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**Wrap Spinning: Principles and  
Development**

by

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# WRAP SPINNING: PRINCIPLES AND DEVELOPMENT

by A G BRYDON and J P VAN DER MERWE

## 1. INTRODUCTION

A wrap yarn is a composite structure comprising a core of twisted or twistless fibres bound by a *yarn* or *continuous filament*. The term wrap yarn therefore includes yarns produced by the hollow spindle method as well as similar structures such as Selfil and Reppo wrapped yarns, but does not, however, include structures such as Dref<sup>1</sup>, Novacore<sup>2</sup> and Fasciated<sup>3</sup> yarns which involve a configuration of wrapper *fibres* around a staple or filament core and which do not employ a continuous wrapper *yarn*.

Wrap spinning, although not new, has become the subject of renewed interest in recent years. The process is claimed to provide the spinner with a highly efficient method of producing yarns of high quality for a wide range of applications. High production speeds are claimed and the resultant yarns possess many desirable qualities.

Wrap yarns were produced more than a century ago by the woven horsehair interlining trade<sup>4,5</sup>. A horsehair core of virtually untwisted fibres having been wrapped first with a yarn in "S" direction and then with one in "Z" direction or *vice versa*. This was then wound and used as weft in high quality interlining fabrics.

Wrap spun yarns are said<sup>6,7</sup> to be as strong as, more regular and bulkier than conventional ring spun yarns, effecting good cover and a full handle when converted into fabric. Wrap yarns have been successfully employed in the production of a wide range of products including both woven and knitted goods, tufted carpets and velour fabrics<sup>8-10</sup>.

## 2. METHODS OF WRAP YARN PRODUCTION

### 2.1 Selfil

A method of yarn production whereby two continuous filaments are wrapped around a staple fibre core on a modified Reppo self-twister has been described by Walls<sup>11</sup>. These yarns consisted of a core of staple fibres which were wrapped in alternating directions with a fine filament by a self-twist unit. A second self-twist unit repeated this action such that the point of low twist of the second filament coincided with the point of high twist of the first filament and *vice versa* (Figs 1 — 3). The resultant yarns were called SELFIL yarns, and information regarding yarn properties has been well documented<sup>11-19</sup>.



Fig. 1 - Configuration of the first continuous filament wrapped around the staple strand<sup>11</sup>.



Fig. 2 - Second continuous filament wrapped around the first, out of step by half of one twist zone<sup>11</sup>.

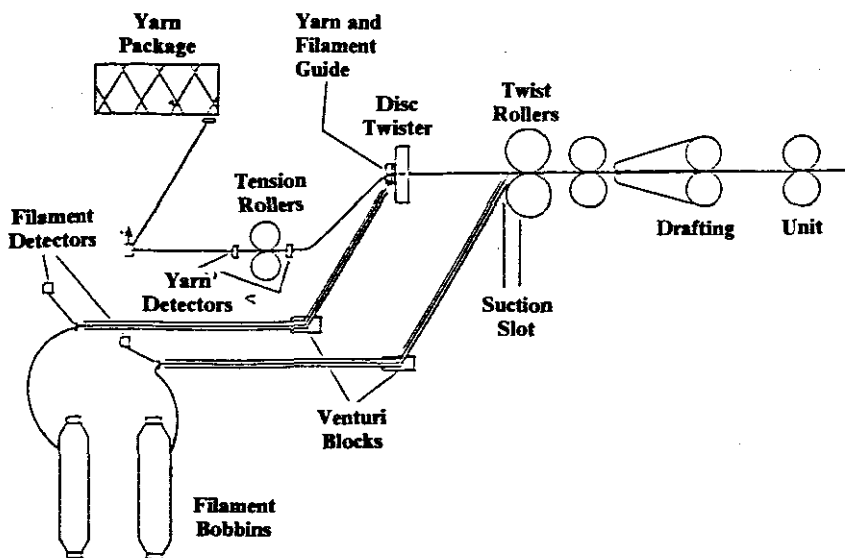


Fig. 3 - The SELFIL machine<sup>11</sup>.

Subsequent work<sup>20</sup> led to the production of SELFIL yarns using only one twister (Fig. 4).

