CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

It has become increasingly important to remain on the cutting edge of technology for a company to remain competitive and survive in today’s high tech industries. Rotor Spinning is a well established yarn producing technology that has been used for more than forty years. Researchers started their research in 1970 and a considerable amount of work has been done on the effect of some variables such as rotor speed, rotor diameter, opening roller speed and twist on yarn quality. Barella et al (1976) published a comprehensive analysis of the process in a series of papers in 1976, which remain till the current time the only concentrated research publications in rotor spinning. The research work done by many workers concentrated on optimization of the spinning parameters to obtain a good quality yarn.

Schlaflhorst, in the beginning of 2002, succeeded in producing a yarn for authentic denim on the Autocoro without the aid of additional mechanical devices. They introduced a kit, “Belcoro Structured Denim” comprising the transfer of technological know-how and spinning component especially adopted to structured yarn. With Belcoro structured Denim, Autocoro spinning mills are able to manufacture high quality structured denim with the Autocoro for the first time without the aid of additional mechanical devices and with a reproducible visual appearance. The cost of the kit is very reasonable and on Autocoro, take up speeds of up to 250m/min are
possible. The Autocoro is expected to give five to seven times higher productivity compared with the conventional spinning process.

According to Oxenham (2002), Rotor Spinning is the only system to offer a real challenge to ring spinning for producing coarser yarn counts. He has given data to substantiate that with the reduction in rotor diameter, which is required for increasing the process speeds, there is a deterioration in yarn quality. The price differential between ring and rotor yarn prices has been found to be a common phenomenon. He is confident that rotor spinning will continue to be used for producing coarse counts. He adds that in order to gain in other sectors, some mechanism of improving certain aspects of yarn quality is essential.

It is also pointed out by Oxenham (2002) that between 1990 and 2000, rotor yarn production has recorded an increase of 40.8%. While the number of ring spindles installed has declined in 1999 as compared in 1987, rotor spindles has remained almost the same during the same period.

Dodd (2002) has provided interesting data to demonstrate that a rotor can produce yarn 7.5 times faster than a ring spindle and an air jet can produce the yarn 13.75 times faster and a vortex can produce this yarn 18.75 times faster.

The main difference between ring and rotor yarns is that ring spinning requires two additional processes namely roving and winding. These make the ring spun yarn more expensive to produce.

The above two examples will suffice it to say that the rotor spinning process requires some changes in order to improve the yarn quality. In ring spinning, air jet nozzles were fitted in order to produce a yarn which is devoid of hairiness. Wang et al (1997) have initiated this type of research and
succeeded in producing a yarn which is devoid of hairiness. There is also little or no published work relating to application of nozzle in rotor spinning in terms of the yarn properties. The provision of nozzle in rotor spinning is an area where work is necessary in order to know its contribution to yarn quality. Some work has been done on the use of two opening rollers in rotor spinning and the results are found to be very encouraging. Earlier Behzadan (1974) has investigated fiber configurations in the opening region of an open end spinning system, having a combing roller type of drafting device.

Hajilari et al (2007) have studied the effect of two separate fiber feed systems in rotor spinning on yarn properties. A modified SE-8 rotor spinning unit of Suessen was used in which two separate fibre feed systems were employed. Raw material used was 38 mm, 1.7 Denier viscose fibres which was used for spinning 40 Tex (14.75 Ne). Yarn properties produced with this unit were compared with that of original yarn which showed that tenacity, elongation and work of rupture of the former had improved over the latter. There was no change in imperfections and yarn abrasion. This shows that increasing the number of feed rollers from one to two had improved the yarn properties.

Mireshghi et al (2005) have studied the effect of a change in a fiber path from one end of the transport channel to the roller wall on rotor yarn properties. Three newly developed transport channels of a rotor spinning system were introduced and tested.

Rotor spinning evolved a breakthrough in yarn production technology when ring spinning was the conventional method of yarn production. Rotor spinning had some advantages over the conventional ring spinning in that it eliminated the winding process. The large packages of rotor spinning yarn with reduced material handling job helps a lot in knitting industry (Alterman 1985). It was found that rotor spun yarn produced even
fabric and knittability and knitting machine stops and fabric appearance of rotor spun yarns were favorable. Hyrenbach et al (2002) found that the rotor yarn offered a clear advantage in terms of physical characteristics and yarn character as seen from Table 1.1.

