Optimizing OCC refining with defloccing

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ABSTRACT: Subjecting pulp to a high shear zone immediately after refining results in more efficient refining. This phenomenon was originally observed to benefit softwood pulp refining. It was attributed to floc reduction based on floc measurements in mill refiners and the observation of reduced headbox plugging. Hence, this phenomenon has been termed "defloccing." The present work shows this technology also benefits refining of North American old corrugated containers (OCC). The combined results of several mill trials with OCC defloccing demonstrate the interactions between OCC refining intensity, defloccing technology, and other state-of-the-art refining improvements. At the same refining intensity, defloccing OCC on 100% recycled machines increases OCC refining efficiency by 15%, with greater efficiency improvement on machines that use softwood as well as OCC. Furthermore, it is shown that the benefits of defloccing are additive to refining improvements made in the refining zone of a refiner plate. Most OCC refiner plate designs can therefore benefit from the addition of a defloccing feature.

Application: As it does for softwood pulp, applying defloccing technology to OCC provides refining energy reduction that is additive to other refining technologies.

It has long been known that flocs are created in refining. Indeed, flocs enable successful compression of fibers between opposing refiner bars by forming a fiber mat. Flocs that remain in the sheet, however, reduce tensile strength [1], and persistent "coherent" flocs can seed the formation of larger flocs [2]. The persistence of flocs as they exit the refiner depends partly on fiber length. Long softwood fibers create persistent flocs, while hardwood flocs typically break up by the time they leave the refiner [3]. Kerekes has demonstrated that flocs at 0.5% consistency entering a hole or slot, as in a screening operation, are robust, but when they do break up, they do so by undergoing extensional strain [4].

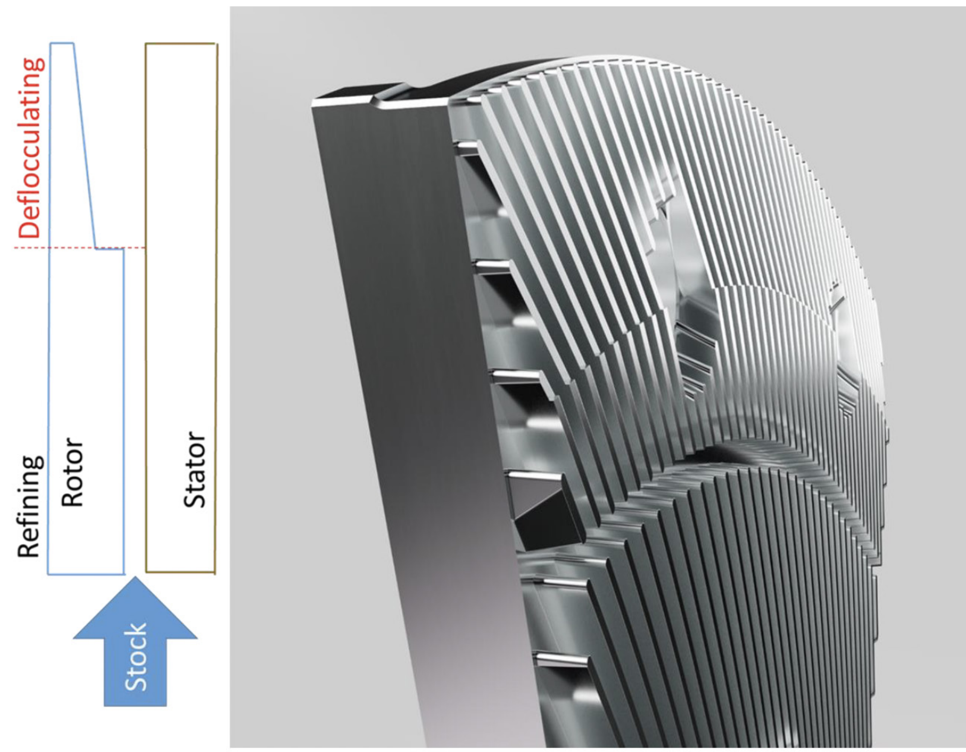
It has also been shown that passing stock through an unloaded refiner reduces the amount of softwood flocs [5]. This observation led to the development of a defloccing zone, typically on the outer perimeter of a refiner plate [6-10]. A set of refiner plates with at least one such defloccing zone is the patented technology known under the trademark D-FLOC-IT (International Paper Co.; Memphis, TN, USA). Defloccing zones reduce the amount of refining energy needed to achieve a target sheet strength [5]. **Figure 1** illustrates a typical defloccing zone.

