COHESIVE FORCES IN A BLEND OF FIBERS

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Approved:

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DEDICATION

I gratefully dedicate this thesis to my wonderful, patient wife, Joan. Her sacrificies have made this educational venture possible, and her encouragement, faith, and love have been boundless.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES

Table Page

LIST OF ILLUSTRATIONS

SUMMARY

In the past few decades, there has been an increasing interest in the blending of synthetic fibers with cotton. This study attempted to determine the effect of cohesion in a blend of fibers and to use a new proposed test method to learn if adequate and reproducible results could be obtained for use in the textile industry. This investigation covered the effect of three levels of turns per inch on 3.0 and 3.7 hank roving of a 65% Dacron-35% cotton blend.

In this investigation Good Middling Medium White Pima S1 Cotton (1-5/32 staple length) and Dupont's polyester fiber Dacron (1-1/2 inches staple length and 1-1/2 denier) were selected. Hank rovings were produced with a count of 3.0 having 1.59, 2.75, and 3.25 turns per inch, and 3.7 with 1.75, 2.75, and 3.25 turns per inch. The roving specimens obtained were analyzed and static cohesive forces calculated.

The results of data obtained showed a ten-fold increase in the force required to draft a roving sample when the twist was increased 1.5 turns per inch. Statistical analysis revealed that the effects of different levels of twist were significant at the 98 per cent level. Weight effects were not significant, nor was the interaction between weight and twist.

Static cohesive force and linear density were plotted with various levels of turns per inch to illustrate the relationship of the variables under study.

After an analysis of this graphical presentation, the following conclusions were reached:

1. Static cohesion forces are greatly affected by the degree of twist placed in the sliver or roving.

2. Static cohesion forces are related to the degree that each fiber is represented in the blend.

3. Static cohesion forces are related to the number of drawing processes to which a sliver has been subjected.

4. Static cohesion forces are not related to linear density (tex).

5. Increases in breaking strength are accompanied by an increase in breaking tenacity.

CHAPTER I

INTRODUCTION

The reduction of production costs, in conjunction with maintenance or improvements of yarn quality, is of vital concern to all spinners of cotton and man-made fibers, particularly at the present time. Great cost reductions can undoubtedly be achieved by the use of high spinning drafts and short processing in the card room, but under these conditions, the maintenance of a high and constant quality of roving becomes increasingly important and effect process control is essential.

In considering roving quality, the uniformity is obviously of great concern; but roving strength and bulk density are also of great concern. Roving strength has a direct bearing on spinning performance and yarn quality; roving twist, which controls the strength of the roving, also has a direct bearing on processing costs. If the roving is too soft, stretching and breaking in the ring frame creel will occur. On the other hand, if the roving is too hard, the resistance to drafting is likely to increase yarn irregularity and cause slippage or "spewing" in the rollers (1).

It is well known that, although positively held and directed, the fibers themselves cooperate in the alignment process on all staple yarn manufacturing systems. The behavior and movement of staple fiber during processing is reflected in yarn properties. Depending on processing conditions, the cohesion of staple fiber roving and yarns can either enhance or prohibit uniform drafting and can lead to actual drafts which are quite different from those for which a frame is mechanically set. The cohesion of loose sliver and roving, and the efficiency with which they can be processed, is dependent on fiber surface contact and characteristics (2).

Before proceeding further, it is in order to define the term "cohesion" and to distinguish it from "adhesion." Cohesion is referred to as the act or state of cohering; a cleaving together, i. e., to cling or adhere closely. Adhesion, on the other hand, is the adhering or the actual sticking together of substances in contact with each other (1). Therefore, cohesion is the clinging together of like objects; for example, fibers in a sliver or roving: Adhesion is the sticking or adhering of two unlike objects such as the placement of a band-aid on your arm or fibers sticking or adhering to the rolls or aprons. Fiber cohesion is defined as the attraction between two or more fibers. This attraction is due to the combined effects of the surface characteristics, length, crimp, finish, and linear density of the fibers (3).

Previous workers (4) have developed the principles of the technique for measuring minimum twist of cohesion and the application of these techniques to the study of the cohesion of worsted and other yarns. These studies led to the establishment of the general properties of the coefficient of minimum twist of cohesion and to the coefficient of cohesion, and its fundamental properties.

However, the necessity for simplifying the measuring techniques to make them practicable for use with conventional apparatus has led to the establishment of new measuring procedures. The influence exerted by such factors as the test length and the pre-tension applied to the yarn have been studied. The extension of the studies of minimum twist of cohesion has led to a consideration of the influence exerted on that parameter by fiber characteristics such as length and fineness, as well as by the chemical treatments which the fiber may have undergone.

The parameter defined as "minimum twist of cohesion" or "residual twist" represents the number of turns remaining in the yarn at the moment of its breaking as a result of fiber slippage when the yarn is simultaneously being submitted to an axial pulling and untwisting action. This is a concept similar to Burlet's (5) "drafting twist" and, according to others, a more proper denomination should be sought. Parisat (6) proposes to designate the determination of the new parameter as "maximum untwisting test."

The conventional method of checking roving strength to determine the amount of twist required is by breaking the strand with the fingers while the bobbin is held in the hand or placed on a creel. The result or decision depends on personal assessment and practical experience, and consequently, it is not ideal even where only a narrow range of cotton types is processed. There is now a wide range of cotton and man-made fiber blends to be considered, and this leads to considerable deviations from optimum conditions.

Probably the pioneer in the field was Braschler (7), because of research concerning breaking strength and twist of cotton yarns, for a Ph. D. Thesis. Early "minimum twist of cohesion" was carried out with a device to load the specimen coupled to the stationary jaw of the apparatus. The measuring technique consisted in fastening the yarn to the stationary clamp of the torsiometer coupled to that apparatus, passing it through the tension measuring device and imparting a previous tension, and then anchoring it to the turning clamp of the torsiometer. When untwisting begins, a small drop in tension is first observed on the tension gauge, due to yarn extension; then, the yarn tension drops sharply as a consequence of yarn breakage through fiber slippage. At this moment the test is stopped and a reading of the twist counter is taken. This is the twist taken out of the yarn within the length limited by the tension gauge and the turning clamp of the torsiometer. Minimum twist of cohesion is found by substracting that twist from the original.

Barella, Miro, and Crespo (4) found that the above technique contained a systematic error which tended to underestimate the coefficient of minimum twist of cohesion by about 12.5%. The new technique made use of an accurate conventional torsiometer with a simple device to be coupled to the stationary clamp permitting yarn tensioning. The technique consists in fastening the yarn in the clamps of the torsiometer, and submitting the stationary clamp to the predetermined tension. Under this condition, untwisting begins. The testing length becomes progressively extended due to untwisting until a perfectly defined point is reached, at which the yarn suddenly breaks through fiber slippage. The test must be stopped at that moment and the value given by the counter of the torsiometer recorded. This twist has been eliminated from the yarn; therefore, by substracting it from the original yarn twist, the minimum cohesion twist when fiber slippage occurs will be found.

More work has been done in the field with yarns in preference to roving or slivers. But, a satisfactory method of measuring roving strength is provided by the use of the Resistiro-Rex, an instrument which measures and records continuously the "drafting resistance"; i. e., the force required to overcome the effects of twist and cause the fibers in the strand to slip past each other.

The instrument enables standards to be set precisely and to be effectively maintained. The principle is to insert twist into the roving to give it a definite fixed drafting resistance irrespective of fiber length, frictional properties, crimp or type, and varying only with the hank roving. Standards have been set for different hank roving numbers, and after a minor adjustment, the instrument indicates immediately a measure of the drafting resistance. This shows:

1. Whether the twist is too low, too high or correct.

2. Changes in drafting resistance which indicate variations in the force required to draft the strand.

3. Any changes in winding tension which may exist at different points in the bobbin build.

4. The average hank roving number which is obtained by weighing a length of roving measured off by the instrument.

Roving from the supply bobbin is run continuously through the instrument in which it is subjected to a load which is increased continuously until the fibers begin to slip. The load at which this drafting starts is indicated continuously on a scale graduated from zero to twelve and at the same time a recording apparatus registers the reading; designated as the "drafting resistance" graphically in the form of a printed chart (1).

