AN ANALYTICAL APPROACH FOR UNDERSTANDING THE PHENOMENON OF WARP-BREAKAGE IN WEAVING

By

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Submitted
in Fulfilment of the Requirement
of the Degree of

DOCTOR OF PHILOSOPHY

to the
INDIAN INSTITUTE OF TECHNOLOGY
NEW DELHI

September 1987

ACKNOWLEDGEMENTS

I, sincerely, express my deep sense of gratitude to Prof. P.K. Hari, Indian Institute of Technology, Delhi and Shri T.A. Subramanian, ATIRA, Ahmedabad, for their fraternal guidance, personal attention and encouragement which spurred me on to completing this thesis.

I am also grateful to the Director, ATIRA and Head of Textile Technology Department, IIT, Delhi, for granting permission to carry out this work. Appreciation is extended to Department of Science and Technology, Govt. of India for sponsoring part of this work.

I also wish to acknowledge the debt owed to my colleagues and friends who generously extended their help and co-operation whenever it was needed.

The assistance rendered by the staff of Physical Testing and Pilot Mill of ATIRA and Weaving Lab of IIT, Delhi, needs special mention.

Lastly, I thank Mr. Y.R. Vora for the efficient typing of the manuscript of this thesis.

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CERTIFICATE

This is to certify that the thesis entitled "AN ANALYTICAL APPROACH FOR UNDERSTANDING THE PHENOMENON OF WARP-BREAKAGE IN WEAVING" being submitted by Satish Kumar Aggarwal to the Indian Institute of Technology, New Delhi, for the award of the degree of Doctor of Philosophy is a record of the bonafide research work carried out by him under our guidance and supervision.

To the best of our knowledge this thesis has reached the requisite standard. The material presented in this thesis, in part or full, has not been submitted to any other University or Institute for the award of any degree or diploma.

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SUMMARY

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The importance of controlling and predicting the warp-breakage rate, before it is actually woven in the loom, needs no emphasis. In the present work, first of all, by making use of the available data, covering a wide range of yarn quality, an attempt was made to structure and evolve a mathematical model to predict, individually, the contribution of some factors to warp breaks in weaving. The results showed that the proposed model is applicable to various types of preparatory conditions in mills. In this model the warp breaks have been broadly divided into following three classes:

Class I : Breaks due to tensile-cum-abrasive failure of yarn,

Class II : Breaks due to obstruction and/or tensile/abrasive failure of gross thick places, and

Class III : Breaks due to failure of knots/splicings and miscellaneous.

The weaving mechanism suggests that in the absence of the complicating factors like obstruction to yarn passage by gross thick places and knots etc., the Class I warp breaks should depend upon the presence of low strength/elongation threads in the yarn. On critical examination, the universal lea-test emerged as a single yarn test which, by virtue of mechanism of

lea break, measures the strength of least extensible threads in the yarn. Examination of extensive data in the count range 28s to 36s (Ne) showed that CSP also correlates well with the other critical yarn properties. This study also brought out that most of the yarns in this count range irrespective of the yarn strength (CSP) are spun to have about 6 to 7% elongation at break. Thus, it reduces the chances of the elongation to be a reliable and effective test to characterise the grey yarns for their weavability. In such a situation CSP remains the obvious choice.

Further experiments showed that there is about 6% loss in lea-strength due to thread slippage during testing. The lea-ratio was found to be increasing with increase in yarn strength.

Now, the question arises as to whether the yarn CSP, a possible indicative of yarn failure due to tensile loading, can also be an indicative of the capacity of yarn to withstand the stresses imposed on the yarn during weaving.

Experiments carried out on five samples of cotton yarn, all of 40s (Ne) count and twist (4.3) but of different CSP levels, showed that there is an extremely good (r=0.99) linear relationship between the CSP and weaving abrasion resistance (weavability-cycles) of grey yarn as measured by the Reutlinger Web Tester. A similar trend was found to exist for 30s (Ne) also. During progressive abrasion the rate of degradation (fibre-loss) of yarn was found to decrease with increase in CSP. These differences in response to abrasion of yarn can be mainly attributed to better fibre-to-fibre interlocking and packing in the case of high CSP yarn spun out of longer and finer fibres. This hypothesis is further supported by the data on inter-fibre slippage (yarn-extension) during abrasion: the rate of inter-fibre slippage decreases as the CSP increases.

Thus, simulation of weaving stresses showed that a yarn breakage is mainly due to inter-fibre slippage associated with fibre loss and fibre breakage on account of repeated weaving stresses. The weaving performance of yarns, therefore, can be compared on the basis of mean weaving abrasion cycles to break the yarn and rate of inter-fibre slippage in yarn. Lea CSP appears to be an useful index of these properties of a yarn.

A careful analysis of individual values of abrasion resistance revealed that the index of skewness increases with increase in CSP: starting with a negative value at very low CSP, the skewness becomes positive at high CSP. At about 2,000 CSP the skewness was found to be zero, symmetrical distribution.

