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TEXTILE TECHNOLOGY

Size Lubrication Methods for Air-Jet-Spun and Ring-Spun Warp Yarns

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INTERPRETIVE SUMMARY

The use of liquid or wax lubricants in warp size for staple fiber yarns has long been standard in U.S. mills. Previous studies have shown that this practice can be detrimental to weaving performance, especially with respect to abrasion resistance. Other studies have shown that a relationship exists among fiber types, size films, slasher settings, and add-on (the ratio of chemical weight added to an untreated yarn weight and compared with the weight of the untreated yarn). This study addresses the effect of size concentration and lubrication on yarn characteristics and weaving performance of air-jet-spun yarns.

Yarns made of 50% polyester and 50% cotton were used for comparative evaluations in this study. Two yarns were made, one conventional ring-spun and the other air-jet-spun. A Callaway laboratory slasher was used to size the yarns with 50% polyvinyl alcohol, 50% cornstarch size at 10% solids[1] for the experiments. To determine the effects of lubrication on size film formation, nine processing conditions were chosen. Either wax or liquid lubricant was applied due to the prevalent usage of these lubricant classes in the industry. Concentrations of 3.0 and 7.0% lubricant were used for the yarns and applied either in the size box or after drying.

Whether the fatty liquid or wax lubricants were used in or after the size bath, they reduced the tensile strength and abrasion resistance of sized yarns. Use of lubricant produced high variations among samples in elongation, add-on, size encapsulation and penetration of yarns.

Addition of lubrication caused both increases and decreases in add-on level, as compared with the respective unlubricated samples. Application of lubricant in either solid or liquid form, in the size bath or after drying caused a decrease in yarn tensile strength for both air-jet and ring-spun yarns. Lubrication used in the bath was more detrimental to single-end strength than lubrication used after the bath was. Liquid lubricant caused greater strength loss than did wax lubricant, whether it was used in the bath or after drying. Net breaking elongation of sized warp yarns with lubricant was less than breaking elongation of sized warp yarns without lubricant in all cases.

Results of the encapsulation analysis showed that application position, interaction effects between application position and lubricant type, and interaction effects between application position and lubricant concentration were significant ($P = 0.05$). In-bath lubrication produced less encapsulation than after-bath lubrication, at the same confidence level.

The primary purpose of warp size is to increase the abrasion resistance of sized warp yarns. For all yarn types, lubrication had an adverse effect on abrasion resistance. Air-jet-spun yarns are less resistant to abrasion than ring-spun yarns are because the former are bound by outer wrapper fibers only and have no internal twist. Increased concentration of lubricants in the size bath decreased abrasion resistance for both yarn types. Better abrasion resistance was obtained from lubrication after drying than from in-bath lubricant use. The difference is particularly important in the case of liquid lubricant with the air-jet-spun yarn.

The general effect of lubricant in warp size is to break apart the size and produce an effect

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[1] Percent solids = (mass of size components excluding lubricants) x 100 / (mass of water). Lubricant concentration is defined as percent lubricant on weight of solids = (mass of lubricants) x 100 / (mass of size components excluding lubricants).

increasingly resembling the state of unsized yarn as more lubricant is added to the size mix. There is similarity in behavior for sized, air-jet-spun yarns to that of ring-spun yarns produced from cotton and polyester blends. Traditional, in-bath lubrication and after-drying applications degenerated the original size film and yarn structure physical performances obtained in the absence of lubricants. Lubricants added after drying caused less degradation of size abrasion resistance than did those added in mixes. Addition of lubricant did not consistently reduce the coefficient of friction of sized yarns. The coefficient of friction generally has been assumed important in determining the abrasion resistance of a yarn moving in contact with another surface, but this and previous studies show no relationship between coefficient of friction and abrasion resistance.

ABSTRACT

No specific studies have been performed to determine benefits of lubricants in size bath mixtures for air-jet-spun cotton (*Gossypium hirsutum* L.) yarns. This study focused on the effect of size concentration and lubrication on the characteristics and weaving performance of modern air-jet-spun cotton-polyester blend yarns in comparison with conventional ring-spun yarn. Two yarns were made using conventional ring spinning and air jet spinning. Yarns were sized with 50% polyvinyl alcohol and 50% cornstarch at 10% solids. Nine processing conditions were chosen; wax or liquid lubricant was applied in concentrations of 3.0 or 7.0 %. Lubricants were applied either at size bath or in after-waxing form. A control sample without lubricant also was used. Samples were tested for strength, elongation and abrasion resistance and statistically analyzed to determine performance differences. Lubricants in application schemes, which include traditional in-bath lubrication as well as after-drying applications, degenerated the original size film and yarn structure physical performances obtained in the absence of lubricants. Lubricants added after drying caused less degradation of size abrasion resistance than did those added in mixes. Addition of lubricant did not consistently reduce the coefficient of friction of sized yarns. Use of traditional fatty liquid or wax lubricants with film forming sizes reduces the breaking strength and abrasion resistance of sized air-jet-spun yarns in a manner similar to that observed in ring-spun yarns.

The inclusion of waxy or liquid lubricants in size formulations for staple fiber warp yarns has been a standard operating practice in most U.S. mills for many years. Most mills apply these types of additives to size formulations in the belief that they improve weaving performance by reducing surface friction of warp yarns on contacting surfaces such as loom reeds, heddles, and dropwires. Previous studies (Thomas and Brayshaw, 1996; Thomas et al., 1997; Walker and Perkins, 1985) have shown that this practice can be detrimental to weaving performance, especially with respect to abrasion resistance.

Recent experiments (Thomas and Brayshaw, 1996) have shown that some films made with size formulations containing lubricants cannot be formed successfully and tested for strength. In the same experiments, all films formed in association with the use of lubricants exhibited fragmentation. The presence of lubricants also causes irregular size film adhesion (Trauter and Weissenberger, 1979).

