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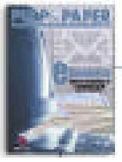
REFINING REFINERS : NEW CONICAL DESIGN



Updated Conical Refiner Design Offers Better Energy, Maintenance Efficiency

By AL LANKFORD

Widely used in the early 1900s, conical refiners have been reworked to eliminate high energy requirement, tendency to cut short fibers

Early in the 20th Century, conical refining evolved away from beaters used for fiber defibrillation (i.e., why some mills still call the refining area "the beater room"). The conical fit the requirements of the time quite well, because it was very good for shortening the long, non-wood fibers then in use. The conical continued to be applicable for stock refining into the 1960s because, as wood fibers began to replace non-wood fibers, long fiber softwoods were used, and cutting was still desired.

However, the tackle system of the older conical refiners limited their ability to fibrillate without cutting. This became more and more of a drawback as short-fiber hardwoods entered the stock furnish. The shorter hardwood fibers require fibrillation with minimal or no cutting to achieve their best papermaking potential. Refining intensities down to 0.2 Ws/M are recommended, [1] and this is usually not possible with the older style conicals.

Conical refiners also had many operational problems. They required significantly higher power, making them energy inefficient. The fillings take 8 to 24 hrs to change, are expensive, and have long lead times. It is often necessary to have 30% more installed refining capacity than is demanded by the furnish requirements to compensate for refiners being down for filling changes.

The disc refiner evolved to replace the conical refiner. In general, disc refiners are able to operate at a higher RPM and use refining plates with a longer cutting edge per unit area. This equates to a lower refining intensity suitable for hardwoods. Disc refiners require relatively less power than the conicals, equaling a lower cost per ton for operation. The cast plates are easier to change, are easier to obtain, and offer more versatility in bar patterns.

