Comparison of Beater Additives with Gelatinized Sulphite on Strength of Kraft Handsheets

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COMPARISON OF BEATER ADDITIVES WITH GELATINIZED SULPHITE ON STRENGTH OF KRAFT HANSDHEETS.

Submitted to Dr. John Fanselow in partial fulfillment of the requirements for a senior project in the curriculum of Pulp and Paper Technology at Western Michigan University

by

Ronald T. Gielczyk

June 1, 1959

Kalamazoo, Michigan
A literature survey shows that a great deal of work has been done on beater additives. It also showed that there is little or no agreement among workers in this field.

Laboratory work was carried out comparing blends of pulp made up of a sulphite pulp beaten to a "gelatinized" mass and a kraft pulp beaten to two different freeness levels with the same kraft pulps to which guar gum and oxidized potato starch had been added. Results show that guar gum is the best strength developer when both mullen and tear are considered.
Objective

The objective of this study was to compare the effectiveness of "gelatinized" sulphite with beater additives, such as potato starch and mannogalactan gum, on the development of strength characteristics in hand sheets of long fiber kraft pulp.

Literature Survey

Many substances have been proposed for beater or headbox addition for increasing the strength of paper. The claims for these adhesives are many and varied. Primarily, however, they are said to reduce refining time and allow the use of a high concentration of cheap fillers or weak short fibered pulps and still enable one to produce a high quality paper. The actual use of these additives is often quite difficult and expensive. Difficulties in use of the additives often occur, such as an excess of additive building up in the white water which sometimes causes plugging of both wire and felts.

Before considering any additive, it may be well to review the mechanism of bonding within a pulp sheet. The action by which pulp strength development proceeds is generally believed to be physiochemical or colloidal in nature and involves the concept of fiber-to-fiber bonding (1). Many theories have been advanced, and there is little if any general agreement among workers in this field.

Campbell's theory for the formation of fiber-to-fiber bonding is based on the drawing together of fibers by the forces of surface tension as interfiber water is removed (2). The surface tension of the water brings the cellulose surfaces sufficiently close to allow their own "crystallizing" forces to act on each other and a bond is formed. In other words, forces
set up by surface tension cause shrinkage even to the point of introducing stresses in the solid particles and the forces that hold the compressed structure together after the liquid is evaporated. Von den Akker (3), in 1947, also did work which supported Campbell's theory.

Cottrall (4), Mark (5) and Landt and Rulon (6) consider free hydroxyl groups to be responsible for bonding by virtue of their great reactivity leading to union whenever they can come into ultimate contact.

Swanson (7) states that one of the most important aspects of paper-making is to prepare the fibrous materials in such form that intimate contact between fibers and fibrils can occur on a molecular scale. This is one of the primary reasons for beating and refining pulps. Campbell's theory (2) of the surface tension pulling the fibers together would be a factor in providing intimate contact between the fibers and fibrils.

The importance of hemicelluloses in improving the beating rate and the subsequent easier strength development of papermaking pulps has been shown by many workers among which should be mentioned Young and Rowland (8), Obermans (9), Ratiff (10), March (11), Wise (12) and Cottrall (13). Generally speaking, hemicellulose can be said to improve bonding by increasing both the rate and extent of swelling, which increases contact and polar bonding on a molecular scale.

Most of the aforementioned workers did their work by extracting hemicelluloses from a coniferous type of wood and then used the extracted hemicellulose as a beater additive. March (12) showed that the strength properties of aspen pulps increased with hemicellulose content up to a maximum of 26.5%. Haaglund (14) states that the quality of the hemicellulose is very important and that the hemicellulose fraction that contains six carbon
sugars (like mannose) will form the strongest fiber-to-fiber bonds.

In view of these theories on sheet formation let us consider the ways in which some beater additives effect the bonding and pulp sheet information. One of the most important recent studies in the field of polysaccharide beater adhesives is that of Leech (15). He investigated the reasons for increase in paper strength when locust bean gum is used as a beater additive. He proposed that the strength of paper depends upon four factors: the strength of fibers, the strength of fiber-to-fiber bonds, the number of bonds (bonded area), and the distribution of bonds as indicated by the fiber distribution or sheet formation. Thus, beater adhesives must increase the strength of paper by affecting one or more of these factors. He found that locust bean gum increased the bonding strength and as a result, 60% strength increase was observed.

Swanson (16) showed that the strength increase on pulp caused by guar gum is very close to the strength increase affected by locust bean gum. Rowland (17) showed that guar gum added in small amounts to kraft stock allows the simultaneous development of both burst and tear. In all types of paper production guar mucilage had a very favorable effect. Cushing (18) compared guar gum with starch and found that one pound of guar gum was equal to 5 to 10 pounds of starch.

