Total sizing system

총 사이징 시스템

Lucyna Pawlowska

Bayer Co.

바이엘코리아

제30회 펄프 · 종이기술 국제세미나

TOTAL SIZING AT THE SIZE PRESS

Robert J. Proverb, Ph.D.
Manager, R&D

Lucyna Pawlowska
Senior Associate Chemist

Kasia Komarowska
Application Specialist

Gina Garro
Application Specialist

Kimberly Dilts, Ph.D. Michael O'Toole Chuck
Hunter, Ph.D.
Chemist Senior Associate Chemist Chemist

Paper Colorants and Chemicals
Bayer Chemicals Corporation
Woodbridge Technical Center
4 Research Drive
Woodbridge, CT 06525

ABSTRACT

Sizing properties in paper are generally developed through the application of both internal and surface sizes. Rosin, wax, and synthetic sizes including ASA, AKD, and stearic anhydride are and have been used to provide wet-end sizing to paper. In many cases, the use of some of these sizes leads to runnability problems that are inherent in the wet-end operation. Variability in furnish, fines, broke, filler, water chemistry, conductivity, and pH control impacts the wet-end operation. Size press chemicals including starch and polymers such as styrene-acrylic, styrene-maleic, and styrene acrylate emulsions are used in conjunction with internal sizes to improve the paper surface for printing and strength properties, porosity, and opacity improvement. This paper will discuss results from a new, proprietary formulation and process that allows application of sizing chemistry more totally at the size press with reduced emphasis on wet end sizing. Runnability issues are thus minimized at the wet-end, chemical usage is more efficient, and significant cost savings can be realized. Case histories will be presented illustrating the advantages of this new application in commercial trials.

WET-END VERSUS SIZE PRESS SIZING[1]

The use of internal sizing, whether it is rosin or synthetic size, has very specific functional requirements in order to maximize the effect of the chemistry in providing desired paper properties. The chemical and raw material components in the wet-end also have an impact on size development and efficiency. Providing a means by which the size becomes substantive to the fiber is key to effective sizing development. This is achieved by taking advantage of the inherent anionic charge of the fiber. Internal sizes are generally water-insoluble materials that are applied in the wet-end as either emulsions or dispersions. In acid papermaking, rosin forms a complex with alum that is cationic under specific conditions. For alkaline papermaking, AKD and ASA are delivered to the wet end as cationic emulsions. The opposite charges of the fiber and the dispersed size attract and bring the size to the fiber surface. The size is distributed accordingly on the fiber surface and thus in the paper mat. Sizing properties are developed in the dryer section as the dispersion breaks and the size spreads along the fiber surface and anchors or covalently bonds with the interactive or reactive elements on the fiber (or starch). In some cases, curing continues as the paper ages. The wet end contains filler particles and smaller fiber fragments, the "fines," that also have net negative surface charge to which the size is attracted. These smaller particles must be retained in the sheet in order to achieve good sizing efficiency. Therefore, the retention system is critical in the employment of internal size. Poor retention of these smaller particles will therefore lead to inefficient size development. The circulation of the unretained size, in conjunction with these particles in the white water system, gives an opportunity for deposits to develop. This leads to more frequent machine down time for removal and cleanup, and may lead to sheet defects as well.

It has been well documented that the chemicals used in the wet end can also have a negative impact on sizing. High conductivity furnishes can interfere with charge interactions that provide the substantivity need to fix the size emulsion particle to the fiber surface, leading to inefficient size development. Excessive use of defoamers will impact the degree to which the size can develop hydrophobic properties. Control of pH is also important. The rosin-alum complex is maximized only in a narrow pH range; synthetic sizes are optimally applied at alkaline pH. Carry-over of bleaching chemicals from pulping operations will also interfere with size efficiency. See Figure 1.

Figure 1. Key Factors in Wet End Versus Surface Sizing

- **Internal versus Surface Sizing**
  - **Retention**
  - **Substantivity**
  - **Addition point**
  - **Wet-end chemistry**

Size press sizing avoids the impact of many of these wet-end chemicals on size development. Chemicals present in the pulp mixture that interfere with wet-end size development have minimal if any impact on size development. The size is added to the fully formed paper sheet, so there is no need for chemical substantivity of the components in order for size component to interact with the fiber surface. Conductivity at the wet end is no longer a concern since electrodynamic charge does not serve any significant role in affixing size composition to the paper sheet. Since chemicals are added after the sheet is formed, their retention is essentially 100% as the size press solution is recirculated. Some advantages in moving size development activities to the size press include: 1.) Improved runnability, since reduced sizing is added at the wet end; 2.) Cleaner white water, providing an opportunity for more complete white water closure; 3.) Improved sizing efficiency, since size is added to the paper sheet and not fines and filler particles; 4.) Improved cost efficiency, since retention of sizing agent is complete and interference from wet-end chemistry is avoided; 5.) The ability to more directly control size development with balance between internal and surface sizing applications; and 6.) The potential for achieving higher sizing levels (Figure 2.)