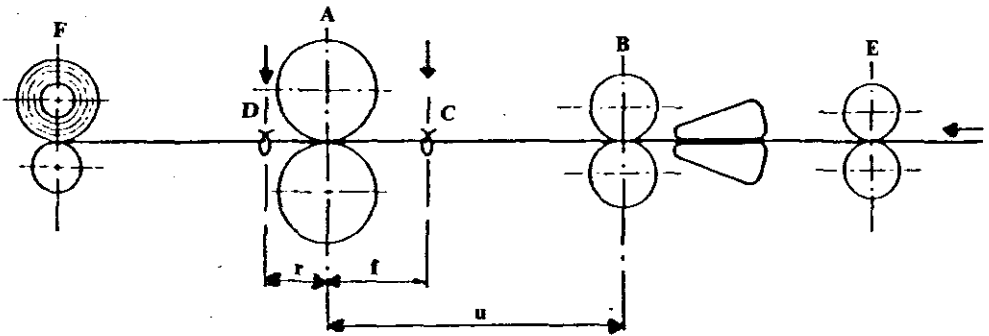


Fig. 4 - Single-twister SELFIL spinner<sup>20</sup>.

A worsted roving is fed into the drafting system E to B and the drafted strand is fed through self-twist rollers at A, which, as well as rotating to move the strand forward, reciprocate longitudinally to impart alternating twist to the strand. A monofilament converges with the strand at C and a second monofilament converges at D. The final yarn is wound at F.

## 2.2 Repco Wrapped Yarns

A method of yarn manufacture which utilizes the self twist principle, has been developed at SAWTRI<sup>21-26</sup>. These yarns are termed Repco Wrapped Core-Spun (RWCS) yarns and consist of a strand of staple fibres and a filament core<sup>21</sup>, selftwisted with a single filament binder yarn (Fig. 5).

