A STUDY ON YARN ABRASION RESISTANCE

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Abstract: This paper reports the preliminary results of yarn abrasion resistance tested with a simple yarn abrasion apparatus. The principal of the fabricated apparatus is based on three-pin mechanism focussing on the yarn external abrasion resistance due to rubbing against the pins. 100% cotton yarns of three different counts were used in the study. These yarns were first evaluated for their twist, hairiness, evenness, tenacity and elongation before a series of abrasion tests were conducted. The abrasion tests showed that the lower yarn count, which has the lowest number of twist and highest number of hairiness, gives the least number of cycles to break the yarn. The mechanism of failure for every yarn was observed to be a slow but incremental drafting of fibres in the abraded zone. Based on the abrasion tests conducted, it was concluded that the apparatus is a useful tool for studies on yarn abrasion resistance and its relation with other yarn physical properties. Further modifications and improvements on the design and dimensions were made which resulted in an improved version of the apparatus.

Keywords: Yarn, Abrasion resistance, Yarn abrasion apparatus, Abradent

INTRODUCTION

Yarn is a generic term for a continuous strand of textile (staple) fibers, filaments or (other) material in a form suitable for knitting, weaving, or otherwise intertwining to form a textile fabric [1]. They are an intermediate textile product constantly and extensively subjected to physical endurance during fabric formation processes. Factors such as surface tension, friction, and abrasion are some of the main causes for yarn failure and degradation, especially when the yarn is subjected to cyclic tension. There is internal abrasion which occurs between the fibres in the yarn structure and also the external abrasion of the yarn surface against other surfaces. External abrasion resistance is particularly important in many applications and for that reason, yarn abrasion test equipments for yarn evaluation and quality assurance are necessary.

Yarn abrasion resistance can be measured from a variety of testing techniques. One of the techniques is to subject the yarn to an abrasive body which moves backward and forward over the yarn under a certain loading or tension. The number of movements until the material is abraded through is the measure of the degree of abrasion resistance. The measurement of the abrasion resistance of yarns is desired to evaluate the potential weakness of the yarns during textile processing. This physical testing technique could provide relative and comparative results thus giving general indications of the yarn performances. These can be achieved by several comparative tests at different apparatus set-up which can be set in a variation of speed, abradent materials and yarn tension.

There are many factors that can influence the yarn abrasion resistance. Studies by Ibrahim [2], concluded that some of the possible factors affecting the yarn abrasion resistance are: the type and quality of yarn to be tested, the type and nature of the abradent, the tension load applied to the yarn, the oscillating speed, the nature of the applied forces, and the atmospheric conditions. Hung and co-researchers [3] who studied the interactions between warp yarns with high speed objects under sideways constraint described that the actual interaction is largely dependent on the yarn structure, initial yarn tension, the abradent surface characteristics as well as the abradent profile. Practically, different machine parameters will give different results. As such, there are currently no standard yarn abrasion apparatus in the market. Nevertheless, there is general qualitative agreement between the results of various types of abrasion test [5].

MATERIALS AND METHODS

In the study, a simple apparatus was constructed to evaluate the yarn abrasion resistance using the principle of abrasion around a three-pin mechanism. The principal of the apparatus is illustrated as in Figure 1 and Figure 2. A length of yarn is threaded between the abradents (pins) under tension (weight). The pins are caused to move backward and forward creating an abrasion zone over the yarn to be tested. This movement will abrasively wear out the yarn and breakage will occur after a number of cycles. As shown in Figure 2, one end of the yarn is fastened at the left-side holder (A), threaded through a ring mounted on the holder (B) and between the three-pin, mounted on rectangular plate. The other end of the yarn is secured on the right-side holder (C). A certain weight is place on the yarn in between A and B to provide the necessary tension to the yarn.