Figure 2. Advantages of Size Development at the Size Press

- **Retention - Essentially complete**
- **Substantivity - Does not play a critical role**
- **Wet-end chemistry - Less sensitivity**
  - **Furnish composition**
  - **Filler addition**
  - **Anionic trash**
  - **Desizing agents**
  - **Pulp mill carryover**
- **Runnability - Cleaner system**
- **Performance/Cost efficiency**
- **Cleaner white water**
- **Increase white water closure**

APPROACH TO THE DEVELOPMENT OF TOTAL SIZE PRESS SIZING

The approach that was taken in developing a size for use totally at the size press was based upon a proprietary formulated anhydride chemistry, employing both a proprietary formulation and application process. This system is known as BAYSIZE® TS size. The sizing system is dispersed on site using simplified equipment. Internal size use is optional if specific sheet properties are needed. The strategy is currently focussed on board and related grades since these areas would most benefit from this new sizing application (Figure 3).

- **Specialized Formulation & Process**
- **Dispersed on-site**
- **Can be run with or without internal size**
- **Target board and specialty grades**

Figure 3. Strategy

LABORATORY EVALUATION

A number of systematic laboratory handsheet studies were performed in the development of this technology. We will discuss here five examples illustrating key advantages to this system.

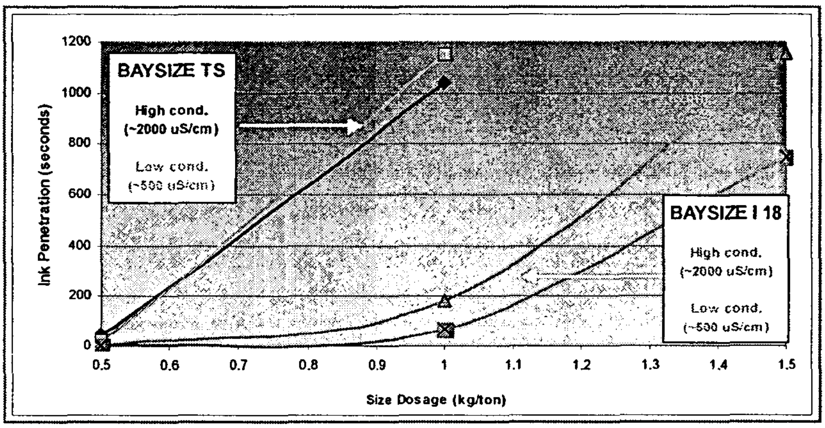
Conductivity.

Electrolyte concentration can have a dramatic impact on sizing. Increased concentration of electrolytes can interfere with the electrodynamics that governs the substantivity of various wet end chemicals with the fiber and filler particles. In these studies two electrolyte concentrations were investigated with 1.) ASA synthetic size at the wet end and 2.) BAYSIZE TS size applied at the surface.

Sheet basis weight was 74 g/m^2. The higher conductivity experiment (Graph 1) showed the expected effect on the internal size performance with the size efficiency decreased at all dose levels when compared with the low conductivity experiment. By contrast, there is essentially no difference in the sizing response at either conductivity level with the BAYSIZE TS size system being applied at the size press. It should also be noted that the dose required to achieve equivalent sizing response is much less with BAYSIZE TS size than with internal size alone.

Graph 1.

Study 1: The Comparison of Sizing Programs in Varying Furnish Conductivity



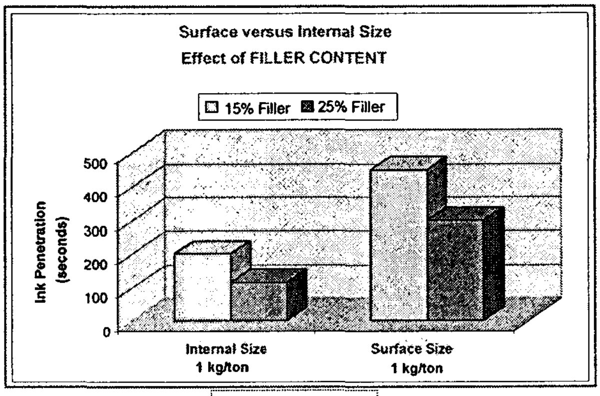
This work shows that increases in conductivity have no impact on the performance of the new sizing system. For the papermaker, this new system provides the opportunity for increasing white water closure and improved savings in operating costs.

Filler.

Filler content can also have a major impact on sizing efficiency. Fillers have high surface area and are negatively charged. There will be some adsorption of sizing emulsion on the filler particle. As the amount of filler increases, more size is adsorbed and the efficiency of the size can be affected. Graph 2 shows the results of a handsheet study using a bleached kraft furnish. With just internal size, changing the filler level from 15 % to 25 % shows a corresponding decrease in sizing from 180 sec to 90 sec, as measured by ink penetration. With the new surface sizing system, the efficiency of the size is higher at an equivalent dose, 420 sec vs. 180 sec. A decrease in sizing is also observed when higher filler levels are used with the new surface application. However, because of the increased efficiency of the new sizing system, the impact of increased filler is minimized, with the potential for using a lower sizing dose to achieve sizing targets. The use of this new sizing system provides the papermaker the flexibility of increasing filler levels while having better control of size develop and cost.

Graph 2.

