New enhancers to improve polyethylene oxide retention performance on deinked news-print

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ABSTRACT

Using a reasonable dosage level, cationic coagulants in commercial dual polymer systems provide few benefits to the effectiveness of polymeric flocculants, whatever their charge characteristics. Several enhancers remarkably outperform the traditional phenolic resin for improving polyethylene oxide performance in the dynamic drainage jar test. There is a strong relationship between first-pass retention and first-pass ash retention for all retention systems except chitosan. Combining polyethylene oxide with any new enhancer gives a cost-effective retention system for newsprint stock containing deinked pulp.

Application:

A new polyethylene oxide retention system is excellent for filler retention and stickies control.

IN DECEMBER 1979, THE AUTHOR PERformed the first paper machine trial with polyethylene oxide on neutral sulfite semichemical (NSSC) stock for a corrugating medium machine in eastern Canada *(1)*. Soon another mill used polyethylene oxide application for opacity improvement in telephone directory grade paper *(2)*. This second application was so successful that the program lasted approximately ten years.

Early applications used polyethylene oxide without any enhancing agent. As a result, performance varied widely *(3)* with no known explanation. To improve the performance of polyethylene oxide, Pelton recommended using sulfonated kraft lignin *(4)*. This approach never found wide acceptance because of the dark color of the lignin products. Work to understand better the polyethylene oxide retention mechanism showed that a useful enhancing agent did not have to be water soluble *(5)*. A network formation was the suggestion for the possible mechanism. This work led to development of an alkali-soluble phenol/formaldehyde resin product *(6)* that has dominated the polyethylene oxide retention system for more than a decade.

Despite the strong performance of phenolic resin and polyethylene oxide retention systems in newsprint, groundwood specialty, unbleached kraft liner board, and other wood-containing paper manufacture, negative observations remain. Some consider the existing polyethylene oxide retention system inefficient for retaining fillers and for stock containing deinked pulp.

For the last two and one-half years, there was a very extensive study at West Tacoma mill using polyethylene oxide on deinked pulp. In June 1993, this mill started a deinking plant that provided over 40% deinked pulp in the furnish to two paper machines. There was careful monitoring of the traditional phenolic resin and polyethylene oxide retention system before and after the deinking plant startup.

Because the paper machine efficiency suffered noticeably due to contamination from deinking chemical carryover, increased filler at the headbox, and stickies deposition, there was an effort to find a more efficient retention system. Evaluation using a dynamic jar included such commercial retention aids as chitosan, polyaluminum chloride, and dual polymers. Testing also included several new enhancers using different chemistry in combination with polyethylene oxide. This paper presents those findings.

EXPERIMENTAL

Pulp furnish

Before the advent of the deinking plant operation, thermomechanical pulp (TMP) was the major component with some fully bleached kraft. With the deinking plant, the total furnish now routinely comprises over 40% deinked pulp for both paper machines. The recovered paper contains 70% old newsprint (ONP) and 30% old magazine grade (OMG). Sometimes other fiber sources are present.

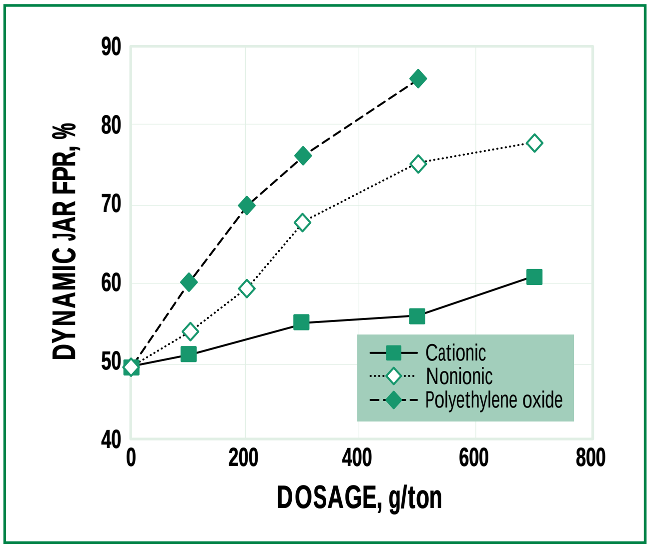
Dynamic jar retention evaluation

Testing used a Britt jar equipped with a 100-mesh stainless steel screen. The chemical addition sequence remained constant throughout the study. The first addition was enhancing agent at 0.4% concentration with mixing for 20 s followed by polyethylene oxide solution at 0.05% active solids. After additional mixing for 3 s, the stock underwent transfer to the dynamic jar.