Casey (19) contents that starch can be used in many cases for building internal strength in paper. He says that starch can do a much more effective job if it is used in the beater furnish rather than as starch applied to the surface. Casey obtained best results with starch when it was added after refining of the pulp.
Swanson (16) states that starch is used in papermaking for two principal reasons: (1) "to increase the strength properties such as bursting strength, folding endurance and (2) to supplement the beating operation."

Cushing (20) states that starch should be added at the wet-end of the paper machine for best control on the machine. He obtained best results by adding freshly cooked starch to pulp at 3.5% to 4% consistance before diluting to headbox consistency.

Richter (21) has done some work on blending an unbeaten pulp with a pulp that had been beaten to a gelatinous mass. The blends of unbeaten fibers with this gelatinous mass have many interesting aspects. Such blends upon being made into handsheets show a higher tear test and lower burst and fold endurance than can be gotten by beating the long fiber fraction to the same freeness. Richter postulated, "that on drying the bonding gel forms intermittent unions which, even though the points of bonding are relatively inelastic, allow the restrictive slippage of the long fiber component which is conducive to the irregular drag tear that favors high tear values."

Richter's data shows that in fiber plus gel blends, the source of the gel whether it be a strong kraft or a less tough sulphite, is of no great consequence when used in limited amounts (0-20% gelatinized pulp). Richter also states that such blends can be brought to higher strength level by slight beating of the long fiber fraction before blending.

After completing this literature survey, the author felt that a comparison of Richter's aforementioned gelatinous pulp and long fiber pulp blends with some of the currently used beater additives as to strength development of pulp would be of interest. A long fibered kraft pulp was
chosen to serve as the base pulp in this experiment. A Mitscherlich sulphite, an easy refining pulp, was chosen to be beaten to a gelatinous mass. Another part of this sulphite sample was beaten to a freeness of 100 ml Canadian standard freeness. This was done in order to determine what would be the effect on strength development of a blend of a kraft pulp with a 100 ml freeness sulphite pulp. Guar gum and oxidized potato starch were selected as beater additives because of their popularity in the paper industry.
Literature Cited


Experimental Design

I Procedure for Materials

A. A kraft pulp was beaten in the No. 3 Valley laboratory beater for five minutes with the weight (5500 grams) on. This pulp served as one of the base pulps in this experiment. It will be referred to as pulp A throughout the rest of this report.

Another sample of the aforementioned kraft was beaten for ten minutes in the No. 3 Valley beater. This was designated as pulp B.

B. A mitscherlich sulphite pulp was beaten in the No. 3 Valley laboratory beater for 40 minutes. The freeness of this sulphite pulp was 107 ml Canadian standard freeness. This will be referred to as pulp C.

Another part of the mitscherlich sulphite pulp was beaten in the No. 3 Valley beater for one hour and 45 minutes. This extended beating time developed a gelatinous mass which was beyond the range of the Canadian freeness tester. This pulp will be referred to as pulp D.

C. Seven grams of guar gum were dispersed in water by adding the gum slowly to the vortex in the water caused by a magnetic stirrer. This guar gum dispersion was then poured into a weighed metal beaker and diluted to 1% by weight. By means of a double boiler, the 1% guar gum was cooked for 45 minutes at 185°F. This guar gum dispersion was under constant agitation and also was kept covered to minimize vapor losses during cooking. After 45 minutes the guar gum suspension was again weighed and enough water was added to make up for the water lost due to vaporization. The guar gum suspension was then diluted to ½% consistence with cold water to stop any further cooking action.
D. The procedure 1-C was followed for oxidized potato starch except that the cooking time was 30 minutes at 185° F.

II Procedure for Making and Testing of Handsheets

A. 35 grams of O.D. kraft pulp A was placed in the TAPPI disintegrator for 250 revolutions. 130 ml of a 10% alum solution was added to control pH at 4.4 to 4.8 and the pulp was given another 250 revolutions in the TAPPI disintegrator. A three gram O.D. pulp sample was removed for the Canadian Standard Freeness tester. The remaining pulp was placed in the proportioning tank of the Noble and Wood. The handsheets were formed, pressed and dried on the Noble and Wood equipment.

All pulp blends were made up to equal 35 grams O.D. pulp and then added to the TAPPI disintegrator. The guar gum and oxidized potato starch were also added directly to 35 grams O.D. pulp prior to the placing of the pulp in the TAPPI disintegrator.

The handsheets were then conditioned at 50% relative humidity and 72° F. after conditioning, the handsheets were tested for mullen, tearing resistance and basis weight according to TAPPI standards.