Other studies (Cahill and Hedrick, 1982; Cahill and Strauss, 1980) have shown the relationship among fiber types, fiber length, size film type, slasher settings, and percent size add-on in laboratory tests and in weaving performance. No specific studies have been performed to determine whether beneficial levels of lubricant exist up to and at concentrations that typically are employed in size bath mixtures. Trauter and Bauer (1984) and others have examined the effects of warp sizes with different spinning systems, such as open-end and ring spinning. They found that size add-on for open-end spun yarns is approximately 10% greater than that for ring-spun yarns under similar concentration levels and machine settings. The question that has not been addressed is the effect of size concentration and lubrication on the characteristics and weaving performance of modern air-jet-spun yarns. This study will focus on this type of yarn in comparison with the conventional ring-spun yarn.

EXPERIMENTAL PROCEDURES

Most industrial practice is focused on producing air-jet-spun yarns in blends of 50% polyester and 50% cotton; therefore, yarns of this blend ratio were used for comparative evaluations in this study. Using 'Memphis' cotton (4.5 micronaire, 2.84 cm staple

Table 1. Staple fiber yarn slashing conditions.

Condition	Size lubrication level
No lubrication	Control
In bath wax, high lubricant content	7.0% conc. in-bath
In bath wax, low lubricant content	3.0% conc. in-bath
After wax, high lubricant content	1.0% by desize
After wax, low lubricant content	0.6% by desize
In bath liquid lubricant, high content	7.0% conc. in-bath
In bath liquid lubricant, low content	3.0% conc. in-bath
After bath liquid lubricant, high content	1.0% by desize
After bath liquid lubricant, low content	0.6% by desize

length) and high tenacity (approximately 6 gpd) polyester fiber (1.2 denier, 3.8 cm staple length), two yarns were made; one on the conventional ring-spinning and the other on air-jet spinning. Optimum processing conditions suitable for each spinning system were used to produce a yarn of Ne35 cotton count.

A Callaway laboratory slasher was used to size the yarns for the experiments. The slasher consisted of a 146 end creel, a high-pressure squeeze box with a single squeeze immersion roll, four electronically heated dry cans, a Strandberg moisture and stretch monitor, a front leasing section, and a constant tension take-up section.

Criteria for evaluation of sizing effectiveness traditionally fall into two categories; (i) the general rule of thumb of evaluation of loom stops in a production environment or (ii) evaluation by use of specific testing procedures in a controlled laboratory setting. Although some limited correlation has been demonstrated between production results and laboratory tests (Thomas and Brayshaw, 1996), loom stop evaluations must be conducted thoroughly with expert observers to be meaningful. A simple evaluation of loom efficiency only measures worker speed and queuing interference, it does not identify specific stop causes, and therefore is invalid as a basis for comparative evaluation. For this reason, testing of the samples was restricted to laboratory evaluations.

Sizing and Lubrication Procedures

To determine the effects of lubrication on size film formation, nine processing conditions were chosen and set as a testing matrix. Yarns for the experiment were sized with a 50% polyvinyl alcohol, 50% modified cornstarch size at a concentration of 10% solids[1] to approximate size formulations for an average weaving mill in a sheeting or print cloth market.

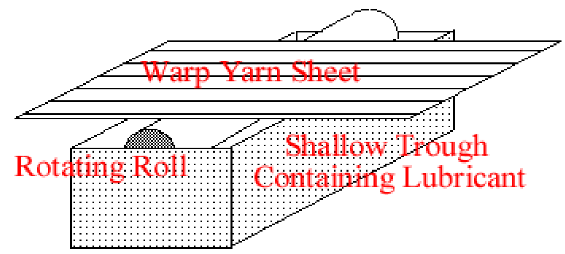

Fig. 1. Schematic of kiss-roll equipment, positioned between the drying and take-up sections.

Either wax or liquid lubricant was applied because of the prevalent usage of these lubricant classes in the industry. The wax used in the experiment was a hydrogenated tallow supplied by a leading manufacturer of warp sizes and additives that represented the animal-fat-based, flake type waxes commonly applied in a size-cooking kettle. The liquid lubricant was a water dispersible, low molecular weight, polar compound of a proprietary content (a somewhat emulsified, mineral based lubricant) that was supplied by a size chemical manufacturer different from the one that supplied the wax lubricant. Concentrations of 3.0 and 7.0% lubricant were used for the spun yarns based on the industry range of 2 to 8% for similar yarns (Table 1).

Lubricant application treatment after drying was designed to deposit lubricant onto the warp between the final dry can and the yarn take-up section. The application method employed was a kiss-roll device (Fig. 1). Desired concentrations were achieved by attaching a voltage regulator to the kiss-roll drive and varying the speed of the roll, thus altering the quantity of lubricant applied per unit time.

Lubricant Content of Warp Yarns

To determine the amount of lubricant applied after the bath, a desize analysis was performed on unsized, lubricated yarn samples. Results of this analysis were compared with a desize analysis of the same yarn samples in the natural state to determine the amount of extractables present. The average difference between the lubricated and unsized samples' desize levels was calculated to determine

Table 2. Add-on of lubricant obtained by samples subjected to after-drying lubrication schemes.

Treatment (ring-spun and air-jet-spun)	Avg. lubricant add-on
	%
After wax, low lubricant content	0.6
After wax, high lubricant content	1.0
After bath liquid lubricant, low content	0.6
After bath liquid lubricant, high content	1.0

Table 3. Sulzer Rüti Webtester spun-yarn testing parameters.

Variable	Setting
Static tension	7.6 N
Abrasion element penetration	3.0 mm
Test speed	335 cycles / min
Impact load per 15 ends	0.03 cN/Tex
Cyclic elongation	0.5 %
Clamp length	500 mm

Table 4. Single-end strength and elongation settings on Instron tensile tester.

Variable	Setting
Maximum load	1000 g
Gauge length	25.4 cm
Rate of extension	25.4 cm / min
Jaw type	2.54-by-2.54 cm pneumatic

the amount of lubricant added after the drying section of the slasher. The average concentration for the staple fiber yarn systems was a high concentration of 1.0% and a low concentration of 0.6%. The results of the corrected lubricant add-on levels appear in Table 2.

To eliminate possible variation among slashing runs, both yarns were sized simultaneously. This procedure assured that the yarns were exposed to identical processing conditions.

