Refining Technique for Hardwood Pulp Using Double Disc Refiners

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Today the paper industry in our country is inclined to the use of more and more hardwood pulp in various proportions in their paper making furnish. During the past few years many leading men in our paper industry have presented papers containing very useful informations and procedures for the utilisation of hardwoods for pulp and paper making. The content of this paper is a resume of informations and general guidelines of the technique of refining of hardwood pulp, which are basically the results of various research work and studies made by personnels of Jones Division USA of Beloit Walmsley group, technical colaborator of Jessop & Co. Ltd.

The strength properties of a sheet of paper depend on the original qualities and strength of the fibers and to the extent of bonding between the fibers that make up the sheet. Fibers are relatively slender tube like structural elements, composed of general layers encased with a harder outer seath called 'primary wall'. Each of these layers comprise finer structural elements known as 'fibrils' which are helically wound and bonded to one another.

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The function of a refiner is to impart a mechanical treatment to the fibers in presence of water to remove that primary wall and break the bonds between the 'fibrils' of the outermost layers to produce a 'frayed' surface, thereby increasing substantially the surface area of the fiber. This is known as 'Fibrillation'. In addition to this the fibers are also made more flexible, so that during sheet formation the fibers conform to and around one another producing large areas of intimate contact. This increase in flexibility is accomplished by a substantial flexure of the fiber. The sub-division of fibers into fibrils and the consequent holding of water in finer and more numerous capillary passages bring about a change in fibers that makes them more reluctant to allow the drainage of water from or through them. Because of the increased surface and flexibility of the pulp fiber in this condition, a greater degree of bonding takes place when the sheet is dried.

In general, the following basic types of work are performed on fibres in a refiner : (1) cutting or shortening of fibers (2) fibrillating of fibers, when they are split externally and made finer

(3) bruising of fibers, when they are split internally and in each case new surfaces are exposed to water. Cutting produces short, stiff fibers that are not flexible and form a bulky sheet, while fibrillating and bruising will give more longer flexible fibers producing higher strength in the sheet of paper. Refiner is generally directed to balance the amount of these difference effect according to the character of paper to the made.

The major portion of the work performed on the fibers takes place at the leading edge of the bars of the refiner filling. Therefore, the total numer of bars and the number of times they cross each other per revolution have a decided influence on the type of treatment of the fibers, assuming throughput, consistency and power consumption are kept constant.

Double Disc Refiners have demonstrated much wider limits of flexibility than other refining machines because of inherent ability to install more bar edges and instanteneous contact area in a disc. This permits the possibility of combining a large number of bar crossings with a high contact area in a double disc refiner and hence they have proven capable of providing better strength development of a more difficult to refine pulps, such as hardwoods. By the frontal action of bars of the discs and due to the uniform wearing characteristics of the parallel refining surfaces of the disc refiners, they offer a good utilisation of power, more accurate and uniform treatment on account of a uniform cushion of fibers with minimum turbulence.

With the hardwood pulps, most of the difficulty steemed from machine runnability problems such as breaks at the couch and picking at the wet presses. With the assumption that the developments of initial wet web strength is an indication of paper machine runability, the double disc refiners are found to be best equipment for use in processing hardwood pulps.

Dr. R.L. Bhargava and Mr. M.B. Jauhari pointed out (IPPTA, Dec. 76) that the short initial fibre length of hardwood pulps led to a number of difficulties on the paper machines, one of the most commonest being the picking of the surface of the paper on the drying cylinders. However, they also observed that hardwood pulps show marked increases in strength on beating.

The prime variables and their effects on the treatment of hardwood pulps in disc refiners are as follows:

1. **POWER** : The intensity of refining is defined as the net refining power divided by the number of bar crossings per unit time.

   The net refining power is the net horsepower per ton per day, where net horsepower is the gross applied horsepower less the backed off power or no-load horsepower. This no-load horsepowr is that required to rotate the unit, with stock flow, at its operation speed with no refining force applied, with the discs in a backed off condition. Therefore, the net horsepower is the result of an increase in turning resistance due to forces exerted on the stock between the refining surfaces.

   Since the refining action takes place at the leading edge of the refiner bars, we define the number of bar crossings with a calculation which determines the 'inch contacts per minute'.

