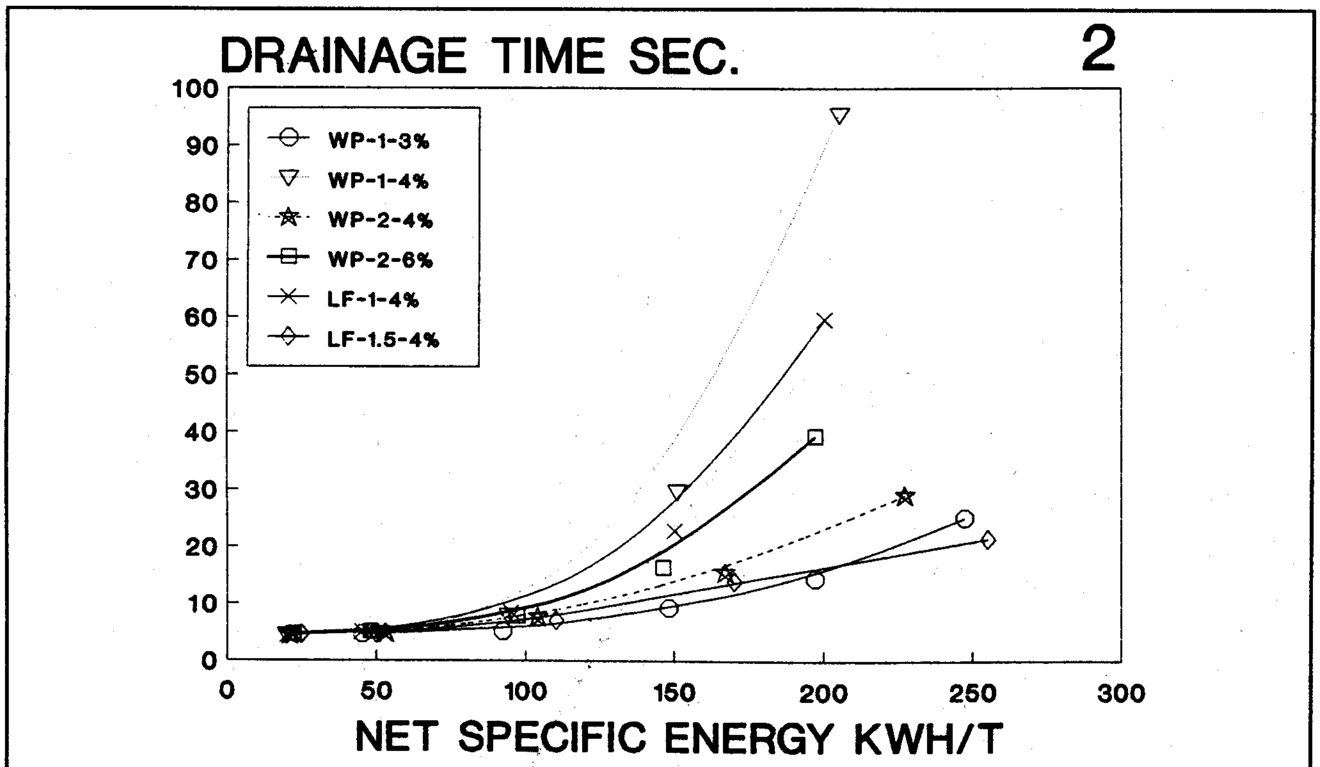
a. Effect of specific edge load

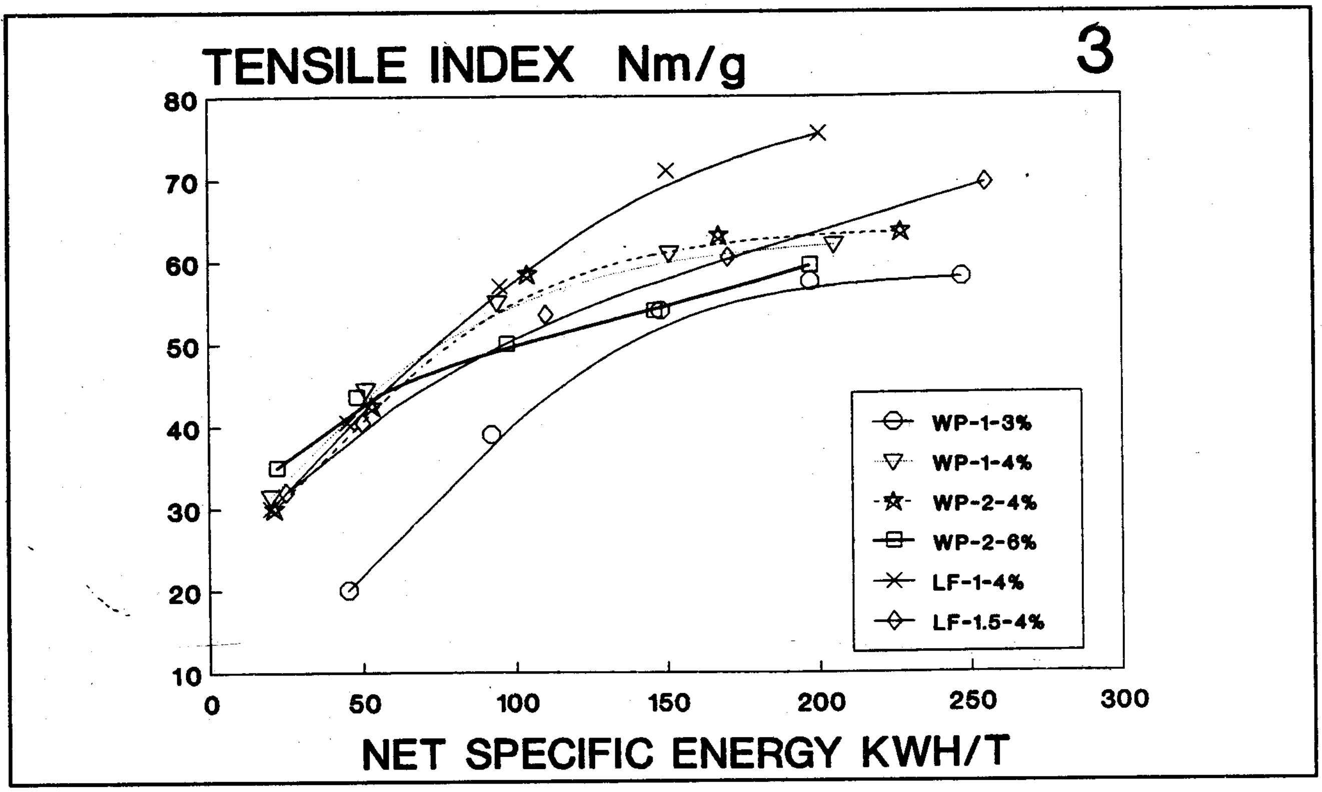
Bamboo pulp was refined at 4% consistency using two specific edge loads. The refined samples were collected at six net specific energy levels viz. 0, 25, 50, 100, 150, 200 kWh/t. The freeness drops at a relatively lower rate for the pulp refined at 2000 Ws/km SEL compared to the pulp refined at 1000 Ws/km SEL **(Fig.1).** Fines generation is higher in high intensity refining and loss in fibre length is more where as the fines generated in low intensity refining is lower and fibre length reductions is also less at given net specific energy levels. If these factors are considered together it reveals that the fibrillation of the fibres improves at low intensity refining while the fibres get cut in high intensity refining (Roy et.al, 1992, 1993). Drainage is better in pulps refined with



