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Fatigue Behavior of Sized Cotton Warps

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Abstract: In this research, we have studied the fatigue behavior of sized warp yarns under cyclical elongation as measured on a Lloyd dynamometer on the basis of damage rate. Fatigue behavior expressed in terms of cycles at failure and the rate of fatigue damage expressed in terms of loss in tensile properties. We have found that deterioration of tensile yarn properties increase with increasing fatigue level. Comparing fatigue behavior of three different sizing agents, PVA have the less damage in his tensile properties. A theoretical model is developed to predict changes in load under longitudinal loading subjected to extension cycling. The model gives the best agreement with experimentally tensile cycling of sized yarn cycled between two base tension limits.

Key words: Cotton yarns, sizing, fatigue behavior, fatigue damage, loss tensile property

INTRODUCTION

Repeated loading and unloading under small stresses often causes stress concentration and decreased resistance of a material, even when the stress intensity is well below the ultimate strength under static load. The capacity of the material to sustain failure gradually diminishes as the number of stress cycles increases, which is attributable to cumulative damage. This phenomenon of decreased resistance of a material to cyclic stresses is called fatigue (Anandjiwala and Goswami, 1993). In the fatigue resistance of sized yarns affects processing performance the behavior of sized yarns during weaving (Anandjiwala *et al*., 1995). As with other engineering materials, research workers have studied the fatigue behavior of fibres (Hearle and Sparrom, 1978; Lyons and Prevoresk, 1962), yarns (Anandjiwala and Goswami, 1993; Nasri and Lallam, 2001), tire cords (Grant and Couturier, 1978) and fabric (Webster and Liang, 1998).

Where the sized yarn is subjected to a known number of cycles prior to its fatigue lifetimes and results are expressed in terms of loss in some mechanical properties, usually tensile strength. If the yarn is subjected to known cycles in progressively increasing order and loss of mechanical properties is estimated at each step, then the rate of fatigue damage can be assessed. This rate yields useful information about unacceptable levels of deterioration in warp properties. The yarn, though not broken, may have poor residual properties after a certain number of fatigue cycles. Such yarn may be prone to failure.

Present research is therefore directed toward establishing a method for assessing tensile fatigue behaviour of staple yarns subjected to cyclic loading and to study the fatigue performance of sized yarns and their correlation to weaving performance.

MATERIALS AND METHODS

Materials: Maize starch, polyvinyl alcohol (PVA) and carboxymethyl cellulose (CMC) were provided by staley Company. In addition to sizing agent, the size formulations contain also plasticizer (glycerol), lubricant (avirol) and stabilicizer (urea). Avirol is a commercial lubricant which is the mixture of fatty acids, fatty alcohols and emulsifiers. Tests were conducted in a Tunisian textile manufactory (SITEX).

Test methods and testing instruments: The yarn was sized under various conditions in an apparatus simulating the sizing machine. The box is equipped with an immersing roller and a pair of squeezing rollers with possible regulation of 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, fatigue failure and tensile loss properties of yarns were tested.

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Sized yarns were subjected to cyclic tensile fatigue at 60 cyc min^{-1} fatiguing speed and a limit base tension between 3 and 5 N. in the fatigue test on Lloyd dynamometer, yarn specimens, 50 cm long, were mounted under base tensions between two clamps (Afnor, 1985). The failure criterion used in this test is the ultimate rupture of yarn. The number of fatigue cycles at break was recorded.

To understand the rate of fatigue damage of the yarns, it is necessary to know the fatigue lifetime of a yarn based on failure. The rate of fatigue damage can be conveniently estimated by subjecting yarns for a known number of fatigue cycles on a time scale of zero to the maximum value of the fatigue lifetime determined on the basis of failure. Fatigue results can then be represented in terms of loss in tensile strength. In this study yarns were subjected to fatigue at a different numbers of cycles and then tested on a dynamometer to calculate the tensile loss after each number of cycles. Results were then expressed in terms of stress and elongation at break.

Fitting aptness can be assessed to predict the best model describing the tensile yarn damage curve. We have therefore used a nonlinear regression procedure that employs an iterative search algorithm in an attempt to determine coefficient R^2. The higher the coefficient (≈ 1), the better the fit obtained.

RESULTS AND DISCUSSION

Understanding the progressive deterioration of important yarn properties (tensile) at increasing fatigue level may yield useful information about potential failure. This in turn may help in estimating the capacity of the material to sustain failure and the phenomenon of impending failure.

Typical load versus extension curve for the first four cycles at small for base tensions (lower limit = 3 and upper limit = 5) is shown in Fig. 1 and the following trends are apparent: first, the gradients of the load versus extension were uniform: load stay constant after loading and unloading. Second, extensions required increased generally as the number of cycles increased and we attributed this to the viscoelastic effects.