Table 1.1   Comparison between rotor and ring spun yarn (Hyrenbach et al 2002)

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Physical Characteristics</th>
<th>Yarn Character</th>
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<tbody>
<tr>
<td>1</td>
<td>Utilisation Coefficient</td>
<td>Yarn Evenness</td>
</tr>
<tr>
<td>2</td>
<td>Breaking Strength</td>
<td>Imperfections</td>
</tr>
<tr>
<td>3</td>
<td>C.V% of Breaking Strength</td>
<td>Hairiness (Less)</td>
</tr>
<tr>
<td>4</td>
<td>Elongation %</td>
<td>Volume (Higher)</td>
</tr>
<tr>
<td>5</td>
<td>Shrinkage</td>
<td>Fiber intimate blend</td>
</tr>
<tr>
<td>6</td>
<td>Fastness to chafing</td>
<td></td>
</tr>
</tbody>
</table>

- Rotor spun yarn is not better than Ring spun yarn.
= Rotor spun yarn and Ring spun yarn similar.
+ Rotor spun yarn is better than that of Ring spun yarn.

Production of continuous length of unspliced rotor yarn on larger package resulted in reduced down time in knitting. It has been reported that the number of defects in rotor spun yarn was reduced by 80%. Rotor spun yarns, due to their surface characteristics and stable nature, give rise to a knitted fabric which has no tendency to spiral when slitting open the knitted tube. The wrapper fibres act as a protective layer and thus abrasion resistance of rotor yarns is good. They have low hairiness and good surface resistance. If the hairiness is further reduced, it will lead to a better yarn and also further improve its abrasion resistance. Furthermore, the labour on changing the needle can be reduced.
1.2 NEED FOR THE STUDY

Rotor yarn is quite different from ring spun yarn in its structure and if the surface is altered by some means it will result in reducing the wear of machine parts and also improving the handle of fabrics. Also, if the strength of the yarn can be improved, it will also aid in improving the knitting performance and appearance of denim fabrics. One of the ways of reducing the hairiness of rotor spun yarns was by passing the rotor yarn through an air-jet nozzle. It was thought that when just by passing the yarn through the nozzle could reduce its hairiness in cone winding, the hairiness of rotor spun yarn could be reduced in the same manner. This improved yarn would lead to a seemingly different product.

1.3 SCOPE OF THE STUDY

The focus of the study is the claimed low strength of rotor spun yarn over the ring spun yarn. This phenomenon is seemingly related to the following factors which are surface characteristics related to yarn structure.

a. Co-efficient of friction between yarn and different surfaces.

b. Tension builds up caused by wrapper fibres.

The study was organized to observe the changes in the surface features of rotor spun yarns after it was passed through the air jet nozzle. The nozzle dimensions were optimized in the beginning and the optimized air-jet nozzle was used for studying the structure and properties of these yarns vis-à-vis regular rotor yarns. The low stress mechanical properties of air jet and rotor yarns namely bending and compression properties were examined.

The effect of gauge length on the tenacity and elongation properties was studied and the tenacity was predicted by Weibull model. Structural
aspects such as migration and wicking were investigated. The other techniques used were swelling index, wicking and twist liveliness.

1.4 OBJECTIVES

The main objective of the study was to investigate the effects of using air jet nozzles on the characteristics of rotor spun yarns. This major objective was expected to be achieved with the following specific objectives.

1. To investigate the effect of using air-jet nozzles on rotor spun yarns characteristics.
2. To study the structural changes in air jet rotor spun yarn vis-à-vis regular rotor yarns.
3. To study the effect of gauge length on the tensile properties such as tenacity, elongation and initial modulus and to model the yarns by Weibull distribution.
4. To study the wicking behavior and low stress mechanical properties of yarn.

Yarn characteristic properties depend on two factors, fibre property and yarn structures. The term yarn structure in the broader terms refers to the number of fibers in the yarn cross-section, packing density, cross-wise migration, fiber extent along the yarn length, irregularity of fiber displacement, twist and the outer form of the yarn. Each spinning system leads to a distinctive yarn structure.

1.5 ORGANISATION OF THE THESIS

The study mainly comprises an investigation of the characteristics of yarns produced in rotor spinning by incorporating a nozzle after the delivery of the yarn. The study is presented in 10 Chapters.
1. Chapter 2 reviews the spinning technologies which involve the air jets.

2. Chapter 3 describes the material and methods used in the study. The methods for assessing the structure and properties of yarns bending and compressional properties are described.

3. Chapter 4 discusses the properties of air jet rotor spun cotton yarns produced with the series of nozzles having different design features and optimisation of nozzle.

4. Chapter 5 comprises a study of fibre migration in jet-rotor spun yarns vis-a-vis regular rotor spun yarns.

5. Chapter 6 investigates the low stress mechanical properties, flexural rigidity and twist liveliness in air jet rotor spun cotton yarns.

6. Chapter 7 describes the wicking behaviour of air jet rotor spun yarns.

7. In Chapter 8 yarn properties of air jet rotor spun yarn in vis-a-vis rotor spun yarn are discussed.

8. Chapter 9 contains data on the effect of gauge length of the tenacity, elongation and initial modulus of air jet rotor spun cotton yarns.

9. Finally, Chapter 10 summarises the work in the previous chapters and major conclusions are drawn. Recommendations for future work are outlined.