The initial implementation of defloccing technology focused mostly on softwood refining based on the observation that refining shorter hardwood fiber does not typically form stable flocs that survive to the exit of a refiner. The fiber from old corrugated containers (OCC) is shorter than that of softwood kraft pulp due to OCC's inclusion of hardwood fibers found in corrugating medium, as well as the shortening of fibers that occurs through the recycling process. Thus, OCC might seem to be a lower priority candidate for defloccing. Nevertheless, there are precedents for benefits from reducing flocs and fiber bundles in OCC with mechanical treatments. Debnath et al. [11,12] used a homogenizing dispersion system to break up OCC used in tissue manufacturing. They achieved improved strength, softness, and absorbency, attributing this to breaking up and redistributing flocs while achieving fibrillation without fiber shortening. This same homogenizing device has been used by Krainer to increase OCC screen accepts when applied to the screen feed [13]. Thus, it would appear that flocs are endemic to OCC repulping, and OCC benefits from a defloccing or homogenization action. The deflaking and dispersion of OCC can also be beneficial for eliminating broke flakes and comminuting contaminants, respectively. Unlike the specific situations that might require deflaking or dispersion, however, defloccing addresses a need that could be common to refining.

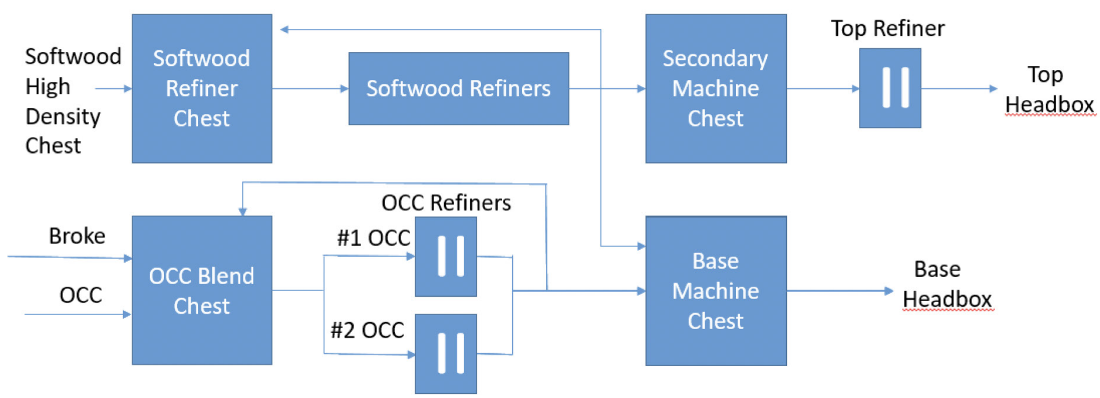
The results with OCC defloccing, to date, have been variable but usually favorable. In the present work, we look at a number of mill installations of defloccing technology on unfractionated North American OCC. We propose a hypothesis that explains these results and points the way to successful incorporation into an OCC refining strategy for most paper or tissue machines that use OCC.

EXPERIMENTAL APPROACH AND RESULTS

Defloccing has been developed solely on the basis of mill trials for multiple reasons. Considering the potentially transient nature of flocs, it is important to evaluate the effect of flocs at actual headbox consistency, shear forces, and chemistry to enable a realistic assessment of the effect of defloccing in the refiner. By contrast, handsheet evaluations of strength are of limited relevance because the low consistency and high agitation of handsheet-making can alter



1. Defloccing zone is located on the outer 5-cm perimeter of a refiner plate. Illustration used with permission from Andritz.

