A Decade of Deciphering the "SUMMER EFFECT"

A decade ago newsprint deinking personnel were striving to prove and understand the cause behind the loss of more than a point of brightness during the summer months. Since then, evidence has been collected that has allowed papermakers to better deal with the phenomenon known as "summer effect."

By Danny Haynes

In 1994, the Effective Residual Ink Concentration (ERIC) measurement developed by Jordan and Popson allowed many Canadian mills to document that the significant losses in deinked pulp brightness during the summer months were due to increased ink content in the final product. This phenomenon came to be known as the "summer effect," afflicting mills throughout North America and, as was learned later, globally.

The Eka Free Ink® program was initiated in 1998 as a response to questions about the problem and the industry-wide need to better understand the increase in ERIC values. The effort would span three years in North America, two years in Europe and in one year in the Asia-Pacific region. The program provided valuable information to the industry about the impact of thermal aging, pulping time, ink attachment, regional issues and options for controlling the summer effect. The benchmarking effort also helped mills justify the addition of equipment and rebuilding of deinking operations. The experience and vast data collected provided insight into ink fragmentation, ink detachment and ink redeposition—information that proved invaluable in developing sulphite-based neutral deinking.

With a decade of effort completed, it is timely to review the results from this effort as the paper industry deals with changes in furnish, worldwide competition for fiber, single stream collection and demand for increased brightness and yield.

UNDERSTANDING THE SUMMER EFFECT

The underlying problem of the summer effect was the increase in ink re-deposition into the fiber or re-attachment to the fiber. Southern mills experience the summer effect more than Canadian mills with increases in ink fragmentation aligned with the ambient temperatures experienced in the various regions. The increased ink fragmentation is due to the thermal drying of newsprint inks. This drying leads to increased ink fragmentation (higher ERIC's) and ink re-attachment (ink that cannot be separated from the fiber by chemical or flotation mechanics). Ink fragmentation increases as the ambient temperature goes above 18° C in North America. Fragmentation will continue to increase by 3.5 points of ERIC per degree increase in Celsius. In fact, this increase in ink fragmentation will lower average brightness by 1.4 points for most mills during July.

HYPERWASHING AND INK DETACHMENT

A critical component of understanding the summer effect was to use a hyperwashing procedure to determine how much ink was still attached or re-deposited to the fiber. While the method does not differentiate ink particles that have never been detached versus ink particles that have re-deposited, it is valuable in measuring how much remains with the fiber. The method does provide a good estimation of the effect on optical properties of small ink particles remaining in or on the fibers.

This procedure compares paper pads produced from the pulp before and after hyperwashing. The washing is done in a dynamic drainage jar starting with pulp at about 1% consistency using tap water and stirring the pulp suspension at 1500 rpm until the turbidity of the outlet is less than 10 NTU, which normally takes 10-15 liters of water for a 10 g pulp sample. A filter screen of 76 microns was used. The method washes out the small ink particles that are free of the fiber, fines and fillers. The ERIC measurement difference between the unwashed and washed pulp is assumed to be the amount of free ink and available for separation by flotation or thickening/washing operations.

In North America and Asia-Pacific, the final deinked pulp (DIP) samples were collected, while for Europe, two pulp sample points were collected. This is because a disperger is commonly used after the first flotation loop in Europe, which impacts the amount of attached ink. The two samples for

Europe were the loop-one flotation accept and the final pulp. The two samples provided an opportunity to see how much ink was re-deposited into the fiber (disperging would not rub off) and how much was on the outside of the fiber (disperging should rub off the ink attached/re-deposited). Yuxia Ben used a scanning electron microscope to show that a large amount of the ink went inside the fiber lumen. The amount of ink still attached or re-deposited inside or outside of the fiber ranges from 65% to 81% based on the change in hyperwash from the start (pulper) to the end of the process **(Table 1)**.

Study	Year	Percentage of ink still attached
Europe	1999	78%
North America	2000 - 2001	79%
Mill Surveys	2001 - 2007	81%

Table 1.

INK TYPE AND THE SUMMER EFFECT

In the deinking world, the ink used on newsprint has two main classifications, flexo ink (water solvent based ink) and non-flexo inks (mineral oil or vegetable oil based inks). Because the summer effect issue occurs due to the drying process of newsprint inks it is important to understand the differences in how mineral oil and vegetable oil inks dry. The rapid aging of newsprint inks in recovered paper is due to elevated storage temperatures. The aging promotes fragmentation of the ink vehicles during pulping, which increases ERIC values. The smaller ink fragments are harder to remove by flotation, and if fragmented into specks below 1 micron in diameter they tend to lodge inside of the fiber, which irreversibly lowers the brightness of that fiber.

