Fine Bar Technology in Refining System for Pulp & Paper Industries:

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ABSTRACT

Refining plays an important role in stock preparation 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). Obtain optimum strength properties with low intensity refining for mixed hardwood & Recycled fiber.

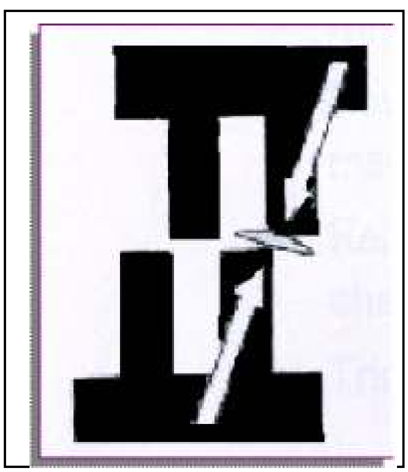
Introduction

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 .

Cost of energy in paper manufacturing is as high as 25-35% depending on grade of paper manufactured. Out of which Refiners consumes around 32% 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.



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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 stress (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 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.

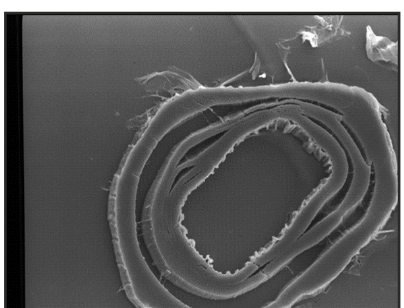
Efect On Fibers During Refining:

(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.

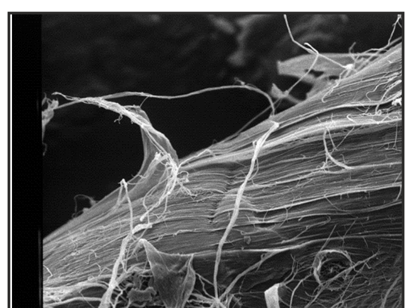
> Forces applied on the fiber by the bars of Stator & Rotor in Refiner cause fibrils to move relative to each other, breaking bonds and thus causing fiber de-lamination.

(b) Fiber Swelling: De-lamination of the fibers allows the entry of water into the fiber walls, causing the fibers to swell. The 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.

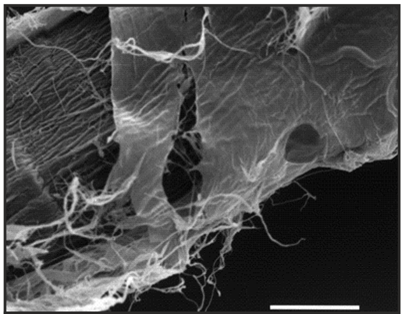
(c) Removal of outer layers: The thin primary wall (or what remains of it following pulping and bleaching) and part of the secondary wall can be removed by refining, exposing a new surface and allowing an increase in fiber swelling. The removed layers



Internal De-lamination



External Fibrillation Fibril Angle



Secondary Layer/Fibrils

increase the fines level in the pulp thus affect paper properties.

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

(e) 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 surfaces 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:

The purpose of stock preparation refining is to develop the desired drainage characteristics and sheet properties, such as bulk / density, sheet strength (e.g. tear, tensile, burst and internal bond strengths), porosity, surface smoothness, printing characteristics and formation.

Refining Action:

The mechanical action on the fiber results in fiber changes of three main types: cutting, splitting and brushing. In general cutting reduces the average length of the fibers, producing short, stiff fibers that form a bulky sheet. Cutting reduces the drainage rate (freeness) with least amount of refining energy. Brushing retains fiber length while developing flexible fibers that conform well during papermaking to produce papers of high strength and low bulk. Splitting produces a combination of cutting and brushing, with paper properties falling between the two extremes. Most stock-preparation fiber treatment involves splitting, because it is difficult to obtain only cutting or only brushing.

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.

Refining Intensity And Refining Power:

Refining intensity and refining power are the most important variables to control to develop fibers suitable for papermaking. Refining intensity is the refining energy applied to the intersecting bar edges of the refiner. Refining power is the net energy applied per ton of pulp. Its is calculated by dividing the net refining power by the total tons refined per unit of time. Refining power is expressed in terms of kWh/ton.

