

Using a formation analyzer to evaluate the performance of additives used in the wet-laid process

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A commercial formation analyzer can be reliably used for screening dispersants and viscosity modifiers used in the wet-laid process. However, the technique does have its drawbacks.

The use of digital image analysis to evaluate changes in formation has become fairly well established in the paper industry. Formation is also a very important property in the production of wet-laid nonwoven webs. However, formation is still evaluated subjectively in many applications. This evaluation is satisfactory in many cases, but a quantitative evaluation offers the advantage of removing subjective judgments from evaluations. To be useful, a quantitative method must correlate well with the conventional visual method of judging formation.

In addition, to be useful the measurement technique must be consistent and not excessively time-intensive. For this reason, a commercial formation analyzer designed for use in the paper industry was evaluated to determine its usefulness for wet-laid nonwoven webs. The theory of the use of digital image analysis for formation measurement is outlined in the literature from manufacturers of this equipment (1). The instrument employed in this study was the Paperlab-1 Formation Analyzer from Kajaani Automation. This instrument uses optical light transmission as a basis for calculation of a formation index.

In some ways, formation analysis of wet-laid nonwoven webs is more demanding than formation analysis of conventional paper. In particular, the nature of the defects or nonuniformities in a wet-laid web are different from those encountered in conventional paper. In general, with conventional paper the fiber source is fairly uniform, and formation is often determined by the degree of flocculation of the fibers. The degree of flocculation is influenced by mechanical factors and chemical additions used to enhance retention and drainage on the machine.

Synthetic fibers are often hydrophobic, and poor formation can result from poor dispersion of the fibers in water. In addition, use of very long fibers (up to 1 in.) can result in the formation of "strings" of fibers that have initially been well-dispersed but reaggregate into large sheet defects.

Chemical additives are often used to help improve forma-

tion when synthetic fibers are used. These additives are generally divided into two classes of chemicals: dispersants and viscosity modifiers (sometimes referred to as "formation aids"). Dispersants are generally low-molecular-weight materials used to aid in the wetting and subsequent dispersion of hydrophobic fibers in water. Viscosity modifiers are used to alter the rheology of the fiber and water system and to help prevent the formation of "strings" of long fibers (2).

Handsheet methods have been developed to simulate formation defects found in machine-produced webs (3). These handsheet methods have been shown to correlate well with results obtained on pilot and production machines. The methods can be used to evaluate the performance of dispersants and viscosity modifiers separately or when used in combination.

For product development, quantitative evaluation of formation can be very helpful in screening possible new products for performance. A meaningful quantitative evaluation can help to remove the guesswork involved in testing possible products that are close to each other in performance. Dosage profiles of candidate materials can be performed to obtain better data for product development decisions.

In the experimental section of this paper, use of the formation analyzer on sheets formed using various combinations of wood pulp and synthetic fiber will be discussed. Use of the formation analyzer to demonstrate dosage effects of dispersants and viscosity modifiers will be demonstrated.

In addition, some possible limitations on the use of digital image analysis for wet-laid nonwovens will be explored. The effect of using two different types of fiber at varying percentages was explored, along with the effect of basis weight within a particular furnish composition.