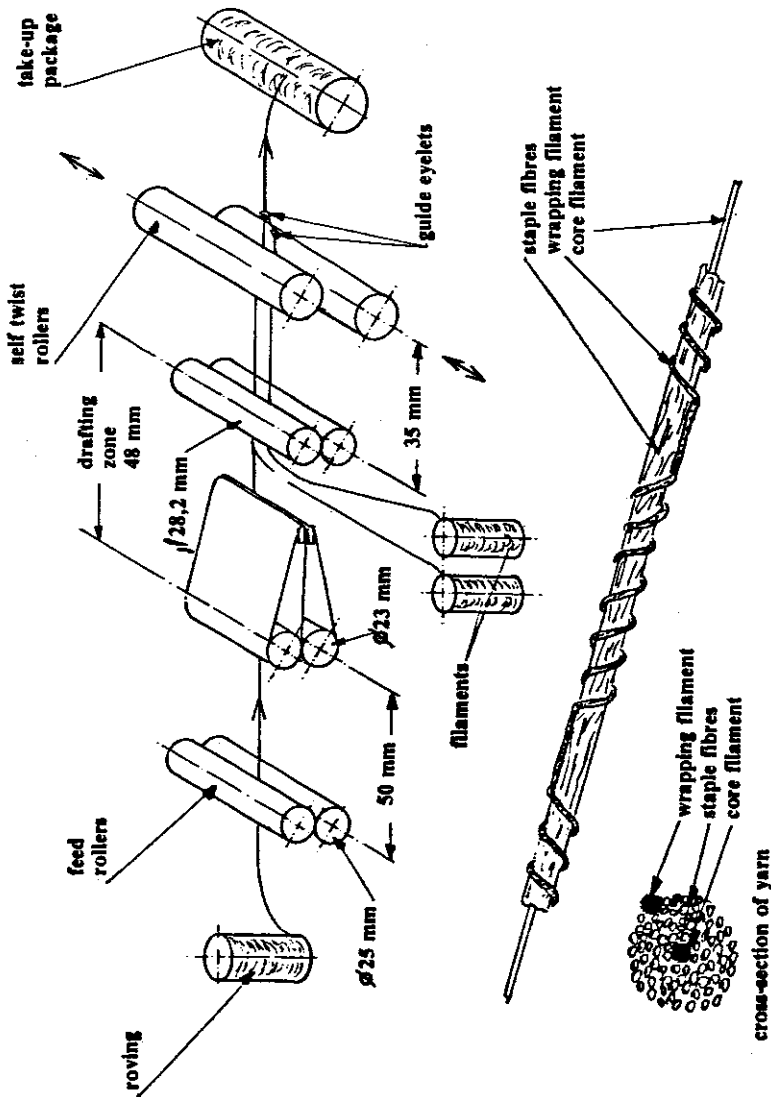
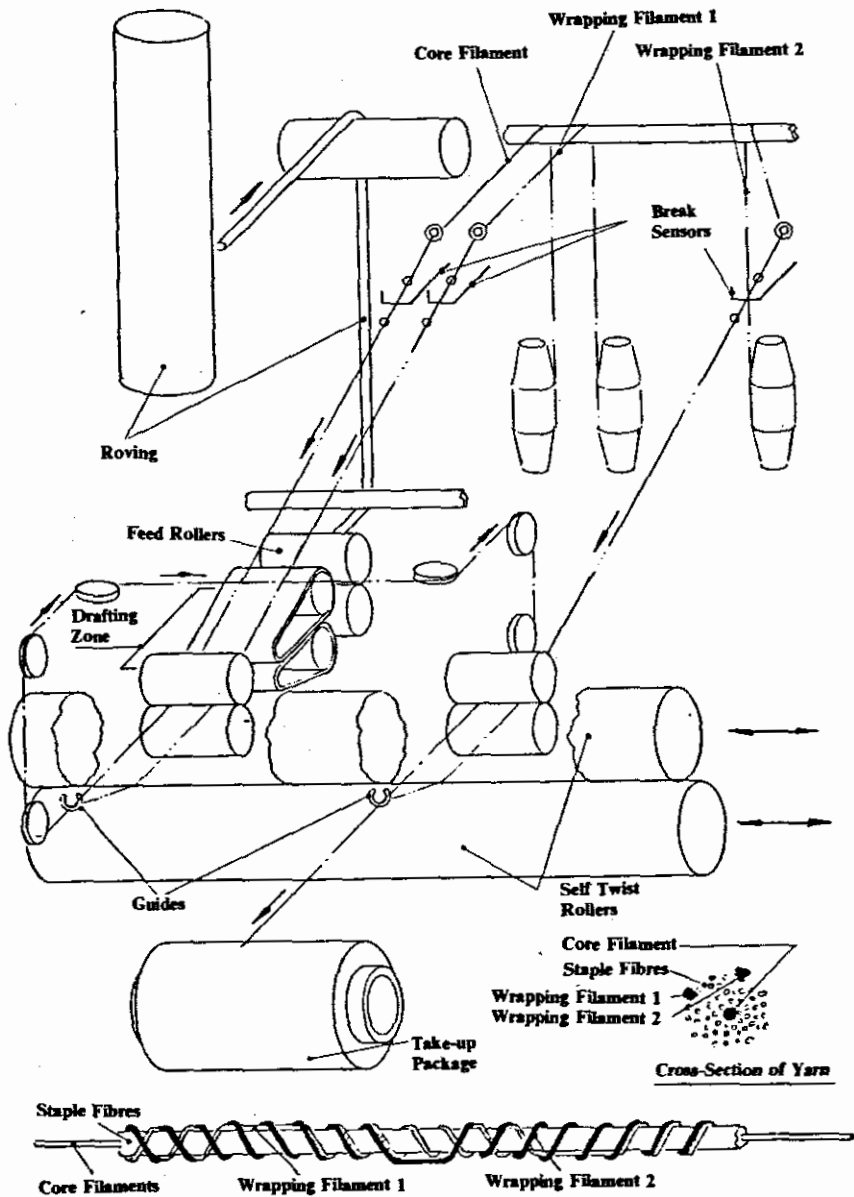


Fig. 5 - RWCS System<sup>27</sup>.