Each sample run was again desized, using a standard laboratory procedure to determine size add-on obtained. Sized and greige yarn samples were analyzed to determine a corrected size pick-up (percent) value. A description of the procedure used to determine these results is shown in the Appendix.

Abrasion Resistance

All sized yarn conditions were evaluated for abrasion resistance using a Sulzer Rüti Webtester. This device simulates the weaving forces of flexure, metal-to-yarn abrasion, static tension, elongation, and cyclic loading (Cahill and Hedrick, 1982; Trauter, 1977; Trauter and Weissenberger, 1979). Anandjiwala and Goswami (1993) among others have shown that the abrasion resistance of sized warp yarns is dependent on the abrasion pin settings of the Webtester. Four trials of 15 ends from each condition were performed. The number of abrasion cycles required to break the yarns was recorded for each end, and the sixth break of each of the four trials was averaged to compute the ST-6 Value, which is an accepted industry standard value for abrasion resistance of sized warp yarns (Trauter and Weissenberger, 1979). The settings for the Webtester evaluations are shown in Table 3.

Size Application Quality

The quality of size application was measured by the encapsulation and penetration testing methodology developed at the Institute of Textile Technology (Cahill and Hedrick, 1982; Cahill and Strauss, 1980). Ten samples of each condition were measured through microscopic photographs to determine how much of the yarn was encapsulated by the size, and how much the size had penetrated into the yarn structure. Size penetration is expressed as a percent, increasing from the outside yarn boundary to the center. Size encapsulation is determined from the amount of the 360° outer periphery of the yarn that is encased with size. Both of these quality parameters were quantified through analysis of stained single-end cross sections.

Tensile Load Response Measurements

The single-end strength and elongation behavior of each of the warp yarns was determined using an Instron tensile tester. Ten ends from each condition were tested and compared using the parameters shown in Table 4.

Determination of Coefficient of Friction

The coefficient of friction is a significant characteristic of textile yarns, because it defines the amount of resistive shear force a yarn will exert and have exerted upon it during fabric forming or preparation processes. A method was designed for measurement of friction using a standard Instron tensile tester with a load cell in the range of 100 g

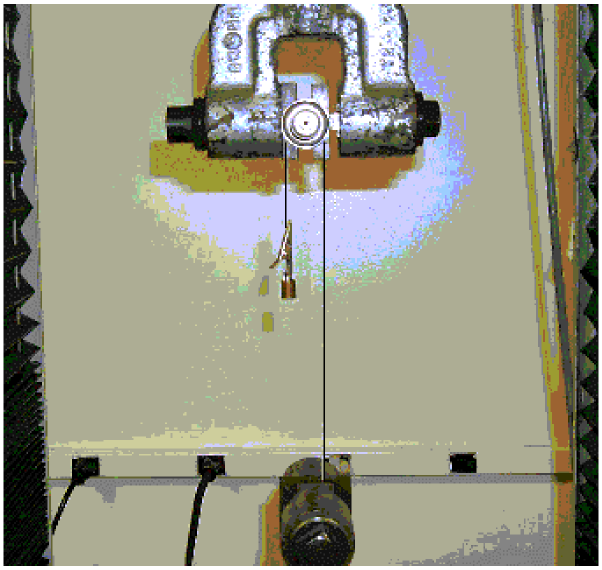

Fig. 2. Setup of the equipment used to test the friction of samples.

maximum load. A capstan device was designed to fit into the upper jaw clamp of the tensile tester. The capstan is a 2.5 cm (1 in.) diameter disk type thread guide of the variety used in warpers or knitting creels, circular in shape and having a grooved surface on the outer diameter that prevents the thread from slipping off. The disk is supported through the center by a nut and bolt that attach it to two flat, rectangular, aluminum plates on either face of the disk. The two plates are offset from the disk perimeter to a center line above the disk so that they form a tongue support that is clamped into the test jaws.

A gauge length of 25.4 cm (10 in.) was used for the test. The yarn length required had to be long enough to extend from the lower jaw, where it is fixed, to the disk, over the disk's grooved perimeter and down below the disk for the specified length. The thread was held in place by a brass weight and alligator clamp assembly that weighed 9.8 g and measured 5.1 cm (2 in.) in length (Fig. 2).

The Instron tester scale was calibrated to zero with the capstan in place and the full scale load set to 100 g. A test yarn and the weight were mounted in the tester, and the initial chart pen location was marked prior to the star of each test. Complete settings for the test are shown in Table 5.

At the beginning of the test, the load required to initiate movement of the yarn across the capstan was registered by the chart pen as a peak followed by a

Table 5. Instron tensile tester settings for coefficient of friction analysis.

Variable	Setting
Maximum load	**100 g**
Gauge length	**25.4 cm**
Capstan device	**2.54 cm diam**
Weighted alligator clip	**9.8 g**
Rate of extension	**25.4 cm / min**
Jaw type	**2.54-by-2.54 cm pneumatic**
Chart speed	**50.8 cm / min**

rapid decrease in magnitude to a level greater than the initial pen position but less than the peak position. As the test progressed, the decrease in thread length on the weighted, registration side of the capstan caused a load decrease at a rate determined by the crosshead speed. The peak indicated the load resulting from static friction and the lower pen position indicated the level of dynamic friction present. When the advancing upper crosshead pulled the thread to the point where the clamp touched the disk capstan, the test was stopped and the tester was reversed manually. Ten samples of each condition were tested in this manner. To avoid inaccurate results due to contamination of the capstan surface by previous samples, the capstan had to be cleaned with an alcohol-based solvent between tests.

Initial (static) friction is determined by use of Amonton's Law as:

$$\mu = (\ln L_1 - \ln L_0) / \theta \qquad [1]$$

where

L_1 = peak load at start
L_0 = initial load
$\theta = \pi$

For determination of dynamic friction, the average load is calculated as

$$L_d = (L_{di} - L_{df}) / 2 \qquad [2]$$

where

L_{di} = initial dynamic load
L_{df} = final dynamic load

Dynamic friction is determined in the same manner as static friction, except L_d is substituted in the equation for L_1.