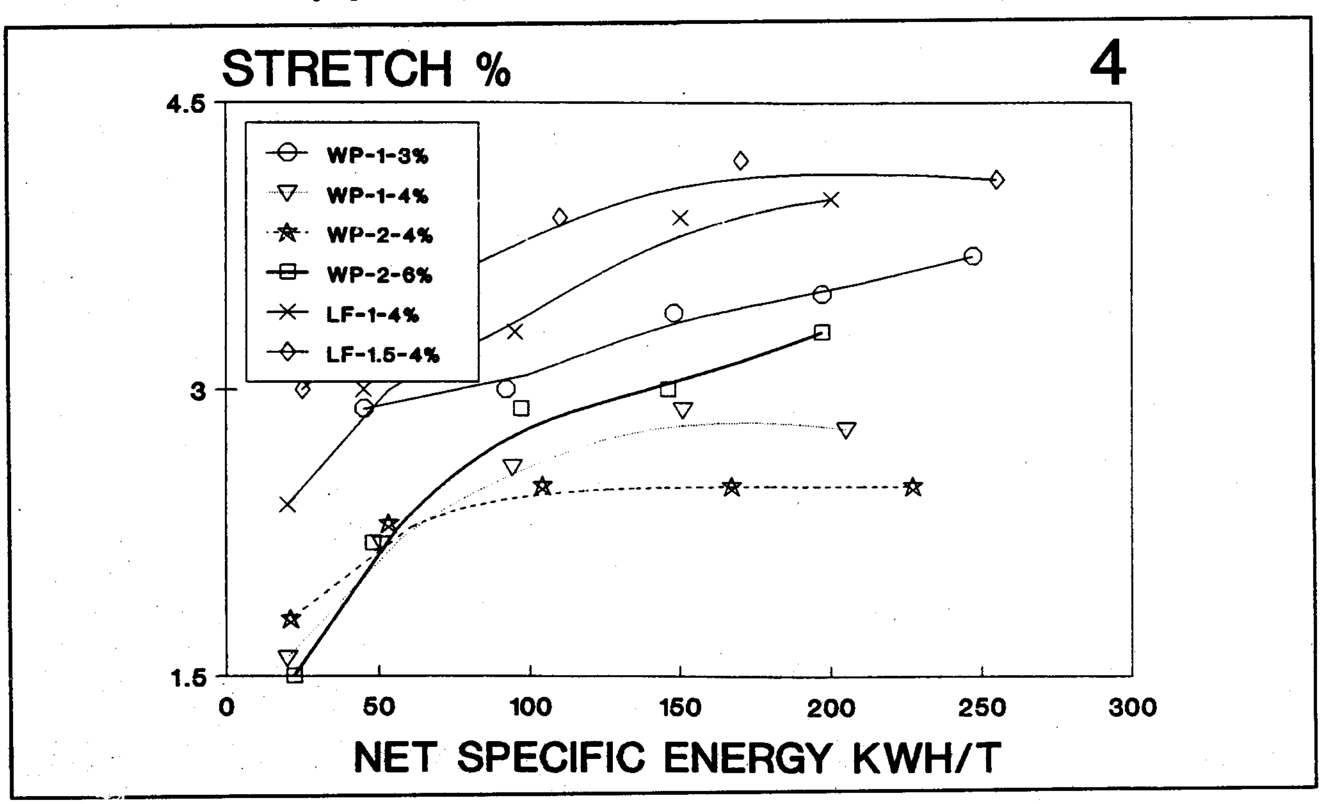
2000 Ws/km SEL as the fibre is cut compared to that of pulp refined with 1000 Ws/km SEL where it is otherwise as the fibrillation of the fibre takes place.