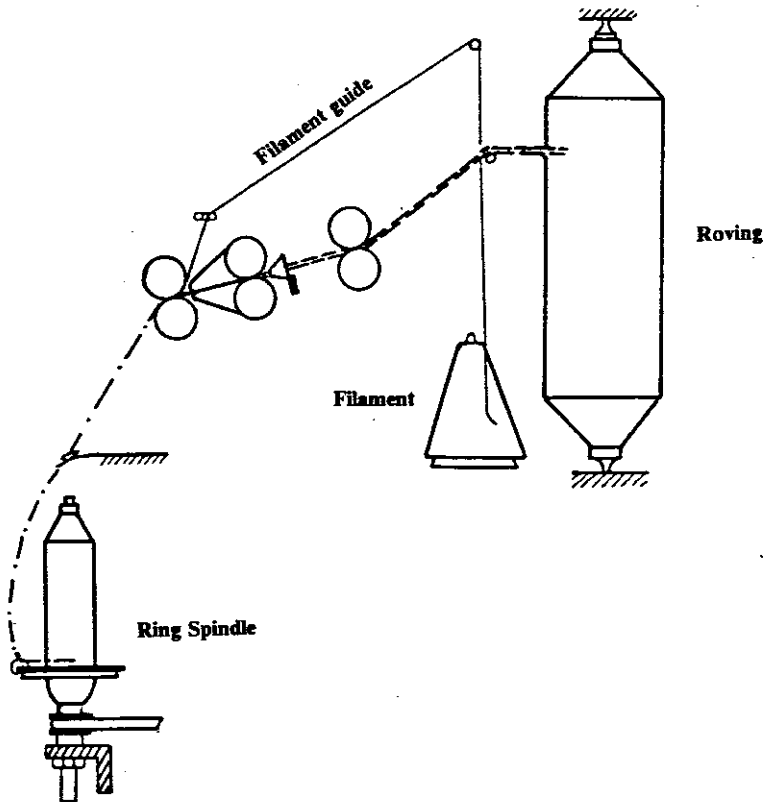
**Fig. 6 - RDWCS System<sup>28</sup>**



The system was initially developed for the production of fine mohair yarns which were subsequently up-twisted and used for weaving. RWCS yarns have since been produced for knitting and the system has been extensively covered in the literature<sup>29-37</sup>. Variations of the system include Repco Wrapped Spun (RWS) yarns<sup>36</sup>, which do not contain a filament core. In addition a further method has been developed<sup>28</sup>, primarily for the production of wrapped core-spun cotton yarns on a self-twist spinner, which could be used readily without the necessity of up-twisting. These yarns have been termed Repco Double Wrapped Core-Spun (RDWCS) yarns and employ two wrapping filaments. The wrapper configuration resembles that of a SELFIL yarn, although the method of introducing the second wrapper filament is completely different (Fig. 6). It was stated that with the exception of yarn tenacity, the RDWCS system produced yarns as good as up-twisted RWCS yarns<sup>28</sup>.

### **2.3 Wrap Yarns Produced on a Ring Frame**

A method of producing wrapped yarns on a ring spinning machine has been described<sup>38-43</sup>. A continuous filament, drawn off a bobbin situated behind the drafting mechanism of the spinning frame is threaded through the delivery rollers so that it will emerge at the front of these rollers alongside the drafted slubbing (Fig. 7). Correct positioning of the filament is achieved by means of a guide at the back of and close to the delivery rollers. Both filament and slubbing are then twisted into a yarn consisting of a core of staple fibres wrapped with filament at the balloon zone. This method has been used both for the production of waste yarns<sup>39</sup> and cotton yarns which need not be sized<sup>40</sup>.



*Fig. 7 - Wrap yarn produced on a ring frame<sup>42</sup>.*

8). A similar assembly<sup>44-46</sup> is used in the production of "Woolfil" yarns (Fig.

