Usage of Fine Bars for Optimizing Secondary Fiber Processing in Refining System :

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ABSTRACT

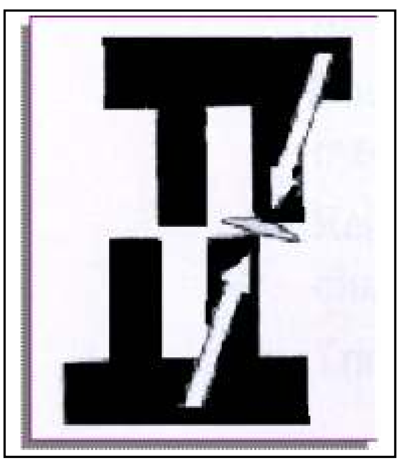
Refining plays an important role in stock preparation the complete paper making process. Next to raw material selection, it has the greatest influence on final product quality. The new finer bar width and narrower grooves, resulting in increased cutting edge length (CEL). The fine bar design secures a reduction in specific edge load (SEL). Obtain optimum strength properties with low intensity refining for Recycled fiber.

INTRODUCTION

There are many steps in the complex process of converting 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.

FFECT ON FIBERS DURING REFINING:

(a) Fiber de-lamination:

Internal De-lamination

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.

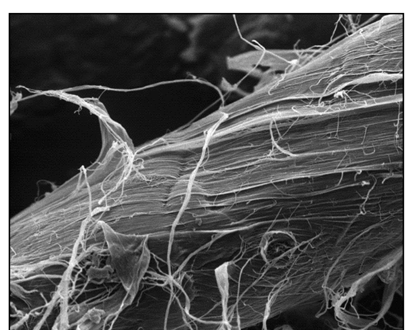
Forces on the fiber in the refiner cause fibrils to move relative to each other, breaking internal bonds and thus causing fiber de-lamination. This has been clearly observed with the scanning electron microscope. Fiber de-lamination contributes to other changes in the fiber such as swelling and increased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

(b) Fiber Swelling:

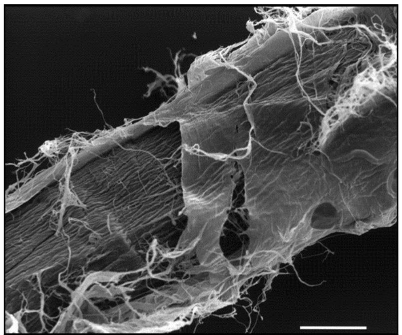
De-lamination of the fibers allows the entry of water into the fiber walls, causing the fibers to swell. The water breaks additional hydrogen bonds creating further swelling. Water Retention value has been shown to increase with refining, proving that there is an increasing amount of water bound to the 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



External Fibrillation Fibril Angle



Secondary Layer/Fibrils

fiber swelling. The removed layers increase the fines level in the pulp thus affect paper properties.

(d) 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.

(e) 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:

To apply mechanical energy to modify fibers & the purpose of stock preparation refining is to changing the fiber structure yields changes in sheet structure & properties such as Tensile, Burst, Opacity, Formation, Tear, STFI, Freeness, Ply bond, Ring Crush, Sheet smoothness, etc.,

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:

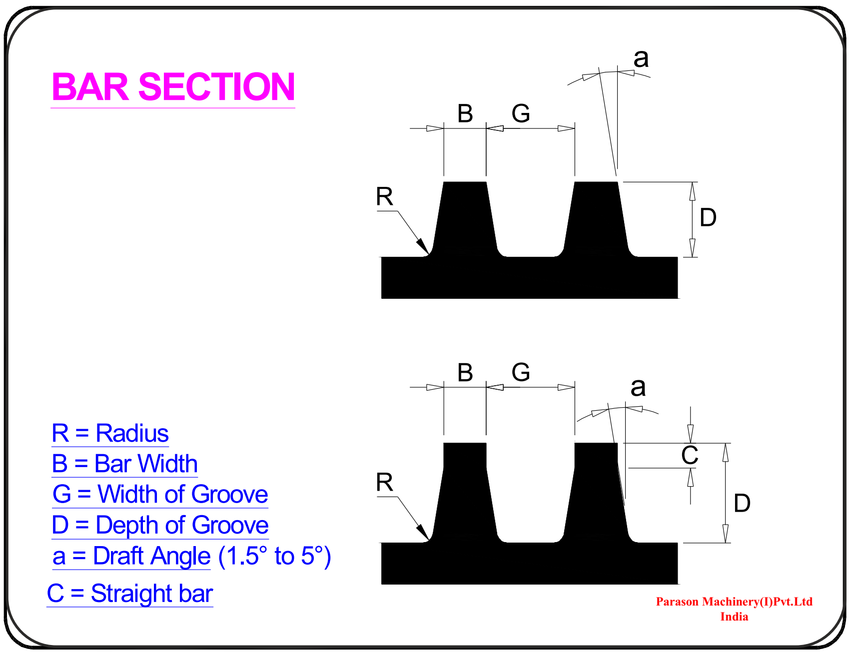
- Regenerate the Swelling and Bonding ability of Fibers.

