GLASS MICROFIBERS IN CELLULOSE PULP ENHANCEMENT

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Abstract

Evanite glass fibers produced by Rotary, Flame Blown and CAT processes, have been used commercially in the specialty nonwoven industry for many years. They were first developed as a substitute for wood pulp used specifically for the manufacture of batter separators. In more recent times, Evanite glass fibers have been extensively used for high efficiency filtration media, and as cellulose pulp enhancement to improve various physical properties of the sheet, especially pore size for liquid filtration and dimensional stability for special grades of papers.

Introduction

Evanite® glass fibers, produced by Rotary, Flame Attenuated and CAT processes, have been used commercially in the specialty paper industry for many years. They were first developed as a substitute for wood pulp used specifically for the manufacture of battery separators. In more recent times, Evanite® glass fiber has been used extensively for high efficiency air (HEPA filters) filtration media, and as a cellulose pulp enhancement to improve various physical properties of the sheet, especially pore size for liquid filtration.

Glass fiber wool is distinguished from chopped textile type glass fiber, or as it is more commonly referred to as "chopped strand", by a distribution of fiber lengths rather than a specified length chopped to rather close limits. Depending on the diameter of the fiber produced, Evanite® fiber may have a diameter to length ratio ranging from 1/500 to 1/4000. Unlike fiber length, fiber diameter is somewhat more precisely controlled during the manufacturing process. Furthermore, Evanite® glass fibers do not have surface treatments/sizing and will not absorb significant moisture under normal operating conditions. They are relatively easy to disperse, have a soft or cotton-like feel and are generally found to be non-irritating to the skin. Evanite® glass fibers are offered to the industry in a wide range of grades from 0.2 to 8.5 microns average fiber diameter. (Table III)

Fiber Manufacturing Process

Evanite® glass fibers are produced using a standard borosilicate glass produced in-house from mined materials using a specially formulated composition depending on end use. Each formulation is comprised of various combinations of raw materials which are introduced into the glass furnace. (Table 1. Typical Raw Materials)

Following the melting and glass conditioning, the glass stream passes through the electrically controlled special material bushing which regulates the flow into the rotary spinner or fiberizer. Primary glass fibers are forced through the perforations along the spinner rim and are immediately attenuated downward by a blast of hot gas in the rotary process. Glass primaries are blasted with a high temperature gas and air mixture to fiberize for flame attenuated products. The resulting fibers are collected on a moving screen under partial vacuum. The fibers are then conveyed to a baling system to compact the fiber into a uniform weight and packaged at an optimum density to minimize fiber damage. The fiber is then placed in a plastic or pulpable paper wrapper.

Fiber Properties

Reliable test methods to determine the average fiber diameter of glass fiber wool, particularly with the finer diameter grades is a fairly complex matter. The best technically available instrument today to measure actual fiber diameter is the scanning electron microscope (SEM). This technique however, is very time consuming and cost intensive, limiting the practicality of using the SEM. Thus, several correlation methods, like air resistance or specific surface area determination, are employed which may be used with a fair degree of confidence. In all cases, the grade standards are established by correlation with SEM or other performance related criteria as established by the user. The fiber evaluation methods (Table II) are used to control the manufacturing process, monitor diameter and confirm the proper grading of the glass fiber wool.

Grading of fiber is based on the determination of the materials average fiber diameter. While the fact remains that a distribution of fiber diameters exists within a grade, the range of this distribution can be controlled and has been determined to be a distinct quality factor. Table III contains a list of grades available for use which will be referenced in subsequent discussion.

Fiber Handling and Sheet Forming Characteristics

Evanite® glass fibers disperse with minimal energy and every attempt should be made to disperse with care. Layers of fiber, or the entire bale, can be added to the pulper for wet laid applications. Refining of glass fibers should be avoided in all instances. Optimum dispersion is obtained at water temperatures of 50° - 90°F and pH at 2.5 - 3.5. However, the fiber can be easily dispersed at a near-neutral pH and ambient water temperatures. The pulping should be adjusted to prevent fiber damage caused by excessive shear.

