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Coal Acids -- A Potential Warp Size for Continuous Multifilament Yarns

By

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Aqueous solutions of the mixture of water soluble aromatic polycarboxylic acids[1] produced by the caustic oxygen oxidation of coal will dry to form a rather tough water soluble film. One possible market for such a material is as a warp size in the textile industry. In this paper we would like to summarize the results of our evaluation of the coal acids for this use.

A warp size can probably best be described as a water soluble coating applied to the warp yarns to increase loom efficiency during weaving. The size is applied to the yarns from an aqueous solution and must be sufficiently water soluble so that it can be completely removed by a dilute detergent solution. In addition, the size must have good adhesion to the yarn and be sufficiently pliable to protect the warp yarns from the flexing, abrasion, and other stresses of the weaving operation.

Just as the above definition implies, the only absolute method for evaluating sizes is to conduct rather extensive weaving trials. However the cost of such a test necessitates some type of preliminary testing to establish a high probability of success. Potential sizes can be evaluated in the laboratory if one simplifies the problem somewhat and looks at the desirable physical properties which are either afforded or enhanced by the presence of a suitable size on the yarn. In the case of a continuous multifilament yarn these properties would include unitization of the yarn and abrasion resistance. It is also necessary to determine if the size has any degradative effects on the yarns physical properties in addition to establishing the ease of application and removal of the size. By comparing the effects of an experimental material and a commercially accepted size it is possible to get an indication of the probability that the experimental material may have for success in a weaving trial.

The coal acids were first evaluated on continuous multifilament nylon yarn. There were two principal reasons for choosing this yarn. First, it is well known that materials having a low pH give the best adhesion to nylon fibers and second, the low viscosity of the size solution suggested that the size might not "lay" the protruding fibrils of a staple yarn in the desired manner. In this evaluation the widely accepted polyacrylic acid size (Acrysol A-1) manufactured by Rohm and Haas was chosen as the control with which the coal acids were compared.

Ease of Application and Removal

Observations made during the preparation of sized samples for testing using the single-end slasher shown in Figure 1 indicated that there would be no problems in applying the coal acid coating to the yarn. While the use of a colored material as a warp size could possibly have certain advantages it has the one major disadvantage in that it must be completely removed from the woven fabric.

Two general methods were used to determine whether the coal acids could be satisfactorily removed from the yarn. The first of these methods was based on the acidic nature of the size. Sized samples of yarn were rinsed with a stream of water for about ten minutes and then after drying were titrated with dilute base to determine the amount of residual acid. The results of this test indicated that the amount of coal acids left on the yarn was below 0.05% size pick-up. A more accurate method was worked out based on the color of the coal acids. In this method samples of the sized yarn which had been washed in an aqueous solution of 0.25% Triton X-100 and 0.25% tetrasodiumpyrophosphate were wound on plastic chips and the color of the yarn determined on a Hunter Color and Color Difference Meter (H. A. Gardener Laboratories, Bethesda, Md.). Samples of yarn sized with Acrysol A-1 and unsized yarn were tested in a similar manner. The results of this evaluation are shown in Table I.

TABLE I

HUNTER COLOR AND COLOR DIFFERENCE METER DATA

Sample	R_d	a	b
Porcelain Standard	77.0	-0.2	+1.8
Unsized Yarn	52.8	-3.0	+3.0
Washed Yarn (Acrysol A-1)	54.9	-2.7	+3.8
Washed Yarn (Coal Acids)	52.6	-3.0	+3.1
Washed Yarn (Coal Acids)	53.3	-3.0	+3.2

KEY: The R_d column indicates the per cent reflectance. The negative numbers in the 'a' column indicate the degree of blueness and the positive numbers in the 'b' column indicate the degree of yellowness.

Although it was impossible to exactly duplicate commercial methods of scouring or size removal, the data in Table I indicates that the coal acids can be completely removed from the yarn.

Yarn Degradation Studies

In certain cases it may be necessary to store a sized warp for prolonged periods of time. Therefore, it is essential that the size have no adverse effects on the physical properties of the yarn. The tensile strength and per cent elongation of nylon yarn which had been aged after being sized with Acrysol A-1 and coal acids were determined and found to be comparable.

