Esher-wyss laboratory refiner-new technological development in assessing energy requirement

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Refining of pulps is the most important phase in papermaking because it greatly influences properties of paper. A correct approach towards pulp type and refining treatment is very essential in saving energy and achieving paper with desired properties. Fiber resources for pepermaking have been changing continually, as new fiber sources are being identified and established. Such changes and new fiber utilization have necessitated optimization of refining methods and equipments.

Traditionally long fiber softwoods have been used in papermaking and beating action was desired to reduce fiber length as well as to develop strength. The techniques of beating are very different for softwoods and hardwoods. The situation is completely different for non--woods, and as a matter of fact these fibrous materials, in particular agricultural residues are not refined because they are considered weak enough to withstand any mechanical action. Consequently they are considered unsuitable for strength critical grade papers However, in reality the situation could be different. It should be possible to refine non-wood fiber as well to develop strength just as we do with wood fiber. What we need is a laboratory refiner which can be used to predict the refining behavior of different pulps and blends and help in optimizing refiner variables like specific edge load, net specific energy, through put and peripheral speed etc.

In recent years various process and equipment parameters have been used to describe the refining process with emphasis on energy utilization, it is important to know what are the energy requirements for freeness and strength development. Many theories have been put forward to describe refining process. The most important and widely used is the specific edge load theory developed by Brecht and Siewert[1]. In this theory the power applied during refining is expresssed as :

1. **Cutting angle** :

   —the angle resulting from the interception of the bar edges = sum of bar angles

   —the larger the cutting angle, the more fibrillation and more gentle the refining treatment.

2. Specific edge load:

   — the degree of intensity, with increasing edge load the intensity of fiber treatment increases.

   $$Bs = Pe/Le$$

   where, Bs = specific edge load (Ws/km)
   Pe = net refining power (W)
   Pe = P total — P no load (kW)
   Ls = edge length per sec. (km/s)

3. Net specific energy :

   — the net specific energy transferred to the stock during a refining process

   $$Wspec. = (Pe * t) / m$$

   where, Wspec. = net specific energy (kWh/t)
   t = refining time (h)
   m = stock quantity (t)

4. Edge length per second :

   — total length of bar edges effective in a refiner with in one second

   $$Ls = Z_R * Zst * l * (n/60)$$

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where, L_s = edge length per sec. (km/s)
Z_R = number of rotor bars
Z_{st} = number of stator bars
l = effective edge length (km)
n = speed (min^{-1})

using the above theory it is possible to know, how to select refining parameters for refining a given pulp furnish with optimum treatment and energy efficiency.

Esher-Wyss Laboratory Refiner :

Early methods of pulp refining included Jokro and Lampen Ball mill. Principle action in these beaters was from crushing of fibers between smooth rotating surfaces and plotting resultant properties against time or wetness. However, there was no way of measuring the intensity of fiber treatment. Current standard laboratory evaluation beaters are the Valley beater and PFI mill. Both of these methods are reproducible and widely used.

In case of Valley beater the results are expressed in terms of time and wetness with no quantification of the intensity of treatment except in terms of weight applied. PFI mill is the most recent type of equipment. The treatment is carried out at 10% consistency and the action is expressed in revolutions. In PFI, once again the action is not representative of mill refiner action as fiber are treated between a barred rotor and stator. In fact, the gentle action together with high consistency generates a pulp with far greater strength for a given wetness than a mill refiner.

All these methods of pulp evaluation do not give a papermaker a quantitative method to evaluate a pulp furnish simulating a mill refiner. A laboratory refiner developed by Esher-Wyss is a pilot plant refiner which could be compared with different types of mill refiners, At the same conditions of net power and energy, different types of refiners will give same fibre development. It is basically a conical refiner which can be used for evaluating 500 g pulp. This unit enables the evaluation of those physical values in refining, which can be measured and controlled during mill operation It has a variable speed drive and a recirculatory system. Calculations involing the use of calibration curves are no longer neceessary, thus eliminating a source of error. Now Esher-Wyss has developed a new generation of laboratory refiner LR1 as illustrated in Figure 1 which incorporates the state-of-the-art technology. It utilizes the latest technological finding and a computerized measurement and data evaluation system. The purpose of the laboratory refiner is to carry out standardized tests on furnish. Commercial refining processes are realistically simulated in a laboratory scale so that technological conclusions be drawn on the refiner behavior of the furnish. The results can be processed for energy inputs versus freeness and physical properties development and property versus property at different energy levels.