RESULTS AND DISCUSSION

The effect of the addition of fatty liquid or wax lubricants in the size bath and after the size bath reduced both tensile strength and abrasion resistance of sized yarns. Use of lubricant produced high variations among samples with respect to elongation at break, add-on, encapsulation, and penetration of yarns by size films. Due to the potential effect of size film pick-up variations among samples, desizing analysis results were applied to tensile testing results to normalize all values to account for variations in individual yarn counts resulting from the presence of warp size and lubricant.

Table 6. Extractables left after desize analysis.

Experimental treatment	Average extractables: Ring-spun yarn	Average extractables: Air-jet yarn
	%	
Unsized	**1.0**	**1.0**
No lubrication	**9.2**	**10.0**
In bath wax, low lubricant level	**9.1**	**10.2**
In bath wax, high lubricant level	**9.1**	**10.3**
After wax, low lubricant level	**9.2**	**10.4**
After wax, high lubricant level	**9.3**	**10.0**
In bath liquid lubricant, low level	**9.3**	**10.0**
In bath liquid lubricant, high level	**9.3**	**10.4**
After bath liquid lubricant, low level	**9.5**	**10.3**
After bath liquid lubricant, high level	**9.6**	**10.5**
Average size add-on	**9.3**	**10.2**
Standard deviation	**0.2**	**0.2**

Lubricant Effects on Size Add-on in Yarns

The use of lubricants had varying effects on the amount of add-on obtained by each sample for both ring-spun and air-jet spun yarns. As shown in Table 6, the addition of lubrication caused no statistically significant changes in add-on level, as compared with the respective unlubricated samples. Therefore the amount of size add-on within individual spun yarn samples was approximately equal. The natural extractable materials were determined for unsized yarns and a total amount of extractable materials was compared for each yarn condition.

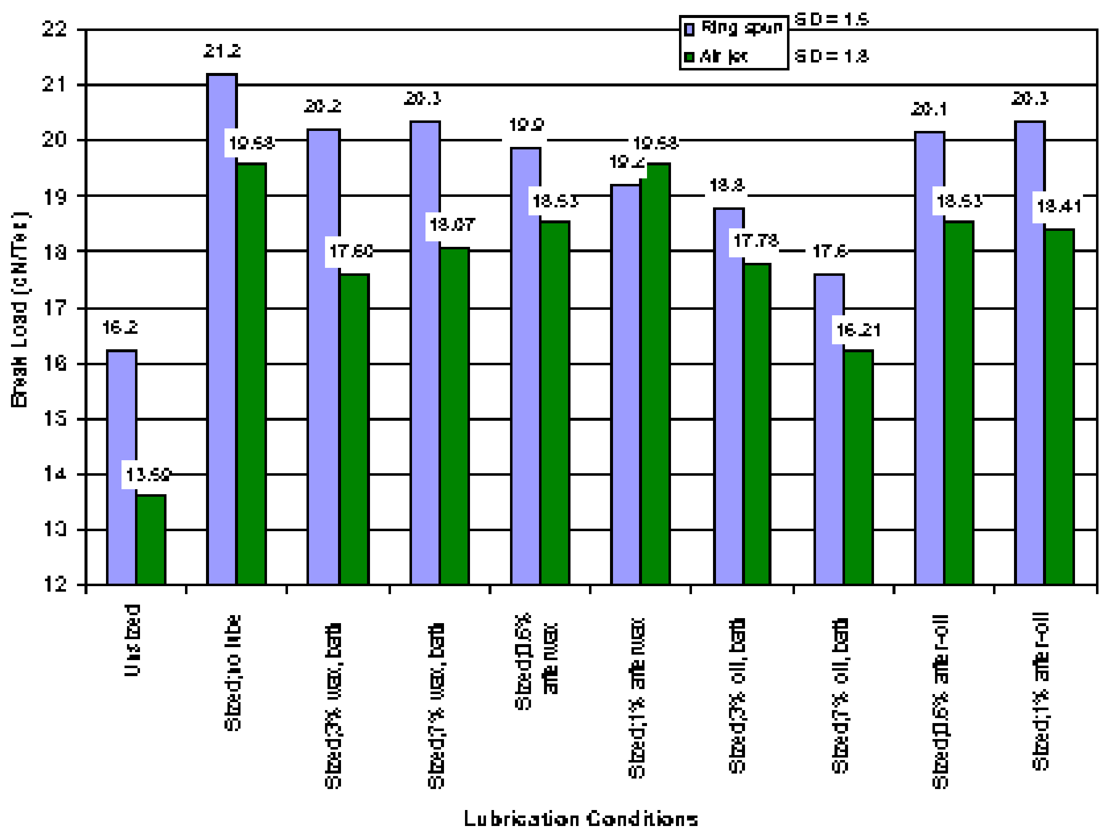

Fig. 3. Single-end breaking strength of yarn samples was diminished when lubricant was applied in the bath. Lubricant applied after drying was more beneficial to strength.

