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EVALUATION OF THE WEAVABILITY OF SIZED COTTON WARPS

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Abstract:

In weaving, a warp must withstand repeated stretching, caused by shedding and beat-up. It is also subjected to abrasion, which is mainly due to shedding and reed motion. The yarns are therefore sized. Two important reasons for applying sizes to spun warp yarns are to protect them breaking during weaving and to decrease their hairyness so that the tendency for adjacent warp yarns to entangle will be reduced.
In this work, we investigated the weaving performance and physical properties of cotton yarn sized at high pressure squeezing. We studied the size penetration, film properties, and the yarn packing density in order to explain the performance of sized yarn.

Key words:

Cotton yarns, sizing, adherence, cohesion, breaking force, weavability.

1. Introduction

As is well known, warp yarns are exposed to various complex stresses during weaving, such as bending forces, dynamic tension of a high periodicity, friction, static electricity, etc. The extent of these stresses varies in accordance with the type of yarn being processed and processing conditions, such as the type of weaving machine, humidity, etc. Moreover, the severity of stresses and subsequent damage to the yarn largely depend on the treatment received during beam preparation [1-6].

Sizing is an established method for improving the weavability of textile yarns. Sizing is the process of coating or impregnating warp yarns with a polymer that improves the efficiency of the weaving operation. In the conventional sizing process, the active agent is applied from a dilute aqueous solution or dispersion, and the yarns are dried to remove the excess water. The drying operation is costly owing to the amount of energy required, and in recent years processes have been developed to reduce the energy costs by minimizing or eliminating the drying phase. Major developments in this area include high pressure squeeze rolling, foam sizing, and hot melt sizing [7-9].

The sizing process provides warp yarns with the necessary strength, elasticity, smoothness, and enables them to acquire resistance to abrasion and static charge. Quality sizing is achieved by deep sizing, where the fibers are fixed in the position in which they were before sizing. Besides deep sizing, it is also important to apply size on the surface to the thread in the form of a film that provides outer protection of the threads [1].

Those in the field of yarn slashing generally agree that sizing agents applied to warp yarns must impart some degree of abrasion resistance. Indeed, many researchers feel that abrasion resistance is the most important property imparted by a size agent.

2. Materials and Methods

2.1. Materials

The warp yarns studied were chosen from among cotton yarns (Nm 12.2). Maize starch, polyvinyl alcohol (PVA) and carboxymethyl cellulose (CMC) was provided by the industry. In addition to the sizing agent, the size formulations also contain a plasticizer (glycerol) and lubricant (Avirol). Avirol is a commercial lubricant which is a mixture of fatty acids, fatty alcohols and emulsifiers.

2.2. Test methods and testing instruments

Before sizing, the following parameters were tested: the breaking force, elongation at break, and abrasion resistance.

The yarn was sized under various conditions in an apparatus simulating the sizing machine. The box used is equipped with an immersing roller and a pair of squeezing rollers enabling regulation of the squeezing pressure. The yarn was dried in a heating chamber. The size was warmed up in the preinstalled box, and the temperature was maintained by a thermostat built into the box. After sizing, the breaking force and abrasion resistance of yarns were tested.

The textechno dynamometer, Lloyd LR5K, was used to test breaking force and elongation at break. The preliminary tension of the yarn tested was 0.5 cN/tex, and the break took place within 20±3 seconds. 100 measurements were carried out for each yarn.

The apparatus used to simulate the abrasion of the warp is relatively simple, easy to use and gives good results in a reasonable time. The individual warps were prepared by taking away randomly after having blocked the loose leads by Scotch tape, in order not to lose torsion. The apparatus includes three principal parts: a head with reciprocating motion of 100 cycles per minute. The tests are carried out on stationary wire, an abrasive element, and a lifting device with a built-in system of tension. Tension caused by weight proved to be most satisfactory for the tests on stationary warps. As there is no standard for abrasion testing, the manufacturer's instructions were applied. 20 threads were abraded simultaneously all the way to breaking. The yarn was tested in an air-conditioned room (65±5% RH and 20±2 °C).