Technological Features ;

- By altering refining parameters, the stock can be examined under various refining coditions (from intensive cutting to intensive fibrillation).
- The laboratory refiner can be converted from conical to disc fillings to reflect the type of refiner used in commercial operation.
- Each time a sample is taken, the specific energy transferred to the stock so far is measured.
- Characterizing the refining treatment is based on the theoretical/practical assessment of refining according to Brecht and Siewert.

Pulps from agroresidues, in particular straws are not usually subjected to refining due to the fear of drainage problems. In view of this we have tried to understand the influence of refining intensity and consistency on the development of fibers in bamboo and rice straw respectively.

Refining of Bamboo Long fiber fraction :

Bamboo pulp was refined using three specific edge loads viz 1000,1500 and 2000 Ws/km. The conditions for refining were as follows :

Refining Conditions

Consistency	:	3%
Spec. edge loads	:	1000,1500 & 2000 ws/km
Peripheral speed	:	950 m/min
Stock flow	:	100 1/min
Net Sp. Energy applied	:	20 to 300 kwh/t

The results indicate that the lower specific edge load yield pulp with better pulp properties at given net specific energy levels. It means that gentle mechanical action leads to better swelling of the fibers alongwith internal and external fibrillation without genera-

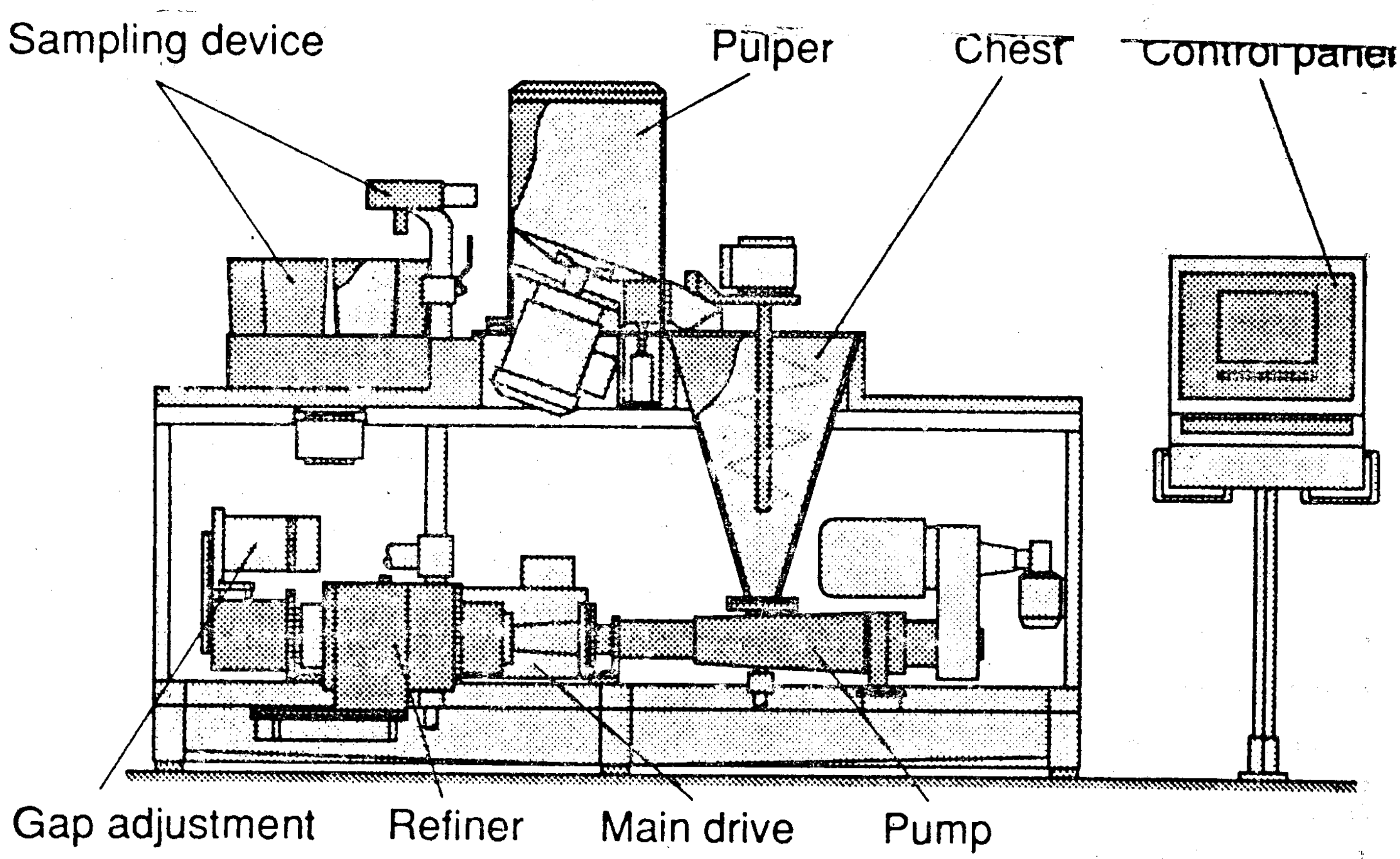
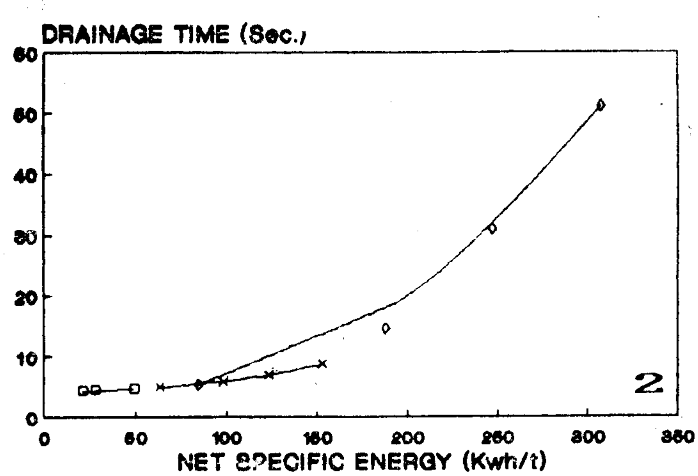
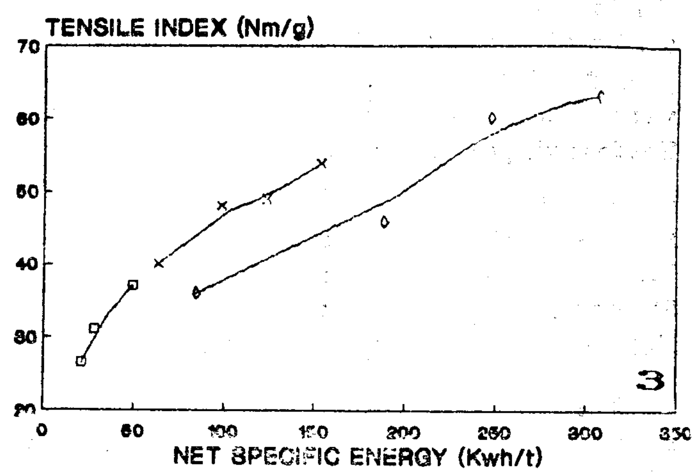


