Fine Bar Technology in Refining System for Pulp & Paper Industries

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ABSTRACT

Refining plays an important role in stock preparation as well as throughout - the complete paper making process. Next to raw material selection, it has the greatest influence on final product quality. The new finer bar width and narrower grooves, resulting in increased cutting edge length (CEL). The fine bar design secures a reduction in specific edge load (SEL) and no-load power. Obtain optimum strength properties with low intensity refining for mixed hardwood & Recycled fiber

INTRODUCTION

- There are many steps in the complex process of converting wood/waste paper into paper. One of these steps is refining. Refining plays a very important role in modifying the characteristics of fibers so that they may form a sheet of paper or paperboard with a specific set of desirable properties such as stiffness, opacity, tear strength or surface smoothness, to mention just a few.
- Cost of energy in paper manufacturing is as high as 25-35% depending on grade of paper manufactured. Out of which Refiner consumes -------% power**.** Ever increasing price of energy has become a serious concern for paper mills and every possibility of saving it is their main approach for profitability.

THEORY OF REFINING

It will be shown that fiber and pulp properties can be manipulated by altering the refiner plate configuration and the operating conditions of a refiner in order to achieve an optimal combination of paper properties.

Pulp refining is a process in which fiber collect on refiner bar edges and are subsequently deformed by compressive and shear forces such that the cell wall of at least some of the fibers is permanently modified. The nature of the cell wall modification is dependent on the magnitude of the compressive stresses (or strains) that occur during the deformation of the fiber. The extent of the cell wall modification depends on how frequently fiber are collected and subsequently deformed for a given mass of fiber. In pulp refining, we are interested in both the magnitude and the frequency of these deformations.

Within each fiber bundles, the average cell wall deformation of individual fibers is directly related to the deformation of the bundles itself: e.g. if the bundle is only slightly deformed, then the average fiber cell wall deformation will also be slight. On the other hand, if the bundle is greatly deformed, then the stresses and subsequent deformation of individual cell walls will be much greater. If the deformation of the fiber bundles is so extreme as to cut it into two, a portion of the fibers within the flock are also likely to be cut.

Effect on Fibers during Refining

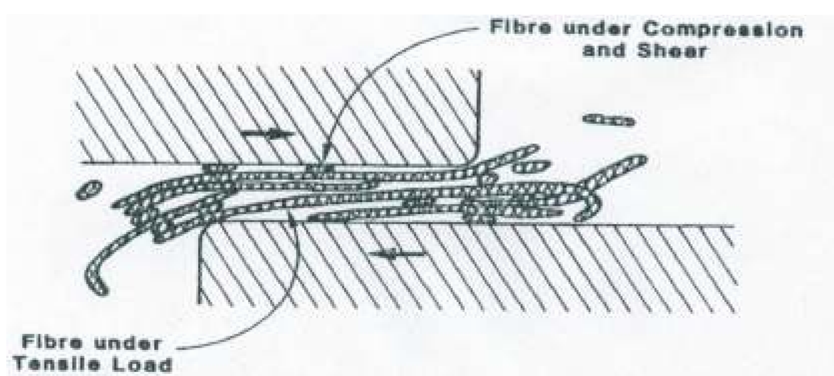
(a) Fiber de-lamination: Forces on the fiber in the refiner cause fibrils to move relative to each other, breaking internal bonds and thus causing fiber de-lamination. This has been clearly observed with the scanning electron microscope. Fiber de-lamination contributes to other changes in the fiber such as swelling and increased flexibility.

(b) Fiber Swelling: De-lamination of the fibers allows the entry of water into the fiber walls, causing the fibers to swell. This water breaks additional hydrogen bonds creating further swelling. Water Retention Value has been shown to increase with refining, proving that there is an increasing amount of water bound to the fiber as the level of refining increases.

(c) Increase in fiber flexibility: Breaking of internal bonds allows fibrils to move relative to each other, making the fibers less resistant to deformation i.e. more flexible. This increased flexibility enables surface tension forces to bring more fibers into close proximity during consolidation of the web. This, in turn increases the level of fiber/ fiber bonding and thus influences paper strength, optical properties and other paper characteristics.