Mineral oil inks are used for the majority of black print and vegetable oil inks are used for color print. For mineral oil inks, the drying process is absorption of the oil into the paper with oxidation occurring in 4 to 6 months. Aging will tend to leave a brittle ink structure that will fragment into smaller ink particles when pulped that results in an ink to fiber interface similar to flexo inks. This auto-oxidation reaction is induced and accelerated by heat, making paper that is 1 to 2 months old behave like newsprint that is 6 to 12 months old.

Vegetable oil based inks undergo significant changes due to oxidation reactions at the double-bond sites that produce cross-linking and chemical bonding to the fiber. This more rigid cross-linked ink particle will have a more plate like appearance similar to a rigid polymer or toner ink speck. This rigid ink particle that is also chemically bound to the fiber will fragment into smaller ink specks when pulped. The larger color ink specks will remain bound to the fiber and produce what appears to be a blue dyed fiber. The rate-controlling step is the oxygen intake and the increased temperature. An increase of 20 C degrees can accelerate the aging or drying effect by a factor of four.

The best example of how regional inks can differ is demonstrated by the Free Ink program carried out in Europe in 1999, which saw a very strong seasonal effect during seven weeks in July and August **(Figure 2)**. Going above an average monthly temperature of 16° C produced a doubling of the final ERIC values and a threefold increase in attached ink. The driver for the magnitude of this change was the difference in inks used in Europe compared to those used in North America. The tendency to use double loops with flotation before and after a disperger means that the European mills tended to have lower amounts of ink attached after hyperwashing and to have lower ERICS for the final DIP. However, with the thermal aging of the ink, the performance fell far below that of North American operations. A mild summer in the year 2000 and an increased export volume of low grade ONP (Old Newspapers) to Asia likely contributed to a better quality of the recovered ONP in Europe. A shorter storage and transportation time, as well as a lower temperature, are known to improve the deinkability of ONP.

CHEMICAL SOLUTIONS

The average mill has been able to control the summer effect by modifying the pulping process, reducing production, increasing chemical usage, or managing incoming furnish. A higher dosage of sodium hydroxide will improve ink detachment and lower the amount of ink fragmentation. The reduction in ink fragmentation will also reduce the amount of ink re-depositing into the fiber. For the North American study, starting in 2000, increasing the dosage from below 0.6% to above 1.0% reduced the final ERIC by 25% during the summer months

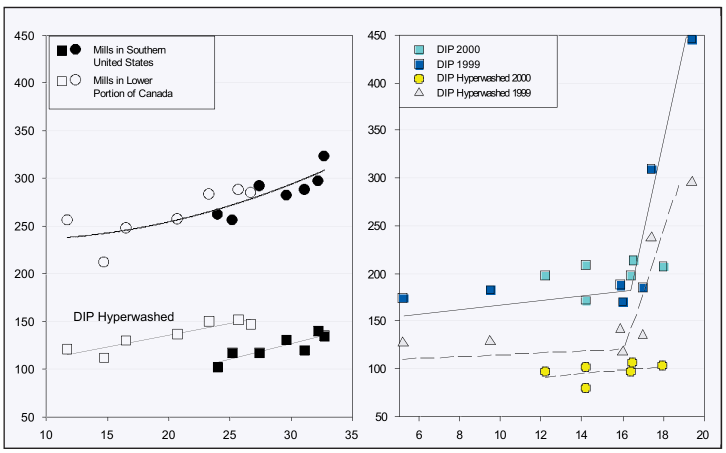

Figure 2

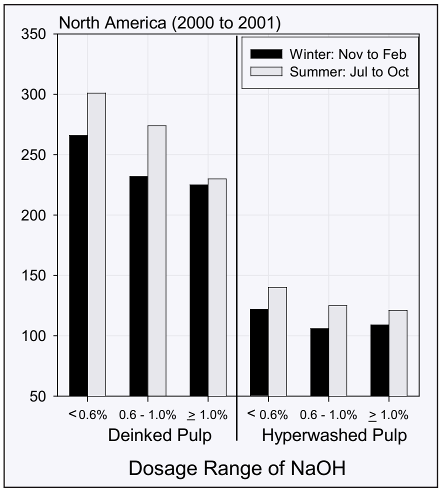

Figure 3

and the amount of ink re-deposited by about 20% **(Figure 3)**.

For most deinking operations, the dump chest after pulping is the first location to obtain a pH value, which will depend on the amount of caustic added, the pulper dilution water and the furnish. Data collected from the studies in North America showed the dump chest pH was related, along with pulping time, to the amount of ink, fragmented ink and attached ink that remained at the end of deinking process **(Figure 4)**. The final ERIC was more dependent on pulping time, while the amount of ink still attached after hyperwashing was dependent on the pulper pH, documenting the importance of caustic to conventional deinking.