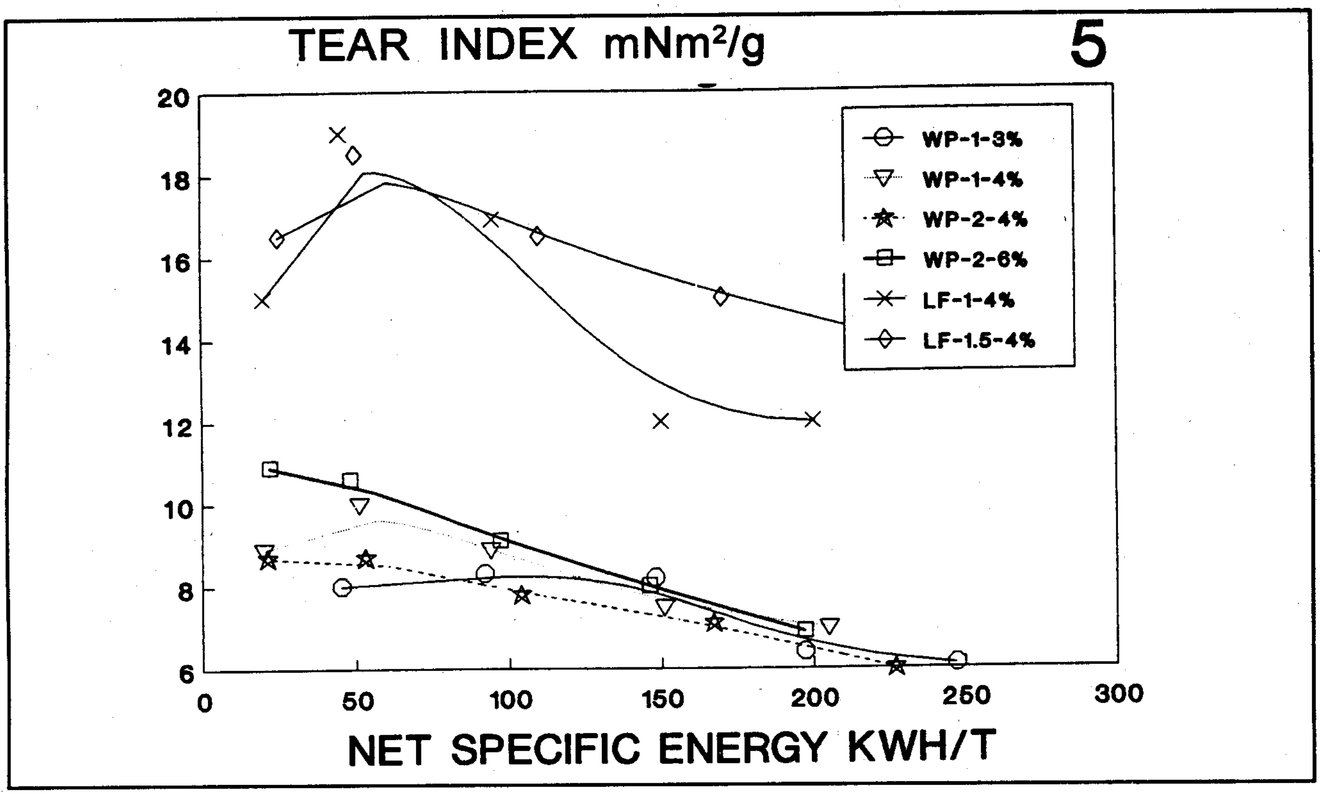
The above results indicate that fibre shortening is low for the low intensity refining which is reflected in the tearing strength of the pulp (Fig.5) and also tensile energy absorption. Tensile to tear relationship





is marginally high for the pulp refined at high intensity refining (Fig.6). As the refining intensity is lowered, the fibre is better developed but the no load power increases. Stretch of the pulp is marginally reduced on increasing refining intensity (Fig.4). Folding endurance is higher for the pulp refined at lower intensity (Fig.8).