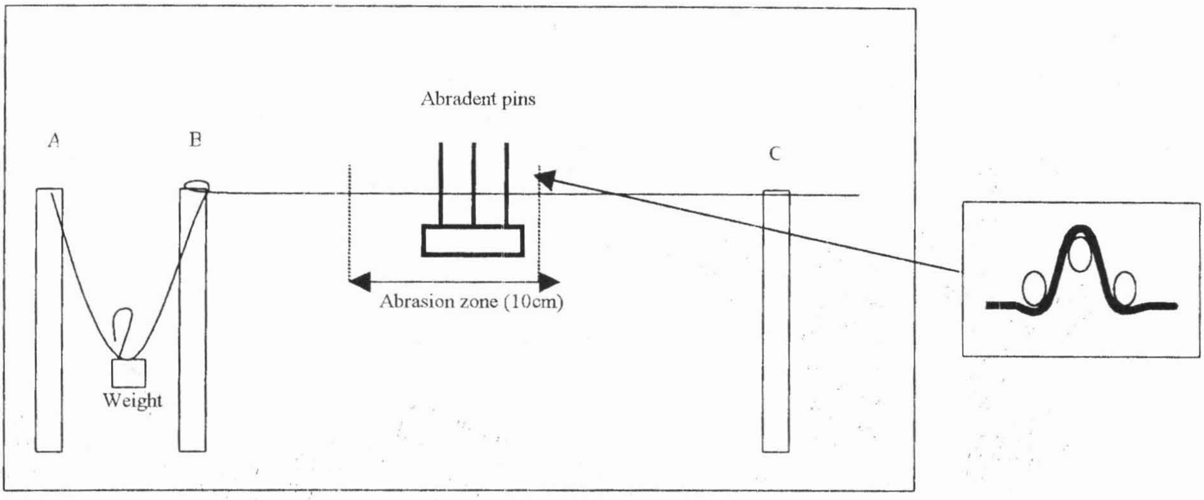

Figure 1: The Yarn Abrasion Principle

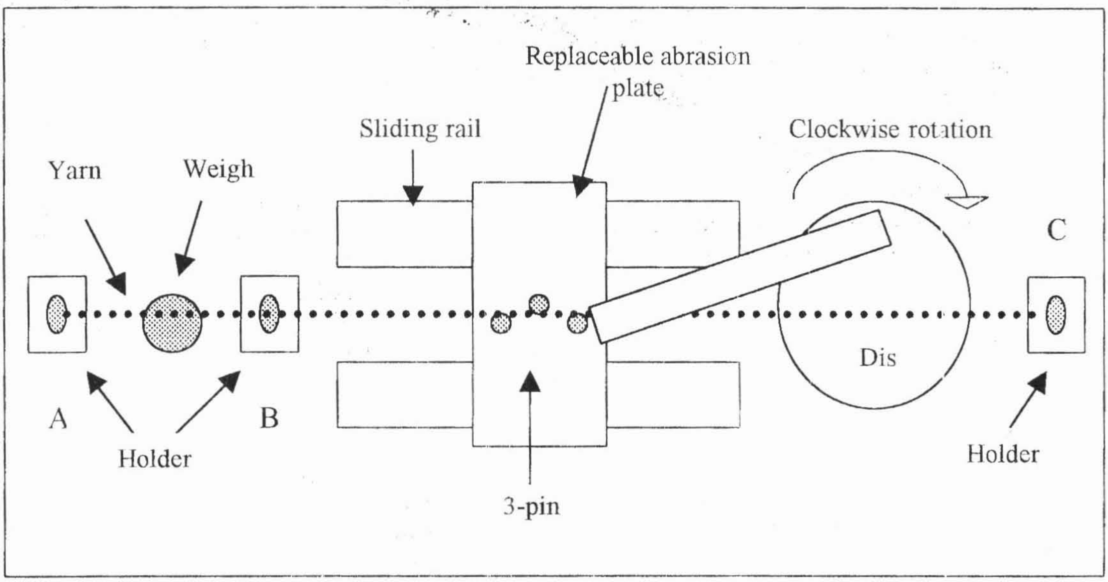

Figure 2: Plan View of the Apparatus

The design of the apparatus is simple, and fabricated from readily available materials. The materials used in the fabrication include plywood, polyvinylchloride (PCV), and aluminium. Figure 3 shows the actual yarn abrasion apparatus. The first step in fabrication is to study the principal of three-pin abrasion mechanism, the concept taken from an earlier work [3]. To make the design workable, a few modifications were made especially on the drive mechanism.