Another instrument designed to test the cohesion of roving and sliver is the West Point Cohesion Tester. The apparatus provides a stationary set of drafting rolls mounted on a beam with a fixed speed of 25 RPM. The second set of drafting rolls are moveable with respect to the first and have variable speeds obtained by gear changes. The minimum separation between the two sets of rolls is 1-1/8 inches and the maximum separation is 8 inches. Both sets of rolls are gear driven by means of small synchronous motors. A transducer is mounted on the stationary rolls for measuring the drafting forces. This transducer translates the drafting forces and their fluctuations into electrical energy which in turn is measured and recorded continuously. Both drive rolls are fluted to avoid fiber slippage during drafting. The pressure rolls are rubber covered and pressure is applied through the bearing by means of screws at each end of the pressure roll shaft. The tester may be calibrated so that the drafting forces in grams can be read directly from the Tensiometer recorder chart (8).

The majority of experiments pertaining to the cohesive forces of fibers have dealt with dynamic cohesion. Attempts to adopt a standard static test are under study by A. S. T. M. with their Proposed Tentative Method of test for determination of fiber cohesion in sliver and top.

The cohesive force for static tests is the load or force required to overcome cohesion of a test specimen held in a fixed position between two slowly separating clamps.

The test procedure is based upon the measurement of the resisting force when a length of sliver or top is pulled in an axial direction. Specified lengths of sliver or top are placed in the clamps of a tensile testing machine and the maximum force developed on separation of the clamps is recorded; the observed breaking load is calculated in terms of the force per unit linear density of the tested specimen. The breaking tenacity is considered a measure of the cohesion of the fibers in the specimen and is reported as milligrams per tex. The testing medium is a constant-rate-of-extension type machine such as the Instron Tensile Tester.

The testing specimen length is governed by the fiber length of the specimen which is placed on a mounting board or sheet of paper 8-1/2 by 11 inches with a 3-inch hole cut in its center. The test specimen is attached to the mounting board by means of cellophane tape and placed in the clamp of the testing machine in such a manner that the innermost edge of the cellophane strips holding the test specimen to the paper mount is aligned with the bottom edge of the top clamp and the top edge of the bottom clamp. The paper mount is then cut into to permit the machine to break the specimen. As breaking occurs, a built in recorder records simultaneously the force to break the sample through fiber slippage. After breakage, the required test length is obtained by cutting it from the mounting board and it is weighed to obtain the linear density in tex and breaking tenacity in milligrams per tex (3).

Using the above mentioned procedures and experiments, the following studies have been conducted by previous authors. Barella and Sust (7, 9, 10) have studied cohesion phenomena in cotton, experimenting with parameters as, (1) influence of testing conditions on cohesion of roving and yarn; (2) influence of fiber characteristics; (3) various staple lengths; and (4) micronaire index from 3.1 to 5.5. Barella, Miro, and Crespo (4) using an advanced Barella regularimeter, studied the effects of tension, staple length, staple diameter, and various chemical treatments. Baster (1) with the Resistiro-Rex instrument studied the various drafting resistance of a full, half-full, and empty bobbin. Scardino, Rebenfeld, and Lyons (2) studied the effect of surface roughness on textile assemblies.

Another factor that was not mentioned, and clearly could have a definite effect on the cohesion of slivers and the drafting resistance is that of hooked fibers. It is well known in the cotton spinning industry that fibers lie crisscross and entangled in a card sliver. Morton and his associates (11) developed a tracing technique which enabled them to see the fiber as it lies in a sliver. Morton's data showed that (1) the majority of fibers in card sliver are hooked at either or both ends and that trailing hooks are more numberous than leading hooks; (2) the process of drafting reduces the number and extent of hooks; a large majority of the fibers have no hooks after the third passage of drawing.

Caveney and Foster (12) reported that the force required to draft a sliver is appreciably different in the two directions and that the difference can be attributed to the different fiber arrangement in the two directions. They found that the drafting force was less when the majority of hooks were fed as trailing. In these circumstances, the higher drafting force may be an indication of less controlled drafting and therefore of a more uneven output.

Consider a hypothetical case where all the fibers of equal length, having equal hooks at both ends, and oriented parallel, are being drafted between two pairs of rollers set at a distance equal to the fiber length. It is clear that in order to straighten out a leading hook the hooked length at the front of the fiber must travel at a faster speed than the rest of the fiber, which will be travelling at the back roller surface speed. The forces *resisting* this faster movement of the hooked portion of the fiber are:

1. The bending force required to straighten out the hook.
2. The frictional force arising out of the surface contact of the hook portion of the fiber with fibers moving at the back roller speed.

The only force *assisting* the hook removal is the frictional force arising out of the surface contact of the hooked portion of the fiber with fibers moving at the front roller speed.(13).

Since the field of studying cohesion phenomena in sliver and roving is relatively new to the textile industry, there is not an abundant amount of information to be found. With the advent of new machinery and the trend toward higher speeds and greater production, this only increases the importance of developing data on cohesion phenomena. It is well known that the amount of twist is probably the major factor in controlling the production rate of yarn and roving. If by studying cohesion phenomena, new techniques could be found to increase the cohesion of fibers through mechanical or chemical means, without altering the quality or damaging the fiber, then production of yarn and roving could be greatly increased. If, for example, a specific hank roving were being produced with 1.0 turns per inch and a method was discovered so that the roving could be produced with 0.9 turns per inch with everything else held constant, then this would represent an increase in rate of production of [illegible] per cent. This would not only represent an increase in production, but also produce a better quality yarn as the spinning frame would have to take less twist out of the roving and fiber slippage could occur more rapidly.

Statement of the Problem

The studies that have been conducted in the areas of cohesion have been primarily concerned with cotton slivers and roving, using the existing dynamic cohesion testing equipment. The objective was (1) to study the effect of cohesion of a blend of fibers; (2) to use a new proposed test method and see if it was adequate and reproducible results could be obtained; (3) to obtain reliable results so future experiments could be conducted to show how static cohesion tests compare with dynamic cohesion tests and to show the effects of chemical treatments.

Since the test method used was only a proposed method, it was interesting to learn if the data obtained was useful and meaningful to the textile industry. A blend of 1-1/2 inch Dacron polyester fiber with 1-5/32 inch Pima S1 cotton, consisting of two levels of hank roving and three levels of twist, was used in conducting this study.

CHAPTER II

INSTRUMENTATION AND EQUIPMENT

Raw Materials Used

The raw materials used in this investigation consisted of a blend of Good Middling White Pima S1 cotton having a staple length of 1-5/32 inches and DuPont's polyester fiber, Dacron, having a staple length of 1-1/2 inches and a denier of 1.5. Tables 8, 9, 10, show data on cotton fiber fineness, strength, and length.

Processing Equipment

The following equipment was used in processing the raw materials in this investigation.

1. Cotton opening line including Saco-Lowell Hopper Feeder, Superior Cleaner.
2. Saco-Lowell Blender Feeder for cotton.
3. Dodenhoff Blender Feeder for Dacron.
4. Saco-Lowell One-process Picker and Picker Hopper.
5. H and B Revolving Flat Card, Metallic clothing.
6. Whitin G-1, 10-1/2 inches Lap Winder.
7. Whitin J-5 Comber.
8. Ideal Feathertouch Drawing, Model 750.

9. Saco-Lowell Roving Frame, FS-3.
10. Whitin Spinning Frame, Model N.

Physical Testing Equipment

The following physical testing equipment was used to evaluate the experimental products.

1. Instron Tensile Tester.
2. Uster Automatic Single-end Tester.
3. Uster Evenness Tester.
4. Spinlab Digital - Fibrograph.
5. Sheffield Micronaire.
6. Pressley Fiber Strength Tester.
7. Spinlab Colorimeter.