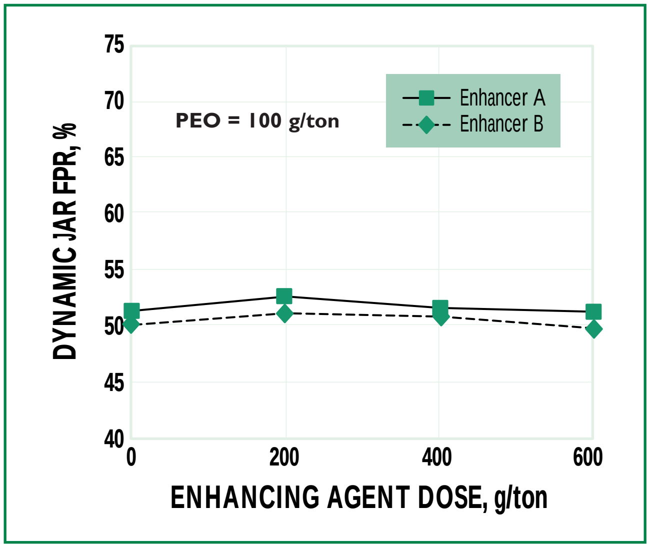
The dynamic jar test for the headbox stock used 800 rpm and 50°C. Expressions for all chemical dosages use dried solids on a pulp basis. For some experiments, there were determinations for both first-pass fines and filler retentions (FPR). Using a Mütek PCD O2 analyzer allowed monitoring of the effect of cationic polymers on cationic demand in dual polymer series.

Stickies determination

A 500-mL sample of stock at 0.7–1.0% consistency was placed in a 1-L



1. Dynamic jar test on headbox stock without deinked pulp using a single polymeric flocculant (May 1993)



2. Effect of enhancers on polyethylene oxide performances before deinked pulp startup with polyethylene oxide dosage at 100 g/ton

Retention system	Dynamic jar retention, as received, %	Dynamic jar retention, washed, %
Control	40.3	42.3
Polyethylene oxide alone, 200 g/ton	49.0	55.2
Enhancer A, polyethylene oxide, 400–200 g/ton	58.6	78.0
Enhancer B, polyethylene oxide, 400–200 g/ton	56.5	85.0

I. Effect of stock washing on dynamic jar retention results using headbox stock with deinked pulp

beaker with addition of a desired amount of chemical. Mixing time varied depending on the type of chemical under evaluation: 5 s for polymeric flocculants, 1 min for polyethylene oxide enhancers, and 5 min for the remaining additives.

Two 200-mL aliquots of the treated stock underwent filtration through a Buchner funnel on a filter paper of 6-in. diameter under vacuum. The filter pad with the attached stock was removed from the funnel. Another filter paper was placed on the exposed—top—side of the fiber pad to create a stock sandwich. The sandwich was then couched seven times between blotters using a TAPPI handsheet roller. The blotters were removed, and the stock sandwich was dried on a hot plate at 105°C until dry—approximately 4 min. After cooling to room temperature, the filter paper on the bottom side was peeled from the fiber pad. If stickies were present in the stock, it was not possible to remove the filter paper without sticking or tearing.

RESULTS AND DISCUSSION

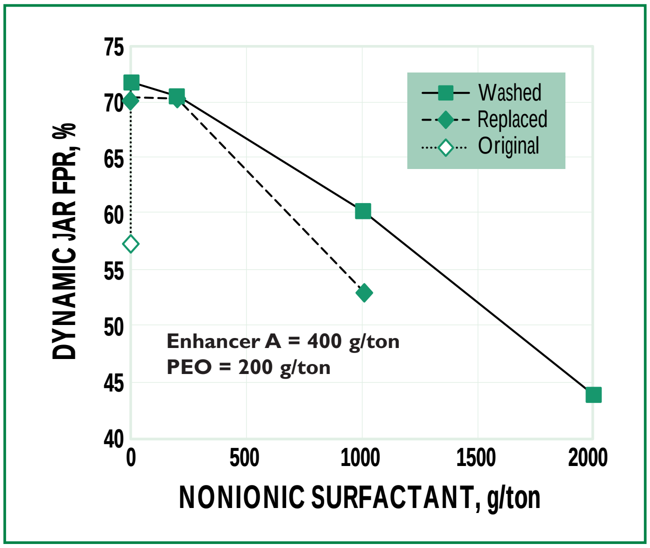
Phenolic resin and polyethylene oxide retention performance before deinking operation

Use of the phenolic resin (Enhancer A) and polyethylene oxide retention system started well before the operation of the deinking plant. The phenolic resin was added at the discharge side of the fan pump. The addition point for the polyethylene oxide solution was after the primary screen. The enhancer to polyethylene oxide ratio was 4:1. **Figures 1 and 2** show the various results for the dynamic jar retention tests on the headbox containing no deinked pulp.

