CHAPTER 1
GENERAL INTRODUCTION

1.1 INTRODUCTION

The demands to achieve greater levels of quality in every sphere of production, to understand material behaviour; and the need to achieve this rapidly and economically with minimum human effort, need very little emphasis.

The explosive and rapid spread of the use of personal computers and their capabilities have given us opportunities to utilize the same to minimize human tedium and also reduce the human element of error involved in various calculations and operations. The personal computer today can perform complex calculations very rapidly, and it can also control an external equipment and acquire data from it directly with minimum human effort. This capability of the personal computer has been tapped in the design and development of a 'state of the art equipment' to measure the torsional property of a textile material in the form of a fibre or yarn.

1.1.1 Torsional rigidity

Torsional rigidity of a fibre is defined as the torque or couple arising when unit length of the fibre is given unit twist. It can be expressed in dyne.cms where as the Modulus of rigidity of a fibre is the ratio of the shear stress to the shear strain.

If $T$ is the torsional rigidity and $s$ the area of cross section of the fibre then the modulus of rigidity $G$ is given by the formula:
\[ G = T \Delta s^2 E \] (1.1)

where 'E' is called the shape factor of the fibre and this depends on the shape of cross section of the fibre.

1.1.2 Twisting of fibres and the existence of snarling tendency \ residual torque

From time immemorial, yarns have been produced by twisting. A majority of the yarns fibres produced in today’s world undergoes twisting at some stage or the other. Torsional forces are involved in the action of twisting. When fibres are twisted, yarn is formed. The cohesive forces arising out of this twisting are responsible for the fibres to remain together in the yarn structure. This twisting is also responsible for the strength of the spun yarn. In the case of a spun yarn as the twist increases, the strength of the yarn increases upto a certain level after which an increase in twist will lead to a decrease in strength. Twisting also creates an opposing torsional force. The energy involved in twisting is expended to some extent as the work done in rearranging the fibres as the spun yarn is formed and also to some extent in the heat generated out of friction as can be imagined. The remaining energy is stored in the spun yarn and leads to the phenomenon of snarling or the residual torque. One way of eliminating snarls is by ply-twisting involving the insertion of a number of twists in the opposite direction to that existing in the singles yarn. However, a torsionally well balanced yarn with minimal snarling tendency will be formed only if the ply twist is optimum. Figure 1.1 shows a well balanced and poorly balanced yarn i.e. a yarn with and without snarling tendency.

1.1.3 Effects of residual torque\snarling tendency

The presence of snarling tendency in the yarn can lead to various problems in terms of quality.
POOR AND WELL BALANCED YARN

FIGURE 1.1 POOR AND WELL BALANCED YARN
In the case of hosiery yarns, excessive snarling tendency will lead to the presence of a defect called 'spirality' which is nothing but a distortion of the wales in such a manner that it is inclined at an angle other than 90 degrees with respect to the courses. This defect is shown in Figure 1.2.

In the case of sewing threads, which are usually made by plying yarns, if the ply twist is not proper, it will lead to an imbalanced yarn causing snarling which may sometimes lead to entanglement and breakage at the needle eye and this is illustrated in Figure 1.3.

In the case of cable yarns used in the manufacture of fish nets, the presence of residual torque can cause distortion of the fish nets.

In the case of cords made by plying and even in braided cords it can lead to entanglement during unwinding. Let us take the case of a parachute, when it is deployed in the air. Excessive snarling\residual torque can cause entanglement of the cords preventing it from opening, and thus causing risk to life and material deployed.

In the case of crepe fabrics produced by highly twisted yarn, when the woven fabric is subjected to a wet relaxation treatment, the potential energy in the yarn due to residual torque gets dissipated in the form of a rearrangement of fibres causing the crepe effect\appearance on the fabric. The crepe effect can be perhaps standardized by standardizing the torque characteristics.

All the above clearly indicates that snarling tendency\residual torque is a very important factor which affects the quality of textiles.

