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Evaluation and Application of Retention Aids for Papermaking System Closure

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ABSTRACT

Reducing the effluent discharge from a paper mill is urgently needed due to tightening environmental regulations and economic reasons. For a paper mill to respond to system closure it is required to adopt the best practical retention system that enables the mill to improve fines retention and drainage. In this study, effects of various retention agents on fines retention, drainage and formation were examined using linerboard stock in the laboratory. Among the retention aids tested, high molecular weight cationic polyacrylamides showed good efficiency both in retention and drainage. On the other hand, high charge density, low molecular weight polymeric retention aids showed little improvement both in retention and drainage. The best retention system selected from the laboratory experiment was applied on a paper machine producing linerboard to evaluate its effect on papermaking system closure.

1. Introduction

Three main problems of securing fibrous raw materials for papermaking, producing quality products from the ever deteriorating fibrous materials, and reducing the effluent discharge to meet the environmental regulations must be solved for today's paper industry to be competitive and to continue its development. Among these problems reducing the amount of waste water discharged from the mill and meeting the environmental regulations are crucially important for today's paper industry.

Many research efforts have been made to tackle this problem of effluent reduction from papermaking processes during last several decades.[1-3] Filtration, freeze recrystallization, mechanical vapor recompression technologies and others have been developed for this purpose in mind. By applying these advanced technologies, it is possible to close the papermaking system completely, i. e., the so-called zero effluent system can be achieved.[4] However, these technologies require extensive capital investments or operational costs that limit their practical applicability. Therefore, if someone is interested in reducing the effluent discharge from a mill without extensive capital investment, it is natural to look up chemical

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approaches providing opportunities of increasing the recycling ratio of waste water in the papermaking process. It has been suggested that this can be achieved by applying a suitable retention program.[5,6]

Reuse or recycle of waste water in a papermaking process provides such beneficial effects as reutilization of thermal energy, chemical additives, and fibrous materials contained in the waste water. And it also minimizes the variation of temperature and chemistry of the papermaking process.

When one increases the recycling ratio of white water in a papermaking system, however, many detrimental impacts do occur. First of all, the concentration of the dissolved and colloidal materials will increase as the system closure increases, which, in turn, reduce the one pass retention. Increase of the temperature of a papermaking system, which accompanies the papermaking system closure, will aggravate slime related problems. Deterioration of paper qualities, corrosion problems, and inefficiency in dewatering have also been recognized as disadvantages of papermaking system closure.[7] Among these disadvantages decrease of fines retention has been pointed out as the most important problem to be solved for achieving papermaking system closure.[8]

Therefore, if one is interested in chemical approaches for papermaking system closure since it requires no extensive capital investments, optimization of the retention system must be achieved in the first place. Because every mill has its own specificity in raw material compositions, final product quality requirements, incoming water quality, and papermaking process itself, a specific retention program must be established for each mill that will fulfill the system closure target most effectively.

In this study performances of various types of retention aids in retention, dewatering and paper formation were evaluate to see their applicability in papermaking system closure for a linerboard mill. And a polymeric retention aid was applied in a linerboard manufacturing process to evaluate its influences on papermaking system closure.

2. Materials and Methods

This study was performed at the Laboratory of Paper Science, SNU, and Shin Ho Paper Jeong Eup mill, which produces linerboard from 100% OCC with two paper machines. PM1 is a cylinder machine which runs at the speed of 145 m/min with production capacity of 170 t/d. PM2 has five Kobayashi formers and runs at the speed of 340 m/min with production capacity of 330 t/d. The immediate purpose of this study was to optimize retention for PM2 which has greater production capacity and speed. This mill utilizes cationic and anionic PAMs as dry strength agents and alum as a pH controlling agent. Small amount of a direct dye is used in top layer.

Effects of various polymeric retention aids listed in Table 1 on retention, drainage and paper formation were investigated.

Stocks were prepared by pulping liner-

Table 1. List of polyelectrolytes evaluated

Polymer Type	Molecular Weight ($x10^6$g/mol)	Charge Density (% or meq/g)
1	5-7	9%
2	5-7	54%
3*	15-18	30%
4	5-7	40%
5	1	7 meq/g
6	7	3 meq/g
7	4	1 meq/g
8	5	1 meq/g
9	5.5	1.5 meq/g

*Polymer 3 is anionic. Others are cationic.

board for 40 minutes at 6% consistency. To simulate the conductivity of the mill process water, calcium chloride was added to the prepared stock to get 600 ppm of hardness. Anionic PAM, alum, cationic PAM and a retention aid were added sequentially to the stock delivered to DDJ in predetermined time intervals. Stirrer rpm was adjusted to 800 for the retention experiments. Retention analysis was made based on the TAPPI Standard T261 cm-90. Since there were limitations in installing chemical feeding system for retention aids to PM2 at Jeong Eup mill, application of multiple retention aids is excluded in this study.