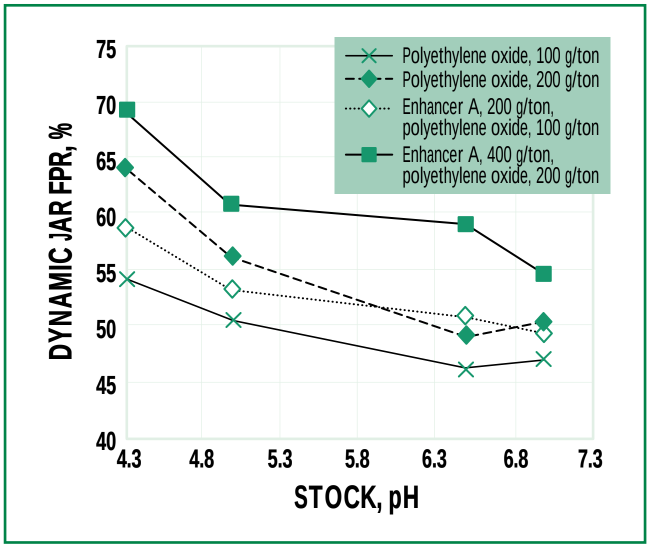
The headbox stock responded very positively to polyethylene oxide. Figure 1 shows that it outperformed two typical polyacrylamide products. Figure 2 shows that addition of Enhancer A and a new Enhancer B provided little benefit on the polyethylene oxide performance. Speculation is that Enhancer A could saturate the stock system or that polyethylene oxide by itself was so efficient that no enhancing agent was necessary. Because of this finding, polyethylene oxide dosage rate increased from 50 g/ton to 100–120 g/ton range, and the ratio of Enhancer A to polyethylene oxide decreased to 1:1.

Effect of deinking chemical carryover on polyethylene oxide retention

Chemicals such as deinking surfactants, sodium silicate, alkali, and other contaminants used in the deinking process can reach the headbox if deinking pulp washing is insufficient. This was the case initially. There were efforts to improve this situation with limited success. The performance of the existing Enhancer A and polyethylene oxide



3. Effect of deinking surfactant on dynamic jar retention for headbox stock containing deinked pulp with Enhancer A at 400 g/ton and polyethylene oxide at 200 g/ton



4. Effect of stock pH on dynamic jar retention for headbox stock containing deinked pulp (September 1993)

Test no.	Sodium silicate, g/ton	Enhancer A, g/ton	Polyethylene oxide, g/ton	FPR, %
Replaced headbox stock				
1	0	0	0	37.5
2	0	400	200	70.2
3	2000	400	200	73.1
Replaced and washed headbox stock				
4	0	0	0	37.4
5	0	400	200	71.2
6	2000	400	200	72.7

II. Effect of sodium silicate on polyethylene oxide retention system for headbox stock containing deinked pulp

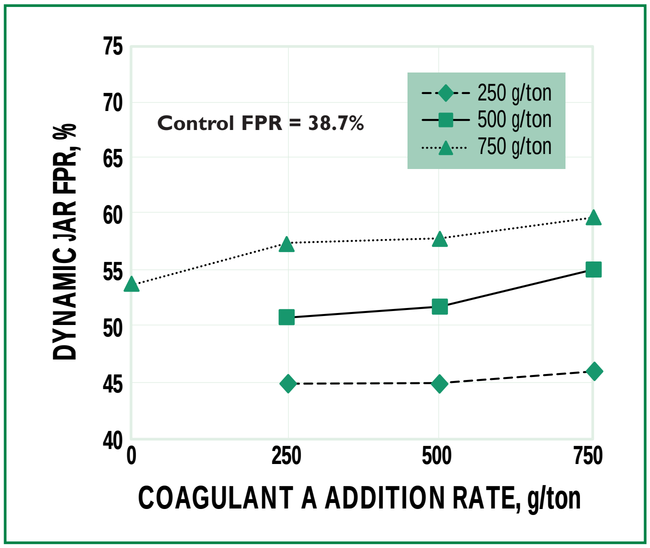
system was adversely affected, thereby causing filler accumulation at the headbox and serious stickies deposition. To confirm the negative impact of deinking chemicals carry-over on the polyethylene oxide retention performance, the headbox stock was filtered and then dispersed with deionized water to the same volume. The redispersed stock was then subjected to the dynamic jar retention test.