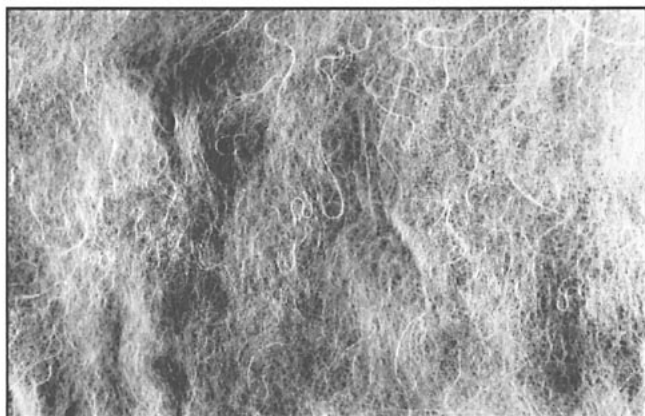
Experimental

Evaluation of dispersant performance

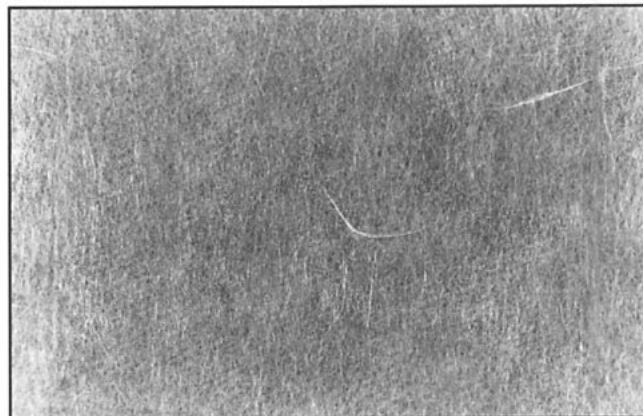
For product development purposes, a series of handsheets were made in the lab. These sheets were made using a 100% 1/4-in. x 1.5-DPF (denier per fiber) polyester furnish. Use of 1/4-in. fibers enables the testing of candidate products for dis-

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5. Pilot machine sheet made with no viscosity modifier



6. Pilot machine sheet made with 200-ppm viscosity modifier



persing polyester fibers without the complication of stringing when longer fibers are used.

A dosage profile was run using two different laboratory synthesized polyester dispersants. These materials are low-molecular-weight copolymers which contain hydrophobic and hydrophilic segments. The two materials tested contained hydrophilic segments of different lengths. Results of the formation testing are summarized in **Table I**.

A higher formation index indicates better formation. In **Figs. 1 and 2**, examples of handsheets made using no dispersant (blank) and 10 lb/ton of polyester dispersant are shown. The difference in formation between the blank and high-dose samples is readily apparent. At lower dispersant doses, improvement in formation could be seen visually but was not as obvious. For either dispersant, the handsheets could be ranked in order of better formation with increasing dispersant dose. However, performance differences between the two dispersants could not be discriminated visually.

However, use of the formation analyzer did allow slight differences in performance of the two dispersants to be discriminated. At every dose, performance of dispersant no. 2 was slightly better than dispersant no. 1. Thus, use of the formation analyzer gave information for further product development work that was difficult or impossible to obtain by subjective visual evaluation.

Evaluation of viscosity modifier performance

A series of handsheets was made with longer polyester fibers to determine if performance of a viscosity modifier could be demonstrated using the formation analyzer. Sheets were made from a combination of 80% 1/2-in. x 1.5-DPF polyester and 20% softwood kraft pulp. A longer mix time was used to evaluate stringing tendencies of the longer synthetic fibers.

A standard polyester dispersant was used at 100 ppm for all of the sheets. A dosage profile of a high-molecular-weight, anionic viscosity modifier was performed to assess its effect on formation of handsheets. Results are shown in **Table II**.

In **Figs. 3 and 4**, handsheets made using no viscosity modifier and 250-ppm viscosity modifier are shown. The difference in formation is obvious, especially in the development of strings of intertwined fibers. For the handsheet dosage series, the correlation between visual formation evaluation

V. Variation in fiber composition

Polyester, %	Wood pulp, %	Formation index
100	0	88.7
80	20	83.1
60	40	80.6
40	60	75.8
20	80	74.1
0	100	60.2

and the measured formation index was very good.

Nonwoven webs produced on an inclined-wire pilot machine were also evaluated using the formation analyzer. These webs were produced from a 100% 3/4-in. x 1.5-DPF polyester furnish. A standard polyester dispersant (100 ppm) was used for both runs. The same anionic, high-molecular-weight material used for the previous series of handsheets was used as a formation aid (**Table III**).

In **Figs. 5 and 6**, samples made using no viscosity modifier and 200-ppm viscosity modifier are shown. The visual difference in stringing tendency and in overall uniformity of the sheets is obvious. This difference was reflected in a large difference in the measured formation indices.

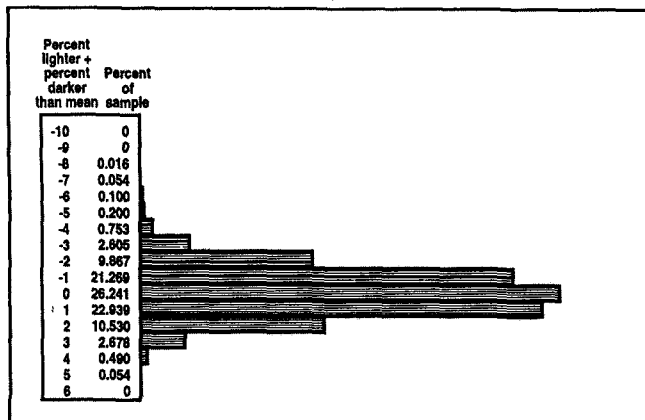
In addition, it is generally accepted that machine-made nonwoven sheets have better formation at a given chemical dose than handsheets. This difference is shown in the higher formation index obtained from the machine-made sheet than that obtained from any of the handsheets.