1.2 RESEARCH OBJECTIVES

1) In spite of the importance of the residual torque characteristics as mentioned above, its precise and absolute measurement is not undertaken in the industry. The main reason for the above is because
KNITTED FABRIC

FIGURE 1.2 SPIRALITY IN KNITTED FABRIC

NEEDLE ON THE SEWING MACHINE

NEEDLE EYE

WALE INCLINED AT AN ANGLE AWAY FROM THE VERTICAL...... DEFECT CALLED 'SPIRALITY'

VERTICAL LINE NORMAL TO THE COURSES

FIGURE 1.3 POORLY AND WELL BALANCED SEWING THREAD ON NEEDLE

POORLY BALANCED

WELL BALANCED

SOURCE : 'KNOW ABOUT THREADS' BY CAUBLE et al (1985)
the measurement of the torque is quite difficult due to lack of easy availability of instruments for the same. Even though some commercial instruments do exist, its application has been mainly limited only to research purposes. With the above in mind, the main objective of this research is the design and development of a suitable instrument for measuring the torsional characteristics of textile material using the personal computer which is revolutionizing almost every facet of industrial activity.

2) Leading textile research organizations have conducted a survey of the characteristics of yarns produced by different manufacturers. These characteristics include strength, elongation at break, evenness, appearance, twist factors, hairiness and various faults. Based on such survey, standards/norms for the above have been established. However, a survey of the snarling tendency/residual torque characteristics of yarn has so far not been reported. In the case of hosiery yarn, snarling tendency/residual torque characteristics has been reported as the major contributor towards the cause of the defect called 'spirality' in knitted structure.

With the above in mind, one of the research objectives of this work was to collect hosiery yarn from different sources in Tirupur, South India, a major center for the production of hosiery items and analyse the same for their residual torque characteristics.

3) Another objective of this research was to knit fabrics from yarns obtained from various sources in Tirupur under similar conditions and assess their spirality and compare them with the absolute value of the residual torque measured.

Indirect methods of assessing residual torque like counting the number of snarls when two ends of a specific length of yarn are brought together and the snarling distance when the yarn just starts snarling were also undertaken to compare it with the spirality of the knitted fabric.
4) Lyocell, a regenerated cellulosic fibre is now gaining in popularity in several parts of the world. It was taken up to study them for their torque characteristics including breaking twist angle.

5) One of the existing methods of obtaining a balanced cotton yarn is by subjecting the same to the process of steam setting, wherein the yarn is loaded inside an autoclave and subjected to steam under pressure.

   It was taken up to conduct experiments of in-situ steaming of the yarn as it was being produced on the ring frame and assess its residual torque characteristics and compare the same with control samples.

6) It was decided to conduct in-situ singeing on the ring frame as the yarn was being produced and see whether the process of singeing and the heat involved will set the yarn.

The thesis consists of twelve chapters including the present one

Chapter 2 contains an extensive literature review on the various methods\ instruments developed for the assessment of the torque characteristics of textile material. This portion is well illustrated. Besides the above literature review, indirect methods of assessing the residual torque characteristics of yarns have also been reviewed along with studies on spirality of knitted structures.

Chapter 3 deals with the design and construction of the computerised torsional rigidity apparatus.

Chapter 4 deals with the Computerised torsion pendulum mode of the above equipment developed.

Chapter 5 contains description of the Computerised torsion balance mode of the above equipment.
Chapter 6 describes the accuracy, repeatability, resolution and reliability of the computerised torsional rigidity analyser.

Chapter 7 describes a novel technique developed for determining the direct objective measurement of the residual torque characteristic of cotton yarns using a polyester monofilament as the standard using the computerised torsion balance mode.

Chapter 8 gives the test results obtained by testing Lyocell fibres for their torsional rigidity and breaking twist angle.

Chapter 9 describes a novel technique of carrying out insitu steaming on the ring frame and it also shows the extent of reduction of the residual torque values obtained by this modified spinning when compared to conventional ring spinning.

Chapter 10 describes a novel technique of carrying out insitu gassing on the ring frame and it also shows the extent of reduction of residual torque values obtained by the modified spinning.

Chapter 11 gives the results of a survey carried out on the residual torque characteristics of hosiery yarns used in Tirupur, India, obtained from various sources.

Chapter 12 is the concluding chapter of this thesis outlining the important achievements and it also includes a brief description of the scope for future work.