Study 2
The Effect of Filler on Sizing Results

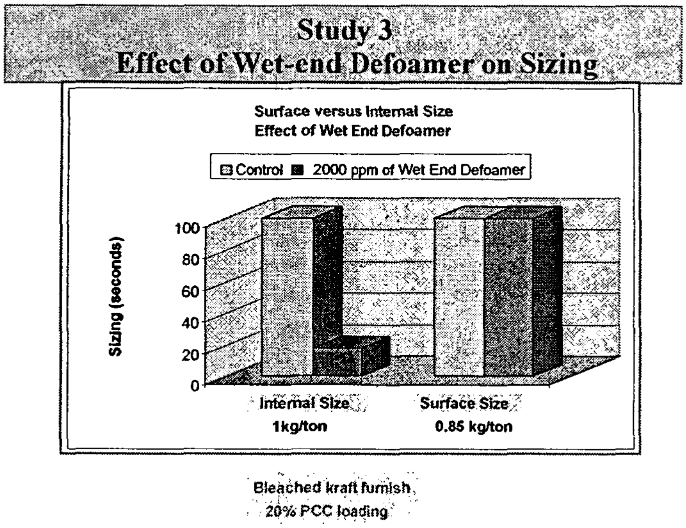


Bleached Kraft Furnish
Filler ALBACAR 5970
(surface area 9 m^2/g)

Defoamer.

Excessive use of defoamer can also show deleterious effects on size response as the Graph 3 below indicates. This study used bleached kraft with 20 % PCC filler. Sizing dose of the surface size was reduced to provide equivalent sizing response as that achieved in the wet end. When 2000 ppm of a wet-end defoamer was added, the paper sized with internal size shows the expected drop in ink penetration sizing response. On the other hand, the paper sized with only the surface size demonstrated no change in sizing performance, i.e., the defoamer had no effect. This is not too surprising since the size is being developed at the size press and not at the wet end where the defoamer is being added. It is illustrative of how the chemical dynamics of the wet end plays less of a role in size development at the size press. This allows the papermaker to be able to use defoamer as necessary to better control the wet end with minimal impact on size development.

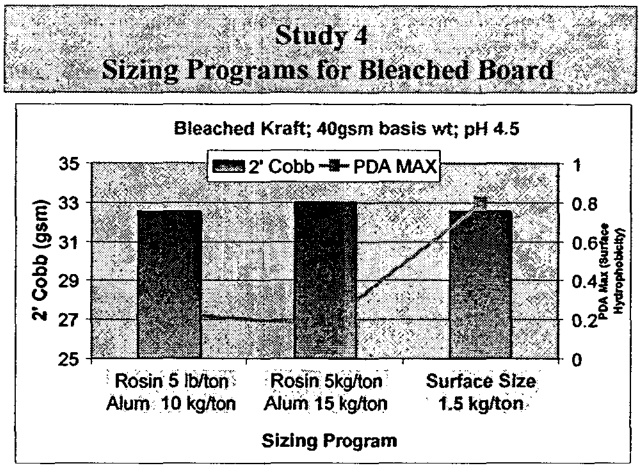
Graph 3.



Acid Papermaking.

Another distinctive advantage of this new sizing system is its ability to develop sizing over a wide range of papermaking pH. With acid papermaking, rosin is the key internal size while with alkaline papermaking, the synthetic sizes ASA and AKD are the key chemicals used. In the last three examples, we discussed papers that were prepared at alkaline pH (7.0-8.0). Graph 4 displays the results of a study performed using an acid pH system. In this case, a bleached kraft furnish was used to prepare paper at a pH of 4.5. The use of 5 kg/ton of rosin with either 10 or 15 kg/ton of alum provided a 2-minute Cobb of approximately 33 g/m^2. With only 1.5 kg/ton of the new surface size treatment, an equivalent Cobb value was achieved. PDA MAX values, calculated using data from ultrasonic measurements, show that the surface-applied sizing system provides higher surface hydrophobicity, an additional value when sizing properties are needed close to the paper surface. These results demonstrate that the papermaking conditions are flexible with regard to wet end pH variability, especially if coated broke is anticipated to be used.

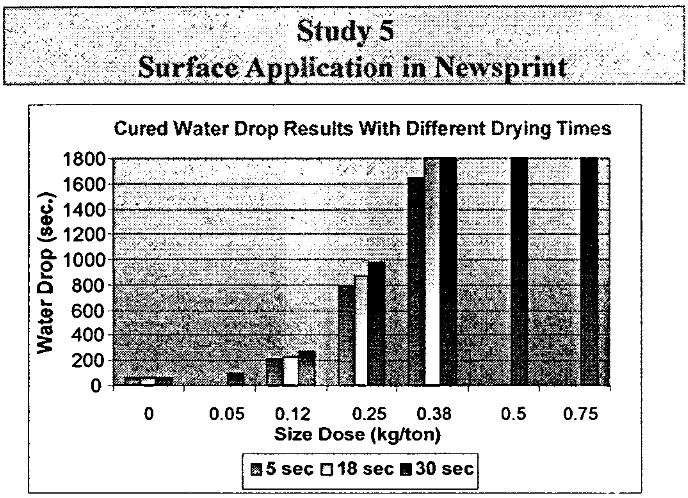
Graph 4.



Newsprint.

Also in the acid pH range is newsprint manufacture. In this example, we used a newsprint furnish prepared at pH 5.5. Graph 5 shows the dose performance relative to a simple water drop test. For this paper grade with minimal size requirements, very low doses of surface application were required to achieve good water drop test results.

Graph 5.



These results illustrate the effective range of papermaking pH over which BAYSIZE TS may be used to develop sizing.

These handsheet studies demonstrated to us that the performance of this new sizing system is versatile and effective, providing the ability to achieve sizing targets at lower doses than with traditional internal sizing programs. It eliminated the need for rosin/alum sizing, although if higher sizing were required, the option of minimizing the use of internal size and providing the majority of the size at the surface of the sheet would be possible. To substantiate these studies we next investigated the application of BAYSIZE TS on a pilot paper machine.