The operating data appears in the following pages except for the Instron Tensile Tester which can be found in the Instron's Technical Bulletin (14).

Table 1. Operating Data for H & B Revolving Flat Card

Name	Diameter	Type Clothing	R. P. M.
Cylinder	50.5"	Metallic	Cotton 165 Dacron 205
Doffer	26.5"	Metallic	Cotton 4 Dacron 9
Licker-in	9.0"	Metallic	Cotton 430 Dacron 550
Weight Fed (Lap Ounces per Yard)			13.50
Weight Delivered (Grains per Yard)			50.00

Table 2. Operating Data for Roving Frame FS-3

Machine Details	
Diameter of Front Roll	1-5/16
Diameter of Middle Roll	1-1/4
Diameter of Back Roll	1-1/2
Roll Settings:	
Front to Middle	2-5/16
Middle to Back	2-5/16
Spindle Speed	1100
Grain Weight Fed	49
Hank Roving Delivered	3.0 & 3.7

Table 3. Operating Data for Whitin Spinning Frame

Machine Details	
Spindles Per Frame	324
Diameter of Cylinder	8"
Diameter of Whorl	1"
Diameter of Back Roll	1"
Diameter of Front Roll	1"
R. P. M. of Spindle	14,000
R. P. M. of Front Roll	165
Type Drive	Tape
Twist Constant	1258
Draft Constant	1505
Twist Multiplier	3.99
Roll Settings:	
Front to Middle	1-13/16
Middle to Back	1-3/4
Roll Pressure (in pounds)	
Back	30
Middle	30
Front	20

Table 4. Operating Data for Uster Evenness Tester

Material Tested:	
Number of Bobbins per Sample	6
Number of Integrator Readings per Bobbin	5
Number of Readings per Yarn Sample	30
Evenness Tester:	
Speed of Testing (Yards per Minute)	100
Time to Run Test (Minutes)	10
Yards Tested	1000
Type of Test	Normal
Integrator Reading	Per Cent C. V.
Comb Slot	No. 7
Range of Scale (± Per Cent)	50%, 100%

Table 5. Operating Data for Uster Automatic Single-end Tester

Bobbin Attachment:	
Number of Bobbins per Sample	6
Number of Breaks per Bobbin	20
Number of Breaks per Yarn Sample	120
Automatic Tester:	
Pre-test Tension Setting	5
Test Length	20"
Loading Time to Break (Seconds)	10±3
Time to Complete Cycle (Seconds)	20±3
Range of Breaking Load (Grams)	200 - 2000
Range of Elongation (Per Cent)	0 - 20
Machine Constants:	
e Value (Elongation)	0.4
K Value (Breaking Strength)	2.1
L Value (Conversion of Breaking Strength to Grams per Tex)	0.707

Table 6. Operating Data for SKF Spintester

Machine Details		
Spindles Per Frame		6
Type of Drive		Tape
Type of Drafting System		Duo-Roth
Type of Creel		Umbrella
Creel Capacity (Bobbins)		12
Clearers	Top - Bottom -	Revolving Suction
Range of Total Drafts		12 to 108
Range of Break Drafts		1 to 8
Range of Twist (Turns Per Inch)		6.5 to 55
Range of Spindle Speeds (Rev. Per Min.)		3,500 to 14,000
Top Roll Weighting		Pendulum Arm
Twist		Z or S
Power Supply		200 Volts
Stop Motion		Automatic Full Cop
Diameter of Back Roll		1.000"
Diameter of Front Roll		1.000"
Roll Settings	Front to Middle - Middle to Back -	1.750" 1.875"

CHAPTER III

PROCEDURE

Preparation of Materials

The sequence of operation for producing the blend of Dacron polyester fiber and combed cotton is hown in Figure 1. There are several ways that one can blend cotton and man-made fibers. In this experiment they were blended on the drawing frame. A temperature of 84 degrees Fahrenheit and humidity of 44 per cent were kept constant in order to secure a uniform blend and fiber distribution.

Conventional opening and picking equipment were used for processing the cotton. Operating data for these processes is reported in the previous chapter. The average weight of the picker lap was 13.5 ounces per linear yard. The picker laps were run through a H and B flat top carding machine to produce a 50 grains per yard card sliver. A doffer speed of four revolutions per minute was maintained to assure uniform good quality sliver. The card sliver was then produced into a 50 grains per yard drawing sliver.

The necessity of having cotton free of short fibers to blend with Dacron made it desirable to include a combing process in the sequence of operations. A Whitin J-5 comber was used to produce a 50 grains per

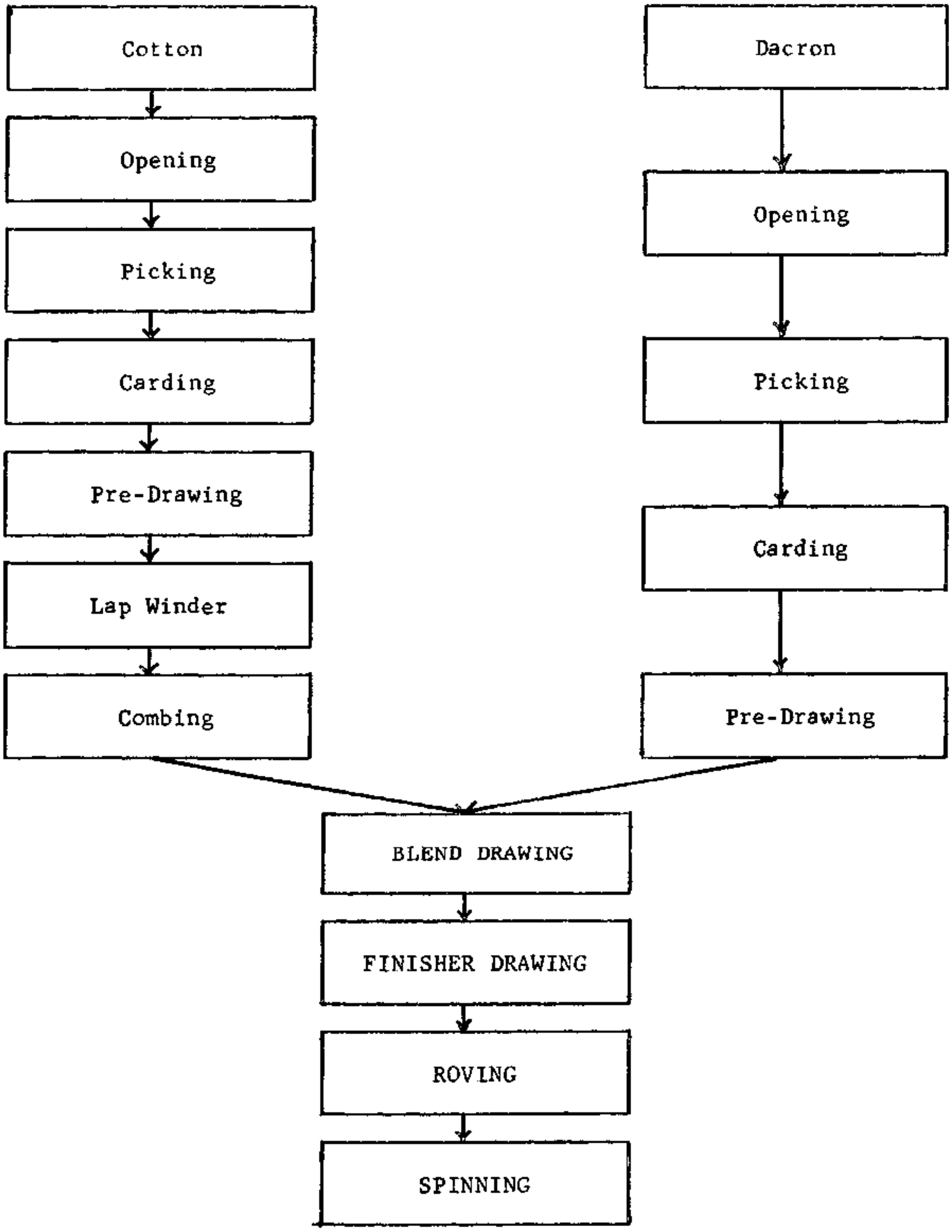

Figure 1. Sequence of Operations

yard sliver ready to blend with Dacron.

