

Effects of debonding agents and refining on the properties of deinked pulp

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ABSTRACT: This study evaluates the interaction between the use of debonding agents and optimum refining levels on secondary fiber. The results showed that, while debonding agents decrease the mechanical strength of handsheets by decreasing fiber bonding, optimizing refining levels could compensate for this loss in strength.

Application: Tissue manufacturers can use the results of this research to offset the negative effects of debonding agents on the mechanical strength of paper.

The increasing use of recycled pulp in papermaking has led to process issues such as increased contamination and stickies, often resulting in reduced paper machine runnability. The finished sheet's mechanical strength and other physical properties also have changed as the trend to replace virgin fiber with recycled pulp continues to grow.

The refining of recycled pulps improves inter-fiber bonding, reducing the need for costly chemical strength agents, and allowing for an increased substitution of recycle fiber for virgin fiber [1]. Repulping under alkaline conditions and refining can enhance secondary fiber strength even further [2], and even reduce the amount of freeness drop experienced through increased refining [3].

Debonding agents, based on quaternary ammonium compounds, typically are used in tissue paper manufacture to improve tissue softness, including "bulk softness" and "surface softness." Debonding agents also decrease fiber-bonding and increase bulk, in turn improving bulk softness. However, the use of debonding agents in tissue paper made from waste paper has been limited because of mechanical strength loss. Techniques to limit the bond-weakening effect of these agents include spraying the softening agents onto the Yankee cylinder or the paper web, or a combination of these two methods, and spraying the sheet in the converting process. All debonding agents reduce fiber bonding and therefore decrease the sheet's mechanical strengths, specifically tensile strength. On the other hand, refining the fibers will develop fibrils and improve inter-fiber bonding [1]. Refining the recycled pulp might compensate for the loss of mechanical strength created by using debonding agents.

Although the effects of refining on the properties of recycled fiber have been well researched, the combined effects of refining and the use of debonding agents on paper properties have not been well documented. This study examines the mutual effects of refining the recycled pulp and use of debonding agents on the physical, optical, and mechanical properties of paper.

MATERIAL AND METHODS

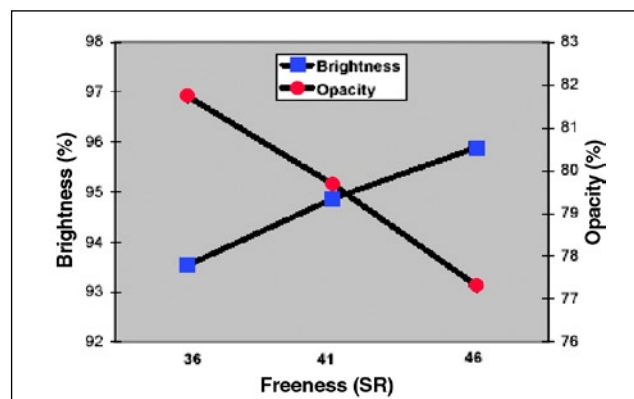
The deinked pulp used in this study was a 70:30 mixture of white edge cutting and mixed office waste provided by the Latif Paper Company, Tehran, Iran. The initial freeness of the control

pulp was 36 SR. Two fractions of this pulp were refined with a PFI mill to 41 SR and 46 SR. A debonding agent (Berocell 589, Akzo Nobel Co.) was added to the refined and control recycled pulps at a 0%, 1%, 2%, and 3% dosage, based on oven-dry fiber. From each pulp, we made three handsheets in accordance with TAPPI T 205 om-88 (Forming handsheets for physical test of pulp) and averaged the test results of the three handsheets. The properties of the handsheets were measured using the following TAPPI Test Methods: T452 om-02, Brightness of pulp, paper, and paperboard (directional reflectance at 457 nm); T425 om-01, Opacity of paper (15/d geometry, illuminant A/2°, 89% reflectance backing and paper backing); T494 om-01, Tensile properties of paper and paperboard (using constant rate of elongation apparatus); and T403 om-02, Bursting strength.

