RECYCLING & RECOVERY

IMPROVED DEINKING FLOTATION FOR PAPER RECYCLING

Paper and paperboard made up the largest share of U.S. landfills, accounting for nearly a quarter (23.1%) of municipal solid waste in 2018. In the same year, about 67% of the materials were recycled. It was necessary, however, to remove ink from the printed papers and paperboard for recycling.

Recyclers achieved this via deinking flotation, in which wastepaper was combined with water and appropriate reagents to remove ink particles from printed materials. Flotation is widely used to remove ink particles in the range of 10 to 100 µm in size. However, this process must be repeated several times to produce paper fibers that are bright enough for manufacturing recycled papers. Also, it is difficult to remove ink particles smaller than 10 µm, limiting the brightness levels that can be achieved by flotation. The ink particles larger than 100 µm are removed by screening.

Aside from the particle size effect, there are other challenges in deinking flotation. First, ink particles (or pigments) are difficult to be lifted (or liberated) off paper fibers. Second, ink particles are often insufficiently hydrophobic, making it difficult to be collected by air bubbles and separated from fibers. This is particularly the problem for water-based inks. Third, the deinking flotation machines used today may not provide sufficient hydrodynamic forces to remove ultrafine ink particles. Water-based ink particles are often less than 1 µm, adding to the difficulty of removing less hydrophobic particles.

Researchers at Virginia Tech addressed the problems noted above and developed novel methods of removing both oil- and water-based ink particles plus the adhesives (or stickies) from recycled fibers. This was achieved with Thiele Kaolin Company, a leaching technology provider for the U.S. paper recycling industry.

PROJECT DESCRIPTION

This two-year project began by developing and validating a new method of quantifying the degree of liberation of ink particles from spent paper fibers (TAPPI Journal, 21, 10, 533-539, 2022). This method is based on measuring the -potentials of a printed paper dispersed in an aqueous phase in the presence of a dispersant (e.g., sodium silicate) and plotting a distribution diagram. Based on this simple method, one not only determine the degree of liberation but also better understand the fundamental mechanisms involved in the mechanisms. The new method also allows one to determine the optimal conditions of liberation for both oil- and water-based inks.

We have also developed the method of dramatically increasing the hydrophobicity of ink particles. For example, we were able to increase the contact angle of water-based ink particles from zero to >140°.

These reagents were also found to increase the size of water-based ink particles, most probably due to hydrophobic coagulation, which greatly improved the efficiency of removing ink particles by flotation. After identifying a suitable reagent suite (composed of dispersant and novel hydrophobizing agents), deinking flotation tests were conducted in a laboratory flotation unit with printed office papers. The test results showed a three-fold increase in brightness over the case of using the industrial standard reagent without compromising fiber yield. These results were later confirmed in pilot-scale tests using both the papers printed in our laboratory and industrial feedstocks.

A high-kinetics flotation machine has also been developed to improve the flotation kinetics. For the recovery of particles smaller

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than 10 µm required high kinetic energy. The new flotation machine developed in the present work greatly increased the brightness of the fibers recovered by flotation over the case of using a mechanically-agitated conventional flotation machine. The improvement was achieved at a substantially lower energy input, which in turn helped maintain the integrity of recovered fibers.

PROJECT IMPACT

The project yielded a suite of new technologies that can lead to improve paper recycling, particularly for the papers printed with water-based inks. The laboratory test results showed nearly a 300% increase in brightness of paper fibers printed with water-based ink without compromising yields.

Application of the new technologies developed in the present work can potentially increase the separation efficiencies between the spent wood fibers and oil- and water-based inks by at least 15 to 20% as compared to those obtained in paper mills. If widely implemented, the fiver recycling industry can save 42 petajoules of embodied energies and reduce 0.9 million metric tons of CO_2, which represent 13 and 9% below the current levels, respectively.

NEXT STEPS

In the near term, Thiele Kaolin Company will implement some of the new reagent technologies developed in the project. The company is currently marketing waste kaolinite particles as additives to deinking flotation. The use of the new reagents can greatly improve the performance of kaolin additives. Virginia Tech and Thiele plan to test the new reagent technologies to commercialization by conducting in-plant tests in an operating plant. Emphasis of the in-plant test work will be on the removal of water-based ink and sticked, which can potentially greatly increase the tonnages of papers recycled in the U.S.

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PUBLICATIONS

Yoon, R.; Noble, A.; Huang, K.; Strickland, K.; Onel, O.; Basilio, C. *New Approaches to Improve Deinking Flotation to Increase the Availability of High-Quality, Low-Cost Recycled Paper Fibers: Final Report for REMADE Project: 18-02-RR-15*. August 2022.

Huang, K., Strickland, K., Noble, A., Yoon, R-H., and Basilio, C., A New Method of Studying the Fundamental Mechanisms Involved in Pigment Liberation from Recycle Papers, Tappi Journal, Vol. 21, No. 10, pp. 533-540

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