The method for preparing Dacron sliver differed from that for cotton sliver. First, the Dacron was processed on the cotton opening equipment and then through a synthetic blender. Using a flat top card 50 grains per yard Dacron card sliver was produced. Following carding, the sliver was treated on a drawing frame for pre-drawing. The treatment parallelized and oriented the Dacron fibers similar to cotton fibers.

To have a 65% Dacron-35% cotton blend, the first operation was the blend drawing where a 50 grains per yard sliver was produced. Using the necessary draft gears, eight ends of blend drawing was reduced to one end of 50 grains per yard at the finisher drawing operation. The finished drawing sliver was then creeled at the roving frame and, using the necessary draft and twist gear, 3.0 hank roving with 1.59, 2.75, and 3.25 turns per inch and 3.7 hank roving with 1.75, 2.75, and 3.25 turns per inch was produced.

Using the 3.0 hank roving with 1.59 turns per inch, doubled creeled, yarn with counts of 40's and 50's were produced. This was accomplished by using the SKF Spintester. The 40's yarns used a 3.88 twist multiplier producing 24.5 turns per inch while the 50's yarn used a 4.09 twist multiplier producing 28.9 turns per inch. Thirty bobbins of each count were spun and tested for breaking strength, elongation, and evenness. The original plan was to do this for each twist level in both of the hank rovings, but time permitted only the spinning of one twist level using the 3.0 hank roving.

All tests were conducted in the A. French Textile School, Physical Testing Laboratory. In this laboratory the atmospheric conditions are kept standard around the clock at 70 degrees Fahrenheit and 65 per cent relative humidity. The tests were made according to the standards set by the American Society for Testing Materials in the Proposed Tentative Method of Test for Determination of Fiber Cohesion in Sliver and Top in Static Tests. Six bobbins from each of the above mentioned categories, making a total of 36 bobbins, were used for testing. For each bobbin in a specific category, 20 tests were run making a total of 120 tests per category or a total of 720 tests for the complete field. In addition, tests were conducted on the 100% cotton card sliver, 100% Dacron card sliver, Dacron-cotton blend draw sliver, and 65% Dacron-35% cotton blend finisher draw sliver. A normal series of 20 tests would consume about 50 yards as suggested by A. S. T. M.

The Uster Automatic Single-end Tester and Evenness Tester were used to evaluate the elongation, breaking strength, and evenness of the yarn and roving.

CHAPTER IV

DISCUSSION OF RESULTS

Before discussing the effects of cohesive forces in a blend, several factors which influenced the actual cohesive force should be described.

Cohesion forces are governed by many factors, with twist being the most predominant. Twist regulates the rate and effectiveness at which the break draft zone can allow fiber slippage. Increase in twist decreases the rate of fiber slippage that can occur in the back zone and therefore increases the draft that must occur in the front zone. A high micronaire index was shown to have an increasing effect on the static and dynamic cohesion factor, with smooth fibers showing a greater cohesive force (1). This is due to the fact that smooth fibers have more useable surface area in contact with other fibers. Paralleling and straightening of the fiber greatly increases the cohesive forces between the fibers (10).

Figure 2 shows the effect of various levels of twist applied to two different hank rovings on the breaking strength of the roving. An increase of 1.5 turns per inch shows a ten-fold effect in increasing the breaking strength.

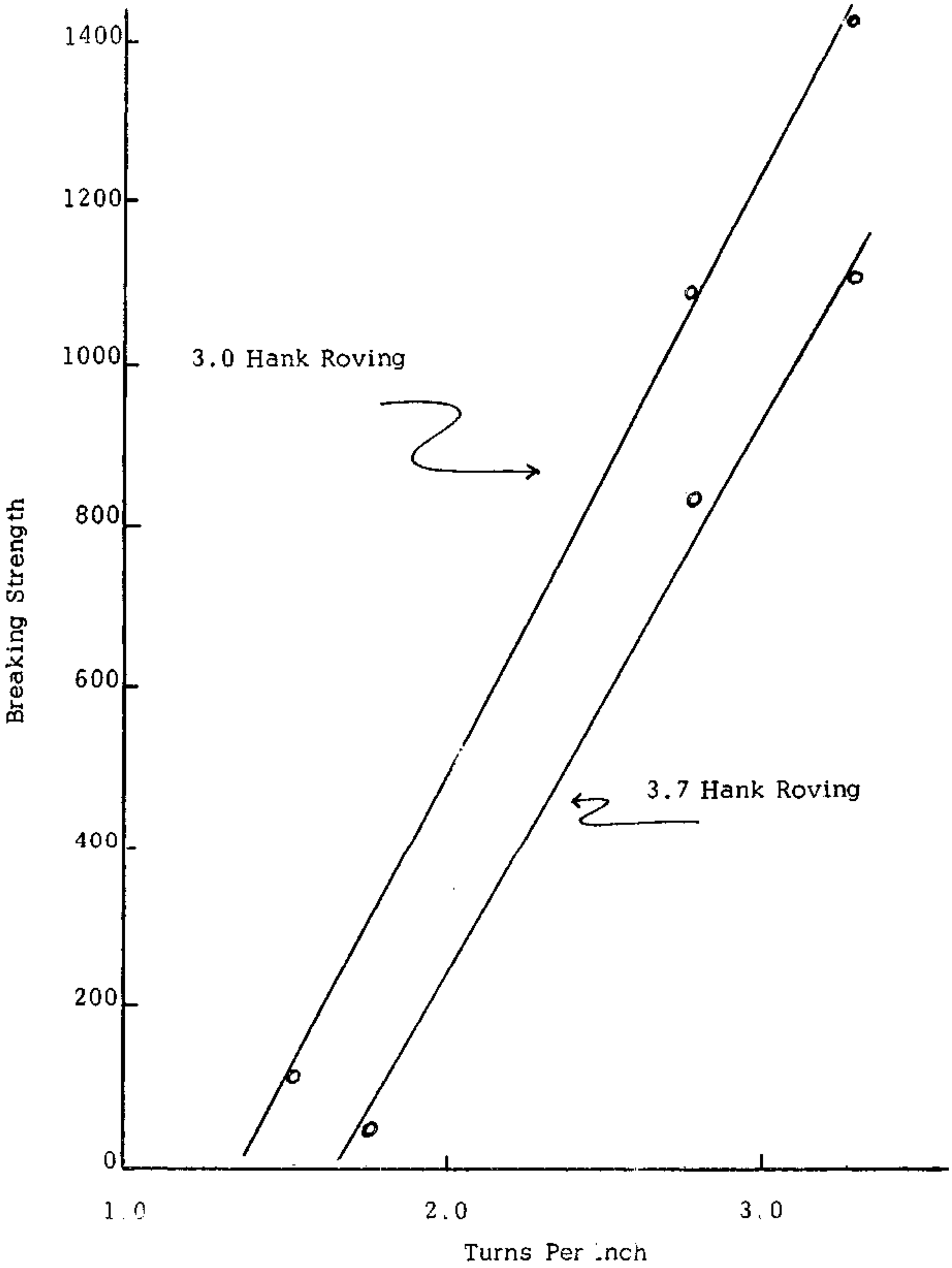

Figure 2. Twist (Turns per Inch) vs. Breaking Strength

Figure 3 shows the same ten-fold increase in breaking tenacity or static cohesion factor. This shows that a greater force will be required in drafting to overcome the increased twist and that, if this cannot be accomplished in a satisfactory manner, then yarn of higher irregularity than normal will be produced.