(d) Removal of outer layers: The thin primary wall (or what remains of it following pulping and bleaching) and part of the secondary wall can be removed by refining, exposing a new surface and allowing an increase in fiber swelling. The removed layers increase the fines level in the pulp and thus affect paper properties.

(e) Micro creping of fibers and the introduction of other defects: These both effect the mechanical



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properties of the fibers. Micro creping produces a more extensible fiber and defects such as kinks and local ballooning of the fiber can cause a reduction in the local fiber strength.

(f) Curling and Twisting of fibers: Fiber twisting and curling influence the network structure of paper and thus affect its properties.

(g) Increase in Specific Surface: The production of fine material with the removal of outer layer increases the specific surface. This is further increased by fibrillation i.e. loosening of the surface fibrils.

(h) Fiber length reduction: This occurs with harsher beating. It has been used to reduce the flocculating tendencies of long fiber pulp but at the expense of tearing strength.

Purpose of Refining:

Product properties within specifications. Runnability on Paper Machine. Change of Pulp properties. Strength properties: Tensile strength, Internal bond. Surface properties: Smoothness, porosity. Other important properties: Formation, Bulk

Why to Refine Recycled Fibers?

- Because once refined Fiber has been developed to give a good Bonding Ability
- But once through the Paper making Process has reduced that Bonding Ability. Once so nicely developed Fibers are not any more in their Condition for the next use in Paper making. Severe Drying and Pressing Forces have created irreversible Changes.
- Recycled Fiber Treatment Process has cleaned but not necessarily developed the Fibers.

It is Desirable to :

- Regenerate the Swelling and Bonding Ability of Fibers.

It is not Desirable to:

- Shorten the Fibers
- Weaken the Fibers
- Increase the De- watering Resistance.
- Reduce the Bulk.
- If not refined in a correct way the result can be disastrous. Undesirable effects such as too high an increase in drainage resistance and major reduction in fiber length and tearing strength.

Specific Edge Load Theory

At the microscopic level of fibers and fiber bundles, refining effects are dependent on the magnitude and frequency of deformations. In the macroscopic world of commercial papermaking, we cannot directly control these factors. However, we can control them indirectly by making two broad assumption.

We can first assume that the greater the number of bar edges available in the refining zone, the greater will be the number of fibers able to absorb a given refining load because fiber bundles are collected on bar edges. The average number of crossing points where bundles can be caught between opposing edges of the rotor and stator plates can be calculated based on the inner and outer diameter of the plates, bar and groove widths, and the average radial angle of the rotor and stator bars. While the term " Cutting Edge Length" is generally used to describe this factor, it is mathematically proportional to the average number of crossing points.

Second, we can assume that the torque applied by a refiner motor is directly proportional to the normal force acting to push a refiner rotor against a stator. This means that, with a fixed motor speed, the motor power is proportional to the normal force.

With these two assumptions, it is possible to conclude that the average magnitude of fiber deformation is directly related to the applied power divided by the product of rotating speed and edge length. This is the basis of the Specific Edge load Theory which was first introduced back in the 1960's. The calculated variable is referred to as 'Refining Intensity' or 'Specific Edge Load' (SEL), and is typically expressed in units of watt-seconds per meter (Ws/m).

In order to calculate the refining intensity, it is necessary to first determine the true load applied to the fibers. In a Refiner, there is significant power consumption resulting from hydraulic losses. The bars and grooves of the refiner filling accelerate and decelerate the fluid as it passes through the refiner, causing a heating of the fluid but no net refining effect on the fiber in the process. This is called the 'no-load power' and it must be subtracted from the total motor load in order to accurately define the net power actually applied to the fibers.

The SEL (I) of refining may be calculated according to the following equation:

$$\text{SEL} = \frac{\text{(Applied Motor Power - No Load Power)}}{\text{RPS x Cutting Edge Length}}$$

$$= \text{Ws/m}$$

Why low intensity refining?

- The biggest increase will be in recovered fiber stock, while virgin pulp will increasingly originate from hardwood.
- Hardwood & Secondary pulps have shorter and thinner fibers than softwood pulps, and resistance against refining load is much lower.
- Recycled fiber we must be more "gentle" in refining, if not, we can only damage the fiber.
- One way to be more "gentle" in the refining is to decrease the intensity by adding bars in the disc.
- Savings in refining energy and longer lifetime of fillings.

