Chapter 1
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Introduction and Objective

1.1 Introduction

Plying of spun yarns for improving physical and tensile properties is an established practice. During plying, the yarn strands consisting of bundle of fibres wrap around each other, which, in turn facilitate better utilization of fibre properties. Thus plying yarns offer significant advantages and therefore is of greater future potential.

However, the degree of improvement in properties as a result of plying depends also on spinning systems. There are four major spinning methods for cotton namely, ring spinning, compact spinning, open-end rotor spinning and Murata vortex spinning. Ring spinning is a continuous spinning system in which twist is introduced into a yarn by a rotating traveler. The yarn twist insertion action and winding action take place simultaneously by means of a rotating spindle. Even though ring spinning has a low production rate, the ring spun yarn structure is generally accepted as the fundamental or basic structure in spun yarn technology [1]. In conventional ring spinning, the drafted strand of fibres before twisting passes through a triangular shaped untwisted region known as spinning triangle. The shape and dimensions of the spinning triangle have a decisive influence on the structure and properties of the yarn. However, in compact spinning, the drafted strand is laterally condensed before twisting by aerodynamic forces so that the width and height of the spinning triangle are reduced to a minimum. The reduction in spinning triangle is expected to influence yarn characteristics [2]. On the other hand, in open-end rotor spinning, fibre bundles from the sliver stock are separated into individual fibres with an opening roller and an air stream. The separated fibres are converted into a continuous strand of yarn passing through a doffing tube [3]. Many open-end spinning methods have been invented but none have been successful than open-end rotor spinning. Recently, Murata vortex spinning, based on the air-jet spinning technology by the Murata Machinery Company in Japan, has been commercialized. With the MVS system, it becomes possible to use a wider fibre length range for 100% cotton yarn, allowing spinning of a wider yarn
size production range. In this system, drafted fibres are introduced into a spindle orifice by an air vortex. While entering and passing through the orifice, fibres that are twisted by the swirling air are also introduced into the outer side of the orifice.

It is an established fact that structure plays a key role in the physical, mechanical and performance characteristics of spun yarns. Hence, study of structure is essential to manufacture yarns for different end uses. A considerable proportion of single yarns need to be doubled and restructured after primary spinning, in order to meet more demanding requirements. The structure of single yarn further changes on plying due to relocation of distribution of fibres in yarn matrix. This necessitates exploring and full understanding of structure of plied yarns as well to predict its performance.

Physical properties of yarns e.g. unevenness, hairiness are recognized as important quality parameters as these not only contribute to the aesthetic appearance of the fabric but also influence the mechanical properties of the yarns and fabrics made there from. Understanding physical properties of plied yarns remains a challenging task as these get affected by the spinning system and process parameters. Amongst various spinning systems which can spin cotton successfully, ring spinning, compact spinning, open-end rotor spinning and Murata vortex spinning are more prevalent in the market. The yarn produced by each system has certain unique characteristics which can not be imitated by the others; while, at the same time yarns spun on these different spinning systems are competing with each other and trying to vie for the same end use space. Appropriate use of these yarns in order to exploit their aesthetic qualities needs to be looked into. Hence, enhancement of properties at the plying stage is another area that deserves attention. Strict association between process parameters and physical properties of plied yarns spun on various spinning systems is yet to be established. Further technical studies have shown that it is possible to produce hybrid folded yarns through plying of singles spun on different spinning systems. This allows in theory to obtain a blending of different physical properties in a hybrid yarn. So, study of properties of hybrid yarns is also a prime requisite.

Beside physical properties, mechanical properties of yarns are of no less importance as these decide their applications specifically in industrial uses. These properties depend also on spinning systems and process parameters. The reported
information for plied yarns on these aspects is very limited. Therefore, there is a need to evaluate the mechanical properties of plied yarns in relation to spinning systems and process parameters.

Amongst mechanical properties of yarn, tensile properties are accepted as one of the most important parameters for assessment of yarn quality. Due to marked structural differences, the responses to the tensile behaviour of these yarns are expected to be different. Further, the tensile strength and breaking elongation of the yarns are not the unique functions, but they depend on the extension rate. From the practical point of view, it is desirable that the effect of operating speed on the tensile properties of the yarn should be known, so that the results obtained from the instruments running at different speed can be correlated and compared. Many research workers have reported on the properties and performance aspects of yarns and fabrics that represent the new spinning systems. Most of the evaluation and comparison, however, was confined to standard test methods and the results thus obtained may not correctly reflect the behavior of the different yarns and fabrics under nonstandard loading conditions. Though many workers have reported tensile behavior of single yarns under standard and nonstandard loading condition, there is no report available for plied yarn on this aspect. In view of this, there is a need to study the tensile behavior of plied yarns under non-standard loading conditions that may be appreciated for non-traditional applications like aircraft, space vehicles, automobiles, reinforced composites and a host of other industrial uses.
1.2 **Objective of the work**

The broad objective of this work is to study the quality aspects of plied yams in relation to spinning systems and process parameters. The specific objectives are:

1. Investigation on structural aspects of plied yams
2. Investigation on influence of ply twist factor on physical properties of plied yams
3. Investigation on influence of ply twist factor on mechanical properties of plied yams
4. Studies on tensile behavior of plied yams through analysis of yarn failure zone when tested under non-standard conditions.