Figure 4 shows that an almost linear relationship exists between breaking strength and breaking tenacity. In order to study the effect of twist and different levels of blending operation, Figures 5, 6, and 7 were prepared. In Figure 5, static cohesive force is compared with linear density using the various fiber components that eventually composed the 65% Dacron-35% cotton blend. This shows a decrease in the cohesive force each time it is processed and also that there is not a definite relationship between the linear density of a specimen and its static cohesive force.

Although the Dacron sample had a much higher linear density than the cotton sample before they were blended, the blending in effect reduced both the linear density of the specimen as well as a significant decrease in the force required for drafting the sample. Also shown, is the fact that it would take a considerably higher force to draft the 100% Dacron sliver than it would to draft any of the other samples. With this in mind, it seemed logical that the product produced from the 100% Dacron sliver would have a higher non-uniformity ratio than either of the other samples tested, though no attempt was made to prove this conclusively.

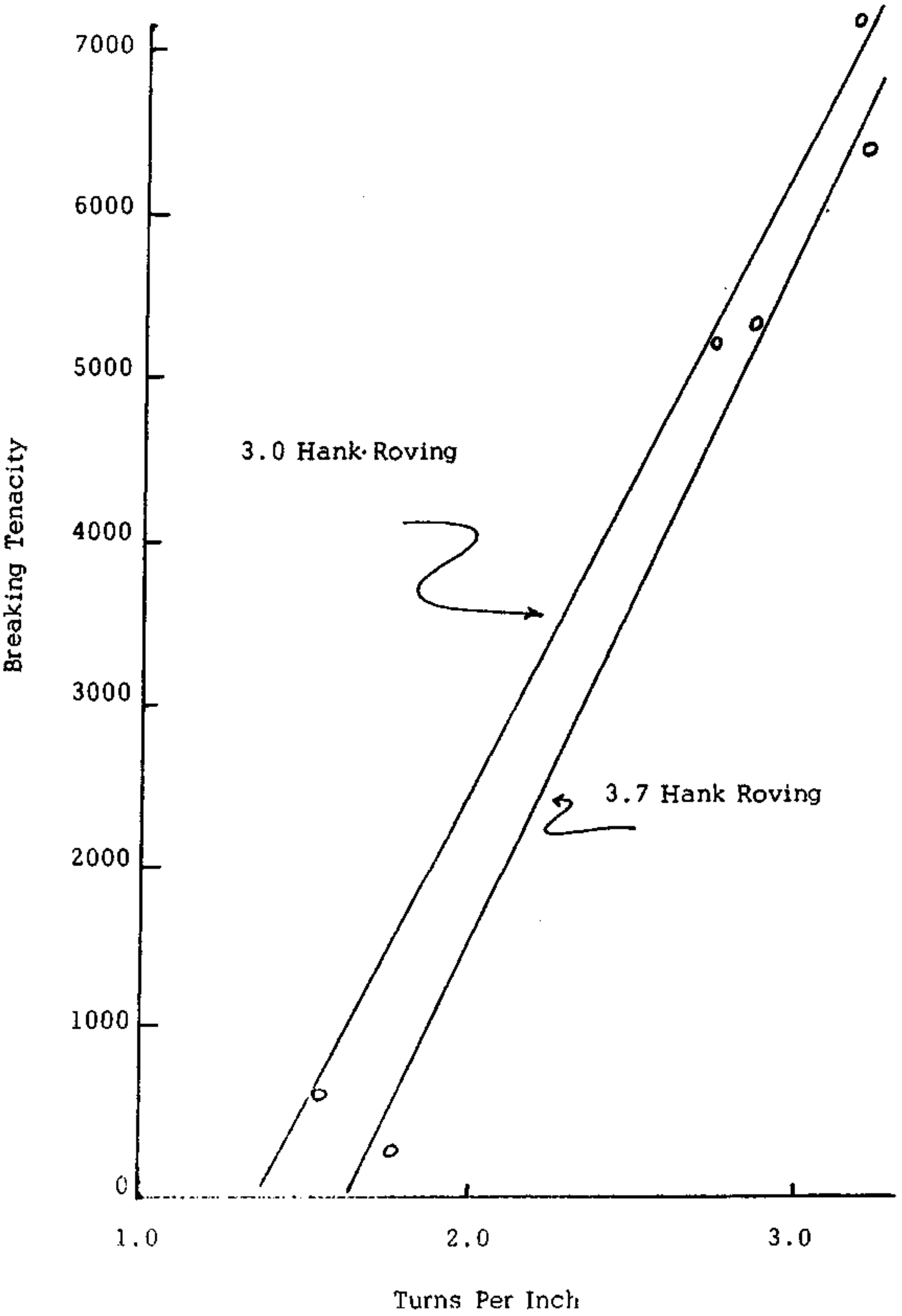

Figure 3. Twist (Turns per Inch) vs. Breaking Tenacity

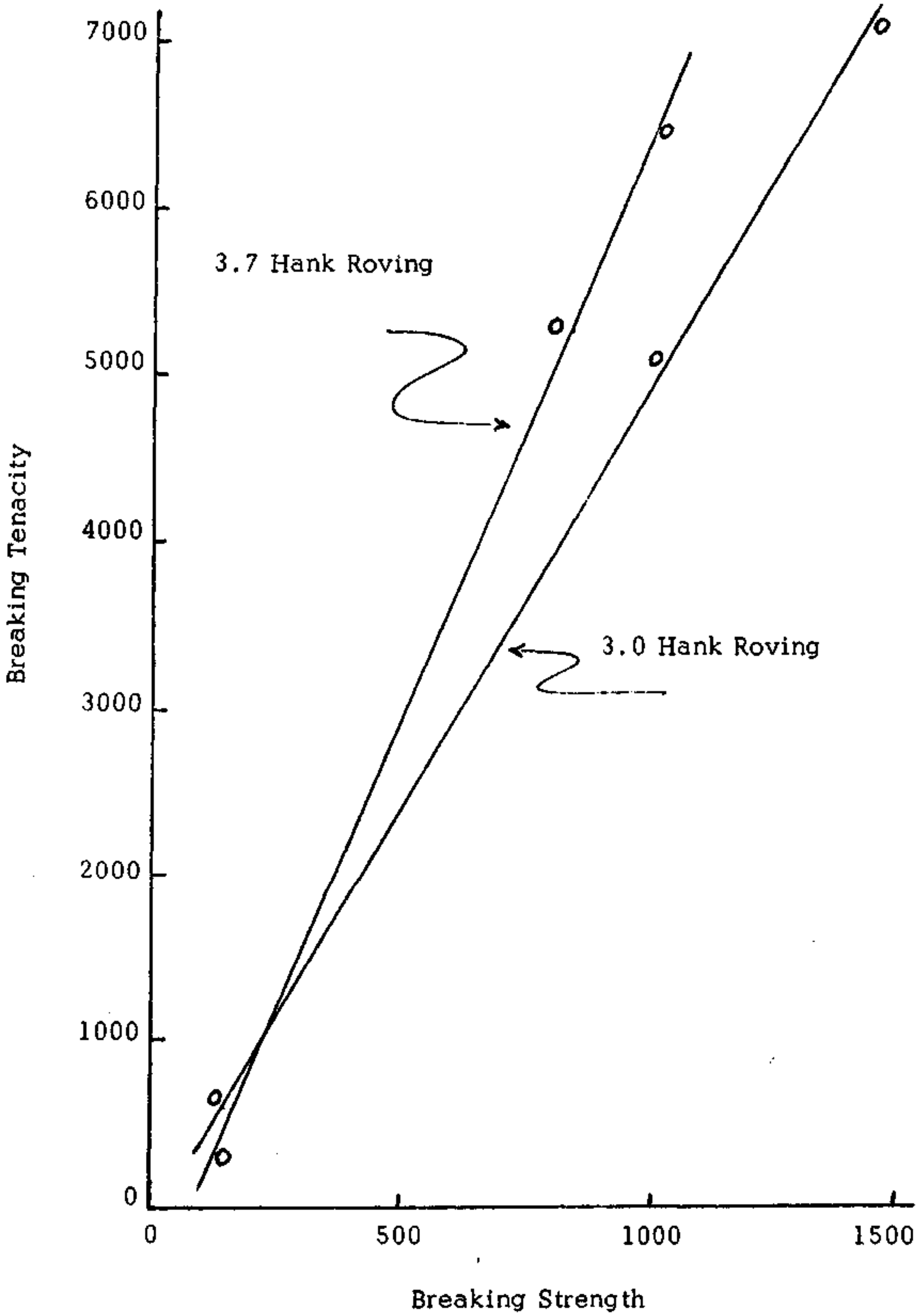

Figure 4. Breaking Strength vs. Breaking Tenacity