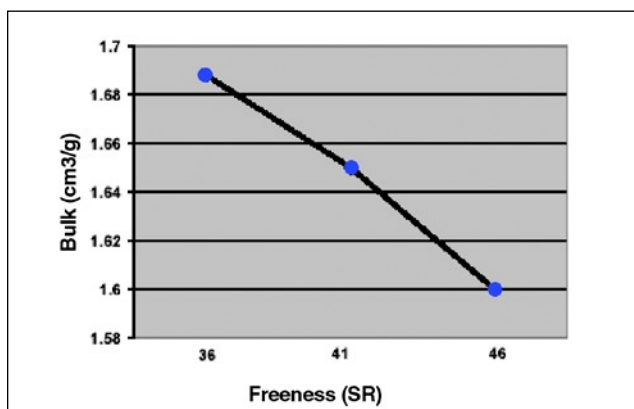
RESULTS AND DISCUSSION

Brightness and opacity

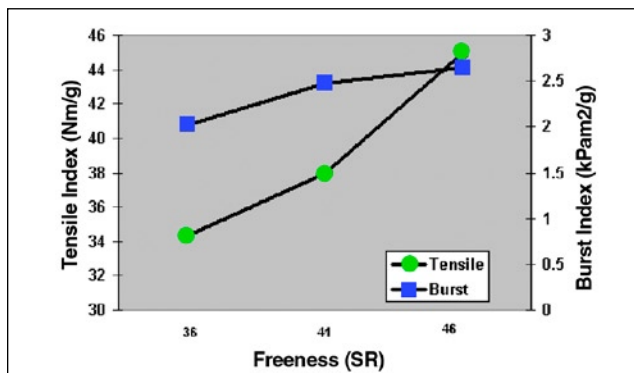
Refining the recycled pulps increased brightness slightly and decreased opacity significantly (**Fig. 1**). The decrease in opacity can be attributed to increased fibrillation creating more fiber-to-fiber (reduced refraction) contact. In virgin and recycled pulps, refining increased fiber-to-fiber contact and decreased opacity. Refining recycled chemical pulp also increased the elimination of fillers or ash from the pulp, thus reducing the sheet's opacity [4]. Sheet brightness might be enhanced through a similar mechanism. Grinding ink particles by refining could make them easier to remove from pulp,



1. The effect of refining on brightness and opacity.



2. The effect of refining on bulk.



3. The effect of refining on tensile and burst strength.

resulting in increased brightness. Enhanced removal of ash by refining also increases brightness.

Bulk

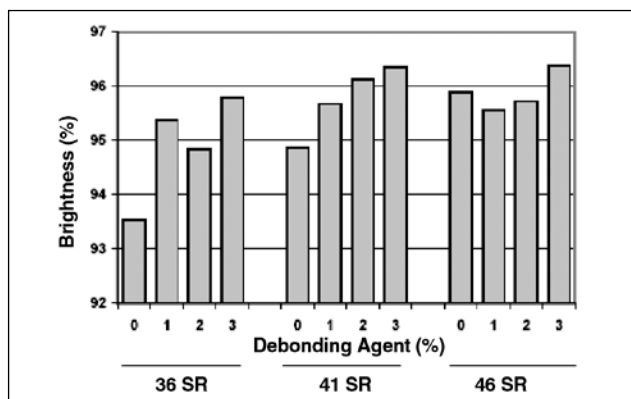
Refining the recycled pulp decreased the bulk of the paper significantly (**Fig. 2**). Generally, fiber refining produces more fiber fines and decreases the average length of the fibers, both of which yield a paper with lower bulk. Increasing the fiber fines and decreasing the length of the fibers is an unavoidable result of refining the pulp [4]. Bulk can be reduced by refining, more with coarser fillings at a lower consistency than with finer fillings. Bulk reduction also increases at higher consistency [1].

Dry tensile and burst strength

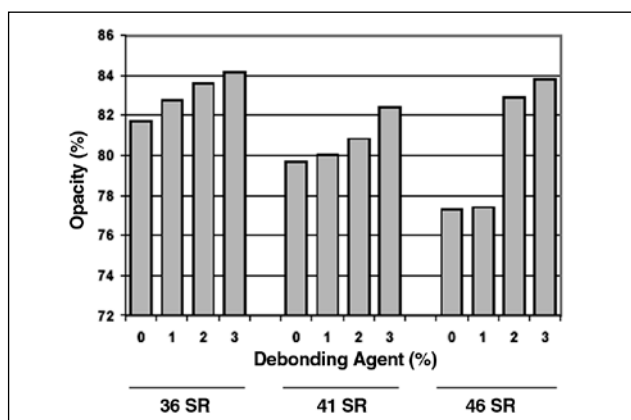
Refining significantly increased dry tensile and burst strength (**Fig. 3**). The increased refining develops fibrillation, more surface area, and thus more fiber-to-fiber contact and fiber bonding [5]. The potentially increased removal of ash also may improve bonding strength.

Figure 4 shows that increasing refining levels and debonding agent dosages increases brightness. Also, the effect of increased debonding agent dosage on increasing brightness is greater at higher than lower freenesses.

Figure 5 shows the effect of refining levels and debonding agent dosage on opacity. Increased refining of recycled pulp decreases opacity; the debonding agent dosage has the opposite effect. Increasing the debonding agent dosage reduces fiber bonding and introduces more spaces in the paper network, thus increasing opacity. The results show that at the lower freeness, adding 2% and 3% of debonding agent in-



4. The effect of refining and debonding agent on brightness.



5. The effect of refining and debonding agent on opacity.

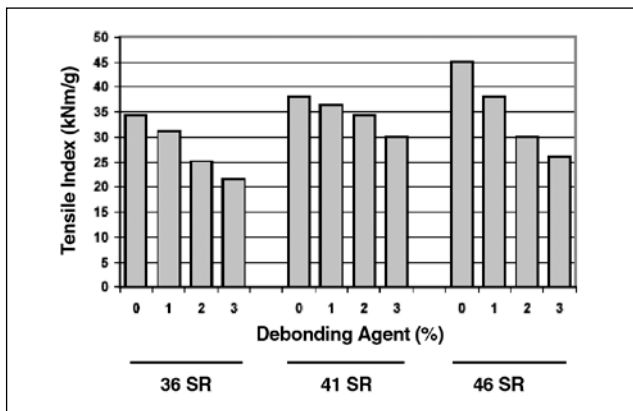
creases the opacity significantly.