Due to its exceptionally good rate of dispersion it is recommended that total pulping energy input be kept minimal compared to what is normally used with cellulose fibers.

Fiber can also be added downstream of the machine chest (fan pump or stock chest), or in the case of partial glass furnishes from a separate tank used strictly for glass fiber. The slurry should pass through a minimum number of pumping operations to avoid fiber damage.

Fiber consistency has been found to play a key role in the resulting physical properties of the sheet. A reduction of pulp consistency in the pulper to less than 1.0% and 0.05 - 0.10% at the headbox while using 100% glass fiber has been shown to be favorable to sheet characteristics.

As an example of improvements to cellulose sheets made possible through partial substitution of glass fibers, the following relationships are shown. The data (Table IV) were generated from binder-free laboratory handsheets using Evanite® 411 glass fiber (3µ) substitutions up to 10% of bleached sulfite pulp. The pulp was beaten to a Canadian Standard Freeness of 300 ml and the handsheets were prepared to a basis weight of 70 gsm.

In a separate study OCC pulp was used in combination with Evanite® grade 716 fiber (5.2µ average diameter) and laboratory handsheets were made. Properties like air porosity, tensile, drainage time, bursting strength, Elmendorf tear and shrinkage on drying were tested. It seems addition of approximately 3% of 716 fibers to OCC pulp can reduce drainage time, enhance air permeability and reduce shrinkage on drying significantly without any adverse impact on physical strength properties.

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Table 1. Typical Raw Materials.

Materials	Chemical Compounds
Silica Sands	SiO_2
Feldspar	$R_2O \bullet Al_2O_3 \bullet 6SiO_2$
Soda Ash	Na_2CO_3
Borax	$Na_2B_4O \bullet 5H_2O$
Dolomite	$CaCO_3 \bullet MgCO_3$
Limestone	$CaCO_3$
Barium Carbonate	$BaCO_3$
Zinc Oxide	ZnO
Other Minor Components	

Table II. Fiber Evaluation Methods

	Tests
Micronaire	Air Resistance of fiber plug
Frazier Air Permeability	Air flow through handsheet
Frazier Air Resistance	Pressure drop across lab handsheet
Scanning Electron Microscope	Actual observation and manual measurement
B.E.T. Specific Surface Area	Rare gas adsorption on fiber surface
Shot Determination	Sedimentation of non-fibrous material
Tensile Strength	Tensile strength of handsheet
Acid Resistance	Weight Loss

Table III. Fiber Grades.

Grade	Nominal Fiber Diameter (microns)
701	0.2
702	0.3
703	0.4
404	0.5
504	0.5
604	0.5
704	0.5
406	0.6
506	0.6
606	0.6
706	0.6
408	0.8
608	0.8
708	0.8
509	1.6
510	2.3
610	2.6
710	2.6
411	3.0
612	3.7
712	3.9
413	4.3
716	5.2
717	6.1
719	8.5

Table IV. Bleached Sulfite Pulp – 411 Glass Fibers.

	% Glass				
Property	0	2	4	6	10
Fold Endurance (D Fold)	167	160	154	111	82
Dry Strength Tensile (lbs/I)	14.2	13.3	13.0	12.2	10.2
Wet Tensile (lbs/I)	5.0	4.1	4.1	3.9	3.2
Elmendorf Tear (gF)	67	64	71	77	71
Air Porosity–Gurley (sec/250cc)	35	23	11	8	5

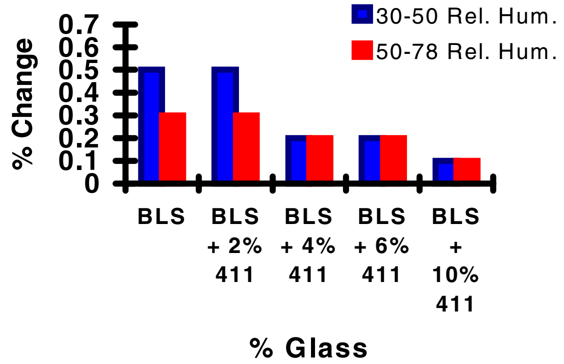

Figure 1. Dimensional Stability.