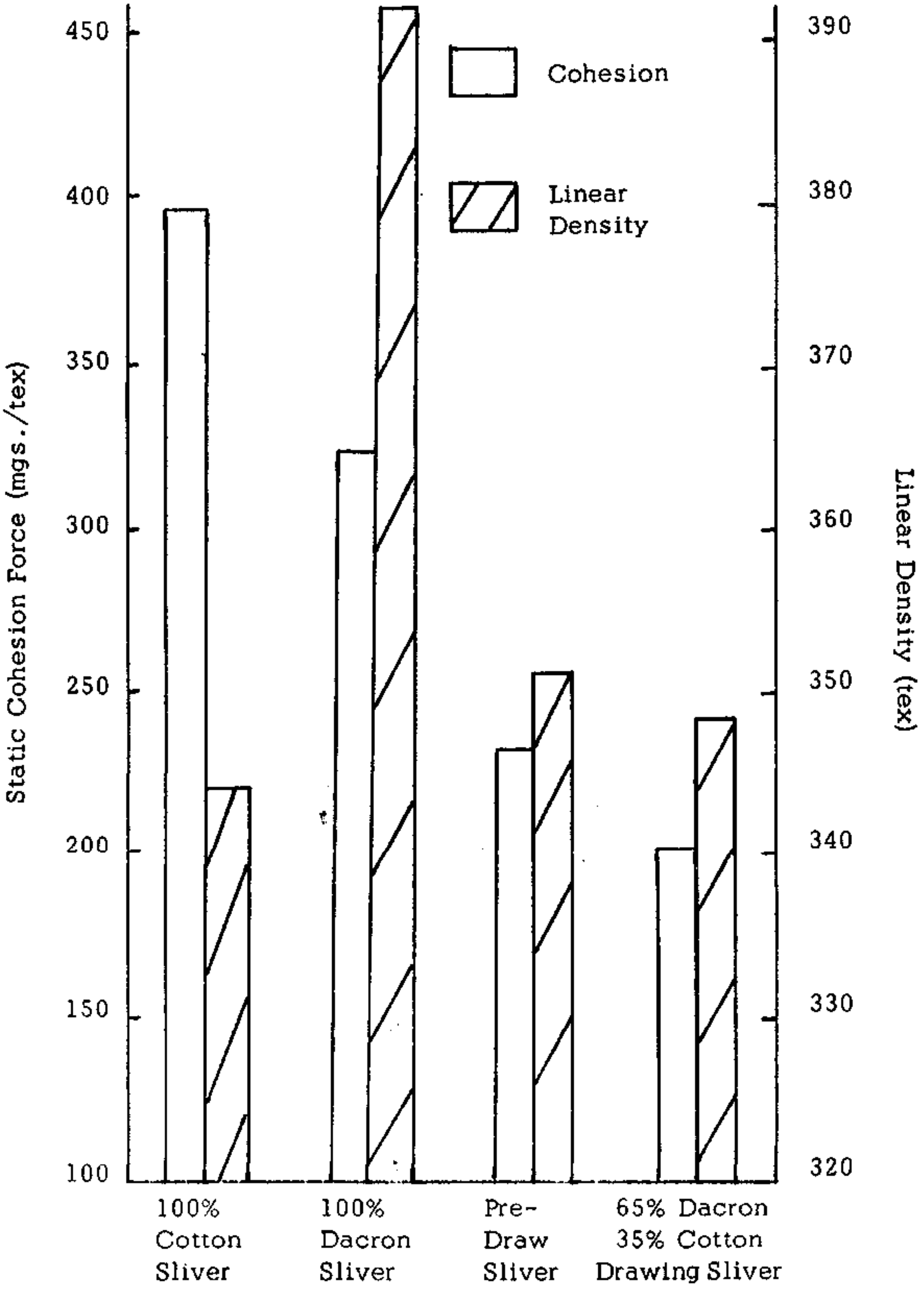

Figure 5. Cohesion and Linear Density of Sliver Samples

Figures 6 and 7 show the effect of three levels of twist on the static cohesive forces of 3.0 and 3.7 hank roving consisting of a 65% Dacron-35% cotton blend.

The graphic representations in Figures 6 and 7 show a ten-fold increase in the static cohesive force as the direct effect of increasing the twist level from 1.59 turns per inch to 3.25 turns per inch in the 3.0 hank roving and from 1.75 turns per inch to 3.25 turns per inch in the 3.7 hank roving. Although a 3.0 hank roving with 3.25 turns per inch and 3.7 hank roving with 3.25 turns per inch are not practical, and would be almost, if not, impossible to spin satisfactorily on conventional equipment, the graph does represent the necessity of producing roving with a level of twist so that spinning can be accomplished efficiently and satisfactorily.

Table 7 shows the result of an analysis of variance (11) for sample weight and three levels of twist applied to the test specimens. The results reveal significant (98 per cent level) effects for twist, but none for weight or weight-twist interaction.

Table 7. Analysis of Variance for Weight and Twist

Source	Sum of Squares	Degrees of Freedom	Mean Square	F-Ratio	F-95%
Weight	.0003	1	.0003	.0150	4.17
Twist	.2077	2	.1038	5.2160	3.32
Weight x Twist	.0024	2	.0012	.6030	3.32
Error	.5969	30	.0199	____	____
Total	.8073	35	____	____	____