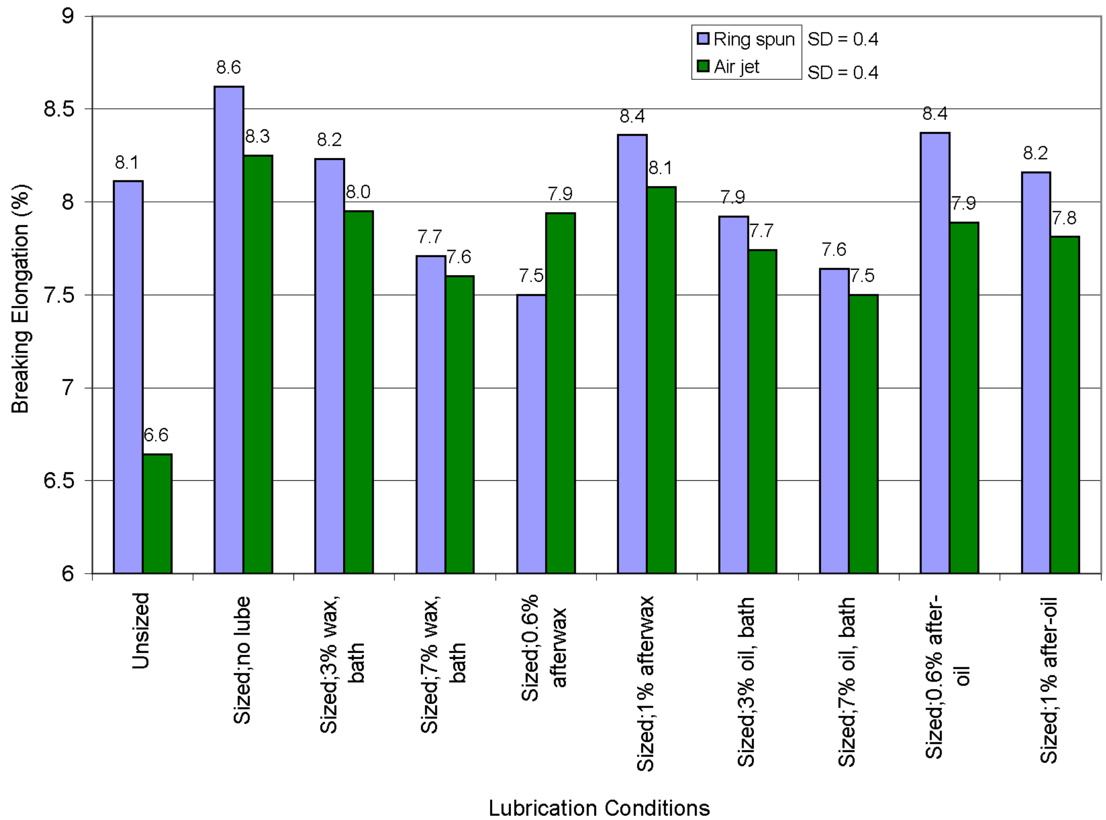

Fig. 4. Breaking elongation of sized yarns with lubricant was usually less than elongation of sized yarns without lubricant, but no differences were greater than three standard deviations from the mean.

Lubrication Effect on Tensile Strength Characteristics

The purpose of sizing is to protect yarns from abrasion in weaving, but size should not significantly degrade the tensile strength or elongation of a warp yarn. Figure 3 shows tensile testing results for tenacity of each yarn type. Tenacity is defined as the breaking strength of a sample in CentiNewtons and normalized to Tex yarn count (cN/Tex). Tex is defined as grams of yarn mass per 1000 meters.

In all but one case, analysis of variance indicated (at P = 0.05) that lubrication used in the bath was more detrimental to single-end strength than was lubrication used after the bath. The analysis also indicated that liquid lubricant had a greater effect on strength loss than did wax lubricant, whether it was used in the bath or after drying. In none of the cases were the differences among sized yarns greater than three standard deviations.

Table 7. Testing results show the degrees of encapsulation and percent of penetration.

	Encapsulation		Penetration	
Experimental treatment	**Ring-spun**	**Air-jet**	**Ring-spun**	**Air-jet**
	degrees		%	
No lubrication	**355.8**		**25.6**	
In bath wax, low lubricant level	**354.2**	**355.0**	**20.4**	**21.5**
In bath wax, high lubricant level	**324.2**	**347.5**	**21.7**	**25.4**
After wax, low lubricant level	**350.8**	**331.7**	**25**	**23.8**
After wax, high lubricant level	**345.8**	**350.0**	**22.5**	**21.5**
In bath oil, low lubricant level	**315.8**	**319.2**	**19.0**	**24.4**
In bath oil, high lubricant level	**317.5**	**302.5**	**18.1**	**15.0**
After bath oil, low lubricant level	**334.2**	**353.3**	**19.2**	**22.1**
After bath oil, high lubricant level	**360.0**	**358.3**	**28.3**	**21.7**
Standard deviation	**17.2**	**20.0**	**3.5**	**3.2**