Figure 6 shows the effect of refining levels and debonding agent dosage on the dry tensile strength of the handsheets. For all three freenesses, increasing the dosage of the debonding agent resulted in decreased dry tensile strength. For 0% and 1% debonding agent dosages, increased refining levels are effective in improving dry tensile strength. When dosing debonding agents to 2% and 3%, the negative effect of the debonding agent on the tensile strength is more than the positive effect of refining, especially for 46 SR.

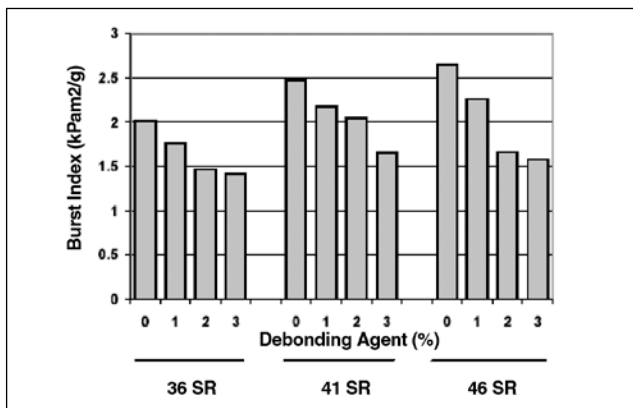
Figure 7 shows the effect of refining levels and debonding agent dosage on the burst strength of hand sheets. For all three freenesses, increasing the debonding agent dosage decreased the burst strength. At a dosage of 0% and 1%, burst strength increased. The increased refining level can compensate for the loss of strength produced by the debonding agent. However, at dosages of 2% and 3% of debonding agent, the negative effect of this chemical on burst strength is more than the positive effect of refining, especially for 46 SR.

Figure 8 shows the effect of refining levels and debonding agent dosages on bulk. For all three freenesses, using debonding agents increased bulk. Increased refining decreased bulk by producing more inter-fiber bonding. When using 0%, 1%, and 2% of debonding agent, the refining of the deinked pulp is more effective on bulk. At 3% debonding agent dosage, refining has little effect on bulk. At 46SR, the debonding agent increases bulk slightly.

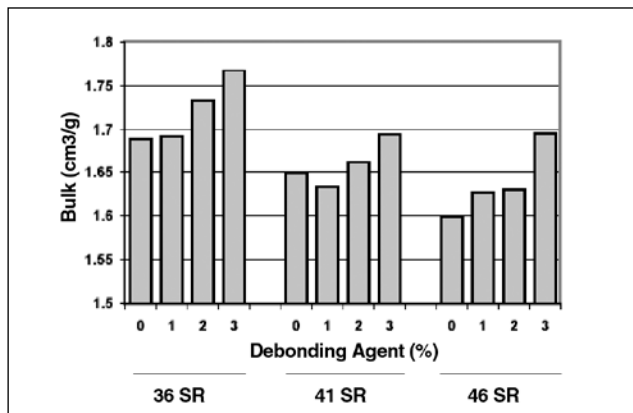
DEINKING



6. The effect of refining and debonding agent on tensile strength.



7. The effect of refining and debonding agent on burst strength.



8. The effect of refining and debonding agent on bulk.

CONCLUSION

This study supports the following conclusions:

- The mechanical strength of deinked pulp can be improved through refining.
- Using debonding agents results in reduced inter-fiber bonding, which then decreases the mechanical strengths of the handsheets.
- Debonding agent dosage and refining levels are inversely related.
- At lower freenesses, the effect of debonding agents on sheet properties is greater than the effect of refining.

• The loss of mechanical strengths of deinked pulp created by addition of debonding agent can be recovered through incremental increases in refining.

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INSIGHTS FROM THE AUTHORS

Debonding agents can be used to improve tissue softness, but these chemicals decrease the mechanical strengths of tissue paper. As R&D manager in a tissue mill, I wanted to know the effect of refining and debonding agents on the properties of paper, especially tissue.

Although the effect of refining on the properties of paper has been studied, the combined effects of refining and debonding agents have not been well documented.

Refining of deinked pulp generally was not recommended for tissue production, because it reduces the bulk of tissue. Our research shows, however, that it is possible to refine deinked pulp without the reduction of bulk if debonding agent are used.

Paper mills (especially tissue mills) can use the results of this research to improve paper properties.

Through future research, we will study the effect of debonding agents on fiber fines and long-fiber fractions of pulp. We also will compare the combined effects of debonding agents and refining on virgin pulp and with deinked pulp.



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