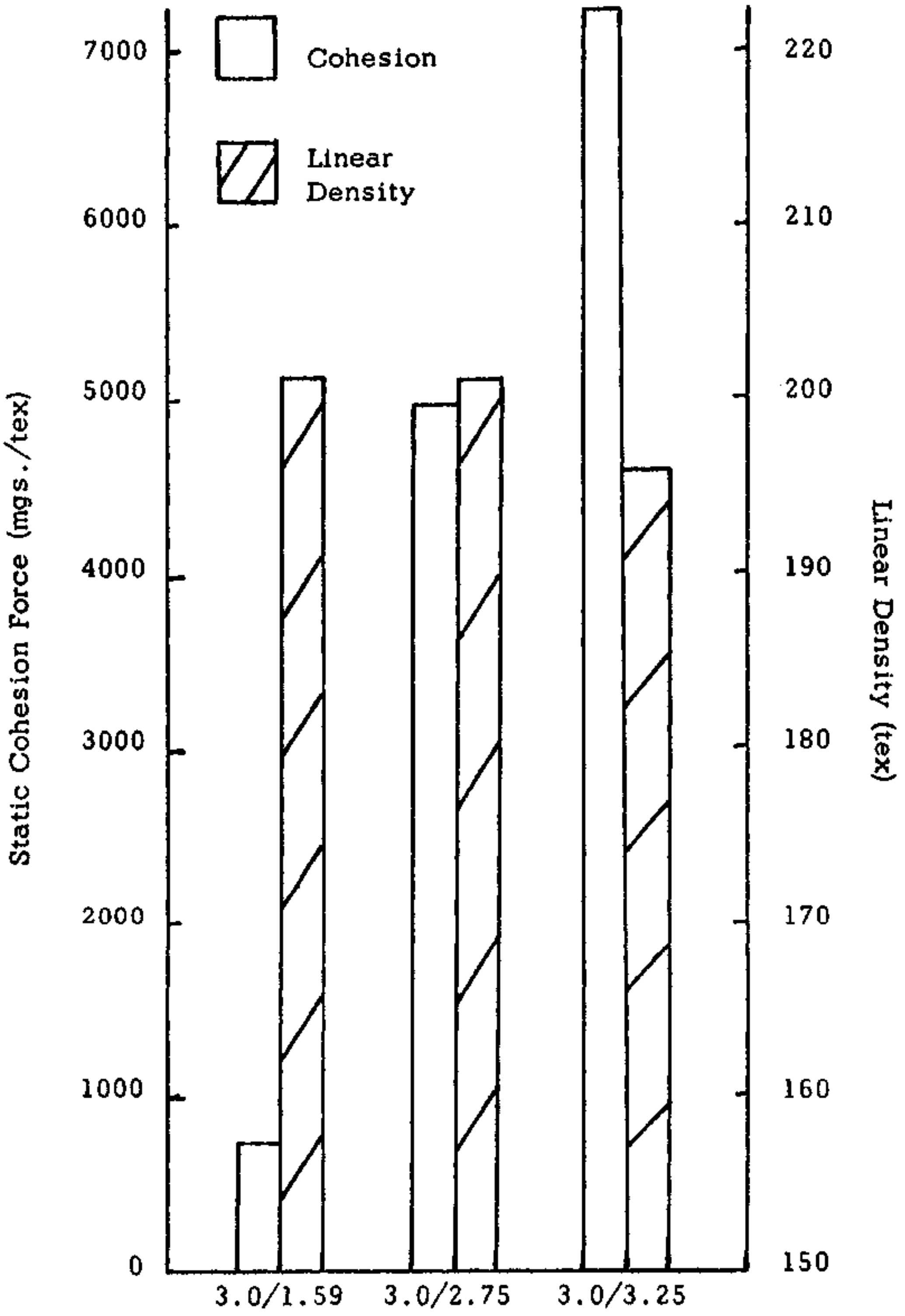

Figure 6. Cohesion and Linear Density of 3.0 Hank Roving with Three Levels of Twist

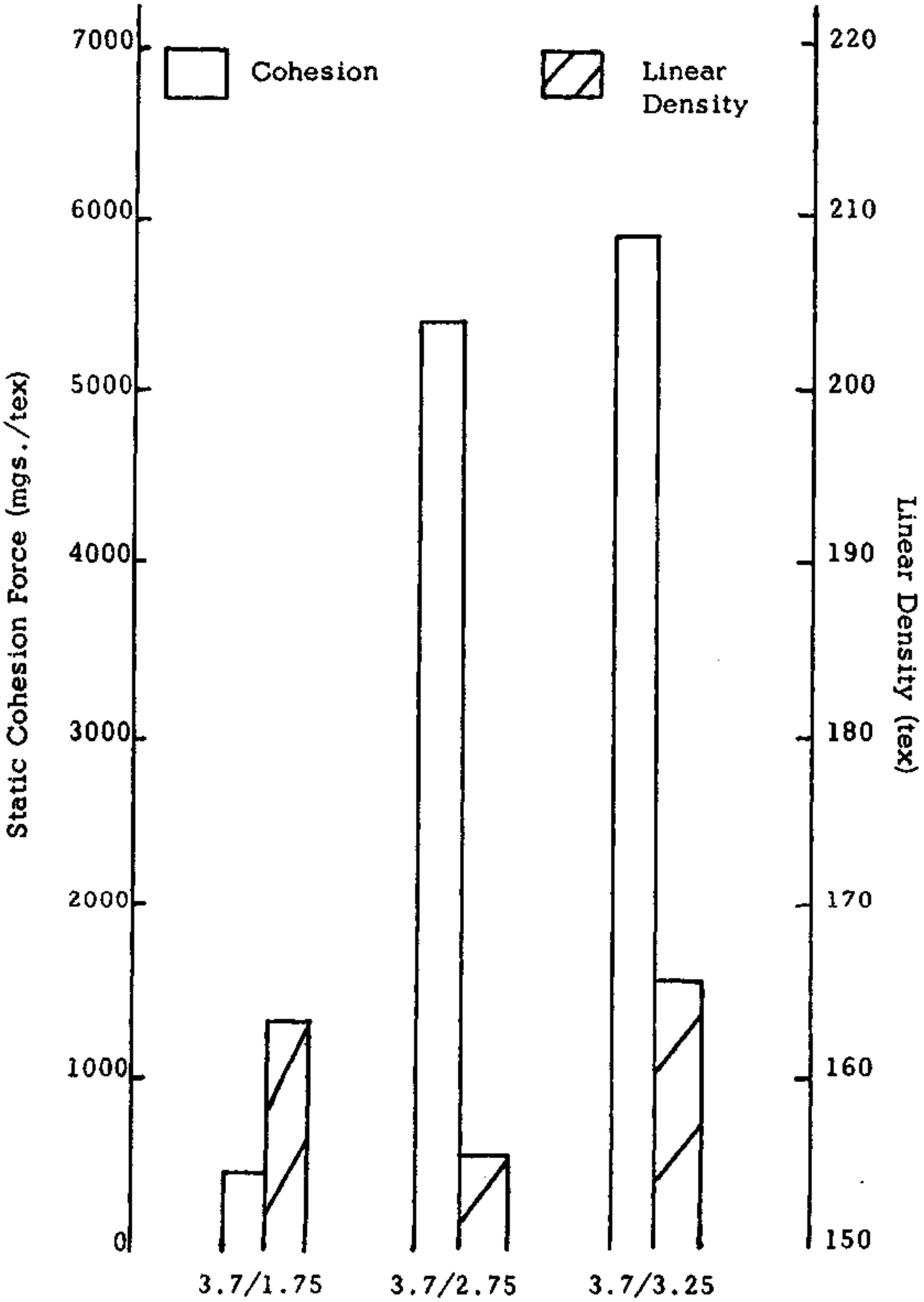

Figure 7. Cohesion and Linear Density of 3.7 Hank Roving with Three Levels of Twist

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The following conclusions, based on data obtained from this investigation, are limited to the types of cotton used, machinery used for processing the roving and yarn, and the range of variables investigated.

1. Static cohesion forces are related to the degree of twist placed in the sliver or roving.

2. Static cohesion forces are related to the degree that each fiber is represented in the blend.

3. Static cohesion forces are related to the number of drawing processes to which a sliver has been subjected.

4. Static cohesion forces are not related to linear density (tex).

5. Increases in twist significantly increase roving strength.

Recommendations

1. An investigation should be conducted to show how static cohesion data compare with that obtained from a West Point Dynamic Cohesion Tester.

2. An investigation should be conducted to show the effect of gauge length and rate of draft on the cohesion forces.

3. An investigation should be conducted to show the effect of various chemical agents on static and dynamic cohesion forces.

4. A. S. T. M. Proposed Test Method should contain information on testing blends of fibers as well as samples that consist of 100 per cent cotton or synthetic fiber.

5. The main objection to the test is that it is difficult to obtain the same amount of tension for each sample as it is mounted. This leads to variation in the weight which causes a variation in the breaking tenacity or static cohesive force.