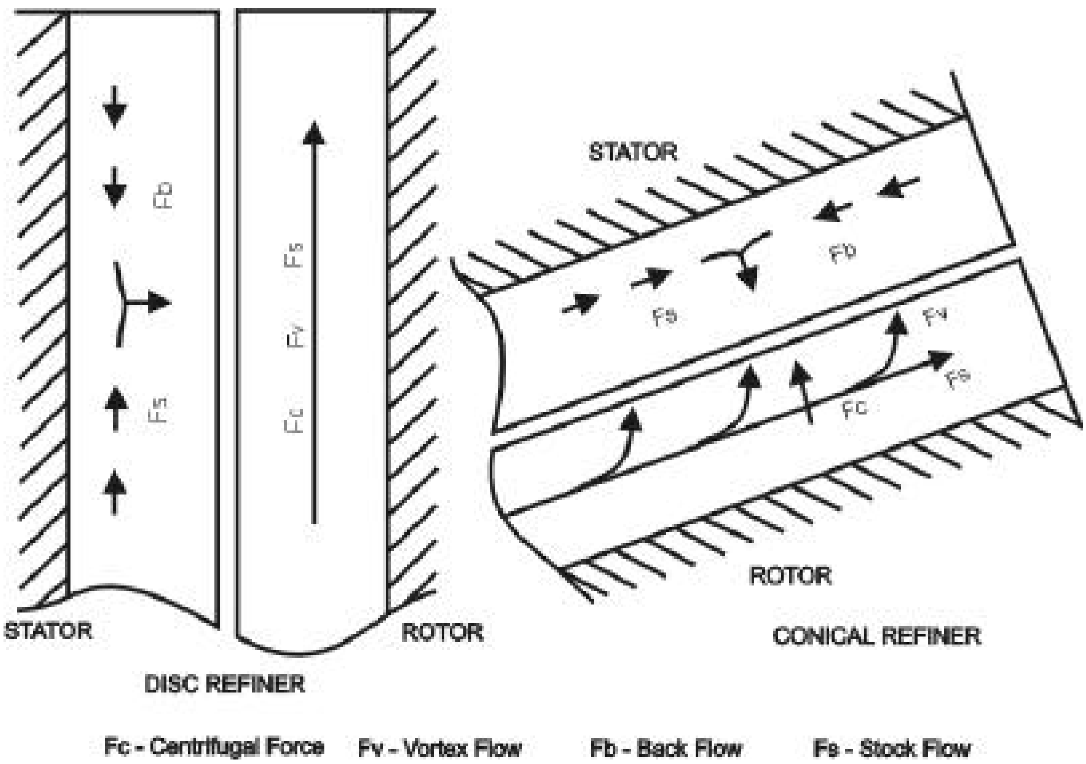


FIGURE 1. Hydrodynamic forces in a disc refiner compared with a conical refiner.

But disc refiners also have their problems. At the larger diameters required for high-speed paper machines, their operating RPM is limited by the circumferential speed at the outside diameter. This limits the ultimate ability to achieve the ultra low refining intensity beneficial to hardwood fibers and mechanical pulps. Due to the vortex flows, stock flow, and centrifugal forces, not all the fibers presented are refined, since some follow the plate grooves from inlet to the discharge.2 It has been surmised that, in some cases, as little as 30% of the fibers get refined in the first pass through a disc refiner. In these instances, refining efficiency and energy efficiency is low (Figure 1).

In a study inserting plastic tracer fibers in a refiner stock flow, the Pulp & Paper Centre of the Univ. of British Columbia determined that many fibers showed no evidence of impact. And the fibers that did were severely deformed, indicating an over-refined state.[3,4]

Therefore, in a disc refiner, it is probable that the fibers that are impacted tend to be over-refined to compensate for those that are not impacted to achieve the overall desired freeness drop. This leads to undue generation of fines, weakening of the refined fibers, and inefficient delivery of energy to the fiber. In another study, Martinez and Kerekes showed that in a single-bar lab refiner, only 0.1% of the refining energy expended resulted in tensile strain of a fiber.[4,5]

REBIRTH OF CONICAL REFINING. Jyhlavara, and then Sunds via their acquisition of Jyhlavara, reintroduced conical refining in the 1980s with its new ConFlo concept- a two-cone refiner with shallow cone angle and lower refining intensities than its ancestors, the Jordans and Claflins. Relative to the ability to provide impacts on the fibers, it was found that centrifugal force and the vortex flows within a conical refiner work to an advantage to force the fibers out of the grooves and into the bar gaps (Figure 1).[2]

Initial and continuing field results with the ***ConFlo*** showed an ability to provide improved fiber development, more complete and homogenous treatment of the fibers, and improved energy efficiency for identical or better fiber development. One author has suggested that the shallow-angle conical refiner is possibly the most efficient refiner for the treatment of softwood kraft.[1]

In the mid-1990s, Pilao S.A. of Brazil, a manufacturer of disc type refiners, began a project to improve upon the available designs of conical refiners. The goals were to develop a unit that combined the fiber development and reduced energy characteristics of the new conical refiners with higher capacity and energy efficiency.

The result of the project was a conical refiner with three refining cones. The refining system is a wide-angle, double-flow conical refiner with a double-sided conical rotor and two conical stators. Like a double disc refiner, the rotor floats and is balanced by stock flow and hydrodynamic pressure on both sides. In concept, the refiner can be thought of as a double disc refiner folded back over itself (Figure 2).