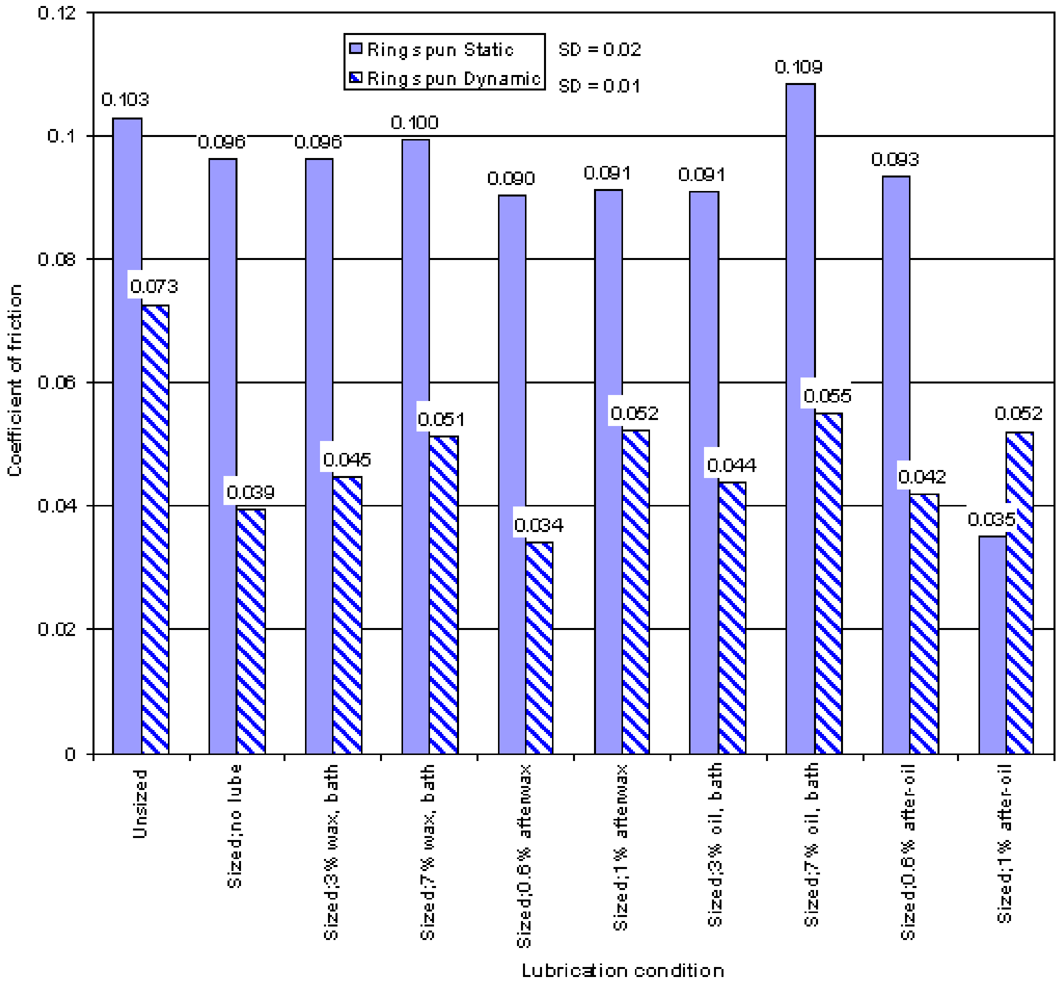

Fig. 5. Coefficients of static and dynamic friction for sized ring-spun yarn samples did not always decrease when lubricants were added to size films.

Breaking elongation often decreases in multifilament and staple fiber yarns after the addition of warp size. This effect was not exhibited in either the air-jet or in the ring-spun yarn samples without lubricant (Fig. 4). In the case of lubrication by means of wax, the breaking elongation of both air-jet and ring-spun yarns decreased as a result of more lubricant addition to the size bath.

Increased quantities of liquid lubricant decreased breaking elongation both for in-bath and for after-bath lubrication, compared with unlubricated, sized yarns. Net breaking elongation in the lubricated samples suffered as compared with unlubricated, sized yarns in all cases. As with results for tensile strength, none of the differences among sized yarns exhibited variations greater than three standard deviations.

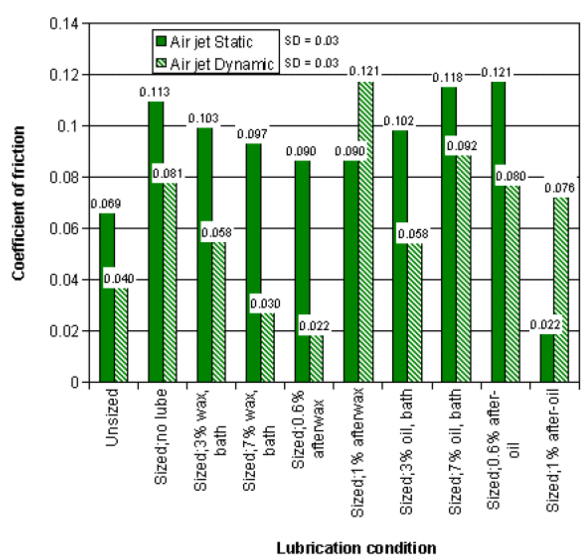

Fig. 6. Coefficients of static and dynamic friction for air-jet-spun yarn samples usually increased when lubricant was added to size films.

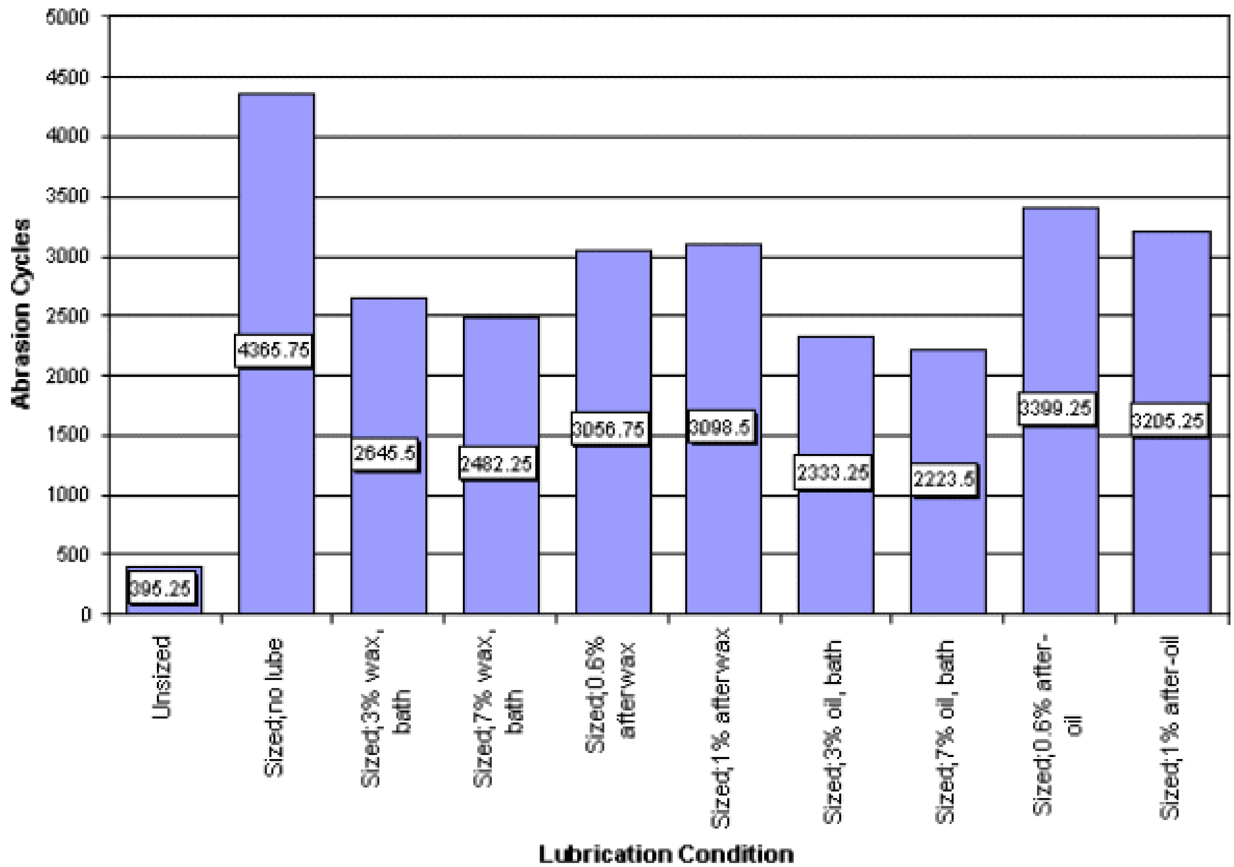

Fig. 7. Abrasion resistance of ring-spun yarn was always lower when lubricants were used with size films.