Abrasion Tests

The most widely accepted method of laboratory evaluation of experimental sizing materials is that of determining the abrasion resistance of the sized yarn. However, the type of abrader and test may vary considerably with the investigator and the type of yarn used (2). The method which we employed in evaluating the coal acids, and which appears to work quite well on continuous multifilament yarns, is based on the Duplan Cohesion Tester (Geier and Bluhm Inc., Troy, N. Y.). See Figure 2. The purpose of a warp size is to reduce the number of breaks in the warp yarns during weaving but this yarn break point is not necessarily a good end point on an abrasion tester. This is particularly true with continuous multifilament yarn where the yarn itself may not break from abrasion alone for several thousand cycles while a good size may well be completely destroyed after 50 cycles. For this reason the "fray-point" was chosen as the end point on the Duplan Cohesion Tester because it clearly shows the point at which the size film is destroyed. The use of this end-point, which is shown in Figure 3, enables one to measure the degree of unity and abrasion resistance imparted to the yarn by the size. By testing samples of yarn having varying percentages of size pick-up we were able to compare the properties of the commercial and the coal acid sizes. The results of this evaluation are shown in Figure 4. The data shown in Figure 4 indicates that the coal acids and Acrysol A-1 afford a comparable amount of protection to the yarn.

The results of the above tests indicate that the coal acids might be a good warp size for nylon multifilament yarns and suggests further testing in the form of a weaving trial.

Other Types of Yarn

On the basis of the favorable results obtained on nylon, the coal acids were also evaluated on other types of continuous multifilament yarn. In each case a commercial size was used as a control. Evaluations were carried out on Dacron, Orlon and cellulosic type yarns and in general the results obtained were very similar to those obtained on nylon. The results of the abrasion resistance studies on these yarns are shown in Figures 5, 6, and 7. These results indicate that perhaps the coal acids might find rather wide application as a warp size for continuous multifilament yarns.

Weaving Trials

After a small scale weaving trial was conducted successfully on equipment located in the Midland Division a larger and more thorough trial was carried out at North Carolina State, School of Textiles, Raleigh, N. C. In evaluating the coal acids in these weaving trials every attempt was made to handle the experimental material in the same manner as it would be handled commercially. These weaving trials were carried out on continuous multifilament nylon yarn and here again the evaluation was conducted in such a manner that the coal acids could be compared directly with the Acrysol A-1 size.

In general the results of the weaving trial followed very closely those of the laboratory evaluation. It was noted during the sizing operation that the coal acid sized warp parted much easier and subjected the yarn to much less strain than did the commercial size. While the length of the weaving trials was not sufficient to calculate with certainty the efficiency of the sizes there were fewer yarn breaks attributable to 'size failure' in the coal acid warp than there were in the Acrysol warp.

It was in the last stages of the weaving trial, that is the scouring step, that the only serious problem was encountered. During this step the sized fabric was accidentally exposed to live steam before the scouring was started. It was found that temperatures in this range were sufficient to "set" the coal acids or actually cause chemical combination with the yarn which prevented the complete removal of the color from the fabric. Further testing in the laboratory indicated that temperatures of 180°F. or greater would cause varying degrees of discoloration in direct proportion to the time the temperature was maintained. It is not uncommon for slasher drying can temperatures to be maintained in this range but the coal acids have the advantage that their high fluidity will allow drying at lower temperatures ($<$160°F.) while maintaining normal slasher speeds. The discoloration would probably also be lessened when the coal acids are used on another fiber where the ionic association of the reactive groups in the fiber and size are not so great.

Summary

The coal acids form water soluble films which may be useful as warp sizes for continuous multifilament yarns. The films appear to impart as much or more abrasion resistance to a wide range of multifilament yarns as commercially accepted sizes. The only apparent problem is the tendency of the coal acids to react with, and thereby discolor the yarn at elevated temperatures.

References

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(2) Seydel, Paul V., Textile Industries, Vol. 121, No. 3, 110-119 (1957)

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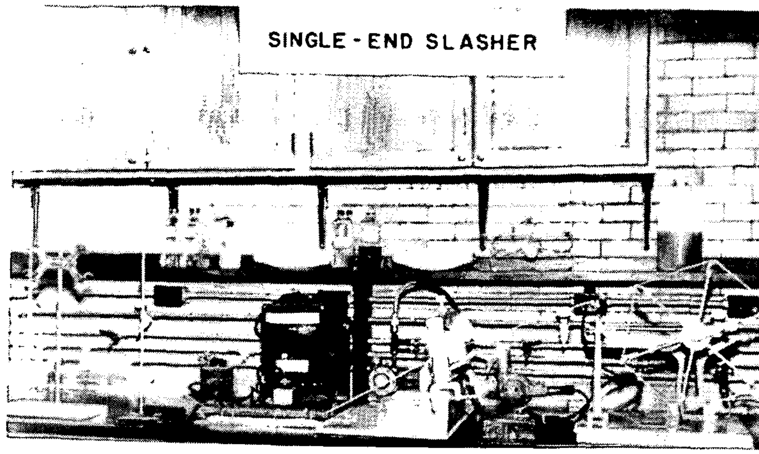

