Wrap spinning technology—A critical review of yarn properties

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The wrap spinning has the advantage of using coarser fibres for finer yarns in addition to its superiority in production and yarn quality. This paper discusses the structure and properties of wrap spun yarns and identifies areas that need researchers' attention to have a better understanding of the applications of these yarns.

Keywords: Composite yarn, Cover yarn, Hollow spindle, Wrap density, Wrap spinning.

1 Introduction

The strength of staple fibre yarn is dependent on inter-fibre frictional forces which are due to twisting of fibres. An alternative method is to bind the staple fibres by wrapping continuous filaments about the untwisted fibre assembly which is in the core. The filament-wrapping twist can either vary in direction as in the selffil system or be continuous as in the hollow-spindle system.

The hollow-spindle system has become very popular in recent years although the technique is not new. Machines by Leesona, Swenen Weller, James Mackie, and Gemmill Schlumberger and Dunsmore have gained importance due to electronic controls. In this method, the untwisted loose drafted fibre strand is wrapped by the continuous filament, forming a composite yarn with a staple core and filament sheath. It is widely recognized that this new technology has the advantages such as high productivity, greater yarn covering ability, higher yarn tenacity and uniformity, possibility of using coarser fibres for finer yarns, great potential of product versatility, etc.

This paper discusses the structure and properties of bound or wrap spun yarn and identifies areas where further work is needed to have a better understanding of the applications of these yarns.

2 Developments in Wrap Spinning

There have been many studies on the structure and properties of wrap spun yarns. A number of patents also discuss the principle of hollow spindle. Audvert1-2 discussed a technique of blending staple fibres with filament yarn in which staple fibres were partially covered with continuous filament; the yarn was produced on conventional ring frames and termed 'covered yarn'. A considerable improvement in yarn properties was seen by using small quantities of continuous filament yarn.

Caban3 introduced a new process for the production of textile yarns with improved properties using the technique of filament wrapping; this was principally carried out in worsted spinning, and the results obtained were very encouraging. In 1970, George Mitor, a Bulgarian textile engineer, designed a hollow spindle which was commercialized by the British textile machinery manufacturer, Gemmill and Dunsmore.

Jung4 pointed out that the properties of wrap spun yarns are largely dependent on the sheath material. Taub5 stated that the uniformity of wrapper filament contributes to the evenness of the composite yarn; this has been found to fare well in weaving and knitting operations. Weisser and Czapay6 attributed the increase in yarn tenacity to the radial pressure on the core by the wrapping filament. Weisser6 and Haldon7 stated that the filament content varies from 1% to 8% depending on the tex of the wrap spun yarn. Taub5 stated that the choice of the filament depends on the tex and the end use requirements of the yarns. Depending on the type of yarns the kind of filament to be used varies. A coarser filament is generally recommended for sewing threads and industrial yarns. Steiner8 stated that a monofilament winds round the yarn like a wire whereas a multifilament winds round the yarn like a ribbon. As is to be expected, the higher strength of the composite yarn is due to the filament modulus and increase in the wrap density; a low frequency of wraps produces a soft and bulky yarn. Maag9 demonstrated that when the wrap...
spun yarn is stressed, fibre slippage becomes predominant until the filament locks into the staple core. This results in a more compact yarn structure and increases the frictional force between the fibres. Jung\textsuperscript{4} pointed out that there is an optimum distance, usually 20-30 mm, between the front roller and the hollow spindle. At distances greater than 30 mm, disorientation of core fibres results in a drop in yarn strength and elongation.

Srinivasan\textsuperscript{10}, in an extensive study on the hollow-spindle yarns, demonstrated that most yarn properties depend on the wrap density and the type and fineness of the filament used. The use of a false twisting device does not affect the tensile properties of the yarn but influences the regularity and hairiness of the yarn, the direction of threading of the filament around the false twister being of importance. He also showed that when a wrap spun yarn is subjected to stress, the extension of the filament in the yarn and the compressive radial force exerted by the filament are affected by the wrap angle and the type and fineness of the filament.

On the basis of his intensive work with wool fibres on wrap spinning, Srinivasan\textsuperscript{10} concluded that:
(i) A coarser filament results in a stronger wrap spun yarn.
(ii) A lower level of wrapping draft produces a more uniform yarn.
(iii) Yarns spun with a monofilament are stronger than those spun with a multifilament of the same linear density.
(iv) The length of the pirn has no effect on the properties of the wrap spun yarn.
(v) The position of the false twister does not influence significantly the properties of the wrap spun yarn.

(vi) For spinning yarns with a low level of wrapping draft (0.9), the maximum possible delivery speed for spinning without end breaks is 55 m/min.
(vii) Comparatively less fly liberates at the front rollers of the drafting system while spinning yarns with long pirns.

Srinivasan\textsuperscript{10} also studied the effect of unwinding tension of the pirns and its effect on the yarn characteristics, and concluded that the unwinding tension of the filament increases as the pirns wind down, mainly due to the frictional resistance offered by the surface of the yarn. He studied the whole dynamics of the pirns during unwinding and, doubtless, his work has shed a lot of light on the technology of wrap spinning. A preliminary work on the characteristics of wrapped yarn has been carried out by Rajkhowa \textit{et al.}\textsuperscript{11}.

A number of studies on the mechanism of breakage of wrap spun yarns have been carried out and notably among them is the one by Behery and Nunes\textsuperscript{12}. Their work dealing with 100\% polyester core wrapped by polyester continuous filament yarns, shows that the tenacity and breaking elongation of the composite yarn increase with an increase in the linear density of the wrapping yarn, its tenacity and wrapping density; the structure of the yarn is affected by the linear density of the wrapping continuous filament yarn and the wrapping density introduces geometrical changes in the fibrous core and leads to an increase in the inter-fibre frictional forces between the individual fibres of the core. Another study by Sengupta \textit{et al.}\textsuperscript{13} revealed that the heat setting of the wrapped yarn improves the breaking energy of the yarns by more than 20%.

Xie \textit{et al.}\textsuperscript{14-16} examined a general model of wrap spun yarn which can be used to predict the

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<th>Table 1 – Factors affecting wrap yarn characteristics</th>
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<td>Factor</td>
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<td>Wrap density</td>
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<td>Type of core used</td>
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<td>Wrapped yarn characteristics</td>
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relationship between yarn strength and structural parameters. They have shown that by applying appropriate assumptions to a general model of wrap spun yarns, it is possible to obtain a much simplified relationship between tensile behaviour and structural parameters. This simplified model has been used to predict the effect of binder type and twist on yarn strength and the data have been found to be in reasonable agreement with the experimental data. It should be stated here that whereas most of the authors have carried out experimental work, Xie et al. have done a theoretical evaluation of the wrap spinning.

3 Concluding Remarks

There have been many repetitions in the work reported by various workers. Further work on the effect of wrapping on the bending and torsional rigidity and fatigue resistance of the composite yarns is required. A little work has been done on the fabrics produced with wrap yarns. The fabrics can be investigated with special reference to their handle, appearance and tailorability. Table 1 shows the various factors affecting wrap yarn characteristics, their effects on yarn/fabric properties and the areas in which R&D efforts are needed.

References