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The Separation of Cotton and Polyester in Rags

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THE SEPARATION OF COTTON AND POLYESTER IN RAGS

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ABSTRACT

The purpose of this thesis was to discover if there was a way to remove or destroy the polyester from rags and leave the cotton in a form which is beneficial to the paper industry. An attempt was made to break up the rags, remove the polyester and evaluate the remaining cotton. The tests were attempted on a fibrous combination of cotton and polyester.

The general trend found that the chemical treatments to the rags from the textile mills gave additional problems and should be investigated.

TABLE OF CONTENTS

INTRODUCTION

Putting waste rags back into fine paper mills was the intention of this study. When synthetics were developed and added to clothing, it gave paper mills many problems. Synthetics give "shiners", which are very glossy spots on paper that has a high finish,[51] and although cotton gives very strong paper, synthetic materials, after they are removed from rags and processed in a paper mill, are so short that they make very weak paper. In papermaking, synthetics usually cause more problems than they solve.[28]

Very strong paper can be made from long synthetic fibers if a bonding agent is used. Synthetic materials are extruded as filament and processed as long strands, yet they do not fibrillate. Therefore, they have very little bonding strength.[55]

Many mills are now using cotton linters instead of cotton fibers due to the high cost of the long cotton fibers which are used in the textile industry. Linters are merely shorter than cotton fibers; therefore, they do not give as much strength or durability but still make a very good sheet of paper. Linters are actually considered second cut cotton fibers.[30]

A few mills actually break up rags which contain cotton and polyester in order to use the cotton in papermaking.[9] These processes are not widely known; therefore, many mills reported the breaking up of cotton and polyester to be impractical, if not impossible, to do. The intention of this study was to evaluate the possible ways of separating cotton from polyester and determine if any of these practices were practical or feasible.

The overall objective was to either destroy or remove the polyester and leave the cotton as unharmed as possible. The long range objective would be to evaluate the findings and investigate the possibilities of

putting these findings to use in a mill. Thus, the economical feasibility and the safety hazards would have to be investigated in the future if a feasible method was discovered.

BACKGROUND

Before the mid-1900's, all paper in the United States was made from cotton fibers. There was no other source of fiber that could provide as good and/or as durable a sheet of paper. Then in the 1900's, there was a frantic search for a replacement, due not only to a rapidly growing population, increased literacy and a democratic society which immensely increased the demand for paper,[38] but also to the development and use of synthetic fibers in the textile industry. In 1910, viscose rayon was the first synthetic to be developed.[1]

In approximately 1800, work was first begun to uncover a substitute pulp on both sides of the Atlantic. It was 1860 before a usable solution was developed. Prior to this time, the wood pulp consisted of chemical pulp mixed with rags, but this was too costly to investigate on a larger level.[38]

Also, in 1949, the textile industry developed permanent press and thus added drip-dry melamines to the rags which ruined the pulper loads for the paper industry. With the synthetics, color fast dyes and chemical additions, most mills could not handle rags and thus many of them turned to linter pulp. Linters are purchased directly from the cotton seed oil mill or linter suppliers, so mills were relatively sure of no problem causing additives.[36]

There is very little printed material on the subject of separation of cotton and polyester, so a literature search was conducted. This search consisted mainly of writing letters to companies and individuals, or talking with industry people who had dealt with cotton based papers. Approximately 50 of the people that responded to the letters said there was no feasible method; therefore, they were either out of the business or using linter pulp. Linter pulp is made from the fibers that are growing by or

attached to the cotton seed, and they are processed after ginning. They usually have to be cooked to remove the oil, and then they are bleached. Linters are shorter than cotton fibers that are used in the textile industry, thus they are referred to as "second cut" fibers and are less expensive.[51]

The experimentations that were performed were the possible methods that were suggested and investigated. These included separation involving sulfuric acid,[8] M-Cresol,[2] "boiling water",[56] a surfactant from CAL Corporation,[9] and caustic soda.[10] The last two were performed in the M & K Digester. In order to get the water up to the temperature that was required, the "boiling water" experimentation was also done in the M & K Digester.