Refining action in stock-preparation refiners take place at the intersecting edges of the refiner bars. For this reason, it is important to determine the total number of bar crossings, which is defined as Cutting Edge Length (Km/rev). This factor can be calculated by multiplying the total length of the refiner bars in the rotor by the total length of the refiner bars in the stator by refiner speed (rpm).

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.

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 n 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 through the refiner, causing a heating of the fluid but no net refining effect on the fiber in 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.

$$SEL = \frac{\text{Applied Motor Powe No Load Power}}{\text{RPS x Cutting Edge Length}} = Ws/m$$

A refiner with a high CEL usually has a low refining intensity per mm cut and does more brushing and splitting than cutting. A refiner with low CEL usually has a high intensity per mm cut and does more cutting than brushing or splitting.

Why Low Intensity Refining?

- The biggest increase will be in recovered fiber stock, while virgin pulp will increasingly originate from hardwood.

- Harwood & Secondary fibers have shorter and thinner fibers than softwood pulps and resistance against refining load is much lower.
- Re-cycled fiber we must be more "gently" 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.

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 order low intensity conditions, there are two possibilities,
  (a) Reduce refining power. (b) Increase cutting edge length (CEL)
- 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)
Soft Wood	2.0 – 6.0
Hard Wood	0.4 – 1.5
Recycled Fiber	0.4 – 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 optional 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 discernible. 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 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 the 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 required to achieve a given pulp quality or drainage level.

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-March 2008)

Net Cost saving after changing the Bar pattern is Rs.19.0Lacs/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 1.14 & 1.17 to 0.79 Ws/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 119gsm.

Parason New Finer Bar Plates:

To meet the increasing demand of paper industry for gentle mechanical treatment of fiber, specially short fiber (hardwood/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. (Referes to literature in the IPPTA magazine January-March 2008).

Parason Finedge Refiner Plates:

Parason Finedge Milled Bar Refiner Plates:

Plates are manufactured using CNC

technology to provide the maximum uniformity in the refining zone. Milled blanks are cast in own foundry as a solid piece to provide uniform hardness through out. The plates will wear uniformly over time, and with the zero draft angle on the bar, hydraulics are maintained longer. The Parason precision CNC milling manufacturing provides accurate groove width, which allows finer bar to optimize low intensity applications. Plate life is also maximized by re-grooving which allows 2-3 life cycles.

Special Features: Narrow bar width, bar width range 1.6, 2.0, 2.25, 2.5mm on wards, High cutting edge length, zero draft angle on the bar, high life (re-cutting possible) & special metallurgy.

Benefits: Low specific edge load, good fibrillation consistent fiber treatment, constant throughput, suitable for Hardwood, TMP, & Re-cycled fiber.

Parason Finedge Welded Bar Refiner Plates:

Plates are manufactured using special casting & Robot welding, CNC technology to provide the maximum uniformity in the refining zone. Welded plates are cast in own foundry to provide uniform hardness through out and welded with special technology. The plates will wear uniformly over time, and with the zero draft angle on the bar, with high bar height, with minimum bar width, hydraulics are maintained longer. The Parason precision special cast, laser & welding, manufacturing process minimizes groove width variations, which allows finer bar to optimize low intensity applications. Plate life is maximized due to high bar height able to maintain in this technology.

Special Features: Narrow bar width from 1.6mm, bar width range 1.6,2.0,2.5mm on wards, high cutting edge length, zero draft angle on the bar, More bar height more life & special metallurgy.

Benefits: Low specific edge load, good fibrillation consistent fiber treatment, constant throughput, suitable for Hardwood & Re-cycled fiber.

Parason Finedge Curved Bar Refiner Plates:

Plates are manufactured using special casting & CNC technology to provide the maximum uniformity in the refining zone. Curved bar plates are special cast in own foundry to provide uniform hardness through out. The plates will wear uniformly over time and having a longer length. The flow of pulp follows the grooves between the bars results in longer residence time. Thus, the result of Finedge curved bars is more gentle refining action which continuous over a long time. Curving the refiner bars causes them to function better as a pump. The half dams between sectors further improve the pulp residence time resulting into improved refining.

Special Features: Longer pulp residence time, high cutting edge length, finedge curved bars function better as a pump & special metallurgy.

Benefits: Finedge curved bars-more gentle refining action, Low specific edge load, good fibrillation consistent fiber treatment, more throughput, suitable for Hardwood & Re- cycled fiber.

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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