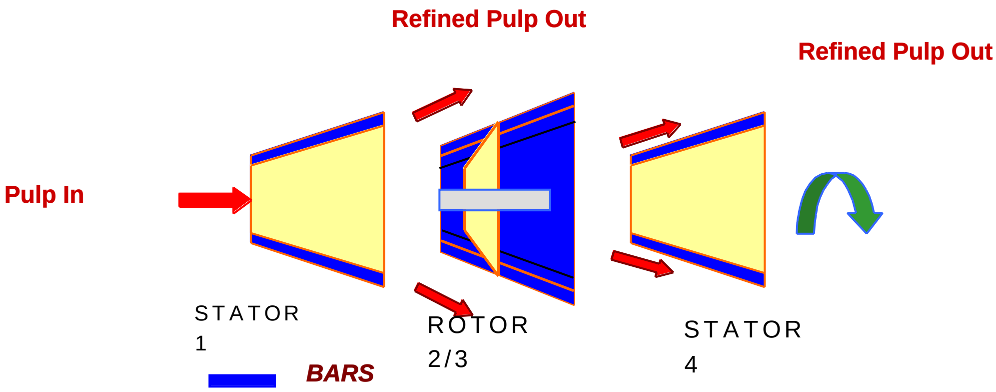


FIGURE 2. Diagram of the new triple cone refiner concept.

The design incorporates small diameter cones with a comparatively high refining area. For example, to achieve the same refining area as a 34-in. double disc refiner, the new design requires cone large diameters of only 21.25-in. Since the diameter of the rotor is smaller, the circumferential velocity at the rotor outside diameter for a given RPM is considerably reduced. This permits the maximum allowable RPM of the refiner to be increased, providing for lower refining intensities.

In theory then, the new conical refiner should be better for hardwood and recycled fiber by providing lower intensity refining, equating to better fibrillation and less cutting. Total energy consumption, including no-load power requirements, is also reduced for the equivalent refining area.

Using the existing designs of the refiner body and rotating elements from double disc refiners, the new refiner project team redesigned the refiner door to accommodate the triple-cone tackle concept (Figure 3). The result was a conical refiner with three cones and four refining surfaces, which functions similarly to a double disc refiner. This also was projected to facilitate operation of the new refiner in the mill environment.

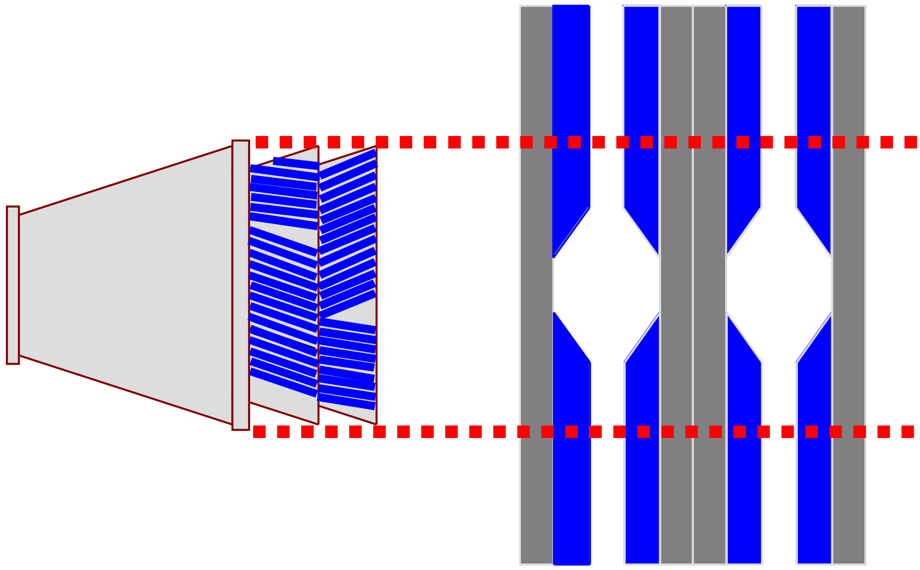


FIGURE 3. Tackle diameter comparison of a triple conical refiner versus a double disc refiner.

The refining tackle is fabricated, providing greater freedom in bar pattern design to suit various applications. The bars are cold re-rolled steel, which are welded to a fabricated steel cone (Figure 4). The leading edge of each bar is 90 degrees and, due to a unique microstructure, stays at 90 degrees throughout the life of the fill (cast bars generally have a leading edge that is greater than 90 degrees and increases with wear). The geometrical relationship of the bars and the grooves also stays constant over the life of the fill (the bar/groove geometry of cast tackle changes as the bars wear).