What does low intensity refining mean?

- The technological results and cost of refining depend on the intensity and frequency of the fiber treatment.
- A globally acknowledged measure of refining intensity is specific edge load
- For refining under low intensity conditions, there are two possibilities

(a) Reduce refining power.

(b) Increase cutting edge length (CEL).

- Reducing refining power results in poor efficiency, with the result that more machines are required for attaining a given refining result. To increase CEL, more bar length is required, and therefore finer bar and narrower grooves are necessary.

Recommended Specific Edge Load For Various Grade of PULP:

TYPE OF FIBER	S.E.L (in Ws/m)
SOFTWOOD, STRONG	4.0 – 6.0
SOFTWOOD, WEAK	2.0 – 4.0
HARDWOOD, STRONG	0.8 – 1.5
HARDWOOD, WEAK	0.4 – 0.8
RECYCLED FIBER, WEAK	0.4 – 1.0
RECYCLED FIBER, STRONG	1.0 – 2.0

Determining "the best" refining intensity for a particular refining application can be considerably more difficult than specifying the required specific energy input. Even with a substantial background of mill operating data, designing a refining system to operate at optimal intensity involves several economic trade offs. Hence, it requires a clear understanding of the economic impact of paper quality improvements.

If a pulp is only lightly refined, the refining intensity is usually not so important because there is not enough fiber modification taking place to make the difference discernable. An exception to this is the refining of unbleached kraft for sack paper applications for which the initial increase in tear with refining can only be assured if the intensity is sufficiently low (i.e. 1.5 2.0 Ws/m)

The benefits of low intensity refining for hardwood pulps and for mechanical pulp post-refining are quite widely acknowledged by papermakers. In the past, the lower limit of intensity had been established at 0.6 0.8 Ws/m due to the limitations of plate manufacturing technology. However, recent developments in this area have enabled intensities of 0.2 0.6 Ws/m to be achieved while maintaining efficiency and hydraulic capacity.

Low refining intensity has long been considered unnecessary for softwood pulps and deemed too costly in terms of potential increases in specific energy requirements. This view is changing as many mills are seeking gains in tear strength and toughness that lower refining intensity can provide. Many mill refiners currently operate in the range of 2.0-4.0 Ws/m. Any easily achieved reduction in intensity will almost always be beneficial to quality.

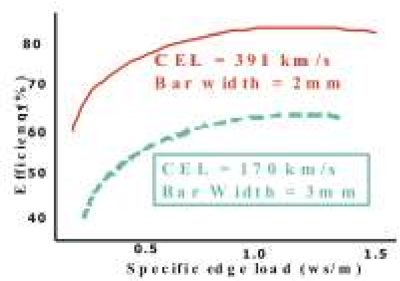
For hardwood pulps, low refining intensity results in greater bulk and opacity at a given level of most strength properties. There is no substantial evidence to demonstrate that refining can be too low in the case of hardwood pulps. Most mill refiners currently operate in the range of 0.6-1.0 Ws/m, and nearly all applications could benefit from any reduction achieved by changing plate patterns. Another key benefit of low intensity refining for hardwood is the reduction in energy required to achieve a given pulp quality or drainage level.

Recommended Specific Energy For Various Grade of PULP:

PULP GRADE	SPECIFIC ENERGY
Soft Wood (Strong)	60 – 200 kwh/t
Soft Wood (Weak)	40 – 100 kwh/t
Hardwood (Strong)	40 – 80 kwh/t
Hardwood (Weak)	25 – 40 kwh/t
Recycled Fiber	20 – 100 kwh/t
Post Refining of Mechanical Pulps	30 - 80 kwh/t
Reject Refining in Chemical Pulp	50 – 100 kwh/t
Trim Refining	20 – 50 kwh/t