Figure 2 and 3 show a typical graph of loss in tenacity and elongation at break with increasing fatigue. Values of tenacity and elongation at break at 0% of characteristic lifetime indicate the properties of yarns before being subjected to fatigue. In general, with increased fatigue level, the tenacity and elongation at break decrease. Such sudden losses in these properties beyond fatigue cycles equal to 80% of characteristic lifetime indicate potential failure of yarns on the loom if they experience a fatigue level of similar magnitude and the actual tension imposed during weaving exceeds the residual tenacity. Progressively increasing deterioration of tensile properties with increasing fatigue level perhaps explains why the same yarns sized at a particular add-on and from the same ingredients under identical slashing conditions behave differently on different looms.

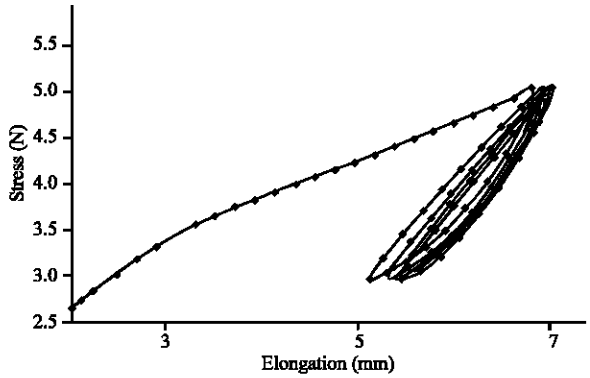

Fig. 1: Load versus extension curves at cycling extension

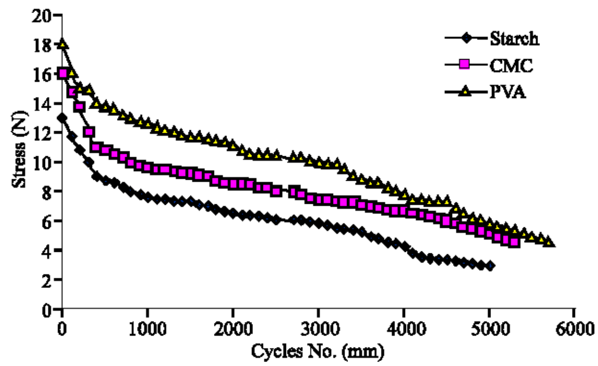

Fig. 2: Loss in tensile load at break with increasing cycle's numbers

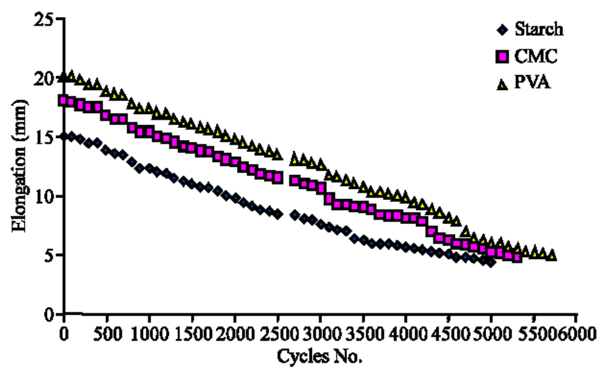

Fig. 3: Loss in extension at break with increasing cycle's numbers

The damage behavior is probably related to the sizing agent, PVA have the good behavior to withstand a repeated stretching. This can be explained, according to our earlier results in these fields, by the adhesive and cohesive properties which are higher for PVA, followed by CMC and maize starch sizes when they are applied on cotton yarn.

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. It is expected that the size material with good cohesiveness and high adhesive strength to the fibre substrate will give better weavability (Behera, 1989).

Effect of base tension: In order to explain the change of fatigue behavior or yarn damage in modifying weaving practice conditions, it is better to measure the effect of upper limit of base tension on fatigue behavior of sized yarns which is directly related to the rate of the severity of repeated shedding and tension amplitude of loom in weaving.

Figure 4 shows the effect of base tension on the fatigue behaviour of the ring spun yarns studied. As expected, the fatigue cycles linearly decreases with an increase in the base tension. The straight line fitted by regression analysis shows that higher tension will obviously accelerate deterioration of yarn properties.

Nonlinear model for change in load with cycling: Change in load with cycling for 20 specimens comprising the main experimental was best approximated by some form of double exponential curve.

