STUDIES ON SEWING THREAD PROPERTIES, NEEDLE THREAD TENSION AND SEAM PROPERTIES IN LOCK STITCHING

By

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ensing thread; Thread properties.

Dedicated to

my wife, children, parents and in-laws

who have been my constant source of support throughout this work

Certificate

This is to certify that the thesis entitled "Studies on Sewing Thread Properties, Needle Thread Tension and Seam Properties in Lock Stitching" being submitted by Mr. D. Samuel Wesley, to the Indian Institute of Technology, Delhi, for the award of the degree of Doctor of Philosophy in the Department of Textile Technology, is a record of *bona fide* research work carried out by him. Mr. D. Samuel Wesley has worked under my guidance and supervision and fulfilled the requirements for the submission of the thesis.

The results contained in this thesis have not been submitted, in part or in full, to any other University or Institute for the award of any degree or diploma.

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Abstract

Sewing thread is a vital element in the seam of garments and other sewn products. The demand for higher production rates in garment manufacturing, the expanding applications of textile materials accelerated the arrival of modern high speed sewing machines with specific functions. These have resulted in increasing demands on the performance of sewing threads. This has not only necessitated the production of better quality threads but also has brought into focus the importance of the properties of the thread that influence its performance.

Compared to chain stitch machines, the lock stitch machine needle thread is subjected to higher stress which is a major constraint in attaining high speed in lock stitch sewing. Further, the lock stitched seam is prone to pucker due to higher sewing tensions. Considering these aspects, the lock stitch machine is selected for the present study. The deterioration of needle thread tensile performance after sewing and its dynamic sewing tension are the two factors that can provide useful information on the important aspects of high speed performance of sewing threads. Though there have been many studies on these two aspects, little has been suggested on the effect of thread structure for better sewing and seam performance. It can be attributed to the fact that there has been very little research on the dynamics of the machine with reference to the way in which the thread and the fabric mechanical properties affect it. The present research work is therefore, aimed at investigating such unexplored aspects of the performance of sewing threads. The objective of the work is to perform a comprehensive study on the sewing thread properties, needle thread tension and seam properties of different structure threads in lock stitch sewing for better understanding of the performance of threads and seam and the lock stitch sewing process. A PC interfaced

dynamic sewing tension measuring instrument is fabricated for measuring the dynamic needle thread tensions.

Twenty nine sewing threads belonging to eight categories are analysed in terms of simple-, loop- and knot-tensile properties. The structure of sewing threads and fibres constituting the threads influence the strength of the sewing threads. Tensile strengths, breaking extension and specific work of rupture in loop and knot forms are lower compared to that obtained in simple tensile test. Threads exhibit less ductility when stretched in loop and knot forms. Spun threads have higher relative- tenacity, extension and work of rupture in loop and knot forms. Heavier threads have lower relative tenacity, extension and specific work of rupture compared to the finer ones.

Stitch length, check spring tension, fabric feed timing and needle thread in-take lengths are varied while keeping the pre-tensions on the bobbin and needle threads and sewing speed constant to find their effects on needle thread tension peaks during sewing. Dynamic needle thread tensions are measured while sewing. Four prominent tension peaks are detected. Longer stitch length causes higher tension peaks and shorter length stitch needs higher pre-tension to obtain a balanced stitch. Incorrect timing of fabric feed can cause very high tightening tension on needle thread. Higher sewing tension is required on the needle thread to avoid stitch unbalance caused due to fabric jamming in case of shorter stitch lengths.

A factorial design approach is used to study the four parameters at three levels: sewing speed, pre-tension on needle thread, tex of the thread and total thickness of fabric plies with a constant bobbin tension. The role of bobbin tension is studied in a separate experiment, while keeping the pre-tension on the needle thread constant. Dynamic needle thread tensions are measured on spun polyester threads at two locations: above the needle bar (bottom segment) and above the needle thread tensioner (top segment). The thread tension measured at two

locations show different values and the effect of the factors on thread tension also differs. Needle thread pre-tension has predominant effect on thread dynamic tension.

A study on dynamic sewing tension has been carried out on sewing threads having different-structures, physical and tensile characteristics. Polyester filament and spun polyester threads exhibit the highest and lowest tightening tension respectively. Multiple regression analysis shows that pre-tension on needle thread and elastic modulus of thread show positive influence while tex, bending rigidity and compressibility of threads show negative on the tension peaks during stitch tightening and the needle piercing the fabric plies. Sewing speed shows positive impact only on the tension peak occurring during needle piercing.

The loss of tensile properties of sewing threads in sewing in relation to thread structures, fibre properties, thread fineness, load-extension and abrasion behaviors are also analyzed using SEM images. All the stitched threads undergo loss of tenacity and extension in sewing. The filament threads suffer lesser loss in tenacity and breaking extension compared to the spun- and core spun- threads. The needle threads suffer greater loss of tensile properties than the bobbin threads. Sewing on thicker fabric causes more damage to the sewing threads than the finer one. Coarser threads experience more loss in tenacity and breaking extension at constant sewing conditions. The twist alteration is a cause of reduction in the strength in sewing, mainly in the case of spun polyester threads.

The influence of thread and fabric properties and certain sewing parameters on seam strength, seam security and seam appearance are analysed. During seam strength test, the angle of stitch loops becomes close to zero that results in higher stitch tenacity compared to the seam that remains flat. The angle of stitch loop is related to fabric properties. The stitch strength is more closely related to knot strength than the simple- and loop-strengths of threads. Both the seam strength and seam efficiency improve with increasing stitch density up to a limit that

depends on the coarseness of the threads. The deterioration of stitch strength with increasing stitch density is an indication of fabric damage by sewing needle. For obtaining maximum seam strength, the upper limit on stitch density is lesser with coarser threads compared to finer threads. The extension of sewing thread during stitch tightening significantly affects seam pucker of light weight fabrics, if the threads are highly extensible. The excessive thread-fabric differential shrinkage causes severe pucker.

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