The results in **Table I** clearly demonstrate a significant retention improvement upon the removal of water-soluble contaminants present in the stock. Enhancer B was superior to Enhancer A in improving polyethylene oxide performance. **Table II** shows that sodium silicate used for stabilization of hydrogen peroxide in the deinking plant showed no detrimental effect on the polyethylene oxide retention system.

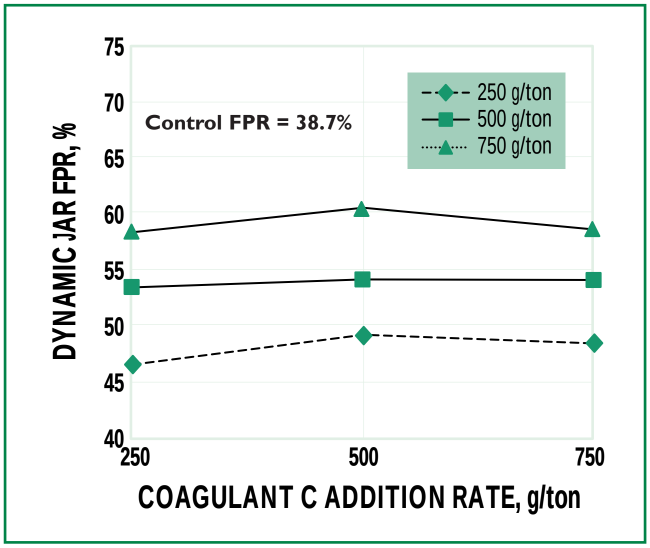
At the time of testing, a nonionic deinking surfactant was used. Attempts to quantify the residual surfactant at the headbox were unsuccessful. A replacement stock was prepared by filtering the stock, followed by redispersing the pulp to the same consistency with deionized water. Another washed-stock replacement was also prepared by inserting an extra washing step to assure a clean stock for a spiking experiment. The deinking surfactant was added to the stock at 0–5000 ppm on dry pulp weight basis or 0–52 ppm on volume. **Figure 3** shows the dynamic jar test results from this experiment. The nonionic deinking surfactant showed a negative impact on the Enhancer A and polyethylene oxide retention performance.

The negative impact was greater for the replaced stock than for the replaced and washed stock, as one might expect. The critical concentration of the surfactant was approximately 2 ppm on volume or 200 ppm on a pulp basis.

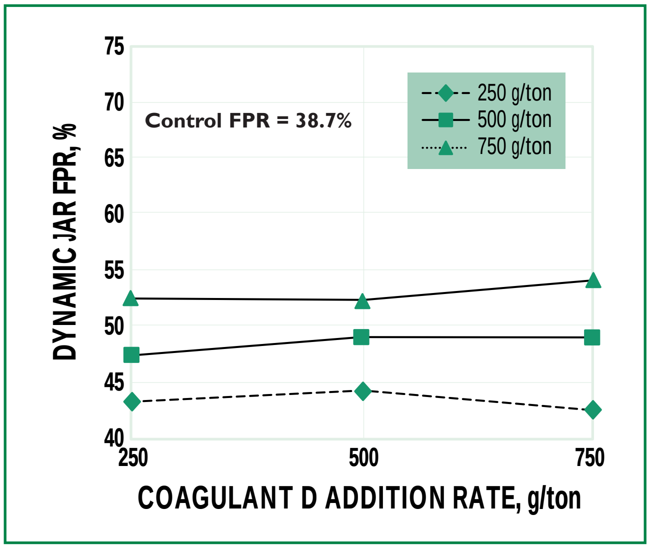
Because there was no acid loop in the deinking process, certain alkali materials reached the headbox and caused the stock pH to increase. **Figure 4** shows that the increased pH harmed the polyethylene oxide retention system. Within the range studied, a lower stock pH has the most effective polyethylene oxide retention performance. A separate test two years later confirmed this. There is no clear explanation. It may suggest that carboxyl groups could participate in the interaction of molecular association. Since the in-