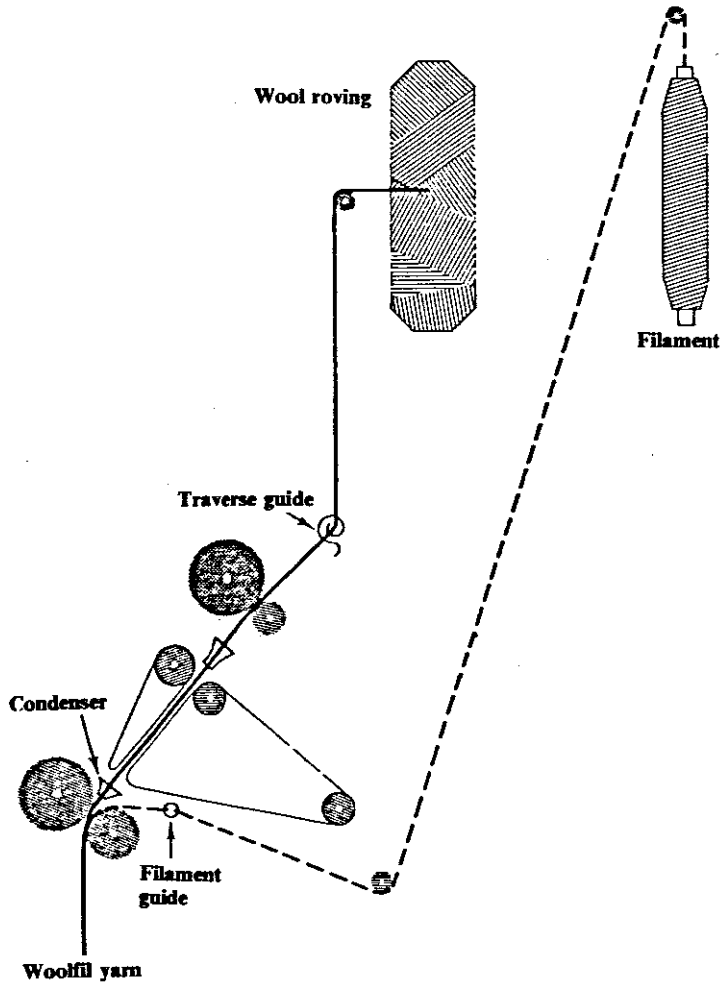


Fig. 8 - Production of woolfil yarn<sup>44</sup>.

## 2.4 Differential Twist Yarns

A further method of wrap spinning is that of passing a core of staple fibres through a hollow spindle, wrapping the fibres with filament<sup>47</sup> and subsequently ring spinning the yarns in one continuous process (Fig. 9). This system is used both for the production of fancy yarns and for the production of straight yarns.

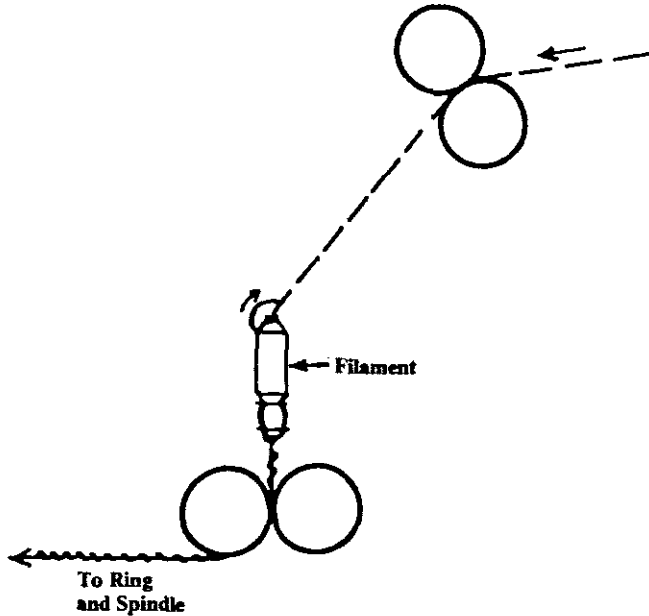
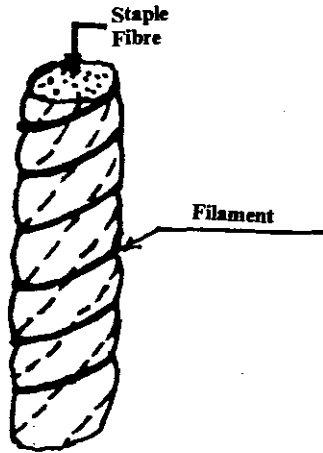


Fig. 9 - "Differential Twist" process<sup>47</sup>.