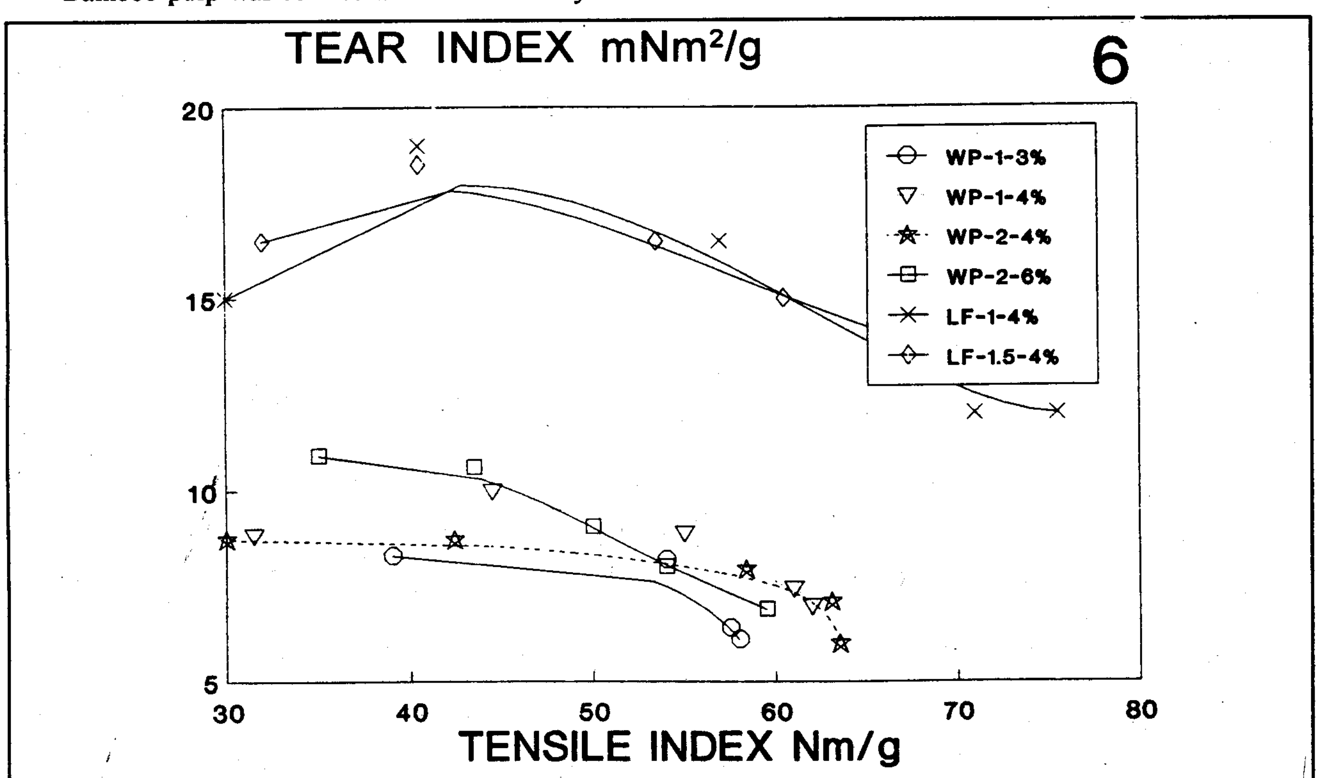


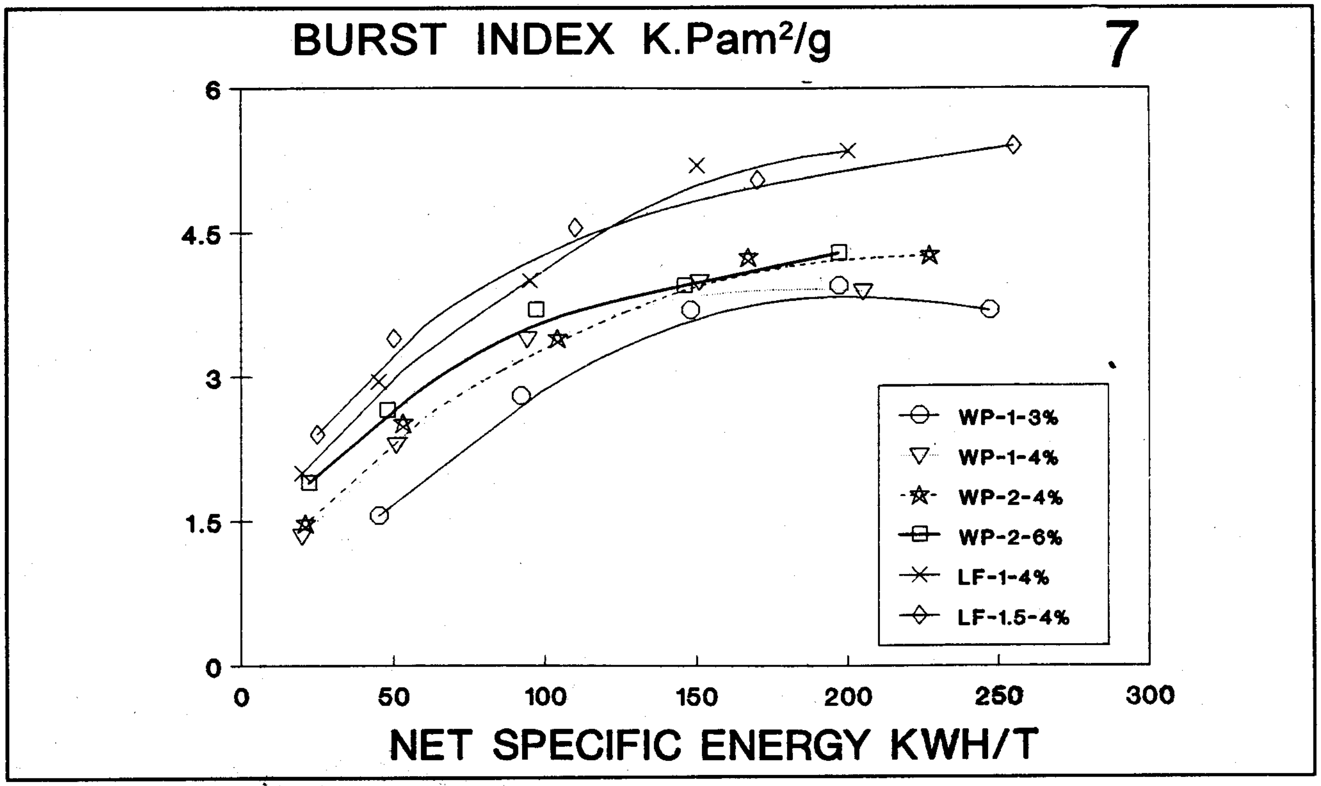


b. Effect of consistency

i) Unbleached whole pulp (WP) refined at 1000 Ws/ km SEL:

Bamboo pulp was refined at 3% consistency and 4% consistency at the same specific edge load. The refined samples were collected at the net specific energy levels ranging from 0 to 250 kWh/t. Freeness values for the pulps refined at 3% consistency are





relatively higher than the freeness of the pulps refined at 4% for a given net specific energy consumed during refining **(Fig.1)**. Drainage time of the 3% consistency pulp is comparatively better than that of 4% consistency pulp **(Fig.2)**. Tensile strength and tearing strength of the pulp refined at 4% consistency are higher as compared to pulp refined pulp at given net specific energy level **(Fig. 3,5)**. This is due to increase in the fibre mass in the refining zone leading to reduction in the severity of impacts as the consistency increases.