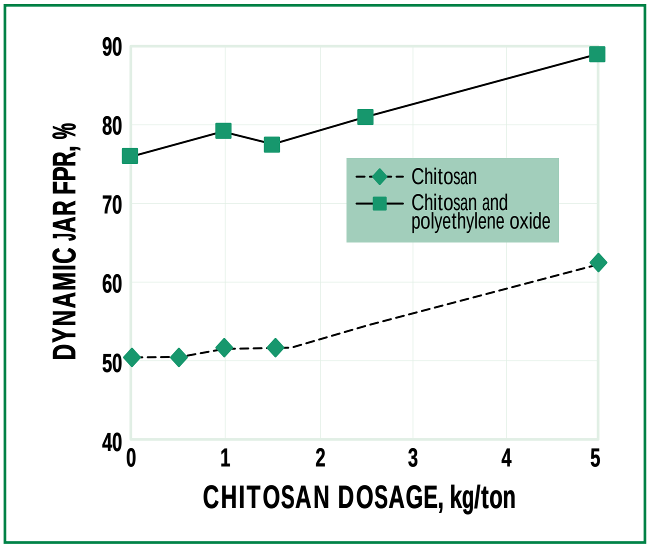
5. Dynamic jar retention for dual polymer system A (cationic/cationic) (April 1994)



6. Dynamic jar retention for dual polymer system C (cationic/nonionic) (April 1994)



7. Dynamic jar retention for dual polymer system D (cationic/anionic) (April 1994)



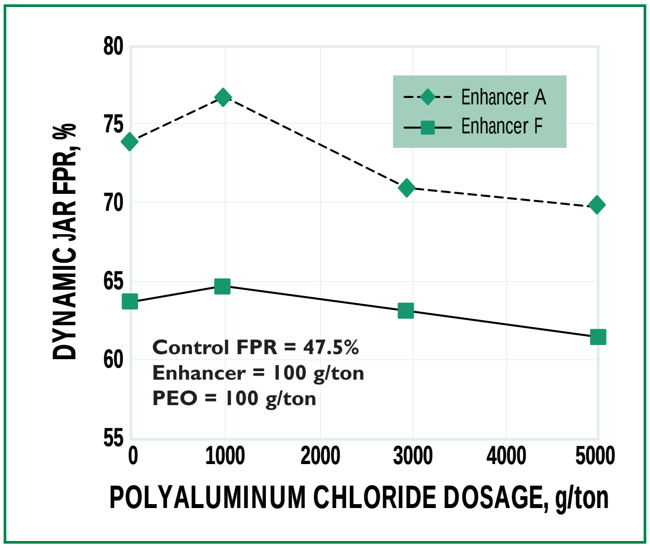
8. Effect of chitosan and polyethylene oxide at 300 g/ton as retention system (May 1993)

creased stock pH also reduced the paper brightness, a pH control range of 5.3–5.5 was adopted using sulfuric acid.

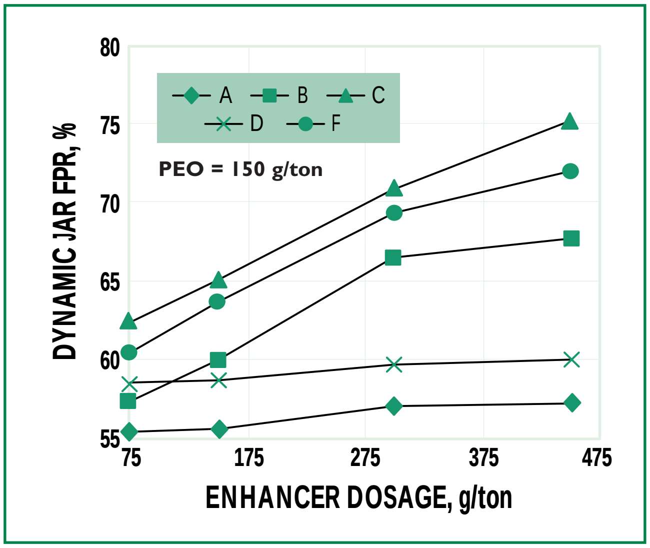
Dual polymer systems

Four typical cationic coagulant and flocculant combinations recommended by three suppliers were examined. The polymeric flocculants included cationic, nonionic, and anionic products. At a combined dosage rate of 1.5 kg/ton, the Mütek PCD value only decreased by approximately 30% for cationic demand. **Figures 5–7** depict the dynamic jar retention results for the three typical systems. The cationic coagulant addition up to 750 g/ton on a dry solids basis gave little benefit to the efficacy of the polymeric flocculants whatever their charge characteristics. Note that the cationic coagulant and anionic flocculant combination was inferior to the other two. The cationic coagulant and nonionic flocculant system was comparable with the most common system using a cationic coagulant and cationic flocculant combination.