Audivert and Fortuny<sup>47</sup> described the system for the production of plain yarns which were termed "Differential Twist Yarns". These yarns consisted of a strand of staple fibre which had been first wrapped with filament and subsequently twisted together with the same filament, the outstanding character being that the twist of the staple fibre was lower than that of the filament (Fig. 10).



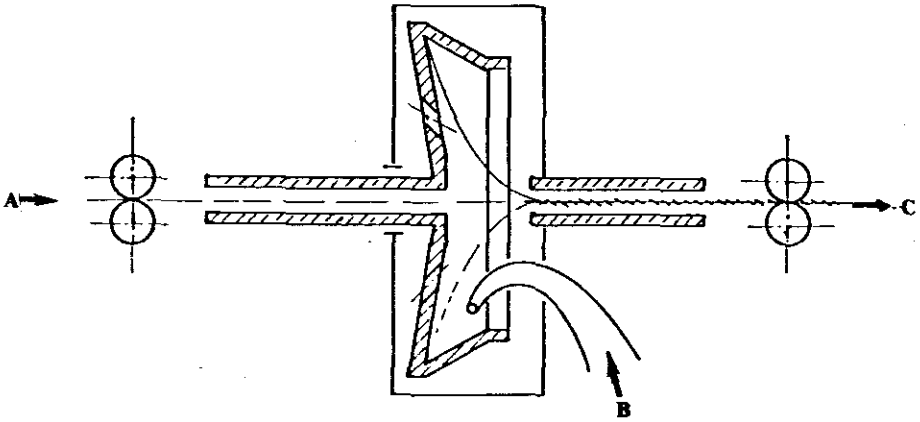
*Fig. 10 - Differential twist yarn<sup>47</sup>.*

The direction of twist inserted by the ring spindle was the same as that of the 'wrapping' twist. In this manner the strand of staple fibre was given twist and the final twist of the filament in the spun yarn was the sum of the 'wrapping' twist and 'spinning' twist.

It was found that tensile properties, spinnability and regularity, of Differential Twist Yarns were invariably better than conventional ring spun yarns and it was thought that the system would be suitable for the spinning of waste yarns.

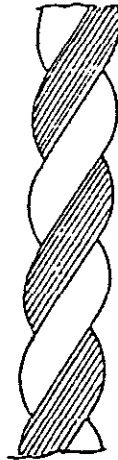
### **2.5 Wrap-Spun Rotor Yarns**

A method of producing Wrap-Spun Rotor yarns has been developed in Czechoslovakia<sup>48,49</sup>. The process which was termed "ROTONA" made its first international appearance at ATME '82. Fundamentally, the system is a modification of the rotor spinning process which makes it possible in one operation to spin a single rotor yarn and to wrap it around another continuous textile product such as a staple core or filament yarn, while it is practically still in the rotor (Fig. 11). ROTONA yarns were designed primarily to replace traditional ply yarns in a broad range of textile products.



*Fig. 11 - Production of wrap spun rotor yarn<sup>48</sup>.*

Component (A) which may be a filament or a staple sliver passes through the rotor. Staple sliver (B) enters the rotor and is formed into a yarn. Due to the tension of the various components and the selected parameters, the wrap spun rotor yarn (C) is formed upon exit from the rotor<sup>48</sup>. A wrap spun rotor yarn is illustrated in Fig. 12.



*Fig. 12 - Wrap Spun Rotor Yarn<sup>48</sup>.*

## 2.6 Hollow Spindle Method

The hollow spindle system of wrap yarn production, in which no real twist is inserted during the actual spinning process, has become generally accepted as the most important method of wrap yarn production.

Patents relating to forms of hollow spindles date back many years<sup>50</sup>. In 1938 BARMAG was issued a German patent which revealed the use of a hollow spindle in the two for one twisting machine, thereby increasing the productivity of the machine by a factor of two. Similar increases resulted when hollow spindles were applied as twister tubes in machinery for texturing man-made fibres by the false twist process. Even earlier, hollow spindles were used for wrapping copper conductors with cotton or insulation in the wire making industry.