CONE → TENSION POST → SIZE BATH → WRINGER → DRYER → YARN REEL

FIGURE 1

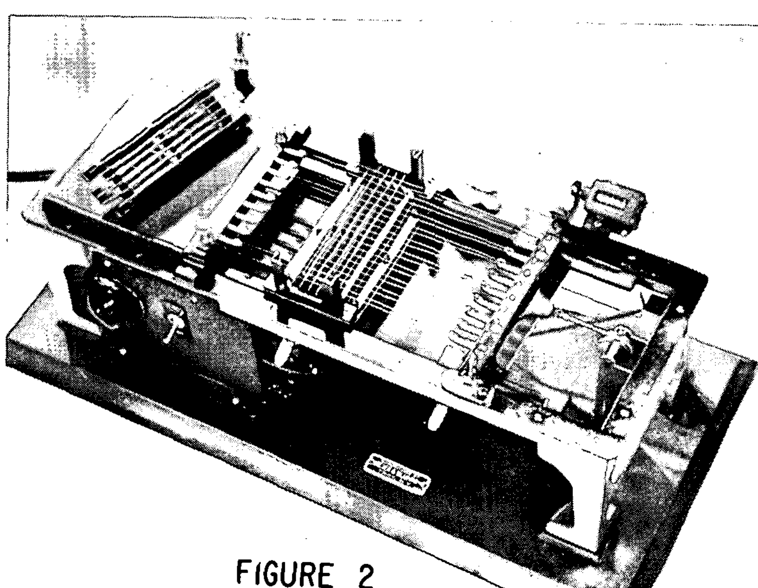

FIGURE 2

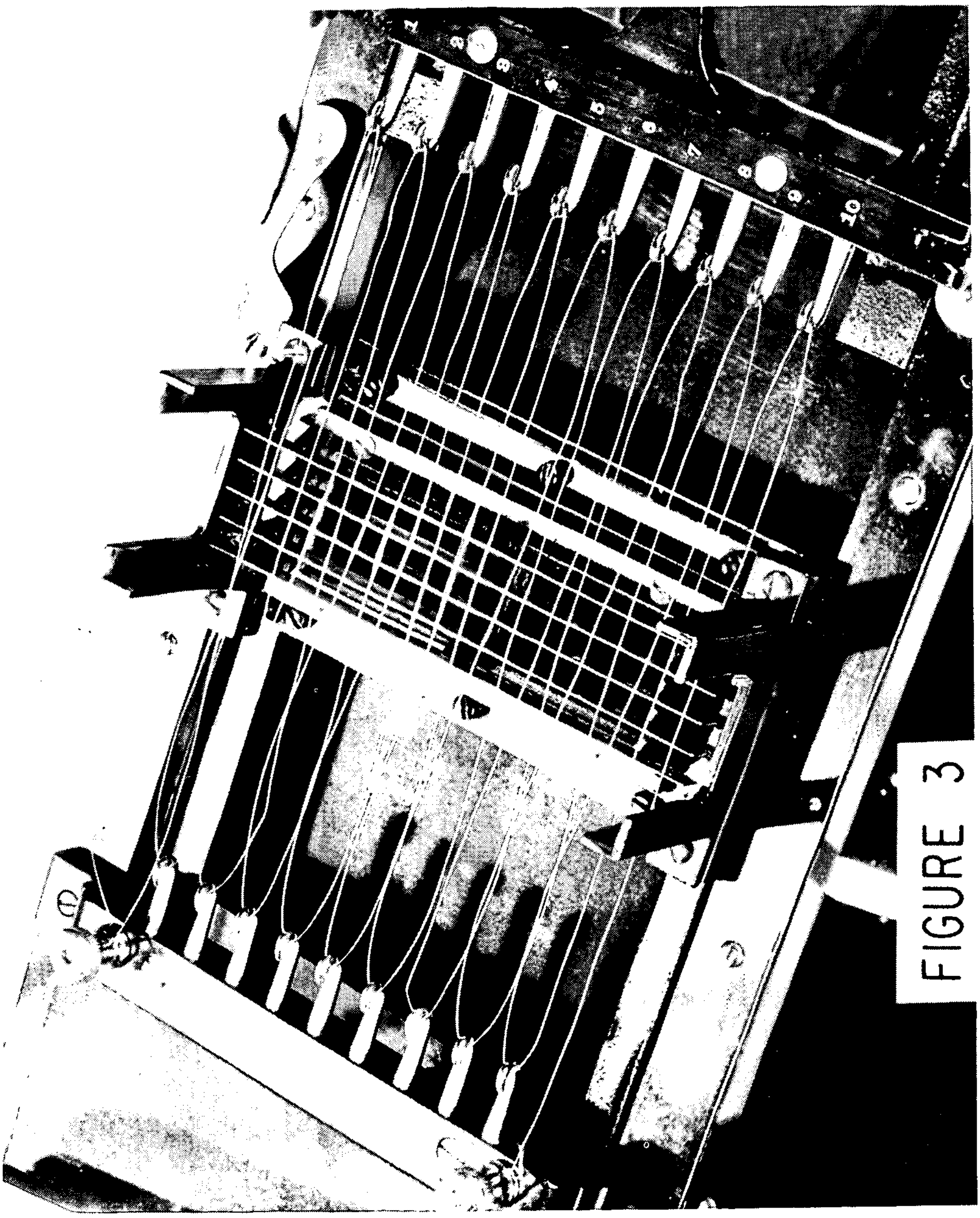

FIGURE 3