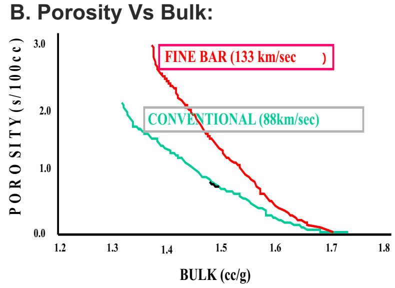
A. Influence of cutting edge length (CEL) on refiner efficiency:

$$\eta = \frac{\text{Total refining power - no load power}}{\text{Total refining power}}$$



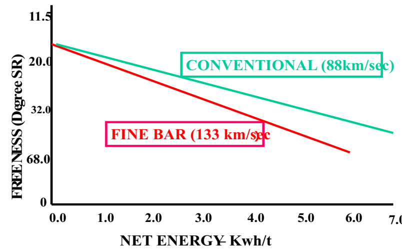
1. One of the key benefits of low intensity refining is the reduction in energy required to achieve a quality or drainage level.

B. Porosity Vs Bulk:



- Significant improvements in sheet porosity at a given bulk
- Gentle refining develops the outer surface of the fiber improved bonding and reduced sheet porosity.
- Typical bulk improvements at target properties have ranged between 2-5%

C. Freeness Vs Net Energy:

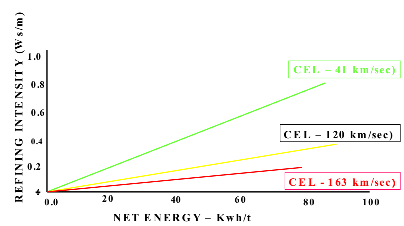


1. Less energy is needed to achieve a given freeness

2. This can be taken as an operating cost reduction, or as an increase in power available for quality enhancement or to accommodate a higher throughput.

3. Refining to 300 CSF (40 Degree SR) with Fine Bar plates resulted in energy savings of 0.97 net kWh/t.

D. Refining Intensity(SEL) Vs Energy:



Benefits:

- 18-30% higher tear, 10% higher Tensile and twice the long fiber content.
- 23-27% energy savings.
- Produces the highest degree of fibrillation and therefore a better bonding pulp.

Case Study: At Ballarpur Industries Ltd., Unit: Shree Gopal Unit, Yamuna Nagar (Haryana)

(Ref. IPPTA Journal, Volume 20, Number-1, Jan-Mar. 2008)

Net Cost Saving after changing the Bar Pattern is Rs. 19.0 lacs/Annum.

Quality Improvement during Refiner running with Fine Bar Plate :

- There was increase in ash content in paper by 1.5%
- Rejection/segregation of paper was reduced by 90% due to wax pick below 13.

CONCLUSIONS of M/s BILT-Yamunanagar

- Achieved reduction in refining

- power by reducing specific edge load from from 1.14 & 1.17 to 0.79Ws/m
- The Specific energy consumption (SEC) reduced from 12.0 to 6.0 kWh/°SR/MT.
- Reduction in the rejection / segregation of paper due to low wax pick below 13.
- Ash content increased by 1.5% from 14.0 to 15.5% in 119 gsm

Parason New Finer Bar Plates:

To meet the increasing demand of Paper Industry for gentle mechanical treatment of fibre; specially Short Fibre **(Hard Wood/Waste Paper**) to develop optimum Paper making properties in a cost effective manner, PARASON has developed ***"FINE"*** and ***"SUPER FINE"*** bar patterns of Refiner Tackles for all sizes of Refiners having Bar width 2.0mm and 1.5mm.

Treating the Pulp fiber with ***"FINE"/"SUPER FINE"*** bar pattern having higher Cutting Edge Length(CEL) will reduce Specific Edge Load(SEL) Thus reducing power consumption as well as improve strength property of Pulp. *(Refers to literature in the IPPTA magazine January-March 2008)*

SUMMARY

Fiber refining is one of the most important unit operations in papermaking, understanding and applying it's knowledge you will be able in getting good runnability of paper machine and high quality of paper at reasonable cost level.

CONCLUSION

Refiner operation on short fiber pulp like hardwood and secondary fiber should be at low specific edge loads below 1.0 Ws/m (low intensity refining) and fillings should have a high cutting edge length. The final result is optimum strength and optical properties, higher refiner efficiency and low specific refining energies.

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