Non-ionic surfactants will also provide better ink detachment than a soap-only based chemistry. A comparison of surfactant-only, soap-only and combination systems (the top five mills in North America all belong to the latter category) shows using a single type of deinking agent gives about average deinking performance. The combination deinking agent approach of the top five mills was 50 to 60 ppm lower in ink content. The role of a non-ionic surfactant in detaching ink is seen in the comparison for the hyperwashed pulp. The mill using just surfactant was able to be reach within about 10 ppm of the top five mills, while the soap-only mills were at the industry average.

MECHANICAL SOLUTIONS

The key to a successful deinking operation is the pulper. The degree of defibering, ink detachment without redeposition and contaminant liberation, are the key metrics in the pulper. When designing, expanding or upgrading a recycling facility, the deinking industry has two pulper choices; batch or continuous drum.

At the beginning of this investigation, it was assumed that the loss in brightness was due to an increase in the amount of fragmented free ink that could not be removed during the deinking processes of flotation and thickening (washing). This meant the measurement of free ink in the deinked fiber would increase as the summer proceeded. However, the underlying problem of the summer effect was the increase in ink redeposition into the fiber or attachment to the fiber (all metrics associated with the pulper as outlined above). Most the new deink mills and upgrades have selected the gentle action of drum pulping to keep plastics, stickies and other contaminants intact.

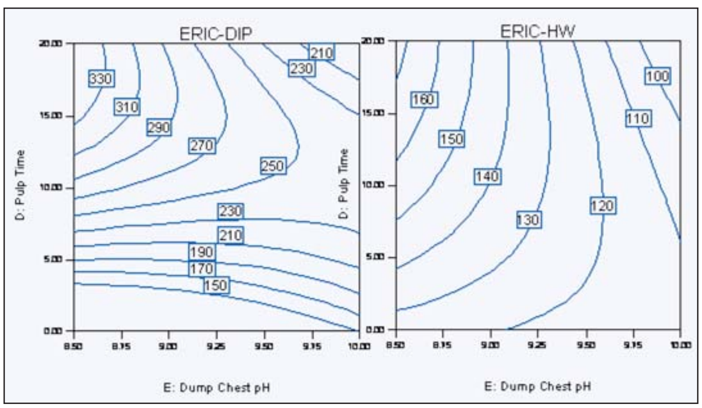

Figure 4

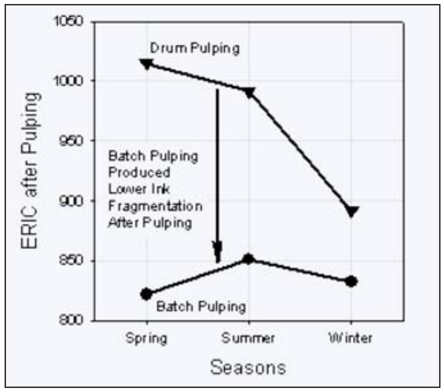

Figure 5

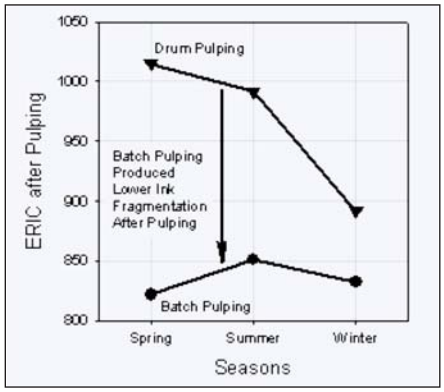

Figure 6

While these are important parameters to consider, from a summer effect perspective, the Free Ink program found that ink fragmentation and redeposition was higher with continuous drums than with batch pulpers using low pulping times **(Figures 5-6)**.

In Europe, the standard design for a newsprint deinking operation is two loops of flotation separated by a disperger. In North America, a significant number of deinking operations have decided to use a single flotation loop design. In the 1998 and 2000 study, the single loop systems were able to maintain comparable performance with double loop designs during the spring and fall.

In the summer months, the single loops had 30 to 50 ppm higher ERIC values for the final DIP samples. If a mill is seeking a mechanical solution to the summer effect, one option is to add a second loop of flotation and to possibly consider a disperger. But both options carry higher energy and capital costs along with more fiber loss.

PROCESS SOLUTIONS

After the initial study, some of the improved deinking performance of North American mills was due to better awareness of the nature of the summer effect and work carried out to improve the deinking performance by optimizing the process, and considering chemical and physical parameters.