The cones are comparatively small and are removed from the door side of the refiner. Filling change from shutdown to startup can be accomplished in one or two hours. When necessary for maintenance, the entire rotating shaft assembly, including bearings, housings, and retainers, can be removed from the door side.

REFINER TRIALS. The first unit was installed in a Brazilian linerboard mill. Initially, the new refiner was installed in parallel with two existing 26-in. double disc refiners in series so that comparisons between the two refining systems could be made. Each refiner in the system was connected to a 450-hp, 885-rpm motor. The production data is:

· Production: 130 tpd
· Raw material: 100% OCC and machine broke
· Freeness in: 575 CSF
· Freeness out: 400 CSF
· Consistency: 4.6%

Trials were run on the mill's standard furnish. Specific refining energy was incrementally increased and samples taken on both systems until no further improvements in sheet properties were obtained. The results are shown in Table 1.

TABLE 1. Trial data: Disc refiner vs. conical refiner			
TEST	(2) DD REFINERS	TRI CONIC	UNITS
Tensile	46.15	47.12	nM/gram
Tear Index	12.99	13.38	nM/m^2/gram
Air Permeability	9.33	7.42	Sec/100 mL
Burst Index	2.38	2.40	$kPa.m^2$/gram
Shopper Drainage	39.00	34.30	Degrees
Net Energy	0.43	0.24	kW-hr/CSF/Ton

The new refiner alone was equal in all measures to the two double disc refiners in series and exhibited significantly better energy efficiency. The results indicated that the new refiner was able to perform better in fibrillation without generating the same level of fines. Although the sheet was formed better-as evidenced in the air permeability and burst indexes-drainage was improved, resulting is less water load in the press and dryer sections. Another sign that less fiber cutting occurred in the new refiner is the reduced degradation of tear while achieving higher tensile. Trials were then conducted on the new refiner alone comparing unrefined and refined furnish per Table 2.

TABLE 2. Trial data: Triple cone refiner vs. unrefined pulp			
TEST	UNREFINED	REFINED	CHANGE
Freeness	575	400 CSF	175 CSF
Tear	133 gm/f	118 gm/f	-11%
Tensile	3.6 kGf/mm	4.5 kGf/mm	+25%
Mullen	29 lb/pol 2	40#/pol 2	+38%

At the conclusion of the trials, the mill elected to remove the two 26-in. double disc refiners and use only the new conical refiner for production. This reduced the process refiners from two to one and reduced total connected energy by 450 hp, equating to energy savings of approximately $76,000/yr. In addition to energy reduction, the mill realized savings by reduction in maintenance and number of fillings purchased annually.

In August 1999, one of the new triple-cone refiners was installed in an upper mid-western U.S. linerboard mill. At the time, the mill was operating one 34-in. double disc refiner with an 800-hp motor processing 150 to 180 tpd of OCC for the top sheet of its two-ply liner. The mill had determined that a second 34-in. double disc refiner operating in series with the existing refiner was required to achieve the new benchmarks that had been set for the final product. However, upon investigation of the new conical refiner and the results at the Brazilian beta site, the mill project team decided to test a conical refiner to see if it could provide the performance required.

The existing 34-in. double disc refiner was removed. The new triple-cone refiner was installed in its place and connected to the existing 800-hp motor. The total motor output was limited to 600-hp, keeping in line with the design criteria of the new refiner. At startup, the new refiner achieved the necessary paper tests on ts own but used only 375 gross horsepower. After a three-month trial, the refiner control was switched over to the mill DCS, and the gross refining power increased to 425 to 450 hp, depending on grade and tonnage. According to the mill, the new refiner is the most stable in DCS control and requires significantly less operator and maintenance attention compared with its double disc refiners. Overall energy savings from the installation is approximately $146,000/yr.