3. Results and Discussion

3.1 Mill Analysis

Qualities of incoming and processing water, headbox and tray consistencies, and retention levels for five formers of PM2 were measured. Since no retention program has been employed in PM2 when this study was started, one pass retention levels were rather low (Table 2). The retention level for No. 2 ply was very low since the basis weight of this layer was maintained at low level to improve the appearance of the top layer (Table 3).

The fines contents measured with a DDJ ranged from 45-50% for headbox samples and 93-98% for tray samples indicating that most of headbox fines are unretained. Since no fillers were being added the fines are mostly fiber fines.

Conductivity of five headbox stocks ranged from 21.2-25.5 mS/cm. This suggests that a polyelectrolyte retention aid effective in high conductivity environment must be selected for PM2. Top ply stock showed the highest conductivity due to the presence of a direct dye in this layer.

3.2 Evaluation of Retention Aids

Effects of seven different retention aids on fines retention are shown in Fig. 1. In general, high molecular weight cationic polyacrylamides (Polymer 1, 2, 6 and 8) showed good retention performance, while low mol-

Table 2. HB and tray consistency and OPR

Ply No.	Headbox Consistency (%)	Tray Consistency (%)	OPR (%)
1	0.97	0.49	49.5
2	1.10	0.62	38.3
3	1.23	0.41	66.8
4	1.33	0.41	69.1
5	1.22	0.46	62.5

Table 3. Basis weight for five layer of PM2

Ply No.	Basis Weight (g/m^2)	Basis Weight (%)
1	36.4	21.9
2	24.3	14.6
3	41.0	24.7
4	31.4	18.9
5	33.0	19.9
Total	166.1	100.0

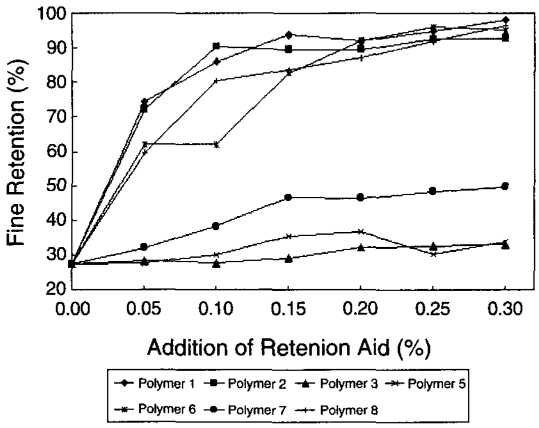

Fig. 1. Effect of retention aids on fines retention.

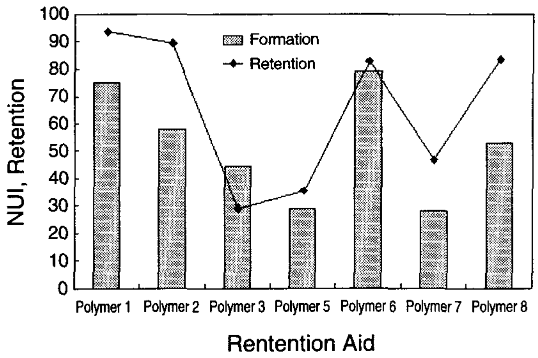

Fig. 2. Nonuniformity index and fines retention for seven polymeric retention aids.

ecular weight cationic PAM, PEI and high molecular weight anionic PAM showed low retention values. The effects of polyelectrolytes on drainage were similar to those on retention; i.e., high MW cationic PAMs gave good drainage characteristics compared to low MW polyelectrolytes.

Among the seven retention aids tested, Polymer 2 and Polymer 8 showed good retention performance and produced sheets with good formation, whereas Polymer 1 and Polymer 6 gave sheets with poor uniformity (Fig. 2).

3.3 Mill Application

The laboratory results were reevaluated using headbox stock at the mill. The hardness level of the headbox stock at the time of testing was 1500 ppm. Test results at the mill were similar to those obtained in laboratory experiments except that slightly lower retention levels were obtained from the mill most probably due to high hardness. Two new polymeric retention aids, Polymer 4 and Polymer 9, which are improved products of Polymer 2 and Polymer 8, respectively, were also evaluated at the mill.

After extensive laboratory and in-mill testing, Polymer 9 was selected as the best retention aid for PM2 of Jeong Eup mill and it was decided to apply this polyelectrolyte for three weeks to PM2. A new feeding system for the retention aid was installed after screen. Since the screen is located very close to the headbox of PM2 it was needed to dilute the retention aid so that complete mixing would occur.

Addition amounts of the retention aid were varied depending on the layer. Greater amounts of retention aid were applied for the outer plies to facilitate drainage during pressing and drying.

Headbox and tray consistencies were measured during the entire period of the mill trial. As shown in Fig. 3, the headbox consistency decreased from 1.16% to 0.78% and the tray consistency decreased from 0.5% to 0.18%. It took about three days to reach a stable condition.