B. The gelatinized sulphite pulp was blended with the kraft pulp in the following amounts, based on O.D. weight.

1. 2.5% gelatinized sulphite: 97.5% kraft pulp
2. 5.0% gelatinized sulphite: 95% kraft pulp
3. 10.0% gelatinized sulphite: 90% kraft pulp
4. 20.0% gelatinized sulphite: 80% kraft pulp

C. The sulphite pulp at 100 ml Canadian Standard Freeness was blended the same as II-B.

D. The guar gum was added to the kraft pulp in the following amounts based on O.D. kraft fiber weights.
D. (Cont'd.)

1. 0.25%
2. 0.5%
3. 1.0%
4. 2.0%
5. 4.0%

E. The oxidized potato starch was used in the following amounts based on O.D. kraft fiber weight.

1. 1.0%
2. 2.0%
3. 4.0%
4. 8.0%

Experimental Results

The results obtained in this experiment were interesting but unfortunately the reproducibility was not as good as one would desire. Freeness values of the various pulps were especially irregular.

For simplicity purposes, the kraft pulps will be referred to in this discussion as:

Kraft pulp beaten for five minutes - - - - pulp A
Kraft pulp beaten for ten minutes - - - - pulp B

Oxidized potato starch gave increases in mullen with increasing amounts of starch used. The highest burst factor obtained was 30.4 using 8% starch with pulp B. Pulp A gave a burst factor of 21.4 with 8% starch. Guar gum increased the mullen factor of pulp factor of pulp A from 9.2 to 34.6 when using 4% guar gum. Guar gum gave higher mullen factors for pulp B than were obtained from pulp A both using the same amounts of gum.

The 10% gelatinous sulphite - pulp A blend gave a mullen factor of 20.1. Upon using pulp B with the same type of blend (10% gelatinous sulphite) a mullen factor of 23.6 was obtained. The blends of pulp D and pulp A showed
a drop in mullen factor for the range 2.5% to 10% pulp D fraction (fig. 5). The duplicate run was quite similar in slope (fig. 13). Blends using pulp B (fig. 5) were also low, for example, the maximum increase in mullen factor was from 15.7 to 19.7 when using 10% pulp D.

Tear factors obtained using oxidized potato starch and pulp A (fig. 2) increased with increasing amounts of starch. Using pulp B the tear factor (fig. 4) was highest (205) for the 1% addition of starch and then became lower for the increasing amounts of starch. Guar gum affected the tear factor of both pulp A and pulp B in the same manner as the oxidized potato starch. However, 1% guar gum gave a tear factor of 225 while 4% starch gave a 221 tear factor.

The gelatinous sulphite blends gave a tear factor with pulp A which reached a peak (fig. 6) when a 10% gelatinized sulphite fraction was used. Increasing this fraction of gelatinized sulphite to 20% resulted in a lowering of the tear factor. The tear factor of the blends using pulp B reached a peak at the lower fractions of the gelatinized sulphite and then dropped as the fraction was increased (fig. 8). The tear factors obtained with the blends of pulp A and pulp D decrease from 163 to the range 135-140 for the 2.5% to 10% pulp D fractions (fig. 6). These tear factors were unexpected but the duplicate run supports this observation. Pulp B when blended with pulp D showed a maximum increase in tear to 219 with a 2.5% pulp D fraction. Increasing the pulp D fraction resulted in a drop in tearing strength.

Thus, it is apparent from results shown both here and in the appendix, that refining a pulp slightly more under the conditions of this experiment improved the maximum mullen obtained. It also allowed maximum tear strength
development with lower amounts of additives or lower fractions of short fiber blends.

Freeness values obtained were quite irregular and exhibited very poor reproducibility. The additives, oxidized potato starch and guar gum gave high freeness values and even when using 4% guar gum or 8% starch did not drop below 580 ml Canadian standard freeness. The pulp blends of pulp C had freeness of 250-300 ml C.S.F. with the 10% and 20% pulp C fractions. The pulp D and pulp A blends gave freeness values that did not go below 500 ml C.S.F. with any of the fractions tested.

In comparing the results from the different additives used and various pulp blends, specific reference will be to the following amounts: 4% oxidized potato starch, 2% guar gum, 10% pulp C fraction and 10% pulp D fraction. The comparisons will be based on the changes in strength that occurred when using pulp A.

Guar gum, oxidized potato starch the blend of pulp A and pulp C raised tear values from 163 to the range 220 to 230. The blend of pulp A and pulp D gave a value of 140 which was a decrease from the pulp A value of 163.

Guar gum gave the highest mullen values which were 24.5. Starch and the blend of pulps A and C gave mullen values in the range 18 to 20. The blend of pulp A and pulp D gave a mullen factor of 9.5. The pulp A had a mullen factor of 9.2. Thus from the comparison of these specific amounts of the additives and blends, guar gum is the best strength developer when both mullen and tear are considered.

Conclusion

Due to the poor reproducibility of this experiment, no conclusions are warranted by the results of this experiment.
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