In addition to reducing the energy required for refining, the mill also saved the expense associated with purchasing and maintaining two refiners and motors. An added benefit is tackle life, since the first set of tackle lasted 8 months compared with 60 days for the previous disc refiner. This mill is now evaluating installing two more of the triple-cone refiners in place of the three double disc refiners operating on the base sheet. It is expected that the overall sheet properties will improve when this takes place. The fillings in the refiners can then be optimized to provide fibrillation in the primary refiner for overall strength properties. The tickler refiner can be used for slight cutting to improve ring crush and ply bond. Overall energy savings are projected to be $438,900/yr.

At an installation at a U.S. corrugated medium mill, the triple-cone refiner replaced two 34-in. double disc refiners and one Jordan, all of which operated in series on 350 tpd of OCC. Each of the double disc refiners used a 600-hp motor, and the Jordan used a 400-hp motor. Approximately 150 points of CSF drop are taken across the three refiners. The new refiner was connected to one of the existing 600-hp motors. At startup, the new refiner achieved all paper tests alone, while using only 425 gross horsepower. After initial trials, the refiner was able to improve the sheet characteristics, as shown in Table 3. The projected annual energy savings in this installation are approximately $325,000/year. A second triple-cone refiner is now being considered for the mill's second paper machine.

TABLE 3. Trial data: Conical refiner on corrugating medium

GRADE	TEST	PREVIOUS RESULT AVG.	NEW RESULT AVG.	UNITS
26# Medium	CMT	49.08	57.04	Pounds Force
26# Medium	Ring Crush	31.24	31.92	Pounds Force
30# Bag	Mullen Burst	16.88	18.96	PSI
30# Bag	Gurley Porosity	24.24	27.52	sec/100 mL

OTHER BENEFITS. These results have been repeated now in trials and installations on most types of furnish and grades of paper (A complete list of grades and energy savings is available in the online version of this article in the Extra Edition section of www.paperloop.com

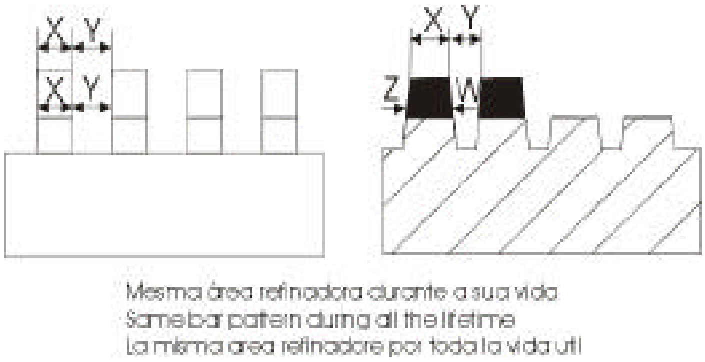


FIGURE 4. Illustrated comparison of fabricated and cast refiner tackle.

In general it was found that the triple-cone refiner did not generate the same level of hydrodynamic forces or flow velocities within the refining zones as an equivalent double disc refiner. This improves the residence time of the fiber in the refining zones, which contributes to the overall energy efficiency. Due to the reduced forces and flow velocities, the new conical refiners are somewhat more sensitive to plugging from furnish contaminants. Good screening is essential to longevity of the tackle, especially in the use of recycled fibers.

The characteristics within the conical refiners improve the flow of the furnish across the bar intersections. The improvement in fibrillation and reduction in fines generation may be the result of more fibers being present at the bar intersections due to this flow characteristic. Lower overall refining intensity also comes into play relative to fibrillation and should be beneficial to the refining of hardwoods and recycled fibers. A secondary result of the improved fiber mat between tackle surfaces is a reduction in metal-to-metal contact and a reduction in the potential of tackle clashing. Both result in improved tackle life when compared with double disc refiners.

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