In order to examine the performance of the apparatus, several trial runs were conducted. The apparatus performed satisfactorily in these trial runs. Initially, the movement of the abradent plate along the track is not reliably smooth as it tends to stop unexpectedly. The problem was minimised with the use of lubrication. This enables some comparative test on the yarn samples to be conducted. During the tests, a constant weight of 50g was used at almost consistent speed of the abradent pins. Extra caution was taken to ensure that the yarn tension for each trial does not vary too much. This has to be considered as the yarn tension will significantly affect the rotational speed as well as the results of the tests. Each yarn samples were subjected to a constant load of 50 grams. Three different sizes of 100% cotton yarns were used in the study: 30's, 20's, and 10's. 40 samples were tested for each yarn count. The physical properties of these yarns were first determined before the abrasion test. The properties evaluated were yarn hairiness, yarn twist, yarn evenness, and yarn tensile properties.

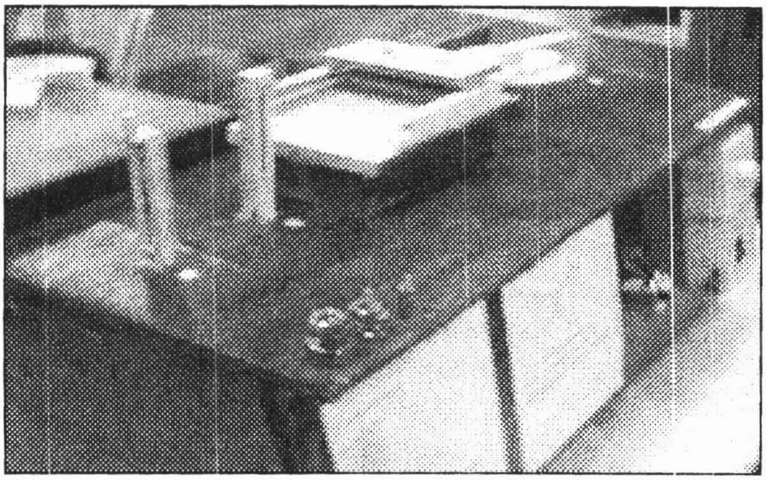

Figure 3: The yarn abrasion apparatus

RESULTS AND DISCUSSIONS

The physical properties of the yarn samples are summarised in Table 1. As the yarns are of different sizes, it was expected that the physical properties would vary among them. These results would be significance if correlations with the yarn abrasion resistance are intended. Based on the results of the yarn properties, the tests on the yarn abrasion resistance are conducted with a hypothesis that the lower yarn count (bigger yarn size) will give less resistance to abrasion. Due to the lower yarn twist, higher yarn hairiness and thin places, the bigger yarn is expected to wear-out faster than the other two samples.

Table 1: Summary of Yarn Properties

YARN COUNT	10's	20's	30's
Twist (tpcm)	4.3	7.5	11.2
Hairs per meter	156.69	45.8	55.01
Elongation (%)	17.11	8.24	4.17
Tenacity (g/tex)	12.45	11.52	13.96
Thin place (-40%)	68	29	45
Thick place (50%)	22	31	52
Neps (200%)	31	44	49

The mean number of cycles to break or fail the yarns is given in Table 2 and Figure 4 and the first ten measurements on each yarn are illustrated in Figure 5. The results of the tests look promising and reliable but are however inconsistent, as high variances among each tested samples were observed and recorded. Some of the measurements have to be discarded as the number of cycles to break the yarn was found to be too lengthy, and some yarns did not break at the abrasion zone. It is presumed that the inconsistency among the results is caused by several factors. The rotational speed is difficult to control, as it can be inconsistent throughout the test and sometimes varied considerably between each test. This factor is related to the drive mechanism design and the materials used. The fabrication of the drive mechanism is of low degree in precision as the disc oscillated eccentrically causing the shaft and the abradent plate to run intermittently along the track.

According to the observations made, the potential breakage on the yarns is more in the abraded zone. This is mainly caused by the concentrated damage due to rubbing against the pins and distributed damage due to dragging. However, breakage could occur at any point on the length of the yarn due to the tension (load) applied to the yarn during the test. The yarn is gradually elongated during each abrasion cycle stimulated by the additional tensional load of the weight.

The results showed a general trend of increasing abrasion resistance the smaller the yarn. The 30's yarn gave the highest resistance to abrasion with most of the breakages occurring after 200 number of abrasion cycles. The mean was calculated to be 397 cycles. For the 20's yarn, most of the yarn breakages occurred between 200 to 500 cycles, giving a mean cycle of 325. Trials with the 10's yarn indicated that most breakages occurred below 200 cycles.