Flotation was suggested,[11], but with further research this idea was discarded. In the study, it was found that there is no flotation chemical available to separate cotton from polyester because they are too similar.

The rags needed to be broken up into individual fibers so they could be successfully separated. The bright red rags also needed to be bleached to a whitish color so the dye could determine what was left. It was said that breaking the rags apart was relatively easy.[53]

The actual separation consisted of removing the polyester from the mixture of polyester and cotton fibers and making sure all of the polyester was removed. If only a fraction was removed, what was left needed to be evaluated.

The specifications to be met were to determine if it was possible to destroy or remove the polyester entirely and leave the cotton unaffected. It would not be practical to believe that the cotton could be completely unaffected unless there was a flotation agent available.

Therefore, the methods suggested were evaluated. Some time was spent on breaking up the rags and trying to bleach them.

EXPERIMENTAL PROCEDURE

The objective of this thesis was to determine if there was a possible method of separating polyester fibers from rags and leaving the cotton in a form usuable for papermaking. There were five different methods of separation that were suggested and evaluated on the cotton and polyester fiber mixture. Three of these methods were also evaluated on the rags.

Three of these processes were done in the M & K Digester. The chemicals used were sodium hydroxide, M-Cresol, ethanol, sulfuric acid, bleach, sodium bicarbonate and a surfactant from CAL Corporation. The actual experiments can be found in the Appendix.

The equipment used was the Waring Blender, the PFI Mill and the M & K Digester.

The procedures included:

1. Breaking the rags apart.[1]
2. Bleaching the rags.[2]
3. M-cresol.[3]
4. Sulfuric Acid.[4]
5. "Boiling Water".[5]
6. Caustic soda.[6]
7. The surfactant from CAL Corporation.[7]
8. Dye formulation.
9. Attainment of supplies.

These processes and lists can all be found in the Appendix. The experiments were performed as reported and three processes were successful on the fibrous combination.

RESULTS

There were three treatments that disposed of the polyester in the fibrous form. These included M-cresol, caustic soda with the surfactant from CAL Corporation and caustic soda alone.

The other trials included "boiling water" which did not affect the fibers at all, and sulfuric acid which destroyed both the cotton and polyester fibers.

The main problem started with breaking up the rags which was not as simple as had been indicated. The other major problem was bleaching the rags, but this was finally accomplished with the surfactant from CAL Corporation.

Once a process was found successful on the fiber combination, it was evaluated on a portion of the rags. This was very discouraging since, regardless of how fast and completely it had disposed of the polyester in the fibrous mixture, it would do nothing to the rags. The only thing that happened to the rags, which was rather unexpected, was the bleaching of the rags with the surfactant from CAL Corporation.

In the three cases which disposed of the polyester, it was disposed of completely. There was only a slight discoloration of the cotton paper due to the polyester yarn being very deeply colored. After the yarn disappeared, the dye had to deposit somewhere.

Lastly, the sulfuric acid disposed of 95% of everything. Unlike the information received regarding sulfuric acid, the polyester was the first to disappear. One source had indicated that polyester could withstand sulfuric acid, but that was not the case here.

CONCLUSIONS

There is no feasible method to dispose of the polyester in rags. It is possible to dispose of polyester fibers and leave cotton relatively unaffected, but with the chemical additions given to rags, it makes it impossible to dispose of the polyester.

This is a very interesting subject and one that needs further experimentation so that a chemical can be devised to dispose of the chemical treatments on the rags. One of the successful methods could then be used to dispose of the polyester in rags and leave the cotton unaffected for papermaking. The most promising method for disposing of the polyester and leaving the cotton unaffected would be flotation. Therefore, an agent would need to be devised to pick out one of the fibers and leave the other one untouched.

APPENDIX

1. Ten grams of red flannel rags were boiled in 500 ml. of 20% caustic soda in a 5 liter metal flask. The rags stayed in this container overnight, after it cooled.[40] The next day an attempt was made to break up the rags in a waring blender. The rags simply knotted together around the impeller. The amount of caustic was increased to 40%, and the P.F.I. mill was used, but the rags would still not break up.[53]

2. Bleaching consisted of ten grams of rags which were measured into a 5 liter beaker. 500 ml. of bleach was then added. This combination was heated to approximately 90-95^{o}C. This process merely turned the rags a light orange color and the dye received was useless on this color.