Besides developing a summer pulper chemistry, mills with batch pulpers worked to reduce pulping time. This ability to reduce pulping time was one the best process changes that could be made. During the winter, the pulping time had less impact on ink fragmentation or redeposition. However, during the rest of the year, going above 6 minutes pulping would increase ink fragmentation after pulping by 200 ppm **(Figure 7)**. For the hyperwash ERIC values, the impact of pulping time is even more dramatic with slushing times (duration of pulping after all of the paper, water and chemicals have been added) of more than seconds leading to higher ink redeposition **(Figure 8)**.

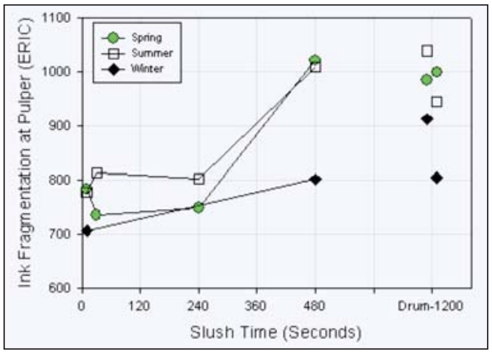

Figure 7

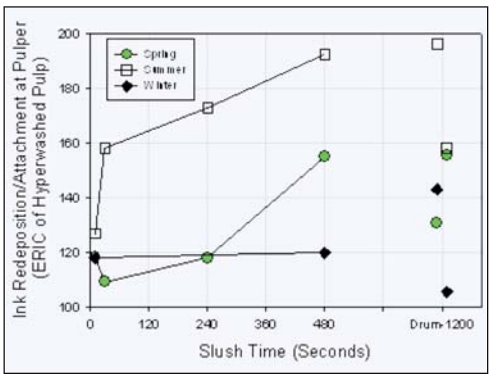

Figure 8

Another process variable that can impact ERIC is the ratio of ONP to OMG (old magazines). The example below is for southern deinking operation using either 70 to 80% ONP or 90% ONP. During this study, many of the mills with poorer deinking performance were using a higher percentage of OMG to compensate. Both process choices gave similar ink content results except for the summer period. During that time, the mills using a higher ONP content saw a spike up in ERIC. The hyperwash values show that the addition of more ONP increased the ERIC values by about 30 ppm during the spring to summer months **(see Figure 9)**.

BENCHMARKING AN INDUSTRY

The final portion of items achieved and learned from the Free Ink programs was the ability to benchmark the industry around the world. This worldwide effort allowed all participants to mark themselves against the rest of the industry. For several of the deinking operation in the bottom 25 percent, the results could provide justification for rebuilding the deink plant or adding additional equipment. At least five different operations in North America rebuilt or added significant equipment to their process after the study.

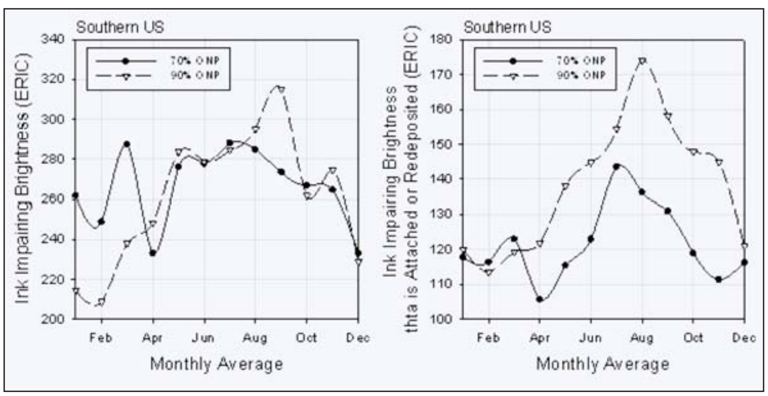

Figure 9

When comparing the world newsprint deinking industry, Europe is the gold standard, followed by North America. Part of the reason for Europe's success is the use of double flotation as mentioned earlier in the article. But the nature of the furnish (lower ink fragmentation and attachment during normal summer temperatures) in that region also contributes to the results.

However, an increase in ambient temperatures in summer can make the best deinking mills in the world struggle with a sharp increase in the amount of attached ink. Asia-Pacific, who pulls newsprint from Europe and North America, must deal constantly with thermally-aged paper transported great distances and times. This no doubt contributes to the region's lower performance. It is noteworthy to mention that at the time of the study the expansion of new deinking operations in Asia/Pacific was just starting. It would be interesting to see how the region performed with the addition of so many modern deinking operations.

CONCLUSION

The Eka Free Ink Program allowed the industry to benchmark its deinking performance and to understand the nature of the summer effect. The combination of the ERIC measurement and hyperwashing allowed the industry to see how thermal aging during the summer months increased ink attachment and lowered the final brightness. Mills have developed shorter pulping times when possible, summer pulper recipes, learned to manage paper inventory, furnish ratio, and added equipment or rebuilt as needed. ■

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