2.3. Weavability assessment

The weavability of sized yarns was assessed by measuring the following parameters:

2.3.1. Adhesive force

The adhesive force between the size materials and cotton yarn was determined by measuring the breaking strength of sized warp on a dynamometer tensile tester using the standard procedure [1].

2.3.2. Cohesive force

The cohesive force of various size materials was determined by measuring the tensile properties of a size film on a tensile tester [1].

2.3.3. Superficial structure of the yarn

Fibrous arrangement is not organized perfectly; the yarn presents many defects: ends of fibres, hooks, loops, gimlets, buttons, etc. An important reason for applying sizes to spun warp yarns is to decrease their hairiness so that the tendency for adjacent warp yarns to entangle will be reduced.

3. Results and Discussion

3.1. Approach to evaluating the weavability of cotton yarn

It is well known that the weaving performance of any sized warp yarn depends on the basic yarn properties, size material characteristics, and finally the properties of the sized yarn itself [7]. These parameters can be quantified in order to assess the contribution of size materials towards weavability, which in turn can be correlated with the measures affecting the weaving performance of yarn taking into account the mechanism of yarn failure in yarn weaving.

In view of this fact, some commercial size agents were identified and characterised from the point of view of their weavability. Subsequently, these size materials were applied to warp yarns, which were subjected to various stresses under simulated conditions in order to evaluate the weavability of continuous filament yarn through the use of laboratory techniques.

3.2. Characterisation of size materials and sized yarn

The performance of size materials in weaving is basically characterised by two important parameters, i.e. adhesion and cohesion properties.

3.2.1. Adhesive force

The interaction of various size materials with cotton fibre was evaluated by measuring the tensile strength of sized cotton warp. The adhesive force in N/add-on for maize starch, PVA, and CMC sizes was found to be 1.4, 2, and 2.5, respectively. This demonstrates that the adhesive force is higher for PVA, followed by CMC and maize starch sizes when they are applied on cotton yarn.

Table 1. tensile properties of 100% cotton yarns at different strain rates.

Strain rate, %/min	Size type	Tenacity, cN/tex	Tenacity CV, %	Elongation, %	Elongation CV, %	Initial modulus, cN/tex	Modulus CV, %
100	CMC	16.15	14.02	4.04	24.31	532	10.97
	PVA	18.32	12.46	5.18	12.3	451	13.22
	Starch	14.66	9.58	3.5	18.00	705	16.16
200	CMC	14.73	13.23	2.93	32.29	546	9.68
	PVA	19.65	12.00	4.27	12.74	527	12.09
	Starch	15.25	14.32	4.73	17.42	625	17.88
400	CMC	13.07	21.24	3.62	16.16	532	9.87
	PVA	17.08	17.28	4.62	16.05	536	14.09
	Starch	14.40	18.25	4.81	12.02	498	22.64

3.2.2. Cohesive force of size materials

The cohesive force of size materials is determined in terms of the film strength, which gives a measure of the relative protecting power of size materials to the yarn surface. The breaking strengths of size films of starch, PVA, and CMC are given in Table 2, which clearly shows that the cohesive force is highest for PVA. It is assumed that size material with good cohesiveness and high adhesive strength to the fibre substrate will give better weavability [1].

Table 2. properties of size films.

Mechanical properties	Size type		
	Starch	CMC	PVA
Thickness, mm	0.53	0.28	0.12
CV in thickness, %	10.64	19.66	2.75
Tenacity, cN/mm²	3.52	3.33	4.03
Elongation, %	20.56	30.29	45.24
Initial modulus, cN/mm²	200.87	150.24	90.80

3.2.3. Yarn surface structure

Taking into account the structure of the yarn, we can note:

- An external layer of fibres little directed compared to its axis. These fibres are variously spaced between one another; which by definition creates a disturbance. It is also the zone of penetration of the size for sized yarns;
- A subjacent layer of fibres, more or less directed, in the interface between the function of disturbance and the function of cohesion, which takes part in both;
- A body with no disturbed yarn.