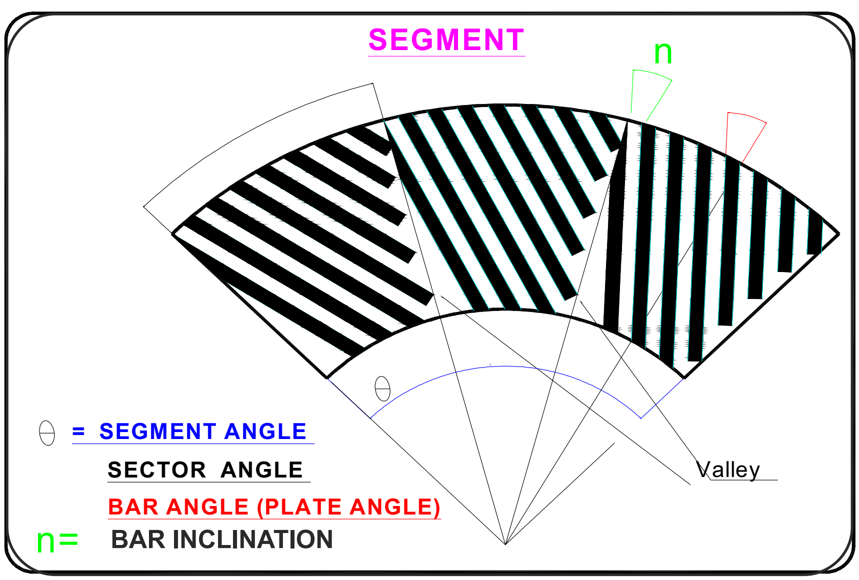
It is not desirable to:

- 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 rotating speed and cutting 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.

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

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.

FUNCTION OF THE REFINER PLATE:

- Effectively feed fiber into Refining Zone
- Convey Fiber (Pump) through the Refiner
- Promote fiber stapling on the Bar Edge
- Develop desired fiber test properties.

WHY LOW INTENSITY REFINING?

- Secondary fibers have shorter and thinner fibers 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.

EFFECT OF INTENSITY ON SHEET QUALITY:

High to moderate intensity can

- Improve formation
- Shorten fiber length
- Increase fines
- Improve sheet smoothness
- Increase freeness to kW response

Low intensity can

- Improve strength
- Maintain fiber length
- Reduce fines
- Improve tear
- Improve Ring Crush
- Improve tensile
- Reduce freeness to kW response

RECOMMENDED SPECIFIC EDGE LOAD:

Type of Fiber	S.E.L. (in Ws/m)
Secondary Fiber	0.5 – 2.0
Bleached Soft Wood	1.5 – 3.5
Unbleached Soft Wood	2.0 – 5.0
Bleached Hard Wood	0.4 – 1.0
Unbleached Hard Wood	1.0 – 3.5
TMP Post Refining	0.4 – 0.8

CONSISTENCY:

- Below 2.5% can cause segment clashing
- Above 6.0% usually requires special pumps
- 3.0% and below increased cutting or fiber shortening increased system instability , increased intensity.
- 4.0% and above increased brushing or fiber development increased system stability decreased intensity.
- Increasing consistency can cause plugging.
- Fluctuations will cause Refiner loading instability

pH CONDITIONS:

- High pH increases fiber swelling from hydration
- The fibers become slippery at higher pH levels
- The slippery effect is greater with unbleached fibers
- Low pH requires special disc materials to prevent corrosion.
- Low pH increases the aggressiveness of the refining process.

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. (Refers 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 Secondary Fiber ,Hardwood & TMP.

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 onwards, 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 Secondary fibre & Hardwood.

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 multiplicity of curved bars have a longer bar length, and therefore lower the power dissipation per bar and per unit length. During refining fiber gently follows the channels between the bars so that long bar path length results in longer residence time. Thus the result of curved bars is a more gentle refining action which continues over a longer time. Curving the refiner bars causes them to function better as a pump.

Use curved bars on flat plates to obtain the benefits of more gentle refining and higher throughput. During refining the fibers are subjected to abrading action, resulting this abrasion will increase the surface area and bonding capability of the fibers. Power dissipation is proportional to the abrasion action, the net result of longer bar length is that the abrasion takes place over a long period of time and is thus of lower intensity. Lower intensity results less cutting or damage of fiber.

Another important design consideration is the amount of restriction flow at the inside diameter and outside diameter of the refiner plate. Although a number of factors effect the openness of flow, the restriction is generally correlated with the amount of open area on the inside diameter and on the outside diameter. By open area is meant the spacing between bars times the height of the bars. Open area on the inside and outside diameter is important to achieve flow. Higher flow improves productivity and lowers costs of processing fibers through the refiner. It is also important that the bar patterns of the refiner plate result in most fibers being brought to the bar surface where the desirable development of fiber can take place. Fibers which reside within a groove between bars and channel out the entire length of the plate without passing over the tops of the bars do not benefit from the refining processing.

To increase the inside diameter openness, the refiner plate is provided with interior chamfers on the curved bars which extend to the inside diameter to increase the inside diameter flow area . By chamfering the interior portions of the bars, the obstruction to flow is reduced and an increased openness obtained at the inside diameter. It will help to maintain the same open area of the inside to outside diameter of the plates resulting constant throughput and fiber development.

Curving the bars in a fashion similar to the vanes on a Pump impeller will serve to pump the stock through the plate, thus improving through put.

In Refiner plates dams have been positioned between the bars to force the flow of stock out of channels. Dams cause problems with plate plugging and can cause too much fiber cutting. The gentle curved bars of plate will gently block the completely radial flow of the stock which is driven radially by a centrifugal force, thus causing the stock to flow out of the channels and over the bars where the stock is refined.

Improvement in Quality:

Increasing Ring Crush, as the curved bars plates make the fibers either shorter or more fibrillated to increase the surface area. This increases the bonding strength of the sheet .

Special Features:
Constant Bar Crossing Angle at all places it is very difficult to maintain in any other designs, Optimized Bar and Groove Width & Geometry, Minimum Draft Angle Square Grooves, sharp bar edges, Anti plugging radial 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, Lowest energy consumption, maximum number of fiber treatments good Fibrillation, Maximum Homogeneity, consistent fiber treatment, Optimum Hydraulics more throughput, Suitable for Secondary fiber & Hardwood.

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 secondary fiber should be at low specific edge loads (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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