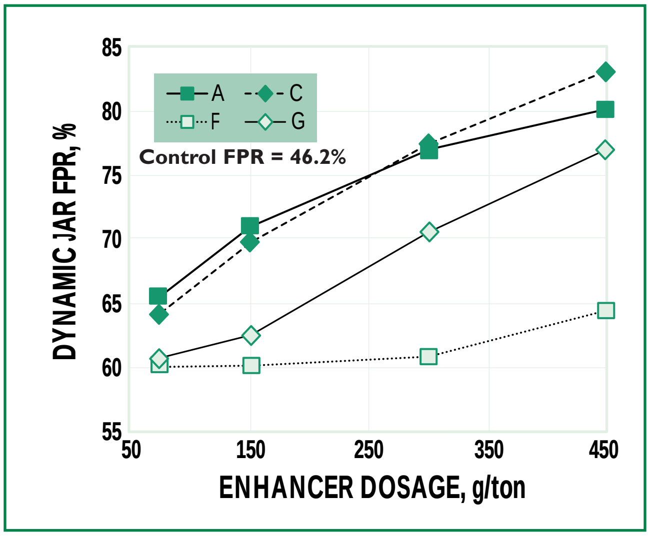
This result strongly suggests that the electrokinetic interaction is not necessary in retention control for newsprint furnishes because of extremely high cationic demands. The charge neutralization concept therefore may not be cost-effective. This is even more true with closure of the white water recirculation. It is important to note that the low-cost alum or polyaluminum chloride can replace cationic coagulants that are important to the true dual polymer retention application. It also is important to mention that any effec-



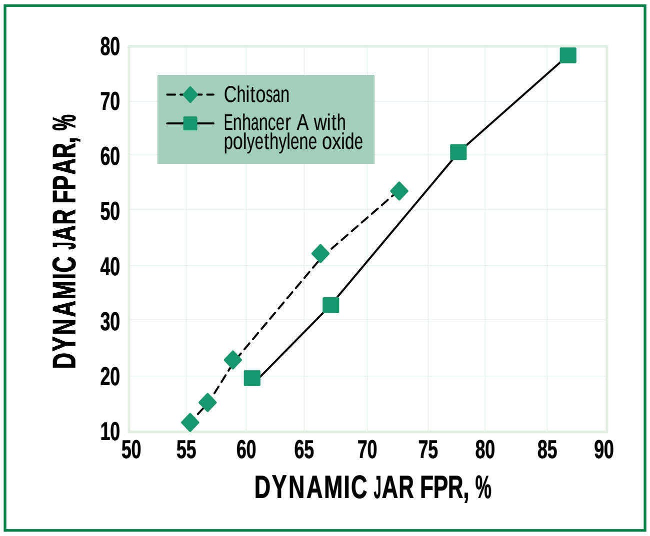
9. Effect of polyaluminum chloride on polyethylene oxide at 100 g/ton retention system (collected and tested July 13, 1995)



10. FPR on headbox stock containing 41% deinked pulp with polyethylene oxide at 150 g/ton (collected and tested May 4, 1995)



11. FPR on stock containing 24% PRF in deinked pulp (41% in furnish) with polyethylene oxide constant at 150 g/ton (collected July 13, 1995)