Fibrous arrangement is not organized perfectly, the yarn presents some defects: ends of fibres, hooks, loops, gimlets, buttons, etc. At the time of the mechanical request (abrasion), a deformation occurs, as well as a removal of the size and an incoherence of fibres. The more this request is violent the more the fibres arrangement is disorganized, which results in a destruction of the function of cohesion and an increase in the function of disturbance (which is what is measured on the pilosimeter).

Figure 1 shows that the disturbance, or hairiness, decreases with sizing, which thus supports better physical properties of the sized yarn. This function of disturbance increases with the increase in the duration of request or perturbation imposed on the sized yarn, along with deterioration of the size film, while maintenance of the surface of the yarn smoothness ensures interfiber cohesion of the external layer of the sized yarn.

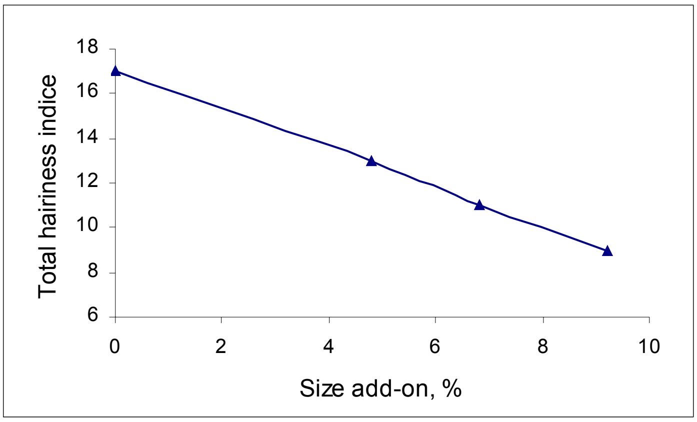

Figure 1. total hairiness indices at different size add-on.

3.3. Tensile properties of sized and unsized yarns

The breaking strengths of yarns sized with three different materials are given in Table 3, from which it may be observed the sized yarn breaking strength increases when compared with unsized yarn, while the breaking extension is reduced. Note that high pressure squeezing produces a 6% increase in breaking strength.

Table 3. tensile properties of the yarn.

Yarn property	Unsized	Sized	
		Low pressure 22 daN/tex	High pressure 33 daN/tex
Breaking strength, cN/tex	17.1	18.09	18.85
Breaking elongation, %	5.6	4.4	4.2

It is clear that high pressure sized yarn shows consistently improved weaving performance over low pressure sized yarn, a fact we investigated by analysing the yarn structure.

The binding force, improved by sizing, helps in an equal distribution of load during deformation and hence result in a higher breaking strength and reduced extensibility.

The yarn packing density is calculated as the ratio of the cross-sectional area of the fibres to the yarn. Table 4 shows that the packing density increases after sizing, and the high squeeze pressure gives maximum packing density, meaning that the squeeze pressure compresses the yarn structure and helps to increase its compactness.

Table 4. Yarn packing.

Yarn property	Unsized	Sized	
		Low pressure 22 daN/tex	High pressure 33 daN/tex
Packing density	0.548	0.593	0.618

Sizing at low squeeze pressure increases the yarn diameter compared to unsized yarn, but squeezing at high pressure (at identical add-on) gives a yarn diameter comparable to or lower than that of unsized yarn. This shows that squeezing during sizing causes compactness in the yarn structure, which increases with increasing pressure. The lower yarn diameter is advantageous during the passage through the dents of the reed on the weaving machine.

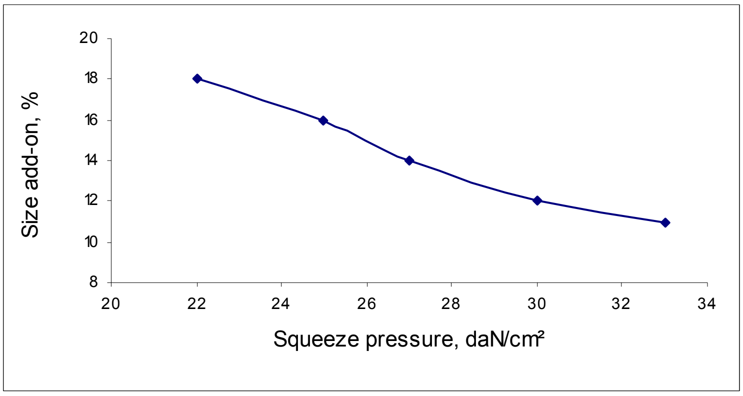

Figure 2. influence of squeeze pressure on size add-on.