APPENDIX

Table 8. Fiber Fineness Test Using Sheffield Micronaire

Test Number	Micronaire Reading
1	3.95
2	4.00
3	3.98
4	4.03
5	4.01
6	3.94
7	3.96
8	3.96
9	4.00
10	4.02
11	3.94
12	3.99
13	4.03
14	4.00
15	4.01
Total	59.82
Average	3.99

Table 9. Fiber Strength Test Using the Pressley Tester (Zero Gauge)

Test Number	Breaking Strength (lbs.)	Weight (mgs.)	Pressley Index	Tenacity (gms./tex)
1	14.00	1.72	8.14	43.63
2	19.21	2.24	8.58	45.98
3	11.25	1.24	9.07	48.61
4	11.00	1.22	9.02	48.34
5	13.82	1.59	8.69	46.57
6	12.51	1.32	9.47	50.81
7	15.70	1.80	8.72	46.73
8	16.80	1.88	8.93	47.86
9	15.20	1.72	8.83	47.32
10	11.40	1.28	8.90	47.70
11	15.90	1.78	8.93	47.86
12	16.40	1.84	8.91	47.75
13	18.10	1.96	9.23	49.47
14	14.70	1.60	9.18	49.20
15	13.20	1.56	8.46	45.34
Total			133.06	713.17
Average			8.87	47.54

$$\text{Pressley Index} = \frac{\text{Breaking Strength in Pounds}}{\text{Bundle Weight in Milligrams}}$$

Tenacity in grams per tex = k x Pressley Index
Where k = 5.36

Table 10. Fiber Length Analysis Using the Digital Fibrograph

Test Number	50% Span Length	2.5% Span Length	Uniformity Ratio (%)
1	0.56"	1.17"	47.86
2	0.51"	1.16"	43.96
3	0.54"	1.17"	46.15
4	0.57"	1.19"	47.89
5	0.55"	1.19"	46.21
6	0.54"	1.18"	45.76
7	0.52"	1.16"	44.82
8	0.54"	1.17"	46.15
9	0.55"	1.17"	47.00
10	0.53"	1.16"	45.68
11	0.56"	1.17"	47.86
12	0.53"	1.16"	45.68
13	0.56"	1.18"	47.45
14	0.57"	1.18"	48.30
15	0.55"	1.17"	47.00
Total	8.18"	17.58"	697.77
Average	0.55"	1.17"	46.51

$$\text{Uniformity Ratio} = \frac{\text{50\% Span Length}}{\text{2.5\% Span Length}} \times 100$$

Table 11. Results of Test on 100% Cotton Card Sliver, 100% Dacron Card Sliver, Dacron-Cotton Blend Draw and 65% Dacron and 35% Cotton Finisher Draw

100% Cotton Combed Sliver		
Weight per Yard Delivered (Grains)	50	
Per Cent CV-Evenness (Avg.)	3.95	
100% Dacron Card Sliver		
Weight per Yard Delivered (Grains)	50	
Per Cent CV-Evenness (Avg.)	4.05	
Blend Drawing (Dacron and Cotton)		
Weight per Yard Delivered (Grains)	50	
Per Cent CV-Evenness (Avg.)	3.80	
Finisher Drawing Sliver		
Weight per Yard Delivered (Grains)	50	
Per Cent CV-Evenness (Avg.)	3.20	
Roving		
Weight Devlivered (Hank Roving)	3.0	3.7
Per Cent CV-Evenness (Avg.)	4.07	4.25

Table 13. Averages of Data Obtained from 3.7 Hank Roving and 1.75 Turns per Inch

Sample	Weight* (gms.)	Breaking Strength* (gms.)	Linear Density* (tex)	Breaking Tenacity* (mgs./tex)
1	.0236	57.9	169.27	343.7
2	.0235	72.5	168.59	430.8
3	.0226	60.8	161.76	371.0
4	.0229	66.7	164.76	406.2
5	.0226	65.1	162.11	401.8
6	.0226	58.6	162.12	360.0
Total	.1378	381.6	988.11	2313.5
Average	.0229	63.6	164.68	385.5

* Figures shown are averages for twenty individual determinations.

Table 14. Averages of Data Obtained from 3.7 Hank Roving and 2.75 Turns per Inch

Sample	Weight* (gms.)	Breaking Strength* (gms.)	Linear Density* (tex)	Breaking Tenacity* (mgs./tex)
1	.0220	840	157.82	5334
2	.0218	840	156.04	5389
3	.0212	828	152.81	5425
4	.0218	844	156.40	5397
5	.0218	828	156.04	5312
6	.0214	837	153.53	5458
Total	.1300	5017	932.64	32,317
Average	.0216	836	155.44	5386

* Figures shown are averages for twenty individual determinations.

Table 14. Average of Data Obtained from 3.7 Hank Roving and 3.25 Turns per Inch

Sample	Weight* (gms.)	Breaking Strength* (gms.)	Linear Density* (tex)	Breaking Tenacity* (mgs./tex)
1	.0230	1019	164.98	6169
2	.0232	1015	166.05	6209
3	.0229	1087	164.26	6643
4	.0230	1104	165.34	6677
5	.0232	1115	166.41	6704
6	.0227	1041	162.84	6406
Total	.1380	6381	989.88	38,798
Average	.0230	1063	164.98	6466

* Figures shown are averages for twenty individual determinations.

Table 15. Averages of Data Obtained from 3.0 Hank Roving and 1.59 Turns per Inch

Sample	Weight* (gms.)	Breaking Strength* (gms.)	Linear Density* (tex)	Breaking Tenacity* (mgs./tex)
1	.0274	124.2	195.77	638.3
2	.0271	125.1	193.99	646.0
3	.0265	118.0	187.54	638.7
4	.0313	111.8	224.05	503.0
5	.0308	128.3	220.80	582.9
6	.0281	128.2	202.57	637.0
Total	.1712	735.6	1224.72	3645.9
Average	.0285	122.6	204.12	607.7

* Figures shown are averages for twenty individual determinations.

Table 16. Averages of Data Obtained from 3.0 Hank Roving and 2.75 Turns per Inch

Sample	Weight* (gms.)	Breaking Strength* (gms.)	Linear Density* (tex)	Breaking Tenacity* (mgs./tex)
1	.0276	1028	197.91	5206
2	.0283	1032	202.57	5094
3	.0284	1047	203.29	5160
4	.0283	1040	202.93	5134
5	.0284	1050	203.65	5156
6	.0283	1052	202.93	5185
Total	.1693	6249	1213.28	30,935
Averages	.0282	1041	202.21	5155

* Figures shown are averages for twenty individual determinations.

Table 17. Averages of Data Obtained from 3.0 Hank Roving and 3.25 Turns per Inch

Sample	Weight* (gms.)	Breaking Strength* (gms.)	Linear Density* (tex)	Breaking Tenacity* (mgs./tex)
1	.0273	1249	195.75	6416
2	.0283	1469	202.57	7180
3	.0274	1459	196.49	7421
4	.0275	1474	197.20	7474
5	.0265	1561	189.67	8276
6	.0279	1432	200.07	7143
Total	.1649	8644	1181.75	43,910
Average	.0274	1441	196.96	7318

* Figures shown are averages for twenty individual determinations.

Table 18. Averages of Data Obtained from 100% Cotton Card Sliver

Sample	Weight* (gms.)	Breaking Strength* (gms.)	Linear Density* (tex)	Breaking Tenacity* (mgs./tex)
1	.483	141.3	345.67	409.0
2	.485	135.0	347.44	388.7
Total	.968	276.3	693.11	797.7
Average	.484	138.1	346.55	398.8

Table 19. Averages of Data Obtained from 100% Dacron Card Sliver

Sample	Weight* (gms.)	Breaking Strength* (gms.)	Linear Density* (tex)	Breaking Tenacity* (mgs./tex)
1	.552	130.6	390.38	330.4
2	.553	130.6	395.73	330.2
Total	1.105	261.2	786.11	660.6
Average	.552	130.6	393.05	330.3

* Figures shown are averages for twenty individual determinations.

Table 20. Averages of Data Obtained from Pre-Draw Sliver

Sample	Weight* (gms.)	Breaking Strength* (gms.)	Linear Density* (tex)	Breaking Tenacity* (mgs./tex)
1	.489	76.7	349.97	219.17
2	.494	76.4	353.90	225.80
Total	.983	153.1	703.87	444.97
Average	.491	76.5	351.93	222.48

Table 21. Averages of Data Obtained from Finish Draw Sliver

Sample	Weight* (gms.)	Breaking Strength* (gms.)	Linear Density* (tex)	Breaking Tenacity* (mgs./tex)
1	.491	77.0	351.38	214.1
2	.489	79.1	350.34	225.7
Total	.980	156.1	701.72	437.8
Average	.490	78.1	350.86	219.9

* Figures shown are averages for twenty individual determinations.

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