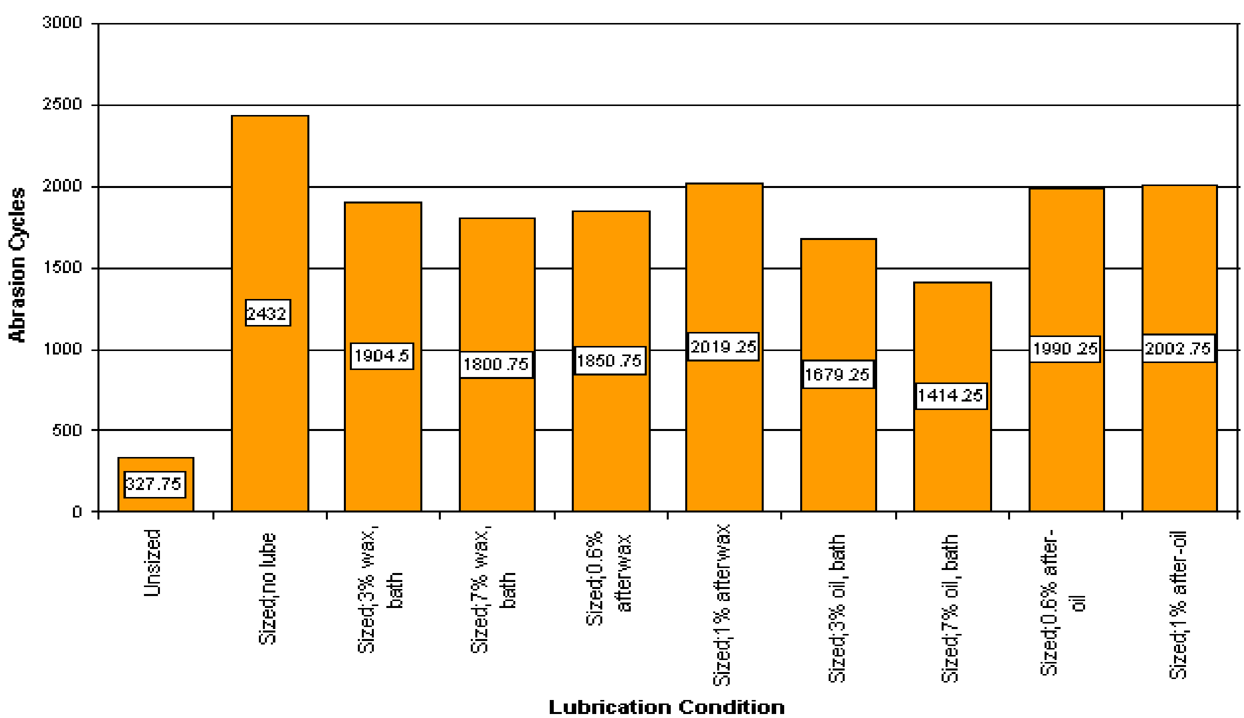

Fig. 8. Abrasion resistance of air-jet-spun yarn was less severely reduced by lubricants used with size films, but average abrasion resistance was lower than that of ring-spun yarns.

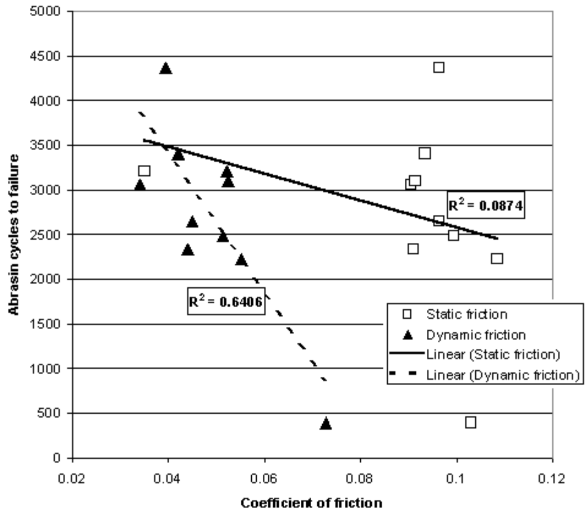

Fig. 9. A relationship between coefficient of friction and abrasion resistance of ring-spun yarns was not apparent.

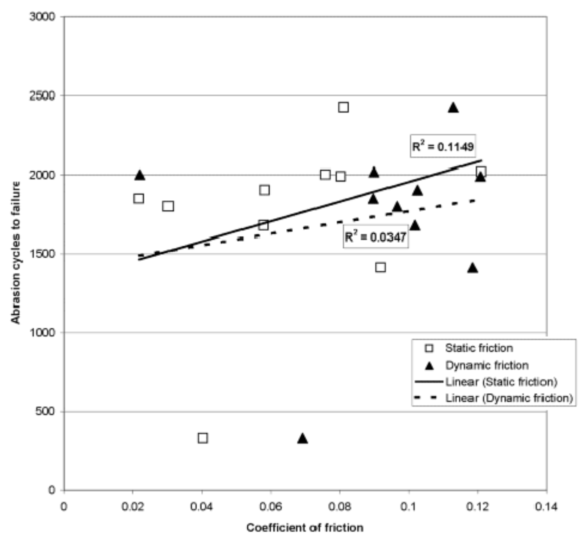

Fig. 10. A relationship between coefficient of friction and abrasion resistance of air-jet-spun yarns was not exhibited.