The total retention level was only 57.2% before applying the retention aid, but it increased to 75% three days after starting dosing the retention aid and stayed stable at the level afterward. Machine speed increased by 20 m/min as shown in Fig. 4.

COD levels of tray water, inflowing waste water to water treatment system, and effluent from the sedimentation clarifier

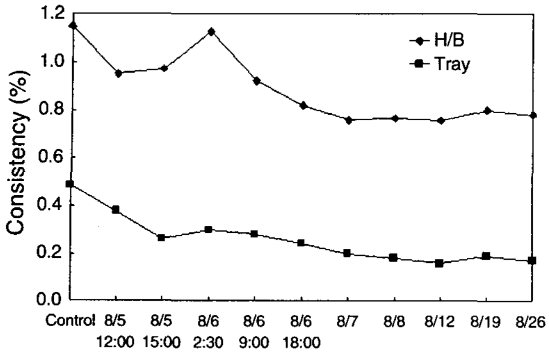

Fig. 3. Headbox and tray consistency during retention trial.

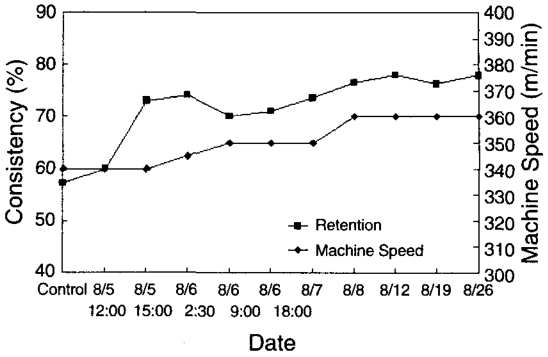

Fig. 4. Changes of retention and machine speed during the period of retention trial.

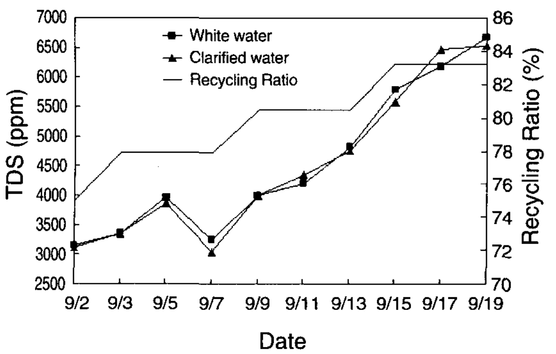

Fig. 5. System closing and changes of TDS of white water and clarified water.

decreased up to 30% during the study period. Most significant reduction was, however, observed for suspended solids, which decreased from 2400 ppm to 1000 ppm. The reduction in suspended solids was achieved in two days after application of the retention aid indicating that suspended solids is the most rapidly influenced by the retention program.

Before the application of retention program about 20 t/d of sludge was produced, but this decreased to 17 t/d after applying the retention aid. 7% saving in waste water treatment chemical cost was also achieved.

3.4 Stepwise System Closure

Since it has been proven that the retention program provided many beneficial effects for the mill, a plan to increase the recycling ratio of the process water was developed. Fresh water used for the showers of breast rolls, cylinder molds and other devices were substituted with recycled water step by step. At first stage, substitution of the fresh water with recycled water was made for the breast roll showers. This action increased the recycling ratio of the process water from 75% to 77.9%. When substitution was made for cylinder mold showers the recycling ratio jumped to 80.5%. Substitution of the fresh water supplied to felt shower with recycled water enhanced the recycling percentage to 83.3%. Amount of fresh water consumption decreased from 12 ton to 10.6 ton, 9.4 ton and then to 8 ton per ton of products by these steps of system closing.

COD, TDS, and physical properties of the linerboard produced were measured during this period of system closure. TDS in white water and effluent from the sedimentation clarifier increased continuously when the replacement of fresh water with recycled water was made (Fig. 5). On the other hand COD levels remained more or less constant when the recycling percentage approached to 80.5%.

Until the second stage of system closure (80.5% of recycling ratio) no significant changes in physical properties of the linerboard were observed.

When the recycling ratio increased to 83.3%, however, significant deterioration in product quality and process water quality were observed indicating that new approaches both in chemistry and process modification are required to cope with the problems derived from the increase in dissolved and colloidal materials.

4. Conclusions

To investigate the applicability of wet end retention optimization onto the papermaking system closure, various polymeric retention aids were evaluated for their performance in retention, drainage, and sheet formation using linerboard stock in the laboratory. A high molecular weight polyacrylamide was selected and it was applied into a linerboard machine. The selected retention aid was very effective in retention and drainage improvement, machine speed increase, and sludge reduction. TDS, COD and SS of white water decreased as retention was increased by the retention aid application.

Stepwise replacements of fresh water used in breast roll shower, cylinder mold shower and felt cleaning shower with clarified water were made to increase the level of papermaking system closure. By these stepwise replacement the amount of fresh water use can be reduced from 12 ton to 9.4 ton per ton of product without loss in sheet properties.

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