STATIC AND DYNAMIC FAILURE BEHAVIOUR OF POLYESTER/VISCOSE BLENDED SPUN YARNS

by

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Dedicated

to

My parents, wife and Om

CERTIFICATE

This is to certify that the thesis entitled "**STATIC AND DYNAMIC FAILURE BEHAVIOUR OF POLYESTER/VISCOSE BLENDED SPUN YARNS**" being submitted by **Mr. Biswa Ranjan Das** to the Indian Institute of Technology Delhi, for the award of the degree of **Doctor of Philosophy** is a bonafide research work carried out by him. Mr. Biswa Ranjan Das has worked under our guidance and supervision and fulfilled the requirements for submission of the thesis. The results contained in this thesis have not been submitted, in part or full, to any other university or institute for the award of any degree or diploma.

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ABSTRACT

The failure of blended spun yarns is affected by the characteristics of constituent fibres and the yarn structure. The reported literatures on spun yarn failure behaviour are mostly concerned with the single component yarns especially the ring yarns. The studies related to the failure behaviour of blended spun yarns impose the complexities in understanding the individual component behaviour as well as the behaviour of the yarn. Hence, the multiple tracer fibre technique is adopted in this research work for studying the failure behaviour of polyester/viscose blended ring, rotor and air-jet spun yarns in both static and dynamic conditions. The tensile failure of spun yarns is studied using a Universal Tensile Tester for explaining their static failure behaviour. The dynamic failure behaviours are studied under both the simulated and real process conditions. The warping process is simulated by transporting the yarn in CTT instrument and the weaving process is replicated by attaching a simple shedding device on the CTT instrument. In order to validate the warping simulation process for explaining the spun yarn failure behaviour, the yarns are also subjected to winding process. The weaving simulation trial is validated by comparing the weavability measured on a Sulzer Ruti Reutlingen webtester. The failure behaviour of yarns is studied in terms of the proportion of fibre break/slip in the failure zone, length of failure zone and configuration of yarn broken ends. The failure behaviour of yarns is explained on the basis of yarn internal structural parameters and constituent fibre characteristics.

The theory of Hamburger is used by taking into consideration of both the fibre and yarn characteristics and it is shown that the fibre characteristics in association with yarn structure can explain the tensile behaviour of spun yarns. Hence, the internal structural studies are carried out in order to explain the tensile properties and spun yarn failure

behaviour. The internal structure of ring, rotor and air-jet spun yarns are found different owing to the difference in the fibre consolidation mechanism of different spinning systems.

The fibre failure coefficient is introduced to explain the yarn failure behaviour. It is observed that the failure of ring, rotor and air-jet spun yarns under static condition is predominately due to fibre breakage. The proportion of fibre break and percentage of sharp broken ends increases with the increase in viscose content in the blends. The failure zone length and sum of percentage of tapered and slipped broken ends decreases with the increase in viscose content in the blends. The fibre failure coefficient follow the exact similar trend with failure zone length & sum of percentage of tapered and slipped broken ends and follow reverse trend with proportion of fibre break & percentage of sharp broken ends with the increase in viscose content. The weaker viscose component contributes more towards fibre break in comparison to stronger polyester. Fibre breakage during yarn failure influences the sharp and tapered broken ends and the slipped broken ends found to be independent of fibre strength.

The ring and rotor yarns under simulated warping and weaving process showed similar trend for the proportion of fibre break and failure zone length. The air-jet yarns display a peculiar kind of failure behaviour. The failure of rotor and air-jet yarns under dynamic condition is predominantly due to fibre slippage. The contribution of polyester fibre towards fibre slippage is higher than fibre breakage for all the considered technology yarns and found to be moreover constant for all the blends. The contribution of viscose component to fibre break is higher as compared to fibre slip for ring yarns and supports more to fibre slip for rotor and air-jet yarns. The influence of fibre slippage on yarn failure behaviour is noticed to be more and more once moving from the static to warping and warping to weaving failure and this is valid for all the technology spun yarns irrespective of their blend proportion. The tension developed on the yarn during warping is comparatively lower than the tension acts on the yarn during tensile testing and weaving process; and in the later repeated stretching of yarns and stress relaxation introduce looseness in the yarn. However, the warp breaks occur over a longer time scale compared to the times to break in static tensile testing and weaving. These factors in dynamic conditions develop lower resistance to fibre slippage and consequently, evidence of higher fibre slippage during yarn failure.

The spun yarn failure under real dynamic condition i.e. winding is performed to validate the simulation trial of warping. It is observed that the yarn failure behaviour in both the winding process and the simulated warping process is moreover same. The air drag is found to have strong influence on the spun yarn failure behaviour during winding. The failure zone length of leading end is found to be shorter than the trailing end of yarn broken end. The length of the broken and slipped fibres is found to be higher for the trailing end compared to the leading end. The length of the broken fibre associated with leading end increase and the length of the slipped fibre of both leading and trailing end decreases with the increase in the viscose content in the blends.

The dynamic tensile properties are evaluated using a CTT dynamic tensile tester and the empirical relationship between the static and dynamic tensile properties is established. The weavability measured both on the Sulzer Ruti Reutlingen webtester and CTT accompanying shedding device are highly correlated. This indicates that the CTT instrument installed with the shedding device is suitable for assessing the weavability. The tensile properties measured under static and dynamic conditions are correlated with both the measured weavability and dynamic tenacity is found to have higher correlation than the static tenacity. The highly correlated dynamic tenacity has better capability to predict the performance of yarns in the post spinning processes. The lowest static tenacity is brought out to be more suitable than the average static tenacity for representing the static tensile strength.

Mathematical modelling is carried out to explain the failure behaviour of ring, rotor and air-jet spun blended yarns under the both static and dynamic conditions. The developed mathematical model is a power equation derived on the principle of matrix reduction. The model comprises of the influential yarn structural parameters and fibre strength. The percentage error associated with prediction of the fibre failure coefficient is well within the acceptance limit and these models possess huge potential for explaining the spun yarn failure behaviour.

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