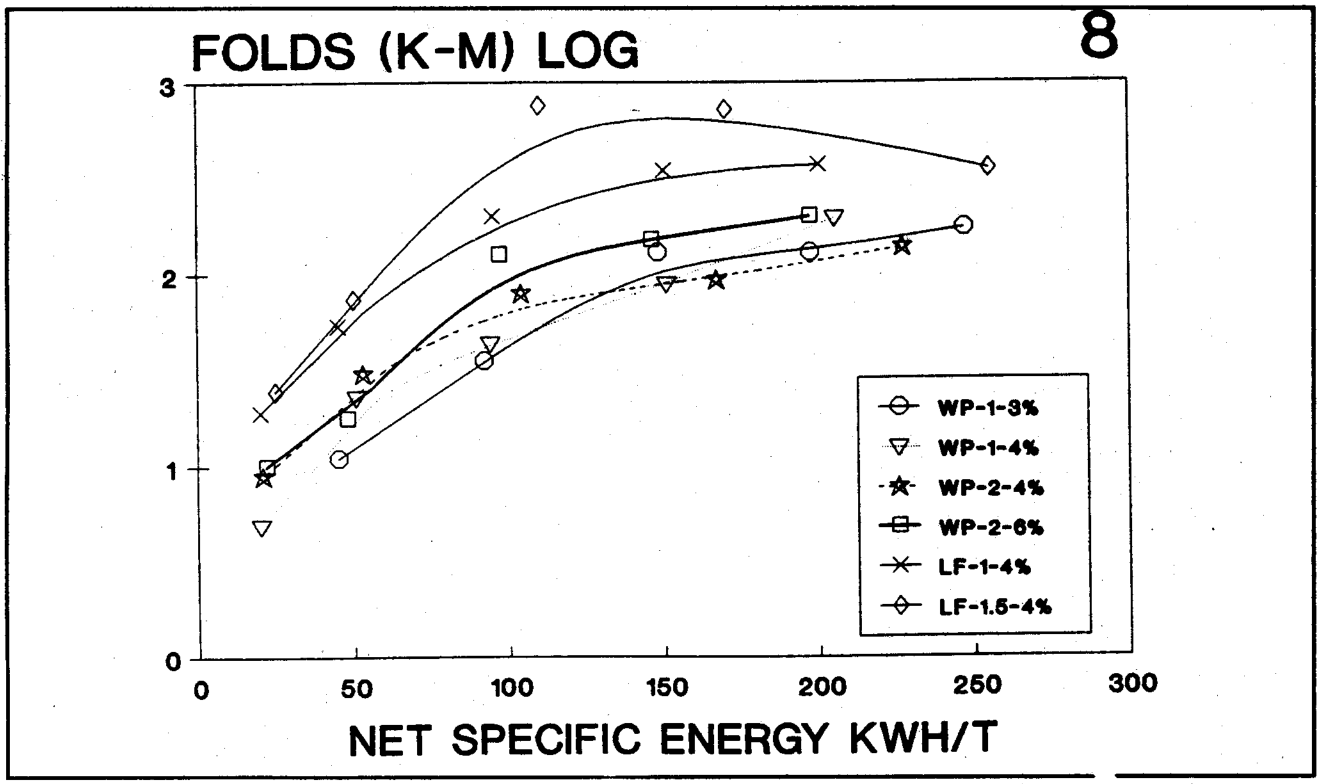
ii) Unbleached whole pulp (WP) refined at 2000 Ws/km SEL:

Bamboo pulp was refined using 4% consistency and 6% consistency levels giving the same specific edge load. Loss in freeness is not much different in both the cases upto 100 kWh/t net specific energy level. Further refining in 6% consistency pulp the freeness is lower as compared to the 4% consistency pulp at given net specific energy levels. Increase in drainage time is similar initially upto 100 kWh/t net specific energy level for both the pulps whereas the drainage time increases rapidly for 6% consistency pulp on further refining **(Fig.2)**. Tensile energy absorption is marginally higher for the pulp refined at 6% consistency compared to 4% consistency pulps. Advantage in 6% consistency refining over 4% consistency refining is the development of tearing strength **(Fig.5)**. The pulp refined at 6% consistency has developed a maximum tear index of 10.9 mNm²/g, while the upper limit is 8.7 mNm²/g for the pulp refined at 4% consistency. The tear to tensile relation is superior for the pulp refined at 6% consistency by about 20-25% **(Fig.6)**. Stretch is improved for the pulp refined at 6% consistency which is about 30% higher than the pulp refined at 4% consistency **(Fig.4)**. Burst and Folding endurance also shows similar trend but the improvement is only marginal for 6% consistency pulp **(Fig.7, 8)**.