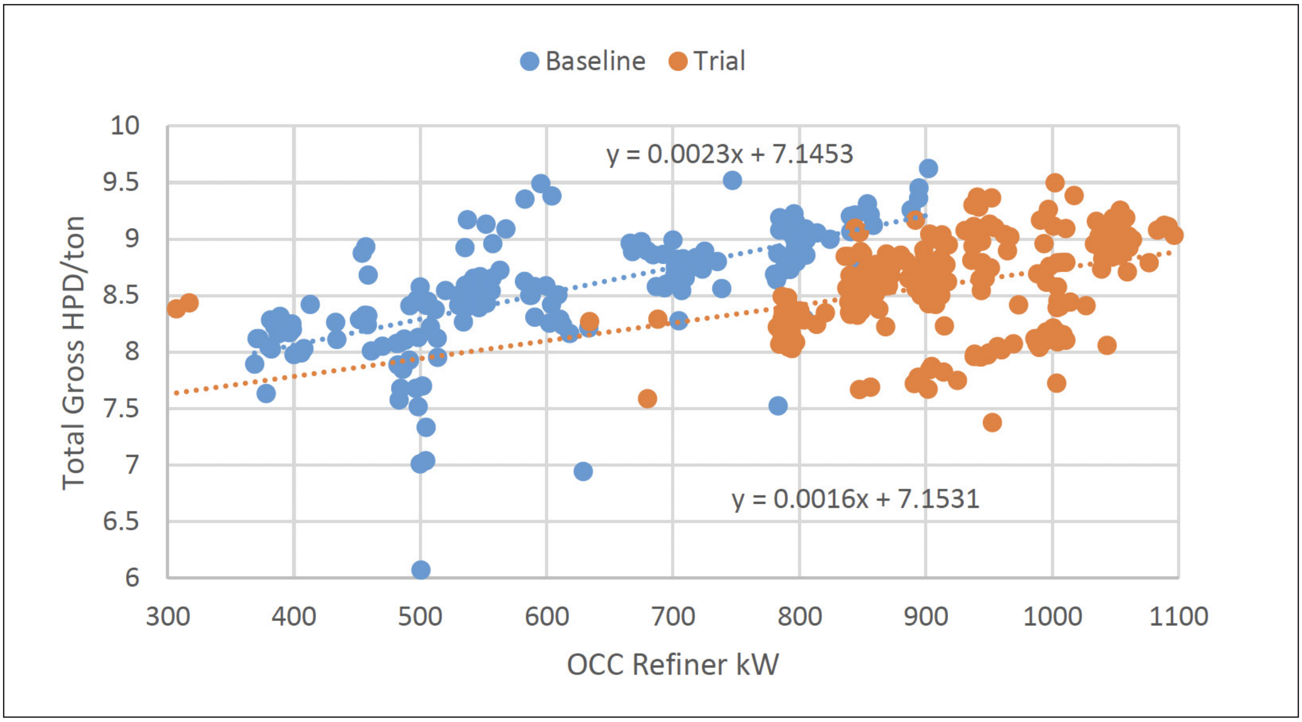


2. Refining layout of Machine A (OCC: old corrugated containers).

flocs. It would also be difficult to understand how pilot scale refiners translate into commercial refiner results, especially pertaining to potentially transient flocs that are difficult to quantify. Finally, implementing defloccing in a mill is lower cost than pilot work and relatively low risk, since refining gaps in defloccing zones expand towards the exit of the refiner, making pluggage in the defloccing zone unlikely. The challenge of mill trials, however, is that multiple variables can change, complicating the analysis. This is especially true in mills that have multiple sources of pulp, such as having both softwood kraft pulp and OCC. Any analysis should simultaneously consider sheet properties and machine speed at a minimum. As defloccers were implemented in mills, the operators maintained existing practices to control refining to achieve target sheet specifications. In the cases presented here, key variables are summarized to illustrate how comparable the baseline and trial conditions were.

Trials on an integrated softwood/OCC machine

In the first example, multiple trials were run on an integrated linerboard machine, Machine A, to validate the effect of the defloccer on the OCC refiners. **Figure 2** shows a schematic of the machine. It typically operates two identi-



3. Energy is lower by 0.59 horsepower per ton per day (HPD/ton) for the heaviest grade (34 lb).

cal OCC refiners in parallel. The OCC is co-refined with broke. Together, they comprise approximately 50% of the total sheet. Energy changes are tracked by comparing the total sheet's gross refining energy by grade between a baseline period and a trial period. Looking at the total sheet's energy use is necessary, because otherwise, changes in one refiner could be offset by changes in another refiner. It is helpful to report all energy as gross rather than net energy, since energy reduction is often the reason for installing defloccers.

The legacy OCC refiner plates on the No. 1 OCC refiner were replaced with defloccer plates that had a 31% lower cutting-edge length. At the same kilowatt loading, this would result in a higher specific edge load. Generally, lower specific edge load favors strength development on fragile OCC fibers, but the increased intensity was a consequence of installing a defloccing zone, which consumed some of the refining bar length. Both the baseline refiner plate and the defloccer were 47-in. diameter. The defloccer had a 2-in. radial defloccing zone but otherwise had the same plate pattern as the legacy plate.

One variable that often changes between a baseline period and a trial period is machine speed. In this case, the speed difference for Machine A between the baseline and first trial period was minor. The greatest difference was in the amount of refining done on the OCC refiners due to having one of the softwood refiners temporarily out of service. **Figure 3** shows that at a higher kilowatt loading on the No. 1 OCC trial refiner plate, the gross refining energy on the total sheet was lower during the trial period for the largest grade, 34 lb/1,000 ft^2 (34 lb). For this grade, the No. 1 OCC refiner defloccer saved 0.59 horsepower per ton per day (HPD/ton) on the whole sheet when compared at 850 kW. The defloccer refiner was only running 25% of the stock for this grade, and both OCC refiners operated at the same kW and flow.

In spite of the 0.59 HPD/ton energy reduction in the trial at constant OCC refining kilowatts seen in Fig. 3, the average total sheet gross refining energy was nominally higher by 0.05 HPD/ton. When the missing softwood refiner was re-installed, however, OCC refining went back to normal, and the average of that trial period was 0.41 HPD/ton lower than the baseline. **Table I** shows these and other key process data as Baseline 1, Trial 1a (missing a softwood refiner), and Trial 1b (back to normal refining). Figure 3 depicts only Baseline 1 and Trial 1a. Trial 1b began when the missing softwood refiner was replaced. It is more representative of the baseline conditions because of the similarity in OCC kW. The 0.41 HPD/ton benefit of Trial 1b compared to Baseline 1 corroborates the 0.59 HPD/ton benefit inferred from the analysis in Fig. 3 reasonably well. In addition, while this analysis is focused only on the largest grade, when most of the grades are included, their average benefit is 0.47 HPD/ton, which is right in the middle of this range.

