THEORY OF REFINING

Here we shall consider the stock preparation refining process. 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 paper properties.

1. **Qualitative Analysis:** This involve the quality of pulp and paper.

   Pulp refining is a process in which fiber flocs 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 and the extent of the cell wall modification depends on how frequently. In pulp refining, we are interested in both the magnitude and the frequency of these deformations.

   Note:

   i. **Nature/Magnitude/ Intensity ---- Compressive stress**
   ii. **Extent/Frequency/ Number of deformation -----**

   In the earlier section on paper structure, the two-fold objective of stock preparation refining was described as follows:

   - Increase the flexibility of the cell wall in order to promote increased contact area, and
   - Fibrillate the external surface to further promote the formation of hydrogen bonds as well as increase the total surface area of fiber available for bonding.

Therefore more refining that is done, the greater the increase in both fiber flexibility and surface fibrillation, also this shows that there is a relationship between refining intensity and cell wall deformation.

2. **Quantitative Analysis:** This involve the quantitative methods for calculating intensity

i. **Specific Energy:** This is the amount of energy that is delivered to the pulp.

$$E = \frac{P - P_{No-Load}}{QC} \qquad E = \frac{Trueloadappliedtothefibre}{QC}$$

Where Q is the volumetric flow rate through the refiner and C is the consistency. It is usually given in kW hr/tonne.

Typical specific energy input for the major grades

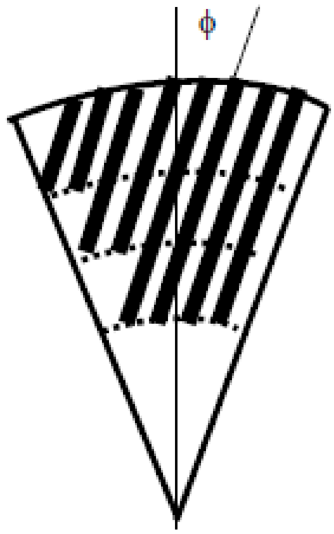
Grade	Pulp	hpd/t	kWh/t
Fine Papers	Hardwood	1.5-6.0	30-120
	Softwood	2.0-6.0	40-120
News	SW Kraft	1.0-3.0	20-60
	Groundwood	1.0-3.0	20-60
Linerboard	OCC	1.5-3.0	30-60

ii. **Specific Edge Load (SEL)/ Refining Intensity (I):** The basis of the Specific Edge Load Theory which was first introduced back in the 1960's is given that the average magnitude of fiber deformation is directly related to the applied power divided by the product of rotating speed and edge length

$$I = \frac{P - P_{No-Load}}{\left(\frac{RPM}{60}\right)(BarEdgeLength)}$$

or cutting edge length

True load applied to the fibers is the total load less the no load. In a commercial 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.



Bar edge length is the total length of bar edges that the fibres will see in one revolution. Note that for a double

$$BarEdgeLength = \int_{R_1}^{R_2} \frac{n_r n_s}{\cos\phi} dr \approx \sum_{i=1}^{N} \frac{n_{r_i} n_{s_i}}{\cos\phi} \Delta r$$

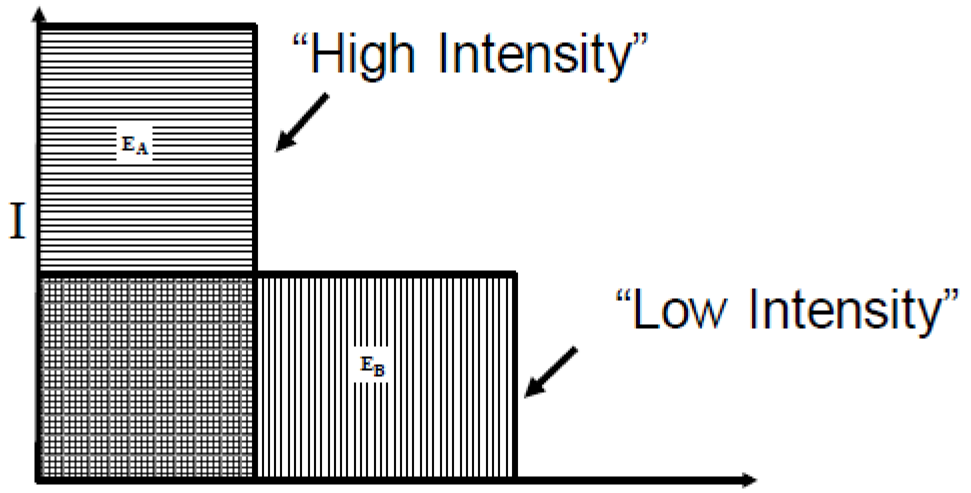
Where φ is the angle the bar makes with the radial direction and n is the number of bars at the radius, r.

Considering the frequency or, more accurately, the average number of deformations per unit mass aspect of qualitative analysis;

$$N = \frac{\left(\frac{RPM}{60}\right)(BarEdgeLength)}{QC}$$

Since the amount of refining (P) is by definition equal to the product of the magnitude and the number of deformations i.e P=I * N

$$E = \frac{P}{K} \bullet \frac{K}{F}$$



However, a useful insight is gained by knowing that applied power determines the magnitude of deformations while throughput determines the number of deformations.

C-Factor Analysis. In recent years, the introduction and application of the C-Factor analysis by R.J. Kerekes et al. has lent substantial credibility to the notion of I and N. The C-Factor analysis takes the refining theory a step further by incorporating values for average fiber length and fiber coarseness in order to calculate I and N on a 'per fiber' basis.