2. LONG FIBRE PULP (LF)

a) Effect of specific edge load:

Bamboo long fibre fraction pulp of 4% consistency was refined at 1000 Ws/km and 1500 ws/km specific edge loads. Loss in Freeness for the pulp refined at 1000 Ws/km is more compared that of the pulp refined at 1500 Ws/km at given net specific energy levels **(Fig.1)**. Drainage property of the pulp refined with a SEL of 1500 Ws/km is superior to the drainage property of the pulp refined with 1000 Ws/km **(Fig.2)**. Tensile strength and tensile energy absorption are higher for the pulps refined with SEL of 1000 Ws/km compared to the pulps refined with SEL of 1500 Ws/km **(Fig.3)**. Maximum achievable tearing strength is not different significantly in both refining intensities **(Fig.5)**. The specific energy



requirement is about 30% higher for the pulp refined at 1000 Ws/km SEL compared to the pulp refine. at 1500 Ws/km SEL. Stretch is marginally higher for the pulp refined at 1500 Ws/km SEL. Stretch is marginally higher for the pulp refined at 1500 Ws/km SEl (**Fig.4**). The stretch value is around 3.5% for the pulps having a freeness of about 400 ml CSF. Burst and Folding endurance values are not significantly different for the two pulps refined at two refining intensities (**Fig.7,8**).

COMPARISON OF WHOLE PULP AND LONG FIBRE PULPS AT 1000 Ws/km

Bamboo pulp and Long Fibre pulps of 4% were refined using 1000 Ws/km specific edge loads. In general the bamboo long fibre fraction has higher strength development compared to the bamboo pulp. Freeness loss is comparatively faster for whole pulp due to the breaking down of the nonfibrous tissue into smaller cells thus contributing to higher surface area, where as the long fibre fractions of bamboo looses the freeness at relatively slower rate (**Fig.1**) at any given net specific energy consumption. Between 100 to 150 kWh/t net specific energy levels the whole pulps have 100 ml CSF lower freeness compared to the long fibre pulps. Drainage property is relatively poor for Whole pulps whereas the drainage property of the bamboo long fibre is superior due to the reduced nonfibrous tissue (Fig.2). Bamboo long fibre has higher tensile energy absorption than the other pulps. Tearing strength and tensile to tear ratio are superior for bamboo long fibre pulp (Fig.5,6) as the fibres remain intact and better swollen in the refining process.

CONCLUSIONS

Based on the refining behaviour of the whole pulp (WP) and long fibre (LF) the following inferences were drawn.

1. Low consistency refining negatively affects the development of fibre and has poor strength properties and also affects the throughput for the given energy. So consistency of 4% or above shall be maintained.

2. Properties for the pulps refined at 1000 Ws/km and 2000 Ws/km SEL are not drastically different at about 100 kWh/t net specific energy consumption. In general the mills producing writing printing grades refine the bamboo pulps to a freeness level around 400 ml CSF. In such cases load of 2000 Ws/km SEL can be advantageously used with out sacrificing much of the strength.

3. A combination of higher edge load (2000 Ws/km SEL) and consistency of 4% (+) are advisable to obtain good quality bamboo pulp with good drainage property which is one of the most important factor contributing to the runnability of the stock.

4. The lower medium consistency (6%) refining gives pulp with improved tearing strength.

5. Significant improvement in properties of bamboo long fibre pulp due to the reduced nonfibrous tissue suggests that fractionation process is useful if value added products like sack kraft are to be produced.

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