As seen in Table I, other important variables were more constant than the OCC refiner kilowatts. The next most significant variation was in the jet-to-wire ratio indicated for the top ply. The main effect of these differences would be reflected in the machine direction/cross-machine direc-

Machine A Trials	Gross HPD/ ton	Relative Reel Speed	Relative CD STFI Index	MD/CD TSI	Relative Mullen Index	OCC Refiners kW	%OCC in Sheet	Softwood Kraft Kappa	Jet - Wire Base Ply, ft/min	Jet - Wire Top Ply, ft/min	Total Draw
Baseline 1	8.56	100%	100%	2.05	100%	617	52%	99	-55	-156	4.2%
Trial 1a – No. 1 deflocccer	8.61	103%	101%	1.91	96%	921	51%	100	-54	-235	4.5%
Trial 1b – No. 1 deflocccer	8.15	103%	102%	1.96	101%	659	49%	99	-57	-221	4.3%
Baseline 2	9.29	98%	98%	2.07	97%	826	53%	101	-54	-82	4.0%
Trial 2 – No. 2 deflocccer	8.38	97%	103%	1.82	95%	403	53%	99	-55	-60	3.9%
Trial 3 – Nos. 1&2 defloccers	8.25	92%	100%	1.85	101%	527	55%	106	-56	65	4.0%

HPD/ton: horsepower per ton per day; CD: cross-machine direction; STFI: short-span compression strength; MD: machine direction; TSI: tensile stiffness index; Mullen: burst strength; OCC: old corrugated containers.

I. Process variables for Machine A trials on the largest grade, 34 lb. Strength indices are normalized for small variations in conditioned weight.

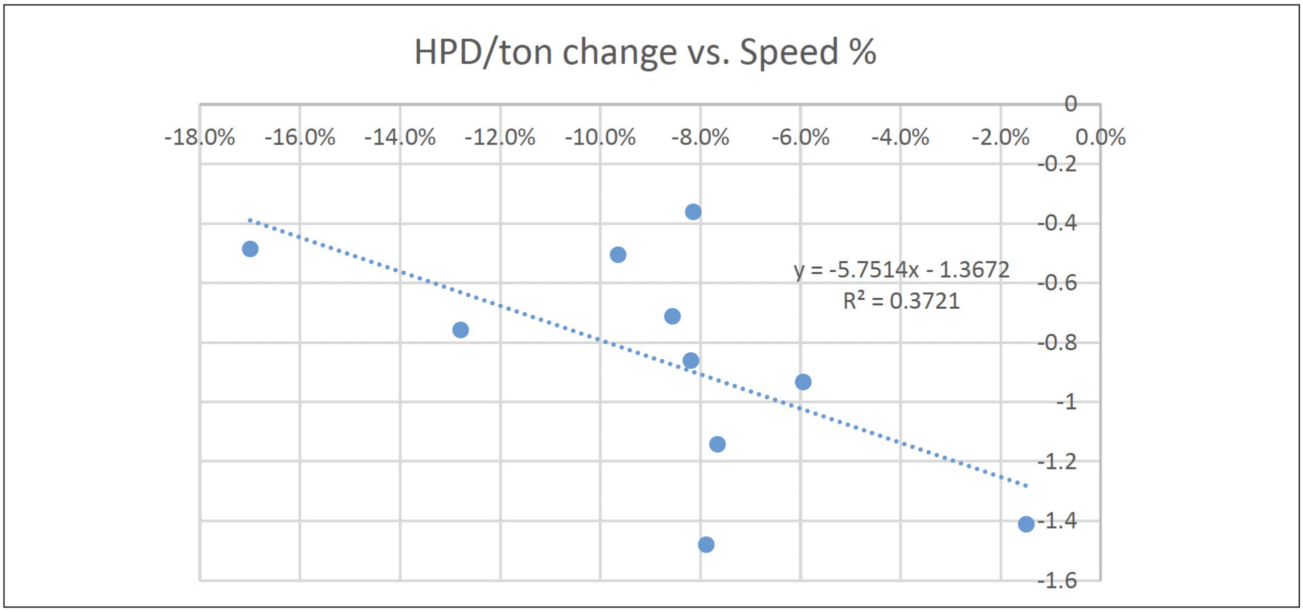
tion (MD/CD) tensile stiffness index (TSI) ratios, however, which are close enough to each other so as to have only a minor effect on STFI (short-span compression strength) index and Mullen (burst strength).

After seven months of operating Trial 1, the No. 1 OCC refiner had the deflocccer replaced with the legacy plate without a deflocccing zone. This initiated Baseline 2. For the 34-lb grade, this resulted in a higher energy use than Baseline 1. The OCC refining increased, but only by half as much as the difference between Baseline 1 and Trial 1a. Once again, the top-ply jet-to-wire ratio changed, but no other differences were obvious. Averaging across all major grades, Baseline 2 required 0.60 HPD/ton more refining energy than Trial 1b. This corroborates the 0.47 HPD/ton energy savings across all grades between Baseline 1 and Trial 1b, as well as the 0.59 HPD/ton estimate of Fig. 3.