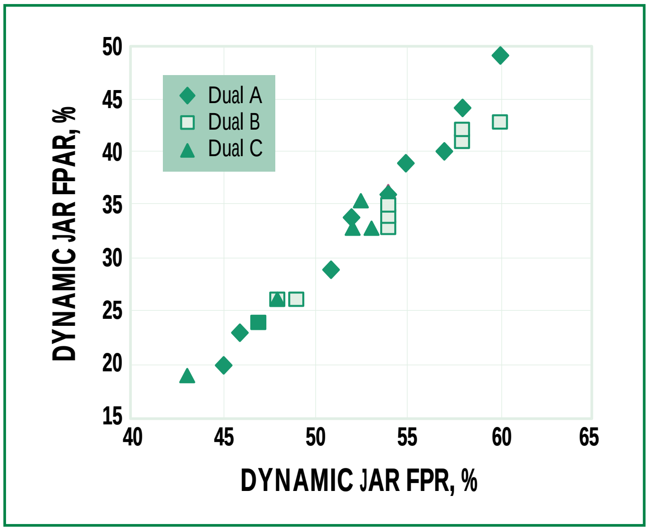


12. Relationship between FPR and FPAR for chitosan and enhancer with polyethylene oxide retention system

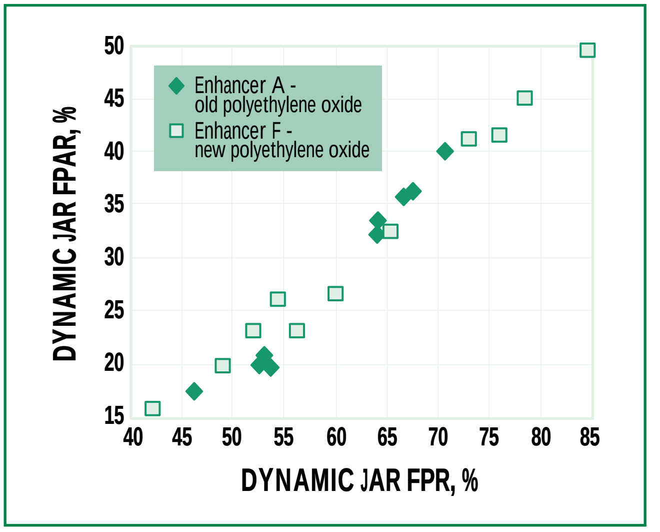
tive retention system, including the enhancer and polyethylene oxide combination, can reduce colloidal anionic trash with concomitant reduction of the cationic demands.

Chitosan or polyaluminum chloride and polyethylene oxide combination

Addition of all polymeric flocculants is most efficient close to the headbox. This also is true for polyethylene oxide. For pitch or stickies control, one normally applies the control chemicals far back in the stock line before sticky agglomeration can occur. Chitosan and polyaluminum chloride therefore may have great value. **Figure 8** shows dynamic jar test results on a headbox stock without deinked pulp. The chitosan application is either by itself or in combination with polyethylene oxide without an enhancing agent. **Figure 9** shows the results from an evaluation of the effect of polyaluminum chloride on two different polyethylene oxide retention systems. At a dosage rate of 1 kg/ton or less, polyaluminum chloride was beneficial to the two polyethylene oxide retention systems. New Enhancer F was again considerably more effective than Enhancer A—the traditional phenolic resin. The results from Figs. 8 and 9 suggest that the polyethylene oxide retention systems are quite compatible with chitosan and polyaluminum chloride. Similar results occur for many cationic coagu-



13. FPAR efficiencies for dual polymer retention systems



14. Comparison between old and new polyethylene oxide retention systems

lants that are commercially available.

New enhancers to improve polyethylene oxide performance

The traditional phenolic resin, Enhancer A, is a condensation product of phenol and formaldehyde containing no sulfonic group. The product has a short shelf life and becomes reddish due to formation of quinones. Some people claim that the phenolic resin and polyethylene oxide combination is insufficient for filler retention and for stock containing deinked pulp. New enhancers based on biphenyl types are now available with both degrees of sulfonation and polymerization under careful control. The new products have much lighter color and a very long shelf life under normal storage conditions.

Figure 10 shows that the new enhancers are more effective than Enhancer A for improving polyethylene oxide retention performance. The headbox stock in this evaluation contained 41% deinked pulp. **Figure 11** shows a similar result with another headbox stock containing 24% process recovered fiber (PRF)in the deinked pulp for a 41% total in the furnish. The degree of sulfonation and molecular weight influenced the efficiency of these new enhancers. Enhancers C and F were many times more powerful than the traditional phenolic resin. There were two machine trials in 1994 on a stone groundwood and high-yield sulfite furnish using Enhancer B with polyethylene oxide. There was a very significant improvement in first-pass retention (FPR) confirming the dynamic jar test results (no data shown).

First-pass retention vs. first-pass ash retention

Newsprint headbox stock generally contains considerable fiber fines and inorganic filler. Retaining these materials is highly desirable for paper machine efficiency and paper quality. The fines retention caused by polymeric retention aids is homogeneous, although some selectivity is possible under certain designed treatments. **Figure 12** shows the relationship between FPR and first-pass ash retention (FPAR) for chitosan and Enhancer A with polyethylene oxide. At a given FPR, chitosan achieved slightly greater FPAR than the polyethylene oxide system. This may be due to more selective retention of inorganic fillers or to the complex formation of metal ions and chitosan. **Figure 13** shows the results of a similar comparison for the three typical dual polymer systems.

There is a strongly linear relationship, suggesting that a greater FPR is essential to obtain higher FPAR. **Figure 14** shows this is also true for the old and new polyethylene oxide retention systems.

The most recent study conducted on the headbox stock containing 24% PRF in the deinked pulp gave even more striking results, as **Fig. 15** shows. The relationship between FPR and FPAR was not strictly linear here. At 65% FPR, the FPAR level of 77% is considerably higher than that shown in Figs. 11–13. This may be from the difference in furnish and ash content. The data strongly indicate that the new enhancer and polyethylene oxide system is excellent for both FPR and FPAR on furnishes containing various types of deinked pulp.