PILOT PAPER MACHINE TRIAL

The conditions under which these trials were run are listed in Figure 4 below. These pilot trials were employed to evaluate the new chemistry and process under a continuous papermaking process. In addition to evaluating the

Figure 4.

Pilot Machine Trial

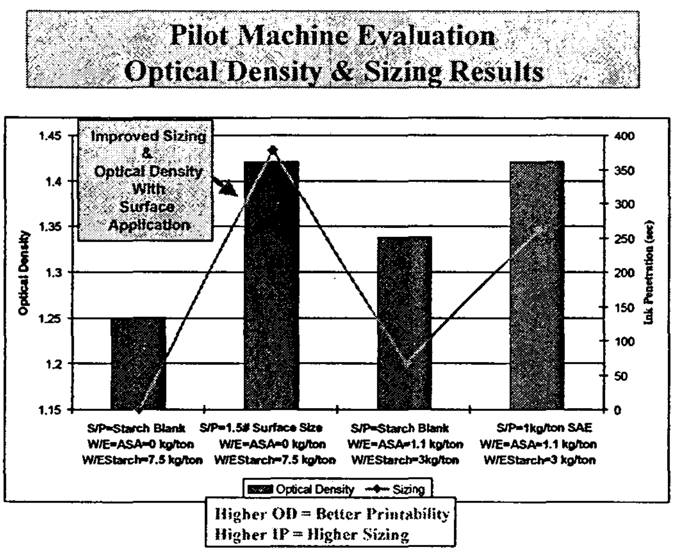
- **Machine Conditions**
  - **Furnish: 70 / 30 HW / SW**
  - **Machine Speed: 18.2 m / min**
  - **Basis weight: 70 g/m^2**
  - **Flooded nip size press**
  - **Ethylated size press starch**
- **Trial Objectives**
  - **Determine runnability without internal size**
  - **Evaluate sizing effectiveness**

sizing efficiency of this surface application, we also want to assess the potential of operating the machine with no size in the sheet going into the size press. This machine is equipped with an offset flooded nip size press.

Print Quality Results.

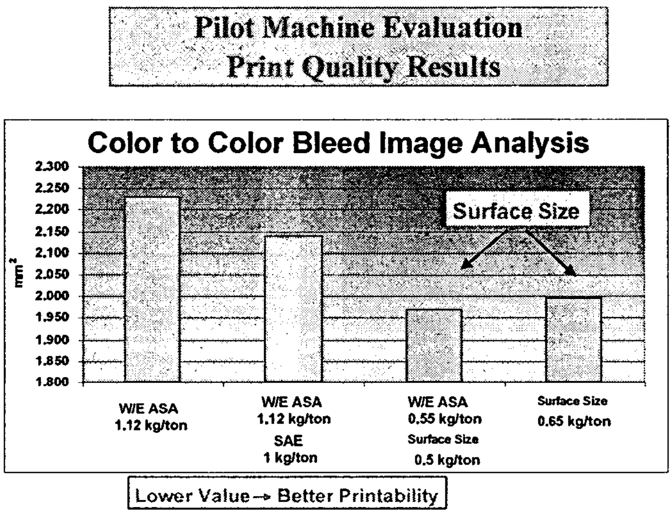
Optical density and ink penetration results are presented in Graph 6. The graph shows that the optical density improves with the application of this new surface size, regardless of whether internal size is used. Thus, the ability to promote optical density properties is enhanced with the surface application, the impact of having the sizing chemistry closer to the surface of the paper being a benefit. The graph also illustrates the influence of the surface application on ink penetration with and without internal size. In both cases, increased ink hold out is observed when the surface treatment is applied. One apparent advantage of the new surface size is the ability to develop higher ink hold out when no internal size is present, thus allowing a lower cost for size development.

Graph 6.



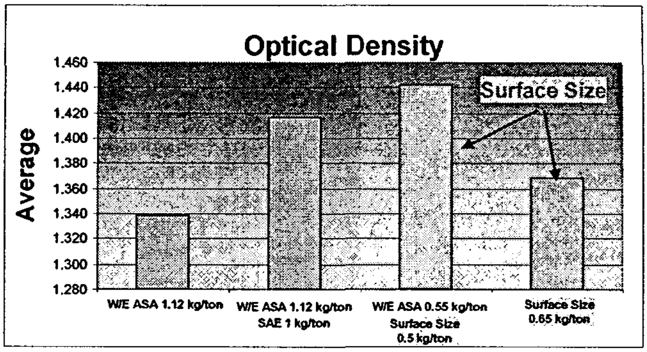
Graph 7 illustrates the benefits of this chemistry in improving color bleed. In this chart, the color-to-color bleed measurements are depicted, with lower numbers representing less color bleed. Image analysis techniques
were used to determine these data. The chart shows four trial conditions and their influence on color bleed. The basic system, using only ASA internal size, gives the poorest color bleed. The use of typical styrene-acrylate emulsion at the size press with ASA internal size gives some improvement. When the new surface treatment

Graph 7.



System is implemented, a lower internal size dose can be used, with significant improvement in color bleed. Ultimately, when no internal size was used and only 0.65 kg/ton of the new surface size system employed, color bleed results were equivalent to when both 0.55 kg/ton of ASA and 0.5 kg/ton of the new surface size are applied. Similar results were obtained with measurement of optical density, as shown in Graph 8.
Graph 8.