After two months of running Baseline 2, a deflocccer was installed on the No. 2 OCC refiner. It showed a 0.96 HPD/ton benefit on the average of most of the grades, and a 0.91 HPD/ton benefit specifically on 34 lb, as shown in Table I. The largest differences in Table I are a decrease in OCC refining kilowatts and a decrease in MD/CD TSI ratio. The MD/CD decrease with the trial would have an adverse effect on Mullen but a favorable effect on CD STFI index of approximately 4%. This probably explains most of the 5% increase in CD STFI Index in Trial 2 compared to Baseline 2. Since the MD/CD and CD STFI index approximately cancel out, the comparison is straightforward.

The final trial, Trial 3, was to add back the No. 1 OCC deflocccer plate so that both OCC refiners were defloccers. This was done two weeks after a top-ply trial refiner plate was installed. The analysis during the two-week period of the effect of the top-ply trial alone showed a negligible impact on energy. Thus, we can reasonably ignore the top-ply trial for the purpose of evaluating the OCC defloccers. The grade averaged uncorrected energy savings of Trial 3 was a 0.91 HPD/ton benefit compared to Baseline 2. The machine was running slower in this case, however, as well as at a much lower energy. If we extrapolate the relationship between speed differences and HPD/ton differences among the grades, as shown in **Fig. 4**, the energy savings at equal speed (the y-intercept) would have been 1.37 HPD/ton. Another noteworthy difference is that Trial 3 had an increase of 5 kappa compared to Baseline 2. This would tend to increase the refining energy requirements. Thus, although there is a fair amount scatter in the 1.37 HPD/ton benefit extrapolated in Fig. 4, we have some reason for expecting it to be conservative. Thus, it appears the benefit of the two OCC defloccers are roughly additive. **Table II** summarizes Mill A trials on the basis of the average of major grades. While mill data is often noisy, the signals obtained in each of these trials indicated that the defloccers consistently made a favorable difference.

Since the deflocccer plates matched the diameter of the



4. Difference between Machine A Trial 3 vs. Baseline 2 (two OCC defloccers vs. no defloccers). The comparison of gross HPD/ton on the total sheet (y-axis) and percentage difference in speed (x-axis) for the top 10 grades of Machine A show a y-intercept that suggests 1.37 HPD/ton energy savings with defloccers if the speeds were equal.

Trial	No. 1 OCC Refiner	No. 2 OCC Refiner	Change in HPD/ton vs. Previous Period
Baseline 1	Standard	Standard	0 (baseline)
Trial 1	Defloccer	Standard	-0.47 (energy savings)
Baseline 2	Standard	Standard	+0.60 (lost energy savings)
Trial 2	Standard	Defloccer	-0.96
Trial 3	Defloccer	Defloccer	-1.37 (versus Baseline 2)
OCC: old corrugated containers; HPD/ton: horsepower per ton per day.			

II. Summary of OCC defloccer trials on Machine A, average of major grades.

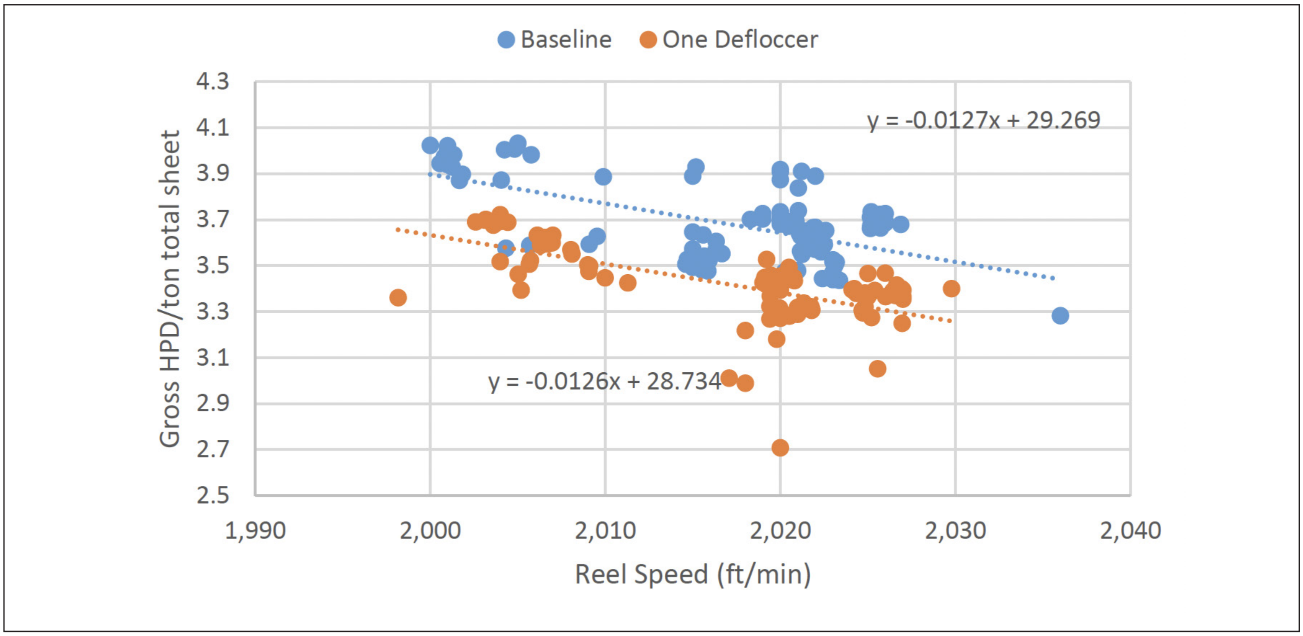
legacy plates, the no-load of the defloccer is lower. As a rule of thumb, the no-load can be calculated as if the plate diameter includes half of the defloccer zone width, so this 47-in. plate with a 2-in. circumferential deflocing zone would have the no load reduced from that of a 47-in. plate to a 46-in. plate. Using standard no-load correlations, this would be a 23 kW no-load savings for the defloccer. This amounts to 0.02 HPD/ton of the energy reduction on the whole sheet. It is insignificant compared to the energy savings due to the deflocing effect itself. Sometimes, larger diameter plates are needed to incorporate a deflocing zone. In these cases, the no-load could increase, depending on the plate design, but in general, energy savings from deflocing overwhelm energy changes due to no-load.