   Inch contacts pre minute = Total length of bars (rotor) × Total length of bars (stator) × Refiner speed (RPM)

   When refining hardwood pulps for maximum strength development, a gentle treatment of the fiber is necessary with lower intensity of refining. It then follows that if a refiner fillings are designed with a high number of inch contacts per minute, the net horsepower per inch contact becomes very low resulting in minimum cutting and maximum bruising of fibrillation.

   Thus the amount of bruising, or fibrillation, can be increased by increasing the number of bars in the filling, increasing the speed of the refiner, or increasing the tonnage.

2. **SPEED** : Different research experiments and the mill trials as well have shown that a considerable increase in physical properties of fibers could be achieved with increased speed which can again be attributed to the greater edge contact at higher speed. But at higher speed the no-load power consumption will increase resulting in lower net power consumption at a given gross installed power. In the case of refining hardwood pulp, the strength properties are increased at higher speeds by arranging the best combination of the refiner disc sizes and the operating speeds.

3. **TACKLE (REFINER FILLING)** : When refining hardwood pulp for maximum strength development, the disc pattern to be used should contain as many narrow bars as physically possible and the refiner speed be high depending upon the disc diameter. In addition to strength development this also enables to retain a higher percentage of longer fibers.

   One additional factor is to be considered when discussing about refiner filling design is the angle of intersection of the refiner bars of a pair of discs. As the angle is decreased, or the closer the bars come to being parallel, the more severe the refining action and thus more cutting. Increasing the intersecting angle between the bars will produce more bruising and longer fiber length. In case of refining hardwood pulps, we can attain higher strength properties by choosing the right bar angle of the disc, depending on throughout at a constant pressure differential and the speed of the discs. For refining hardwood the ultimate result of researches in Brazil and North America have suggested a bar pattern with bar width of 3 mm and the width of the groove between bars also 3mm with a height of bars being 6 mm to 10 mm. Experiments conducted with varying rotor bar angles and constant stator have shown that burst, breaking length and long fiber content are marginally higher with higher bar angles whereas tear remains about equal.

Generally for refining hardwoods, stainless steel disc pattern milled into the blank disc has been most successful choice. Machining of the disc pattern allows the use of a more homogenous material and the machining of very narrow bars without the danger of any breakage. When casting discs of nickel choromium alloys, the resulting material is usually considerably harder and therefore more subject to breakage when cast in a narrow bar pattern.

4. **CONSISTENCY:** When the consistency is increased the fibers are closer to each other and this produces more fiber-to-fiber action and better distribution of fiber over the leading edges of the bars, which produces more bruising and less cutting, all other factors equal. Experiments on hardwood refining have shown that normal development levels could be satisfactorily achieved by low consistency refining alone and bonding strength actually was higher using low consistency refining only. However, the tear and the percent stretch values were substantially improved by pre-refining at a high consistency followed by low consistency finish refining.

5. **SERIES REFINING** : Series refining in two or more refiners produces better physical properties than single pass refining. Maximum strength values are obtained in case of hardwood refining, by keeping the specific power per unit of refining area low to obtain a gentle treatment of the fiber.

These are, in general, the primary variables which are to be taken care of during refining of hardwood pulp. In a furnish comprising of two components (hardwood and long fibered pulp), having a mix in excess of 25% : 75%, each should be refined separately when one component may undergo an undesireable fiber shortening leading to low tear before the burst strength of other component develops. But again we know that this is economically not very feasible idea in our country to have two different streets of refining as this calls for two separate streets of pulping processes. However there are other opinions of refining mixed pulps when hardwood is one of the components, which may help us in refining these components separately. One of them is from a report in the use of eucalyptus in Spain : "to keep energy consumption down and make best use of eucalyptus fiber, it is suggested that instead of refining all the pulp to a given °SR, take a portion and refine it to a higher degree, leaving the rest unrefined. Basically the °SR after the mix of the refined and unrefined pulps should be a desired one. This theory finds use in the mixing of long and short fibers, where the short fiber is highly refined to develop the maximum bonding capacity, and less energy is consumed". (PPI, Dec 77).

To conclude, it is our belief that with the installation of more and more disc refiners in new mills in our country, with the plan of replacing the existing refining systems with modern double disc refiners in our mills and with the research works and mill trials being undertaken in different parts of the world, the use of higher percentage of hardwood in paper making furnish is obvious.

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