Pilot Machine Evaluation
Optical Density Results



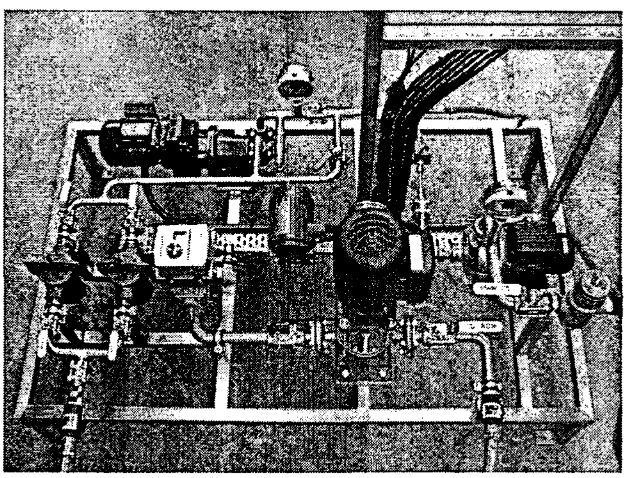
Higher Value → Better Printability

It is clear from these pilot machine studies that improved sizing can be achieved, at low doses with the potential for significant cost improvement in size development.

COMMERCIAL TRIALS

Encouraged by these results, we next ran several commercial machine trials to evaluate the potential of this new sizing system in liner board and newsprint applications. For these trials, the commercial scale equipment used to prepare the dispersion going into the size press is shown in Figure 5.

Figure 5.



Overhead View of BAYSIZE TS Dispersion Equipment

Case Study 1: Linerboard.

This mill produces a variety of grades of 100-170 g/m^2 linerboard (Figure 6). Its wet-end system was comprised of MOW and OCC, running at alkaline pH using ASA as the sizing system. They were experiencing high sizing demand, with variable sizing response because of fluctuations in wet-end composition

Figure 6.

Case Study 1
Internal vs. Surface Application of Size
Linerboard Application

- **Gap Former with Flooded Nip Size Press producing 100 - 170 g/m² Linerboard**
- **Machine Speed: 580 - 825 m/min**
- **Machine Production: 30 - 43 tonnes/hr**
- **80 - 100% MOW / 0 - 20% OCC**
- **Size Press Starch Pick-up: 25 - 50 kg/tonne**
- **Sizing Specification: 120 / 140 g/m² (t / b) 30 min Cobb**

(Figure 7). They have a flooded nip size press with starch pick-up of 25-50 kg/tonne.

Figure 7.

Case Study 1
Mill Issues with Wet-End Size Application

- **High sizing demand – average of 2.15 kg/ tonne (4.3 lb/ton)**
- **Sizing variability due to wet-end variability**
- **Porosity increase with internal size application**
- **Sheet harder to dry with internal size application**

The mill ran several trials with this new size press sizing system, eliminating the use of size in the wet end. The results obtained were dramatic (Figure 8). Sizing usage was reduced 43%, from 2.15 to 1.25 kg/tonne. Starch and alum were eliminated from the wet end, providing a production increase of 1.8 tonne/hr. Sheet porosity was unaffected with no increased demand on the dryers. Subsequent trial work was followed by commercialization. The mill has been commercial on this new sizing system since July of 2002.

Figure 8.

Case Study 1
Mill Results with Size Press Size Application

- ***Size Reduction* from 2.15 to 1.25 kg/ tonne (4.3 to 2.5 lb/ton) = 42%**
- ***Elimination of Starch & Alum* from the wet-end**
- ***Production Increase* by 1.8 tonne/hr = 5% improvement**
- ***No Negative Effects* on porosity or sheet drying**

Mill commercial since July of 2002

Case Study 2: Newsprint.

The case study is concerned with a newsprint application (Figure 9). This mill has a twin wire former, producing >600 metric tons/hr. Operating pH of the mill is 4.5 to 5.5. The size press operates at a pH of 6-7. In order to achieve sizing targets, it was using 2 kg/ton of rosin for internal sizing and 1-2 kg/ton of modified styrene acrylic resin for surface sizing.

Figure 9.

Background

- **Twin wire**
  - **650 mtons/hr, 1,200-1,300 m/min machine speed**
- **Furnish : TMP**
- **Wet-end pH : 4.5 - 5.5**
- **Size Press Starch : Ethylated (2-6% solids)**
- **Size Press pH : 6 - 7**
- **Incumbent Sizing System :**
  - **2 kg/tonne of rosin (internal sizing) and 1-2 kg/tonne of Surface Size (modified styrene acrylic)**

The mill's objectives in running trials was threefold: 1. Improve runnability and cleanliness in the wet end by replacing existing sizing system; 2. Maintain sizing specifications; and 3. Maintain COF specifications (Figure 10). Again, several trials were run to optimize the new sizing system for this mill operation.

Figure 10.

Case Study 2

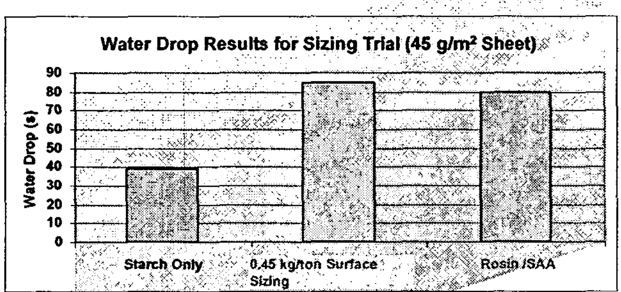
Trial Objectives

- **Improve runnability and cleanliness in the wet end by replacing incumbent internal and surface sizing**
- **Maintain sizing specifications of 80 - 100 seconds of water drop sizing**
- **Maintain coefficient of friction specifications of 0.45 - 0.55**

Trial results showed equivalent sizing (Graph 9) and COF specifications. Runnability was improved with the

Graph 9.