Trial on 100% OCC machine, Machine E

A recycled linerboard machine had previously converted all refiner plates from standard designs to a premium plate design based on demonstrated energy savings. As a next step in optimization, this machine trialed one of these premium plates with a defloccer added. The plate diameter increased from 36 in. for the existing plate to 38 in. for the defloccer version, and the plate pattern changed slightly. The net effect of these changes was a nearly constant intensity at the same kW loading. **Table III** shows the impact of one defloccer operating with a total of either two or three refiners over several key grades at constant reel speed. **Figure 5** shows the range of speed covered in the baseline and trial periods for a major grade. The trend lines allow interpolation to a common speed, taken as the median of the range. In this case, the median is 2020 ft/min, which leads to the 0.33 HPD/ton difference between the baseline and trial cases listed in Table III. **Table IV**, however, compares the averages of several key process variables. It shows an average refining difference of only 0.19 HPD/ton. This is based on the averages of the entire data set rather than

Grade	Number of Refiners Used	Baseline Gross HPD/ton	Defloccer Gross HPD/ton	Difference, HPD/ton
33 lb	2	1.93	1.71	-0.21 (savings)
34 lb	3	3.71	3.61	-0.10
35 lb	3	3.68	3.35	-0.33
36 lb	2	1.92	1.78	-0.14
Weighted average	2.41	2.67	2.48	-0.19

III. Energy savings by grade with one defloccer added to a premium plate in 100% OCC Machine E. The baseline consists of all premium plate designs that had been previously demonstrated to be more energy efficient than the previous standard plates. All comparisons are made at the median speed for each grade, so speed is not a factor.



5. Adding a defloccer to one of the three sets of premium refiner plates operating on this 35-lb grade on Machine E saves 0.33 HPD/ton on the total sheet at the median speed of 2,020 ft/min.

Machine E	Gross HPD/ton	Relative Reel Speed	Relative CD STFI Index	MD/CD TSI	Relative Mullen Index	Total Draw
Baseline	3.68	100%	100%	1.88	100%	2.2%
No. 1 defloccer	3.49	99%	100%	1.86	103%	2.3%
HPD/ton: horsepower per ton per day; CD: cross-machine direction; STFI: short-span compression strength; MD: machine direction; TSI: tensile stiffness index; Mullen: burst strength.						

IV. Key process variable averages for the 35-lb run of Machine E. The HPD/ton difference is different from Fig. 5, because averages are being compared rather than comparing at median speed.

the energy difference compared at the same median speed. The low variation between the average process variables in Table IV gives confidence in the similarity of the process conditions. Considering the sensitivity of refining energy to reel speed for this machine, however, the most accurate representation of the energy savings is the 0.33 HPD/ton obtained by comparing at a common speed. In either case, a benefit exists that illustrates defloccing technology is additive to other refining innovations. In fact, defloccing is not, strictly speaking, about refining. It is about what happens immediately after refining.

Summary of trials on other machines

In addition to the previously mentioned trials on integrated

Machine	100% OCC	Intensity Increase at Constant kW	Deflocced Percent of Total	Baseline Gross HPD/ton	Defloccer Gross HPD/ton	HPD/ton Reduction	Efficiency Increase on Deflocced Stock
A – Trial 1	No	31%	23%	7.67	7.20	0.47	27%
A – Trial 3	No	31%	47%	7.67	6.30	1.37	38%
B	No	14%	38%	5.39	4.70	0.69	34%
C	Yes	46%	68%	4.05	3.92	0.12	5%
D	Yes	48%	40%	3.98	3.98	0.00	0%
E	Yes	-4%	43%	2.67	2.48	0.19	17%

V. Summary of results on OCC deflocking from different machines.

Machine B	Gross HPD/ton	Relative Reel Speed	Relative CD STFI Index	MD/CD TSI	Total Draw	1st Press Load, pli	2nd Press Load, pli
Baseline	5.47	100%	100%	2.26	3.2%	527	590
2 defloccers	4.50	107%	98%	2.15	2.9%	161	594
Furnish	**OCC**	**Softwood Kraft**	**Semichemical Hardwood**	**Softwood Kappa**			
Baseline	36%	42%	22%	105			
2 defloccers	46%	27%	27%	108			

HPD/ton: horsepower per ton per day; CD: cross-machine direction; STFI: short-span compression strength; MD: machine direction; TSI: tensile stiffness index; OCC: old corrugated containers.