3. The ingredients for the M-cresol trial were:

   200 ml. M-cresol
   3 grams polyester fiber
   3 grams cotton fiber

   The temperature of the M-cresol was brought to 140^{o}C and the cotton and polyester fibers were added. The suspension was left at 140^{o}C for one-half hour. The fibers were then put into another 125 ml. of M-cresol, also at 140^{o}C. This remained at 140^{o}C for another one-half hour. The fibers were then removed and placed in 100 ml. of ethanol for five minutes, followed by another 100 ml. portion of ethanol.[2]

   Since this process was so successful on removing the polyester fibers, the same was attempted on the red flannel rags. The same amount of chemicals and timing was performed on 6½ grams of rags with no success. Upon removal, the rags looked and weighed almost exactly what they did initially.

4. The next trial was with sulphuric acid. This included:

   100 ml. 1% H_2SO_4
   100 ml. 70% H_2SO_4
   2% $NaHCO_3$

   Twenty grams each of cotton and polyester were placed in 100 ml. of boiling 1% H_2SO_4 for approximately ten minutes. The excess acid was then removed by suction. After the remaining fibers had cooled, 100 ml. of 70% H_2SO_4 were added. After five minutes, 95% of the fibers were gone.[8] This process was not investigated in any other manner.

5. After further research on "boiling water", it was discovered that the rags needed to be brought up to 230°C for the polyester to turn into terephthalic acid.[56] This was attempted, but the M & K Digester can only go up to 200°C. Therefore, the rags were brought up to 190°C and 90 psi for about four hours, and then left overnight. This temperature was not hot enough, so the fibers were relatively unaffected.

6. Sodium Hydroxide in the M & K Digester was attempted. The process used was:

   40 lbs. steam
   137.448 grams polyester
   150.62 grams cotton
   2800 ml. H_2O
   400.136 grams NaOH

   This was left in the digester for four hours and remained there overnight.[10] This process disposed of all of the polyester in the fibrous combination. This same process was used on rags:

   40 lbs. steam
   297.54 grams red flannel rags
   2800 ml. H_2O
   401.217 grams NaOH

   This was left in the digester for five hours and remained there overnight. Nothing happened to the rags.

7. A surfactant was received from CAL Corporation and a process was employed using it. This consisted of:

240 grams NaOH
4800 ml. H_2O
50 ml. CAL 700 VMM
178.94 grams cotton
183.264 grams polyester

This was placed in the M & K digester and heated to approximately 135°C and 50-55 psi pressure.[9] It was left at this temperature and pressure for four hours and then remained in the system overnight. This disposed of all the polyester in the fiber mixture, so it was used on red flannel rags:

241 grams NaOH
4800 ml. H_2O
70 ml. CAL 700 VMM
384.27 grams of red flannel rags

The digester could hold more, but this was close to the amount of fibers it would hold. Even though there were similar amounts of everything, the rags were allowed to stay in the digester for eight hours at this temperature and pressure. The rags were left in the digester overnight, but when the digester was opened, the rags were still in the form in which they had been placed in the digester. However, this process had disposed of all the color in the rags.

8. The dye, which was used on the rags that were taken out of the digester after they had been treated with the surfactant, was as follows:

1 gram dye
25 ml. H_2O

These were mixed together in a beaker and the rags were then placed in the beaker. After removal, there were two very distinctive colors - blue and green - which was assumed to be cotton and polyester.

9. A. Rags were purchased from Cedar Springs Red Flannel, Inc., in Cedar Springs, Michigan.

   B. The cotton linters were obtained from Simpson Paper Company in Vicksburg, Michigan.

   C. The polyester yarn was purchased from Meyers. It was 100% Kodel polyester and made by American Thread Company.

   D. The chemicals were obtained from the Department of Paper Science.

   E. The surfactant was received from CAL Corporation. David York, a manufacturers representative, sent it to the department.

   F. A dye determining polyester and cotton was sent by Pylam Products Co., Inc., Garden City, New York 11530..

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