Stickies control

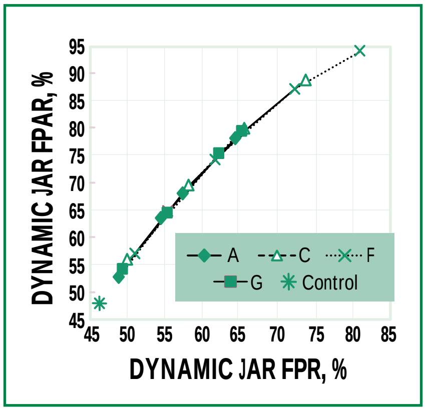
The phenolic resin with polyethylene oxide system is very effective for pitch control *(7, 8)*. Although the

KEYWORDS

Addition polymers, deinked stock, deinking, drainage jars, filler retention, flocculants, newsprint, polyphenolics, polyethylene oxide, pulps, retention, retention aids, stickies, surfactants.

Chemical	Addition rate, g/ton dry basis	Stickies reduction, %	Mechanism
Control	0	0	
Enhancer with polyethylene oxide			
Enhancer A	300	70	
Polyethylene oxide	100		Flocculation
Enhancer F	300	80	
Polyethylene oxide	100		
Chitosan	1000	70	Fixation
	2000	80	and
	3000	100	flocculation
Polyaluminum chloride	5000	50	
	10000	60	Fixation
Control A	1000	80	
	5000	>90	Plasticization
	10000	60	
Control B	1500	20	
	3000	60	Unknown
	15000	50	
Control C	2200	60	
	11200	80	Encapsulation
	22000	100	
Control D			
Polymer 1	500	20	
Polymer 2	500		Emulsification
Polymer 1	1000	50	and
Polymer 2	1000		fixation
Polymer 1	500	90	
Polymer 2	1500		

III. Detackification of headbox stock with chemical additives in July 1994



15. FPAR vs. FPR for polyethylene oxide and enhancers at the same dosage (collected July 13, 1995)

same retention system was effective for furnishes containing recycled pulp *(9)*, no data are available for its ability in controlling the white pitch. Stickies from deinked pulp differ from that of wood extractives.

This work evaluated various additives available for stickies control using the method described in the experimental section. Four samples collected in the deinked plant contained large but much less sticky particles than that of the headbox stock. This strongly suggested that fine stickies were not readily retained in the sheet under the existing wet-end chemistry control program. The sticky contaminants accumulated in the white water recirculation system and caused sticky deposition problems after agglomeration. This author speculates that a stock containing more fiber fines should be stickier using the stickies measurement of this study. The white water contained much more sticky materials than that in the headbox.

The stickies determination used room temperature without pH adjustment with a headbox stock. Stock tested three times gave reasonably reproducible results. There was a comparison of the stickies content for the control with results from any treatment. This allowed a visual estimate of the stickies reduction due to the chemical treatment. The test used the bottom side of the fiber pad only. **Table III** provides the results.

Virtually all chemicals evaluated showed benefits for stickies control, although their control mechanisms varied. Considering the addition rate on dry pulp basis and sticky reduction, enhancer and polyethylene oxide, chitosan, polyaluminum chloride, Control A, Control C, and Control D (two components) were all useful. Because of shear sensitivity, one can only apply the enhancer with polyethylene oxide combination near the headbox. It is possible that a good FPR regardless of mechanisms should reduce the sticky deposition by attaching the sticky particles to the fibers. Chemicals designed for sticky deposition control based on stabilization such as dispersant are inadequate. The Control D (two components) did not cause fiber flocculation within the dosage range studied. This suggests that it may not be a cost-effective retention system.

CONCLUSIONS

Using the work in this study, it is possible to conclude the following:

- Before the deinking plant operation, the headbox stock responded very strongly to polyethylene oxide alone in the dynamic jar retention evaluation.
- Deinking chemicals carryover—especially the nonionic deinking

surfactant—impaired the performance of phenolic resin with polyethylene oxide retention system. Better deinked pulp washing should alleviate this problem.

- For newsprint furnishes with high concentration of anionic trash, the conventional dual polymer systems using electrokinetic charge interaction may not be cost-effective for retention control.
- Within the dosage range studied, cationic coagulants used in the dual polymer systems showed little beneficial effect on the performance of polymeric flocculants, whatever their charge properties.
- All the new enhancers studied remarkably outperformed the traditional phenolic resin in improving the efficacy of the polyethylene oxide retention aid.
- Of the six new enhancers investigated, Enhancers C and F are many times more powerful than Enhancer A.
- There is a strong relationship between FPR and FPAR, suggesting that the fines retention is nonselective. Greater FPR is essential for higher FPAR.
- The new enhancers with polyethylene oxide are excellent retention systems for newsprint furnishes containing deinked pulp. These systems are also very effective for filler retention and stickies deposition control. **TJ**

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