VI. Machine B process variable averages for 36-lb grade.

Machine A and recycled Machine E, we ran trials on three other machines, B, C, and D, as shown in **Table V**. Machine B was in a different mill from Machine A. It has a single stage of OCC refining as two parallel refiners. Unlike Machine A, OCC is refined before being combined with broke. The trial replaced both standard OCC refiners with defloccers within a short time of each other. **Table VI** shows the process conditions for a 36-lb grade as an example. In addition to OCC and high-yield softwood kraft pulp, this machine also uses semichemical hardwood pulp. There are some other process differences shown as well. On balance, the 0.97 HPD/ton of apparent energy reduction should be reduced, since the other differences likely favor an overstated energy difference: slightly lower CD STFI index and MD/CD, higher speed, and lower softwood content for the trial. Variables that directionally oppose these include a lower first press load and a higher softwood kappa number in the trial. If we interpolate the data to the median speed, we find the trial is 0.76 HPD/ton lower than the baseline. This is a more realistic number for this particular grade. Averaging all grades gives an energy reduction for the defloccer that we estimate at approximately 0.7 HPD/ton.

Machines C and D used no high yield softwood kraft. Like Machine B, Machine C also has a single stage of OCC refining with refiners in parallel. It made a significant change to the refining plate design and added a defloccer at the same time. The average for the 33-lb grade's representative process variables in **Table VII** show a slight energy penalty. Speed is the most different variable, but a plot of gross HPD/ton against speed shows no significant slope over the span of speeds. Since the other variables are comparable, little correction is likely needed, and we can take these results at face value. The reason for perceiving a small net benefit rather than a small penalty in Table V is the result of averaging all of the grades together in this same fashion.

Machine D installed a defloccer in a second stage of OCC refining. This is the only result that showed no effect when averaging together all of the grades. This trial was done by keeping the identical OCC refiner, except adding a deflocing zone by reducing the height of the outer perimeter of the bars, much like in the Machine A trial. This resulted in a higher intensity. The process conditions for the representative 35-lb grade in Table VII show a slightly lower MD/CD and correspondingly higher STFI index and lower Mullen strength for the trial, so the most significant difference

Machine – Case	Gross HPD/ton	Relative Reel Speed	Relative CD STFI Index	MD/CD TSI	Relative Mullen Index	Total Draw
C – Baseline	3.69	100%	100%	2.24	100%	3.0%
C – 2 defloccers	3.86	111%	101%	2.27	103%	2.8%
D – Baseline	4.89	100%	100%	2.33	100%	3.2%
D – 1 defloccer	4.98	95%	103%	2.18	95%	3.4%

HPD/ton: horsepower per ton per day; CD: cross-machine direction; STFI: short-span compression strength; MD: machine direction; TSI: tensile stiffness index; Mullen: burst strength.

VII. Machines C and D process variable averages for 33-lb and 35-lb grades, respectively.

is the speed. Within the scatter of the data across all grades, there is no basis for saying there is either an energy benefit or penalty. Thus, it is reported in Table V as having no impact on energy reduction.

DISCUSSION

The variation in results in Table V is significant. The deflocing performance is best characterized by the last column, the efficiency increase on the basis of 100% deflocced stock. This is calculated as the change in energy use on the total sheet divided by the percentage of the sheet that is deflocced, then divided by the gross HPD/ton of the baseline. It linearly extrapolates the effect of deflocing the whole sheet. As nearly as we can tell, deflocing benefits scale linearly [14].

It is surprising that for both examples of machines that contain softwood, OCC deflocing promotes more energy savings than deflocing in 100% OCC machines. Perhaps the role of softwood in the broke has something to do with this, but only Machine A co-refines OCC and broke. Machine B does not, and their improvements are similar. The more likely explanation is that a synergy exists between reducing OCC flocs and forming a sheet with softwood kraft fibers. Just as Krainer demonstrated a screening efficiency improvement with another floc-breaking treatment [13], perhaps deflocing enables a formation efficiency improvement by liberating the smaller OCC fibers to form networks with the larger softwood fibers. We have seen before how the effect of deflocing softwood in a top ply refiner has a greater effect than can be attributed to refining efficiency alone, per se, but rather implicates a synergistic downstream effect [5]. This is an area of future investigation.