Case Study 3
Internal vs. Surface Application of Size
Newsprint Application



Higher Water Drop Results indicate Better Water Holdout (sizing)

elimination of rosin and alum from the wet end (Figure 11). The cleaner wet end reduced the number of holes observed in the sheet. This mill is now commercial on this new sizing system.

Figure 11.

Case Study 2
Trial Results

- **Sizing and coefficient of friction specifications maintained at 0.45 kg/ tonne (0.9 lb/ton)**
- **Runnability improved due to elimination of rosin/alum size**
- **Cleaner wet end reduced holes in sheet**
- **Mill replacing incumbent dual sizing system**

FINE PAPER COMMERCIAL TRIALS

With the success in board and newsprint commercialization, we turned our attention to fine paper. It is clear that size development in most fine paper applications would require the presence of some internal size to facilitate sizing development at the size press. The two examples to follow illustrate the scope of this new technology in fine paper applications.

Case Study 3: Offset Printing Paper.

This mill produces several fine paper grades, including 74 g/m^2 offset. The primary objective of the trial was to reduce the amount of size being used at the wet end, replace their current surface size, and develop requisite sizing by the use of BAYSIZE TS at the size press while maintaining all grade test specifications. The machine is a Valmet Sym-Former with a Gate Roll size press (Figure 12). The trial was run for 12 hours with no runnability

Figure 12.

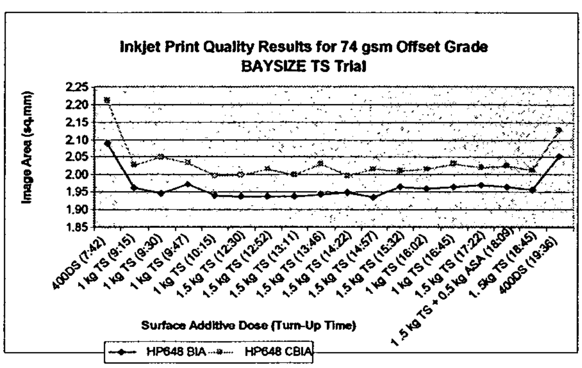
Background

Machine Configuration	**Valmet Sym-Former**
Production Rate	**16 tonnes/hr**
Machine Speed	**777 m/min**
Filler	**PCC & GCC**
Ash Content	**16 - 17%**
Internal Sizing Agent	**Baysize I 18**
Size Press Configuration	**Gate Roll**
Surface Size	**3.5% Basoplast 400 DS**

problems. The results from this trial are shown on Graphs 10 and 11 and Figure 13. In Graph 10 is shown the ink jet print quality as measured by image analysis where smaller letter area defines improved print quality. As the graph indicates, the letter area improves with the elimination of the incumbent SAE resin and with increasing dose

Graph 10.

Case Study 3: Fine Paper
Ink Jet Print Quality - 74 g/m^2 Offset



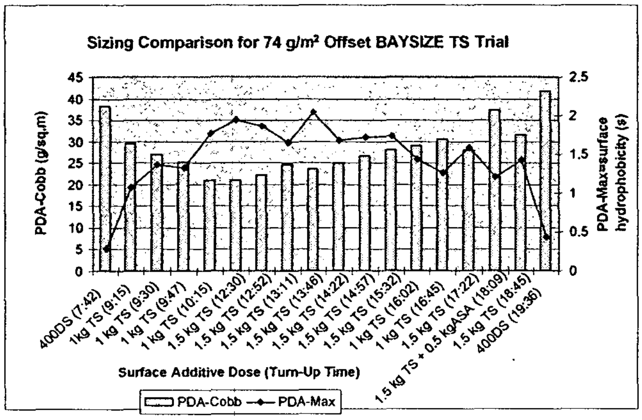
Lower values indicate better inkjet print quality
(BIA=Black Image Analysis, CBIA=Color Bleed Image Analysis)
0.65 kg/ton of ASA internal size

of BAYSIZE TS size at the size press while the internal size is reduced to 0.5 kg/tonne. Graph 11 shows the sizing results reported in terms of ultrasonic measurements. These results show a similar response as illustrated in

Graph 11

Case Study 3: Fine Paper
PDA Sizing Results for 74 g/m² Offset

PDA Sizing Results for 74 g/m² Offset BAYSIZE TS Trial

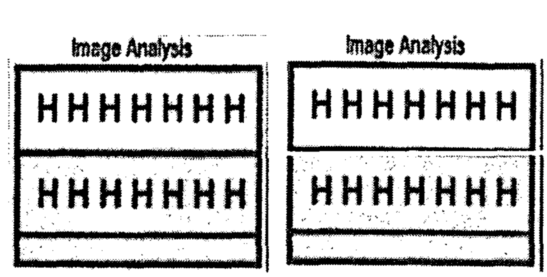


Higher values indicate higher PDA-Max sizing (surface hydrophobicity)
Lower values indicate higher PDA-Cobb sizing (bulk hydrophobicity)
0.65 kg/ton of ASA internal size

Graph 10. The PDA Cobb values show improvement when BAYSIZE TS size replaces the incumbent surface treatment program. The PDA MAX value demonstrates the hydrophobic character at the surface of the sheet, with higher values indicating increased hydrophobicity. Note the low surface hydrophobicity when the SAE resin is used. Finally, print quality in ink jet printing was directly measured and is shown in Figure 13. The BAYSIZE TS

Figure 13.