Basis weight effects

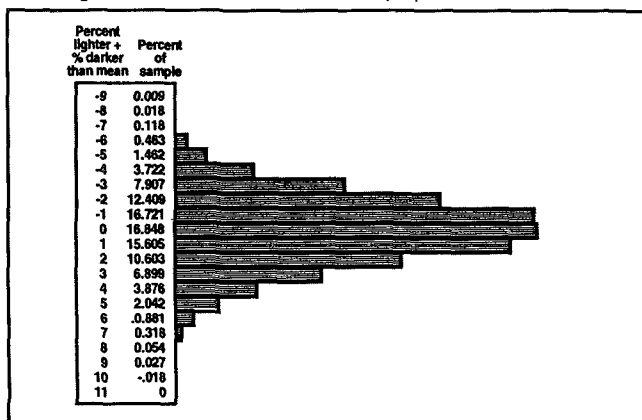
Based on these results, the formation analyzer showed promise as a useful tool in evaluating the performance of chemical additions used in the wet-laid process. The next step was to determine what effect variances in furnish composition and basis weight would have on the measured formation index. Unwanted effects on the measured formation index could impose some limitations on use of the formation analyzer as a research quality-control tool.

A series of handsheets was made using a furnish consisting

7. Histogram obtained from 100% polyester handsheet



8. Histogram obtained from 100% wood pulp handsheet



of 80% softwood kraft pulp and 20% 1/2-in. x 1.5-DPF polyester fiber. Polyester dispersant and viscosity modifier were added to assure good dispersion of the polyester fibers. The basis weight of the sheets was varied to determine the effect on the measured formation index (Table IV).

Despite the fact that these basis weights were varied over a wide range, this data indicates a possible limitation of the use of the formation analyzer. Ideally, differences in basis weight would not affect the measured formation index. In general, an increase in basis weight results in a more uniform perceived formation because areas of the sheet that are lighter in weight than the norm still contain enough mass to block transmitted light. However, for this series of sheets, the surprising result was a decrease in the measured formation with an increase in basis weight. Therefore, in this case, the measured formation index did not correlate well with the standard visual evaluation of formation.

Effect of varying fiber composition

A series of handsheets was made using a furnish consisting of combinations of softwood kraft pulp and 1/2-in. x 1.5-DPF polyester fibers at varying percentages (Table V). Total basis weight for the sheets was held constant. Dispersant and viscosity modifier were added to aid in dispersion of the polyester fibers.

These data indicate a possible limitation on the use of the formation analyzer. Use of the two different types of fiber results in different types of defects in the sheet. With a high percentage of long polyester fibers, the overall uniformity of the sheets was quite good, but some stringing defects still detracted from a visual formation evaluation. As the percentage of wood pulp was increased, fewer large stringing defects were seen in the sheets, but the overall uniformity was not as good due to small flocs formed by the wood pulp fibers.

In Figs. 7 and 8, histograms obtained from the 100% wood pulp sheets are shown. These histograms and the formation indices from the handsheet series show that detrimental effects to the formation measurement were dominated by the effect of the small flocs formed by the wood pulp fiber.

In this case, the correlation between a visual formation evaluation and the measured formation index was not as good. The effect of the small wood pulp flocs dominated the

formation measurement, but the defects produced by the longer polyester fibers contributed to poor perceived formation.

Conclusions

In this paper, automated digital image analysis has been evaluated as a tool for formation measurements on wet-laid nonwoven webs. With fiber composition and basis weight held constant, correlation between the measured formation index and visual evaluation was quite good. This makes the technique very useful for screening of performance of dispersants and viscosity modifiers used in the wet-laid process.

Some possible limitations on the use of the formation analyzer were also demonstrated. Variations in basis weight and fiber composition can result in cases where the correlation between visual evaluation and the measured formation is not as good. □

Literature cited

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