For similar CSP, a coarser (30s Ne) yarn showed a much higher abrasion resistance than a finer (40s Ne) yarn. This indicates that in addition to CSP, other yarn parameters eg. number of fibres in yarn cross-section, twist etc., are to be considered for comparing the simulated weaving performance of yarns of different counts. Further, an increase in yarn tension and abrasion-intensity (penetration of abrading element) decreased the abrasion resistance of yarn; the effect of former is more pronounced than the latter. The reduction in abrasion resistance due to these variables was found to be more for a low CSP yarn than for a high CSP yarn.

Effect of Sizing:

Sizing is another process which largely influences the weavability of a yarn. Therefore, to study the effect of sizing on weavability of yarns, all the five samples were sized to two levels of size add-on namely 6% and 12%.

As expected, tensile tests showed that on sizing the tensile strength and modulus increase while elongation decreases. The gain in strength was found to be increasing with increase in CSP and size add-on.

The basic relationship between the CSP and abrasion resistance of grey yarns was found to be unaffected by the process of sizing at both levels of add-on. Interestingly and significantly, the data bring out the fact that the percent gain in abrasion resistance on sizing increases linearly with CSP. The level of improvement and slope of the line, however, depend on the level of size add-on. Further, it was found that the yarns of CSP less than 2,000 register a decrease in number of abrasion cycles when sized to 6% add-on, and even at higher add-on of 12%, the gain is very marginal. This means that yarns of CSP less than 2,000 are not particularly strengthened by sizing to resist abrasion.

This observation is also supported by the analysis of individual values of abrasion resistance. It showed that weak elements in the yarn, which are particularly vulnerable to weaving stresses, are not much helped by the process of sizing. As a result of this the distribution of sized yarn abrasion resistance becomes more negatively skewed: the minimum value of grey yarn CSP at which observed skewness becomes zero is found to be about 2,200 for sized yarn as against 1950 for grey yarn. This indicates that the sizing process leaves behind in the yarn a high frequency of low-abrasion threads which in turn could be a prominent source of excessive warp-breakage. Thus, this study quantifies the minimum requirements of yarn CSP for satisfactory weaving.

Further, experiments on progressive abrasion showed that even after sizing a low CSP yarn deteriorates in terms of strength, elongation and modulus at a much faster rate than a high CSP yarn. The practical significance of this finding is that during actual weaving due to loom stresses a low CSP thread, as it approaches the fell of cloth, becomes more susceptible to cause a break than a high CSP thread.

No doubt, lea CSP is a useful index to characterise the grey yarns for their weavability. However, in the absence of data on grey yarn quality to compare and characterise the sized yarns for their weavability, it becomes necessary to evolve a weavability index using the data on weaving abrasion resistance of sized yarn and rate of inter-fibre slippage during abrasion. The proposed weavability index correlates very well with CSP and the frequency of imperfections in the grey yarn.

A quantitative analysis of data showed that there is a very good relationship between the abrasion resistance of grey and sized yarns.

However, the quantitative approach has shown that the frequency of Class I warp breaks decreases with increase in yarn CSP; in the case of yarns having CSP 2,300 or more the occurrence of such breaks is rare. It indicates that the CSP test loses its discriminatory power to classify the yarns having CSP 2,300 or more for their weavability. In such cases, the warp breaks due to other reasons, Class II and III, become important.

The Class II warp breaks are due to tensile/abrasive failure of gross thick places and/or obstruction by them to the passage of yarn through healds and reed. Therefore, experiments were conducted on a 30s (Ne) carded yarn to study the effect of size of the yarn fault and sizing on their weavability.

Results showed that the presence of A_3 and A_4 classimat faults does not affect the tensile properties of even sized yarn. However, C_3, C_4 and all D faults considerably reduce the yarn strength and elongation even after sizing. It was found that faults introduce into the yarn a very high frequency of low strength, elongation and abrasion threads which in turn could be a prominent source of warp breaks. When subjected to tensile load, most of the yarns broke at or in the vicinity of faults. The frequency of such yarns increased with increase in fault length and cross-section.

The Class III warp breaks are due to failure of knots/splicings in weaving. However, the present trend is to replace the knots with splicings. Therefore, in the present work, splicings were evaluated for their expected performance in weaving.

Results showed that the splicing process not only reduces the tensile strength and abrasion resistance of yarn but also introduces into it a high frequency of low strength/abrasion threads which are a prominent source of warp breaks. When subjected to tensile load most of the spliced yarns broke at the place of splicing; some of them showed a prominent stick-slip phenomenon.

These results helped a lot in understanding the phenomenon of warp breaks in weaving. Simulation of weaving stresses on Reutlinger Web Tester showed that a yarn breakage is mainly due to inter-fibre slippage on account of repeated weaving stresses. The inter-fibre slippage is greatly governed by fibre-to-fibre friction inside the yarn. Under practical normal conditions, grey yarn CSP appears to be a convenient indirect measure of this property of yarn.

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