Case Study 3: Fine Paper
Ink Jet Print Quality - 74 g/ m² Offset



Baseline Condition
Turn-up = 7:42

1 kg/ ton BAYSIZE TS
Turn-up = 9:47

size program shows less feathering and a sharper image than with the baseline system. The post-trial analysis is shown in Figure 14. Machine runnability with this program was excellent, all sizing specifications were met with reduced use of internal size. Print quality improved in a number of different tests. Further trial work is pending.

Case Study 3: Fine Paper (74 g/m^2 Offset) Trial Results

- **BAYSIZE TS provided good runnability and machine cleanliness**
- **Sizing specifications were met**
- **Paper produced had improved ink jet printability**
- **Further trials pending**

Figure 14.

Case Study 4: Laser Copy Paper

This mill produces several grades of laser copy paper. The machine conditions are listed in Figure 15. On this top wire former, a SymSizer is used for surface treatment. Trial objective was to improve optical density over that

Figure 15.

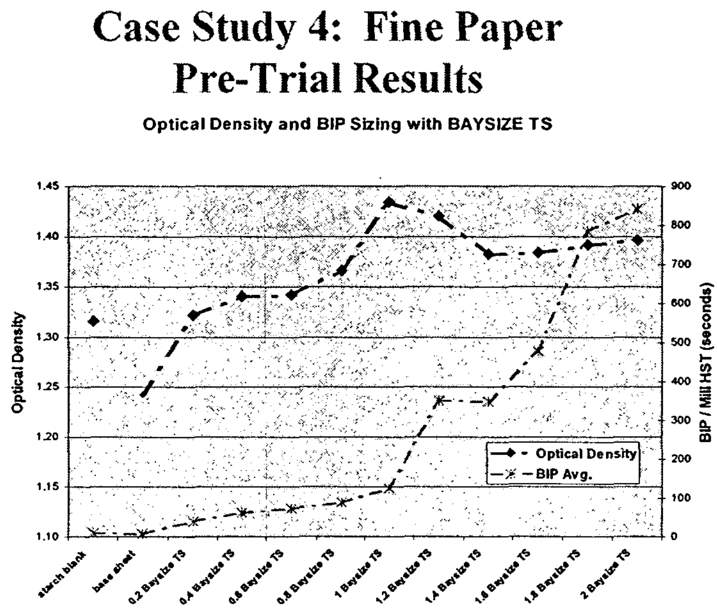
Case Study 4

Background

Machine:	**Valmet Top Wire Former**
Production:	**433 tonnes/day**
Wet-End Additives:	**BAYSIZE I 18 (0.8 kg/tonne)**
	Pencat 700 starch (with BAYSIZE I 18)
	Alum (0.5 kg/tonne)
	Dyes, OBA
	PCC - 19% ash
Size Press:	**Surface Size - *Chromaset 800 (0.7 - 0.8 kg/tonnes)***

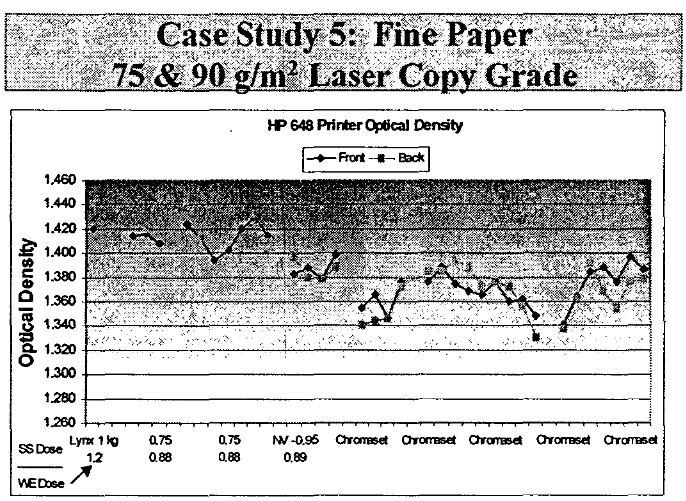
of the incumbent sizing system. Pre-trial lab work with mill furnish is shown in Graph 12. Ink penetration sizing
increased with increasing BAYSIZE TS dose with a corresponding increase in optical density.

Graph 12.