We know that high packing density increases fiber cohesion and reduces interfiber slippage, which helps to improve weaving performance. It is clear from our structural studies that the better weaving performance of yarn sized by high pressure squeezing is due to uniform size coating, increased size penetration (Figure 2), and higher yarn density (packing density).

Size penetration has a dual role: it provides interfibre binding and an anchorage for the size coating. Size coating protects the yarn surface and embeds the protruding fibres. Excessive size penetration and coating are harmful, because more size dropping is generated on the weaving machine for high pressure sized yarn, and the film thickness is lower but the penetration is higher than the low pressure sized yarn for identical size add-on. The greater penetration for high pressure sized yarn helps in interfiber binding and better anchoring of the size film to the yarn surface, which improves abrasion resistance (Figure 3).

3.4. Abrasion properties of sized and unsized yarns

The increase in the number of abrasion cycles to break between unsized and sized yarn is relatively large, and the minimum values of some samples are greater then the average values of unsized yarn. This means that there are some places in the unsized yarn which are not protected, and thus weaker. These places are prone to breaking when the yarn passes through drop wires, heald frames and the reed. The minimum values of abrasion cycles to break for unsized yarn means that yarn increases abrasion resistance by sizing.

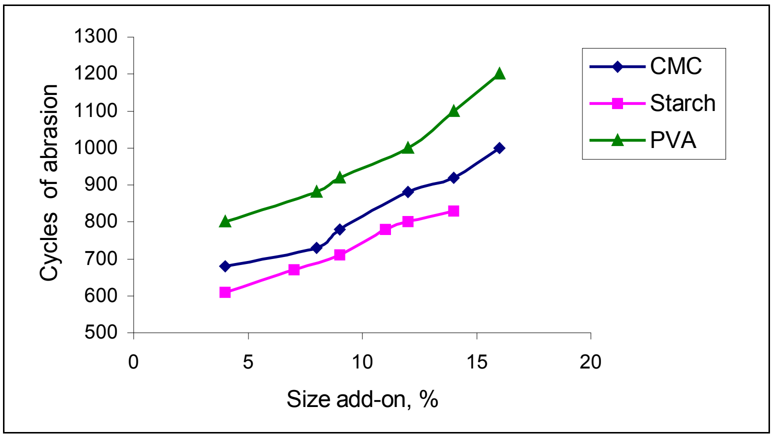

Figure 3. abrasion resistance of yarns sized with different agents.

An unsized yarn requires more strokes of the abrasion tester than a sized yarn to make it hairy. The fibers are glued together, and only after the skeleton of the sizing agent has been broken by the flexing action of the pins of the abrader are fibers loosened from the yarn structure. With low size content, the breaking up of the size skeleton of the abraded part of the yarn requires only a few strokes of the abrader, and the result is a lower abrasion-resistance of the sized yarn. With higher size content, the breaking up of the skeleton of the sizing agent takes much longer and results in a higher abrasion-resistance.

4. Conclusions

The improved weaving performance of yarn sized at high pressure squeezing is due to the better anchorage of the size film arising from increased size penetration and higher packing density. The circularity of the yarn cross sections is not affected by high pressure squeezing, which provides uniform size coating.

Since yarn is split because of various weaving stresses, such as cyclic loading, compression, and abrasion, less splitting means a better weaving performance.

Lower weaving performance may be attributed to the poor adhesive force of size towards cotton fibre and also to the film strength, which provides less protection to the yarn surface.

Size materials, owing to their superior adhesive and cohesive properties, offer better weavability. A high degree of penetration inside the yarn provides a better binding force. Poor weavability results when there is less penetration of the size material to the yarn core, resulting in a low binding force of the fibres.

The adhesive power of a sizing agent is an important factor in the assessment of its suitability, inasmuch as the adhesive power of sizing agent is what gives the sized yarn a higher abrasion-resistance.

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