The difference among the 100% OCC machines is most likely due to the effect of intensity when a defloccer was introduced. As mentioned previously, in Machine E, the intensity was maintained by increasing the plate diameter and modifying the plate pattern slightly to minimize intensity differences so that the only difference was the defloccer. This resulted in 17% energy efficiency improvement, similar to what we often see in softwood deflocing. The exact opposite of this case was Machine D, where the identical plate diameter and pattern were maintained except for the incorporation of a deflocing zone. In this case, because the plate diameter had a smaller diameter than Machine A, the deflocing zone consumed enough outer bar length to decrease the cutting-edge length by 48%, thereby increasing intensity at the same kW loading by a comparable amount. It is widely known that lower intensity generally favors effective tensile development and fiber length conservation in OCC refining [15], so in the case of Machine D it is likely that the increase in intensity exactly offset the benefit from deflocing. Machine C was a similar situation, with a 46% increase in the intensity. Nevertheless, the results were slightly favorable, probably because other changes were incorporated into the plate. These changes had been shown elsewhere to favor OCC refining.

At a sufficiently short fiber length, we expect the benefits of deflocing will be reduced and, at some point, disappear. In short fiber furnishes, such as European OCC, fractionation is used to mitigate the short fiber length. The short fraction typically remains unrefined but the longer fraction is refined. Based on deflocing results with North American OCC, deflocing would likely be beneficial on the long fiber fraction's refiner in European OCC. The role of deflocing on recycled furnishes in general merits consideration, as it appears that some level of deflocing and/or homogenization is beneficial following repulping.

CONCLUSIONS

While deflocing was initially visualized as pertaining primarily to softwood, it applies well to OCC also. Deflocing OCC in a machine with a kraft softwood pulp results in approximately a 30% energy efficiency improvement. The results are more variable with OCC than with softwood, resulting from the compromise between providing a deflocing zone and the need to maintain low intensity when refining OCC. For 100% OCC sheets, the deflocing benefit is offset by a 50% increase in intensity, but at equal intensity, it produces approximately 15% improved refining efficiency.

Defloccing of OCC was applied to a state-of-the-art premium OCC refining plate to make a further improvement in refining efficiency. Although the defloccing zone can be incorporated into a refiner plate, no refining happens in the defloccing zone, so in principle, defloccing can be combined with any refining technology. **TJ**

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LITERATURE CITED

1. Waterhouse, J.F., *Tappi J.* 76(9): 129(1992).
2. van de Ven, T.G.M., *Annu. Trans. - Nord. Rheol. Soc.* 14: 9(2006).
3. Lumiainen, J.J., in *Papermaking Part 1, Stock Preparation and Wet End,* Fapet Oy, Helsinki, 2000, Chap. 4.
4. Kerekes, R.J., *TAPPI J.* 66(1): 88(1983).
5. Anderson, D. and Schuster, L., *TAPPI J.* 21(5): 259(2022). https://doi.org/10.32964/TJ21.5.259.
6. Anderson, D.E., U.S. pat. 10,794,003 B2 (Oct. 6, 2020).
7. Anderson, D.E., U.S. pat. 11,001,968 B2 (May 11, 2021).
8. Anderson, D.E., U.S. pat. 11,421,382 B2 (Aug. 23, 2022).
9. Anderson, D.E., U.S. pat. 11,905,658 B2 (Feb. 20, 2024).
10. Anderson, D.E., U.S. pat. 11,965,290 B2 (Apr. 23, 2024).
11. Debnath, M., "Mechanical modifications of recycled fibers using a high-shear homogenizer for sustainable hygiene and packaging solutions," M.S. thesis, North Carolina State University, Raleigh, NC, USA, 2021.
12. Debnath, M., Salem, K.S., Naithani, V., et al., *Cellulose* 28: 7981(2021). https://doi.org/10.1007/s10570-021-04024-0.

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13. Krainer, C., "Don't let rejects take away your precious fibers," Webinar, IPPTA, Saharanpur, U.P., India, 2021. Available [Online] https://ippta.co/wp-content/uploads/2021/08/Webinar-with-IBS-290521-Final-Proceedings.pdf <26Mar2025>.
14. Anderson, D., Schuster, L., and Haymon, B., "Meet deflocciers: Improving refining efficiency with defloccing refiner plates using various fiber blends," *TAPPICon*, TAPPI PRESS, Peachtree Corners, GA, USA, 2023.
15. Cai, H., Yuan, Z., Tong, G., et al., *BioResources* 15(1): 347(2020). https://doi.org/10.15376/biores.15.1.347-359.

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After implementing defloccing on several softwood refiners, we wanted to see whether a similar benefit could apply to old corrugated containers (OCC) refining as well. Others have pointed out benefits for OCC from mechanical action that is more gentle than refining. This study demonstrates benefits can be achieved without capital by implementing defloccing as part of the refiner plate.

The most difficult aspect of the study was that benefits from OCC defloccing have been variable. The range of experiences provides a basis to formulate a working hypothesis, presented here, to explain these differences.

Through this study, we saw just how efficient machine operators are. Regardless of what kind of plate changes are made, operators quickly adjust to maintain sheet quality. The swing in the refining capability is reflected in the energy use. A surprising finding was that OCC defloccing is more beneficial when softwood is present.

The set of experiences presented here can guide refiner optimization in mills that use OCC and other fibers. Now that defloccing has been implemented widely throughout our company, as a next step, we will focus on improving our scientific understanding to do further optimization.

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