Table 2: Mean numbers of cycle to break the yarn

Yarn count	Mean no. of cycles to yarn failure
10's	169
20's	325
30's	397

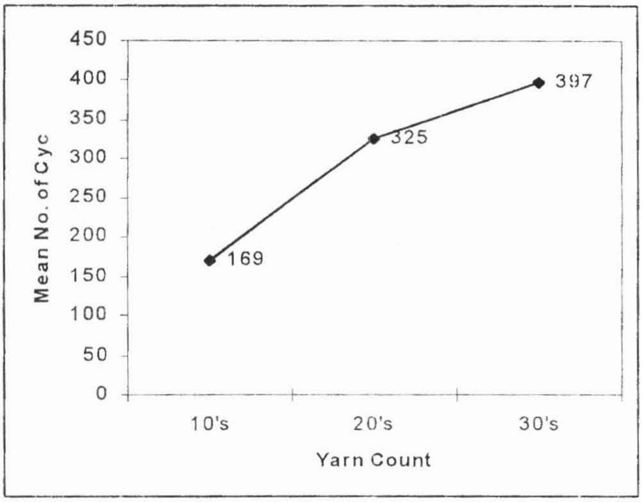

Figure 4: Yarn count versus mean no. of cycles

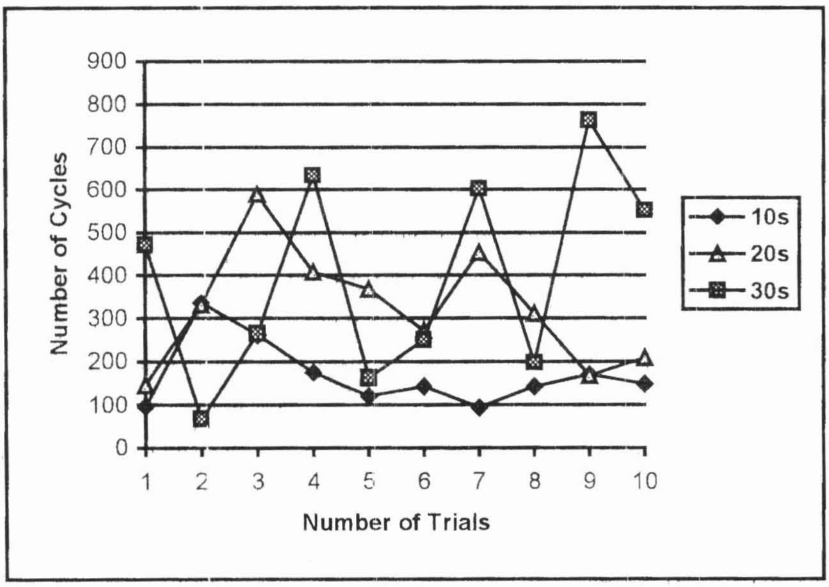

Figure 5: The number of cycles to break the yarn

The yarn of 10's is the bulkiest, and gave less resistance to abrasion i.e. less number of cycles to break the yarn. This was expected, considering that the yarn has a much lower yarn twist and in agreement with other studies [3]. The yarn is less compact which could either mean less cohesion or less inter fibre frictional forces, as compared with the other 2 yarn samples. In addition, the 10's yarn has the highest number of hairs on its surface, and this indicated that yarn hairiness could also give some effect to the yarn abrasion resistance.

The results of elongation tests are not consistent, therefore, no relationship could be made. The relationship between the yarn abrasion resistance and the yarn tenacity could not be established as well, since the tenacity values are almost the same for all the yarn count. The values of imperfections show no significant differences among the samples.

CONCLUSIONS

Based on the trial test conducted, it can be concluded that the apparatus is principally workable, although some of the tests did not give consistent results. Nevertheless, the initial experimentation has lead to the fabrication of a better yarn abrasion apparatus. This was the major part of the project. The design and dimensions of the apparatus were further improved in the actual fabrication. The initial design, for example, is only intended for single yarn test. It is more appropriate to have more than one yarn tested simultaneously. This could give comparative results which are more reliable and subsequently reducing the time to conduct the test. Other significant improvements on the new apparatus are such as installing an automatic counter, a stop motion mechanism, and the availability of several types of abradent materials. The outcome of the newer version of the apparatus will be discussed in another technical paper.

ACKNOWLEDGEMENTS

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