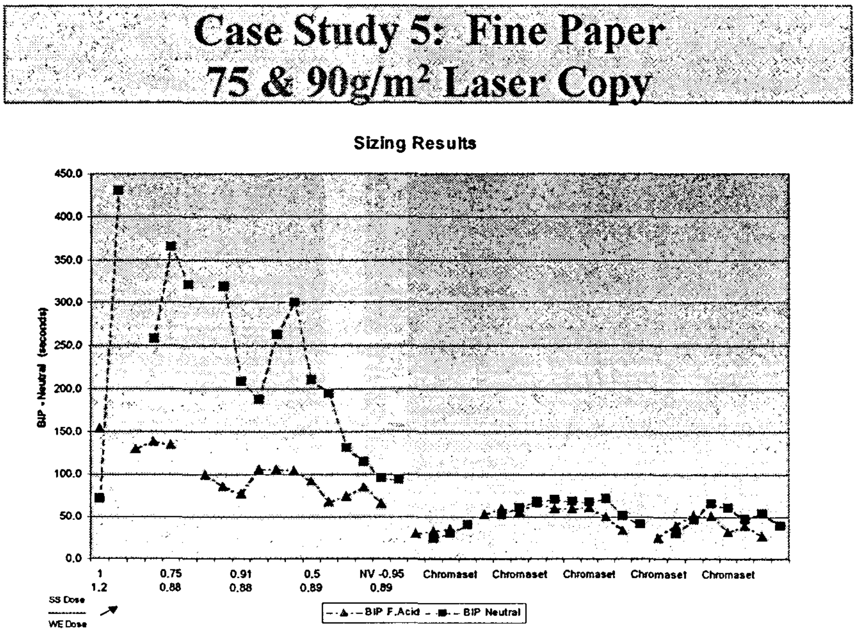
Optical density results from the trial are shown in Graph 13. Highest optical densities were achieved with BAYSIZE TS size being added at the SymSizer and BAYSIZE I 18 size being used at the wet end. A number of different ratios of internal and surface size were investigated for BAYSIZE TS size, the incumbent surface size, and another competitive surface size. In all cases, the highest optical density was achieved with the BAYSIZE TS size

Graph 13.



program, at 30-40% reduced dose over the incumbent surface treatment system. Sizing results from the trial work are shown in Graph 14. High HST values were achieved with BAYSIZE TS added at the size press while the

Graph 14



standard 1.2 kg/ton of internal size added at the wet end. Sizing specifications were met with much reduced doses of surface size. Trial review (Figure 16) shows that optical density target was met with 0.5 kg/ton of BAYSIZE TS,

Figure 16.

Case Study 4: Trial Summary

- **Optical Density achieved at Baysize TS dosage of 0.5 kg/ton**
- **Optical Density of 1.4 +/- 0.3 was maintained during the trial (15 reels)** ***mill not able to achieve this target with incumbent sizing system or during previous trials***
- **About 50 - 75 seconds higher HST vs. incumbent system**
- **Follow-up trial pending**

with higher doses leading to higher optical densities than could be achieved previously. HST sizing was 50-75 seconds higher than with the incumbent sizing system. Follow-up trial is pending.

CONCLUSIONS

The implementation of this new sizing system, providing total sizing at the size press, will give the papermaker opportunities to see significant improvement in mill operations. The increased sizing efficiency will lead to lower sizing costs at the very least (Figure 17). Reduction in sizing use should also provide lower chemical costs, reducing the need for chemical scavengers and promoters. Accordingly, elimination of starch and alum in the wet end will increase drainage, yielding increased production rates and higher profitability.

Figure 17.

Cost Reduction Benefits

- **Increased sizing efficiency**
- **Lower overall chemical cost**
  - **Scavengers**
  - **Promoters**
  - **Strength aids**
  - **Emulsification agents**
- **Higher production rates may be realized**
- **Increased white water closure potential**

Application of the size at the size press will give a more efficient sizing system, reducing the size dose requirements (Figure 18). More of the size is retained at the size press than is possible at the wet end. Influence of desizing agents like some of the commonly used defoamers, is now minimized or eliminated. The same is true of pulp mill chemical carry over, many elements of which are deleterious to wet-end size development. In recycle furnishes

Figure 18.

Efficiency Benefits

- **Reduced size dosage requirements**
- **Increased size retention**
- **Wet-end size interactions eliminated**
    - **Desizing agents**
    - **pulp/bleach mill carryover**
- **Reduced sizing variability due to furnish quality**
- **Improved wet-end chemical usage**
    - **Scavengers**
    - **Promoters**
    - **Strength aids**

where the composition of the pulp varies from batch to batch, applying the total sizing system at the size press eliminates the influence of this variable on size development, hence, a more reliable sizing system is provided.

Application of the new sizing system at the size press demonstrates critical compatibility with a wide variety of size press conditions (Figure 19). Anionic, nonionic and amphoteric starches can be used. Starch source can be corn, potato, tapioca, and wheat. Furthermore, starches can be pearl, oxidized, ethylated or enzyme converted. Other work also shows that blade metering size presses can be used as well.

Figure 19.

Versatility Benefits

- **Compatibility with a wide range of size press starches**
    - **Type**
        - **anionic, nonionic, amphoteric, corn, potato, tapioca, wheat and pearl**
    - **Modified**
        - **oxidized, ethylated, enzyme converted**
- **Application in variety of size presses**

The above work summarizes this new approach in achieving more total sizing at the size press. This system consists of new, formulated chemistry with simplified equipment requirements. The benefits summarized above show the potential that this new sizing system can provide to today's papermaker, in an economic environment where cost improvements are necessary to remain competitive.

REFERENCES

1. For detailed discussions of these topics see the following texts and references cited therein:

   The Sizing of Paper, Second Ed., W. Reynolds, Editor, TAPPI, 1971
   Papermaking Chemistry, L. Neimo, Editor, Fapet Oy, 1999
   Paper Chemistry, J. C. Roberts, Editor, Chapman and Hall, 1991

ACKNOWLEDGEMENTS

This paper could not be written without the effort of a number of dedicated colleagues. Included among these are Dr. David Dauplaise, Mr. Michael Scanlon, Mr. Duane Mayeda, Mr. Ray Magboo, Mr. Ivan Vazquez, and the Paper Colorants and Chemicals Marketing and Sales Teams.