In order to allow as any curves as possible to be fitted, we chose the following model:

$$y = y_0 + A_1 \exp(-x/t_1) + A_2 \exp(-x/t_2)$$

Where:

y	=	Load
x	=	No. of completed cycles
A_1, A_2, t_1 and t_2	=	Model parameters

A theoretical model for the tensile fatigue behavior of yarns (Fig. 5), based on two-exponential form, gives good agreement with experimental stress fatigue curves. Our two-exponential term model predicts the change in load during cycling, which is consistent with statistical analyses. We have therefore used a nonlinear regression procedure that employs an iterative search algorithm in an attempt to determine coefficient R^2. The higher the coefficient (≈ 1), the better the fit obtained.

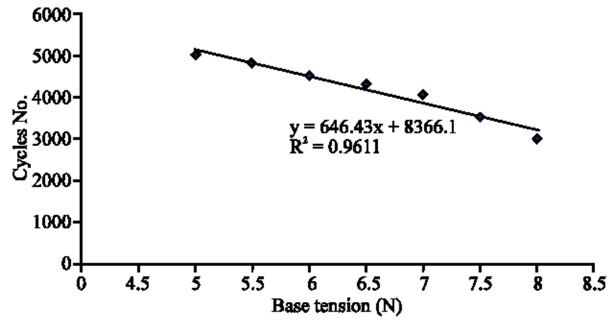

Fig. 4: Effect of upper limit base tension on fatigue behavior of sized yarns

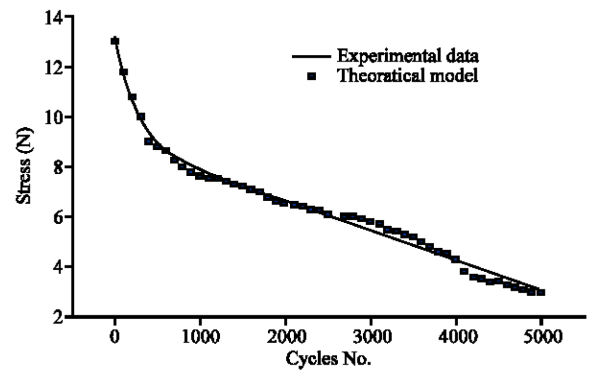

Fig. 5: Fitting of loss tensile curve with increasing cycle's numbers

CONCLUSIONS

The tensile fatigue behavior of sized yarns under cyclic elongation can be satisfactorily measured using a Lloyd dynamometer. The criteria used to measure the fatigue resistance of the yarns at failure and damage rate. An objective assessment of fatigue resistance of yarns on the basis of failure and damage rate yields useful information. The failure criterion provides information about extreme fatigue lifetime and the damage rate criterion yields useful information about the rate at which the fatigue resistance of the yarn deteriorates. Diminishing resistance and reduction in the yarn capacity to sustain failure may provide knowledge about impending failure. Losses tenacity and elongation at break measured on the basis of rate of fatigue damage criterion are substantial and more rapid after the imposed fatigue are greater than 50% of the characteristic lifetime, which implies that the yarns may fail long before attaining their characteristic lifetimes.

Warp yarns under a state of dynamic loading on a loom have to withstand cumulative damage caused by tensile fatigue at relatively low loads. To evaluate the fatigue phenomenon of sized cotton yarns and its correlation with performance on a loom, one must first under stand basic mechanical properties of yarns in terms of sizing agents and base tension.

The effect of base tension influences the fatigue resistance of the sized yarns; the increase in the base tension linearly decreases the resistance of yarn under applied fatigue.

Changes in load with cycling are best predicted by the double exponential nonlinear model expression.

REFERENCES

AFNOR, 1985. Determination of the tensile stress and strain at break, simplified method. NFG 07-002. Paris.

Anandjiwala, R.D. and B.C. Goswami, 1993. Tensile fatigue behavior of staple yarns. Textile Res. J., 63: 392-403.

Anandjiwala, R.D., M. Carmical and B.C. Goswami, 1995. Tensile properties and static fatigue behavior of cotton warp yarns. Textile Res. J., 65: 131-149.

Behera, B.K., 1989. Ph.D Thesis, IIT Delhi.

Grant, J.N. and G.M. Couturier, 1978. Effect of dynamic fatigue test on mechanical properties of tire cords. Textile Res. J., 21: 867-875.

Hearle, J.W.S. and J.T. Sparrom, 1978. Tensile fatigue of cotton fibres. Textile Res. J., 48: 242-243.

Lyons, W.J. and D.C. Prevoresk, 1962. Law of cumulative damage in the fatigue of textile fibres. Textile Res. J., 32: 448-459.

Nasri, L. and A. Lallam, 2001. Fatigue failure in technical polyamide 66 fibres. Textile Res. J., 71: 459-466.

Webster, J. and R.M. Laing, 1998. Effects of repeated extension and recovery on selected physical properties of ISO-301 stitched seams. Part I: Load at maximum extension and at break. Textile Res. J., 68: 854-864.