Figure 1. ESHER-WYSS LABORATORY REFINER LR1

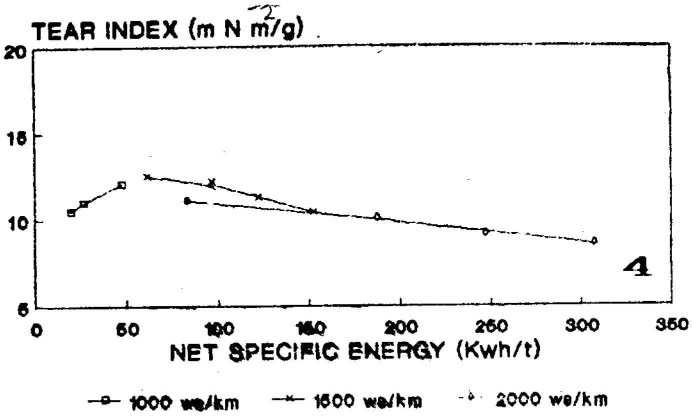
ting excessive fines which effect the drainage (Fig. 2). Improved swelling of the fibers during gentle refining causes better conformability of the fibers resulting



increased binding leading to better tensile (Fig. 3) and burst without much loss in tear (Fig. 4) and similar



observations were made by Damer and Ratneiks[2], on Eucalyptus pulps. Higher specific edge loads have negative effect on the drainge, and the strength development also is poor due to shorting of the fibers. Higher specific edge loads may be helpful to improve formation, which is not advised as it is always



EFFECT OF SPECIFIC EDGE LOAD ON REFINING OF BAMBOO LONG FIBER

Figures 2-4

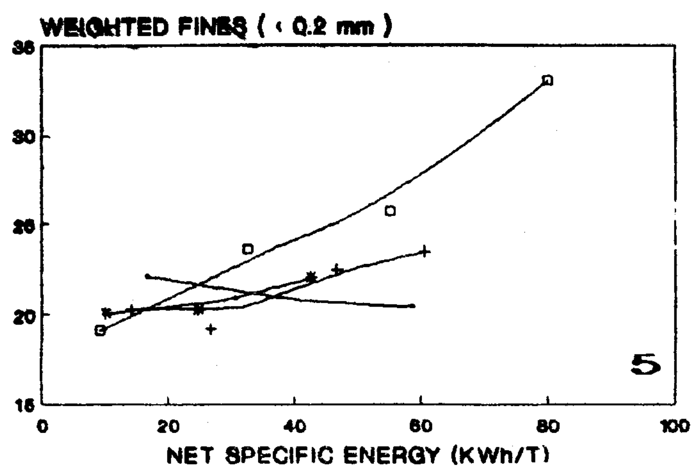
possible to add short fibers to the stock instead of wasting the reinforcing long fibers.

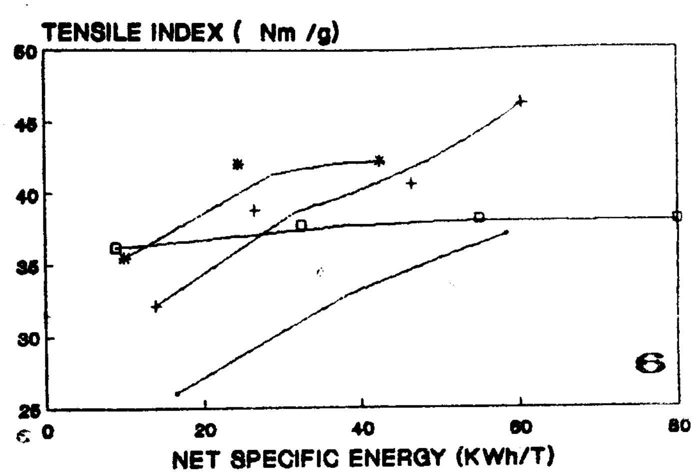
Refining of Rice Straw pulp :