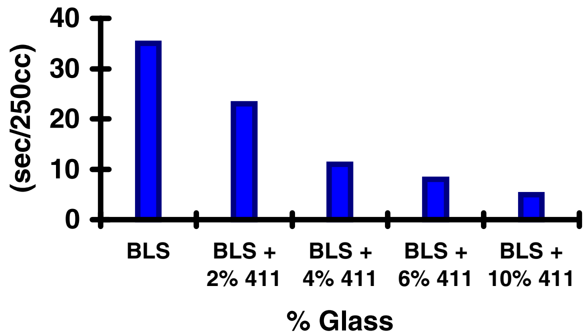

Figure 2. Air Porosity – Gurley.

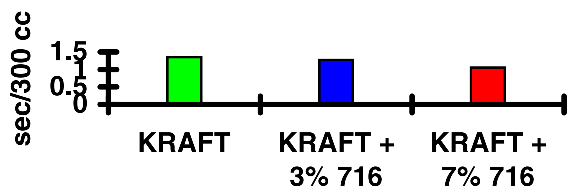

Figure 3. Air Porosity (Gurley).

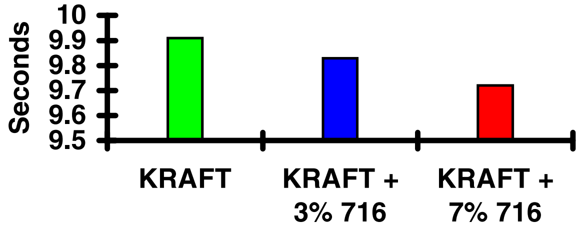

Figure 4. Drainage Time.

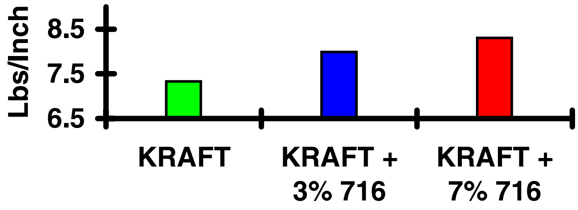

Figure 5. Dry Tensile.

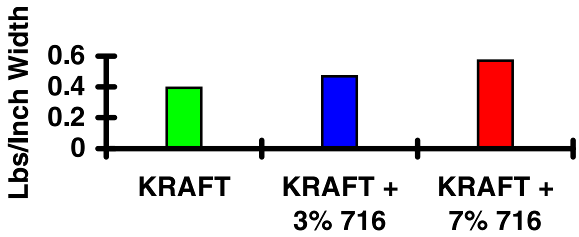

Figure 6. Wet Tensile.

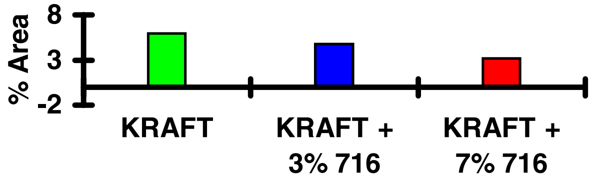

Figure 7. Shrinkage on Drying.

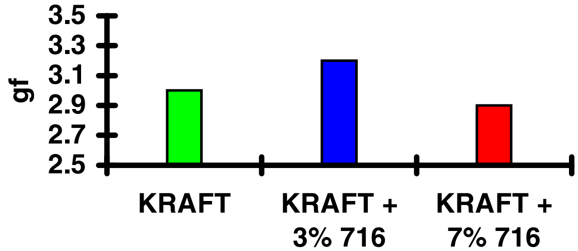

Figure 8. Elemendorf Tear.

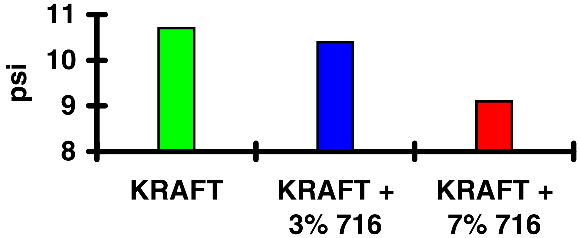

Figure 9. Bursting Strength.