Lubrication Effect on Penetration and Encapsulation

Analysis of variance indicated that application position and the interaction of yarn type to concentration were significant ($P = 0.1$) for air-jet and ring-spun yarns. With air-jet yarn, penetration decreased as the concentration increased, but the opposite occurred in ring-spun yarn.

These differences in penetration were thought to be caused by the structural differences between the yarn types. Unlike ring-spun yarn, air-jet yarn does not have a helical structure. The more parallel structure of air-jet yarn does not provide as many fiber pathways from the outside of the yarn to the core as does open-end and ring-spun yarn. Limited fiber pathways mean fewer size entry areas, hampering size penetration. Also, the air-jet yarn's wrapper fibers are composed mostly of polyester, which is an oleophilic material. The liquid lubricant is attracted to the polyester wrapper fibers. This liquid lubricant acts to block penetration of size film former into the yarn structure, so more size should be on the wrapper fibers when higher liquid lubricant concentration is present.

The liquid lubricant used in the bath was more detrimental ($P = 0.1$) to penetration than was wax lubricant used in the bath.

Results of the encapsulation analysis showed that application position, application position to lubricant type, and application position to concentration were found to be significant at $P = 0.05$.

In-bath lubrication produced less encapsulation than after-bath lubrication did ($P = 0.05$). The encapsulation improved at the high concentration level when the lubrication was applied after the bath, and deteriorated when the high concentration of lubricant was used in the bath. Liquid lubricant used after the bath yielded a better encapsulation value than did wax lubrication, but liquid lubricant used in the bath gave lower encapsulation values than wax lubrication did. These findings corroborate earlier observations (Thomas and Brayshaw, 1996) that the liquid lubricant in the size bath degrades size film, even at approximately the three standard deviation level. Results of the analyses of penetration and encapsulation are shown in Table 7.

Effects of Lubrication Schemes on Coefficient of Friction

Results of tests for static and dynamic friction for ring-spun, open-end, and air-jet-spun yarns are shown in Figs. 5 and 6.

Analysis of variance showed, at the $P = 0.05$ confidence level, that the use of liquid lubricant in the size bath increased both static and dynamic frictional coefficients for all lubrication methods employed for both ring-spun and air-jet-spun yarn types.

Abrasion Resistance Effects of Lubrication

The primary purpose of warp size is to increase the abrasion resistance of sized warp yarns. For all yarn types lubrication had an adverse effect on abrasion resistance, as shown graphically in Figs. 7 and 8.

Yarn type, lubricant type, and application position all had a significant effect ($P = 0.05$) on the ST-6 values. Concentration of lubricant had a significant effect ($P = 0.1$). Air-jet spun yarns are less resistant to abrasion than are ring-spun yarns because the former are bound by outer wrapper fibers only and have no internal twist. Increased concentration of lubricants in the size bath decreased abrasion resistance for both yarn types. Better abrasion resistance was obtained from lubrication after drying than from in-bath lubricant use. The difference is particularly important in the case of liquid lubricant with the air-jet-spun yarn.

There was only weak correlation between the coefficients of friction, either static or dynamic, and the abrasion resistance of yarns both for ring-spun yarns (Fig. 9) and air-jet-spun yarns (Fig. 10). This result confirms similar findings from previously published research results in the field of warp sizing (Thomas and Brayshaw, 1996).

CONCLUSIONS

It was demonstrated in previous work (Thomas and Brayshaw, 1996; Thomas et al., 1997; Walker and Perkins, 1985) that the general effect of lubricant on ring-spun yarns in warp size is to break apart the size and thus produce an effect that increasingly resembles the state of unsized yarn. This effect was more pronounced at the higher concentration of lubricant in the size mix. The present study has shown similarities in behavior for sized, air-jet-spun yarns to that of ring-spun yarns produced from cotton-polyester blends. Lubricants in application schemes that include traditional, in-bath lubrication as well as after-drying applications degenerated the original size film and yarn structure physical performances obtained in the absence of lubricants. Lubricants added after drying caused less degradation of size abrasion resistance than did those added in mixes. Addition of lubricant did not consistently reduce the coefficient of friction of sized yarns. The coefficient of friction generally has been assumed to be important in determining the abrasion resistance of a yarn moving in contact with another surface. These and previous (Thomas and Brayshaw, 1996) studies show no relationship between the coefficient of friction and abrasion resistance.

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APPENDIX

Desize analysis procedure

1. Cut two 10-g samples per condition, including unsized yarn.
2. Place samples in uncovered containers and into a hot-air oven at 105 °C for 5 h.
3. Remove and cover containers and place them in desiccators for 1.5 h.
4. Remove samples from the desiccators, individually weigh and place them into separate sections of bag.
5. Weigh the samples and fill a container for each with a 50:1 weight ratio of tap water.
6. For a polyvinyl alcohol or polyester resin desize add the following:
   Nonionic surfactant (e.g. "Triton") @ 0.050 × Material Weight
   Sodium Carbonate @ 0.125 × Material Weight.
7. Place samples into solution. If polyvinyl alcohol is desized, boil for 30 min; if performing a polyester resin desize, do not boil.
8. Rinse the samples in hot water. If no starch size is present, proceed to step 12.
9. For starch size, fill container with a 50:1 ratio of tap water. Add the following to the water:
   NaCl @ 0.50 × Material Weight
   Enzyme (amylast type) @ 0.50 × Material Weight
10. Place samples into solution and simmer for 1 h at 80 °C (176°F).
11. Rinse the samples in hot water.
12. Centrifuge the samples until they are dry, and place them in individually designated containers.
13. Repeat steps 2 and 3.
14. Weigh the samples individually and use the equations below to determine size pick-up (%):
    a) Extractables = {[Dry, unsized weight from (5) above - Dry, desized weight from (14 above)] × 100} / Dry, desized weight from (14) above
    b) Pick-up percent = {[Dry weight from (5) above - Dry, desized weight from (14) above] × 100} / [Dry, desized weight from (14) above - Extractables from (a) above