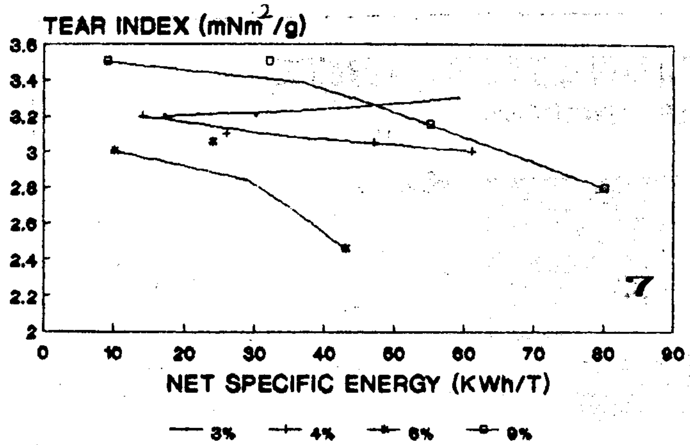
Optimization of sp. edge load in bamboo fiber refining has improved our undesrtanding regarding it's effect on the development of fiber. The straw pulps, especially the rice straw pulps are highly heterogeneous in nature and the fiber content is low compared to any other wood pulps[3]. In this context, it becomes more important to selectively develop the fiber without significantly disturbing the rest of the nonfibrous portion of the pulp to achieve improved strength with good drainage property. Hence the rice straw pulp was refined at low specific edge load (275ws/km). The following conditions were used for refining :

Consistencies	: 3%, 4%, 6%, and 9%
Spec. edge load	: 275 ws/km
Peripheral speed	: 950 m/min
Stock flow	: 100 l/min
Net Spec. energy applied	: 0, 20, 40, 60, 80 kWh/t

The responses of the pulps to net specific energy consumed vary at different pulp consistencies[4]. Rate of strength development depends on consistency. Optimization of refining consistency helps in optimizing the net specific energy requirements of a given type of pulp. In the present experiment, weighted fines content as determined by Kajaani FS-100 is not increased much in relation to net specific energy in the consistencies ranging from 3% to 6%, but increased dramatically in 9% csy (Fig. 5) with increased net specific energy. The tensile strength improved with increased net specific energy consumption at consistencies ranging from 3% to 6% (Fig. 6). Increase in tensile strength is more rapid in 6% csy compared to 3% csy and 4% csy. Maximum tensile is developed in 4% csy, but it is highly energy intensive to attain this level. The tensile curve in 9% csy has it's peak at 9kWh/t net spec. energy consumption and further energy input has no positive effect on the tensile strength. Refining with 6% csy at about 25 kWh/t net spec. energy appears to be ideal for rice straw pulp, since a maximum improvement in tensile is achieved at this level of refining. Burst strength also develop better in 6% csy compared to 3% to 4% csy. Burst strength develop more rapidly in 6% csy upto 25 kWh/t net spec. energy where as to develop the fiber to similar strength in 4% csy it consumes double the energy. Tear is marginally effected in all the cases (Fig. 7).







EFFECT OF CONSISTENCY ON REFINING OF RICE STRAW PULP

The above experiments on the bamboo long fiber and rice straw pulp suggest that : (a) medium specific edge load of 1500 ws/km is ideal for developing bamboo long fiber, (b) higher specific edge loads (2000 ws/km) tend to cut the bamboo long fiber and effect the strength properties in negative manner, (c) low consistency refining of rice straw pulp is energy intensive to develop the fiber to optimal level, (d) consistency around 9% and above of rice straw pulp lead to excessive fibrillation and fragmentation of parenchyma cells causing no improvement and/or loss of strength properties with severe drainage problems, (e) consistency around 6% at 25 kWh/t net spec. energy consumption appear to be ideal to achieve optimal strength properties for rice straw pulp.

Our experience with agroresidues is that the refining behaviour of different pulps vary depending on the composition of the pulps. It requires optimization for various refining parameters those exist in the mill. Hence, it becomes unequivocally significant to have a labscale refiner to simulate the mill operations and Escher-Wyss Laborefiner LRI appear to fit in the bill. It is needless to explain its utility in improving the stock preparation and energy conservation.

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