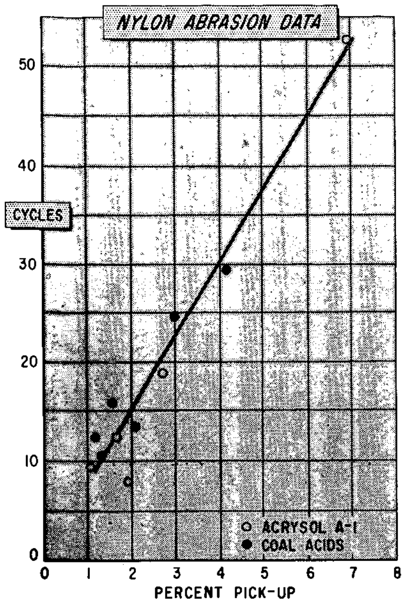

FIGURE 4

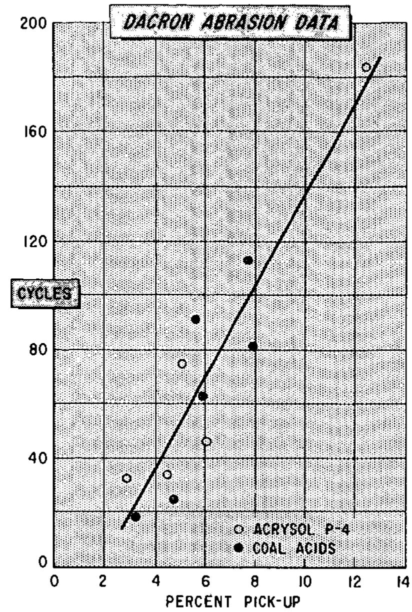

FIGURE 5

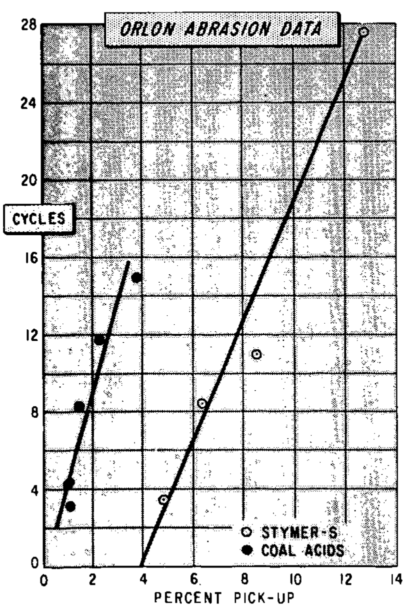

FIGURE 6

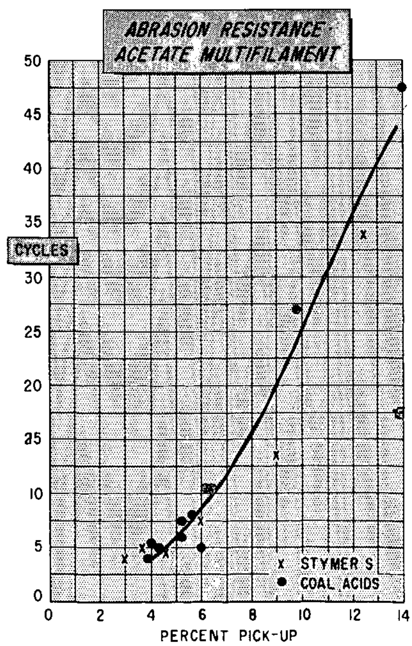

FIGURE 7