Further developments subsequently evolved primarily for the production of fancy yarns, whose production was previously impossible either for economic or technical reasons. Wrap spinning technology is now highly advanced and at ITMA '83 eleven manufacturers offered different variations of this system for producing wrapped and fancy yarns<sup>51</sup>.

The hollow spindle method of wrap yarn production involves the drafting of a sliver produced either on the worsted, semi-worsted or cotton system of manufacture into a roving of parallel fibres which is then passed together with a fine filament, through a hollow spindle onto which the filament package is mounted. By rotating the spindle, the core is helically wrapped with filament. The filament exerts radial pressure on the fibre core resulting in frictional forces acting between the individual components, which, together with the wrapping filament, are responsible for yarn strength<sup>52</sup>.

## 2.7 Wrap Yarns Produced on a Woollen Card

Wrap yarns of the type described above are currently produced on specially designed wrap spinning machinery incorporating hollow spindles. However, a system whereby wrap yarns can be produced directly on the condenser of a woollen carding machine, thereby eliminating the need for a separate spinning machine, has recently been described<sup>53-58</sup>.

Hollow spindles were fitted between the rubbing apron and the condenser surface drum of a woollen carding machine (Fig. 13), thus producing a wrap yarn from staple fibres in one continuous process. An additional method was described whereby the rubbing aprons were bypassed so that yarn was produced from fibre ribbons as presented by the condenser tapes, thus eliminating the rubbing aprons and eccentric motion of the condenser. The production of double wrapped yarns and fancy yarns was also described.

The physical properties of the wrap yarns compared favourably with that of woollen ring spun yarns. It was reported that economical advantages could be

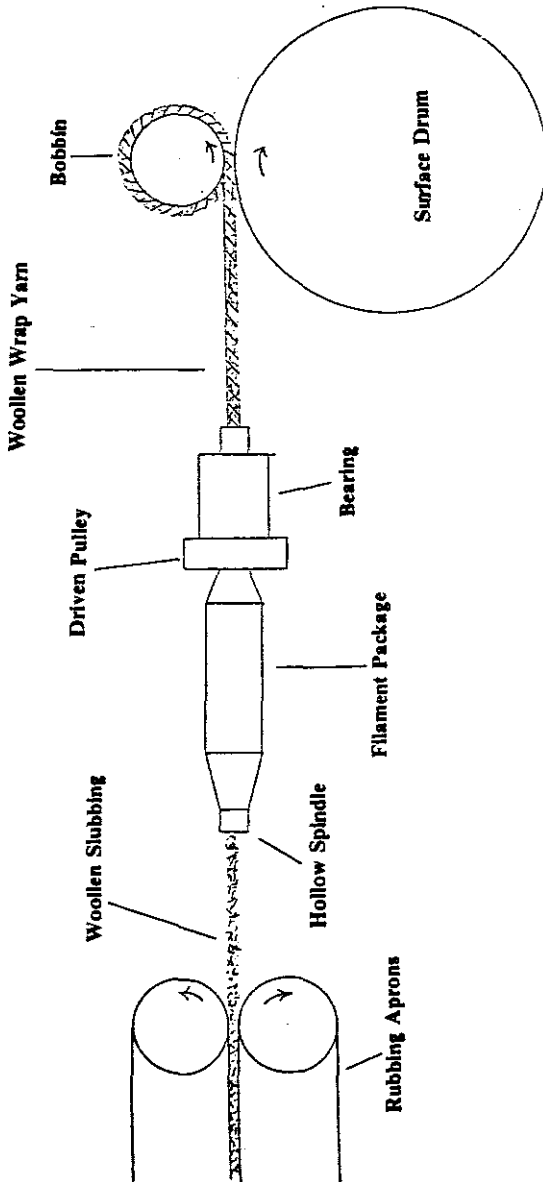


Fig. 13 - The production of a wrap yarn directly on a woolen condenser.



gained due to the low spindle speed. Furthermore, in addition to the elimination of a separate spinning process, it was considered possible to modify the condenser creel in such a way that the wrap yarn could be wound directly onto packages, such as tapered cones or parallel-sided (cylindrical) packages, thereby possibly eliminating the winding process.

The effect of various parameters on the properties of the latter yarns has not been fully investigated. All further discussions will therefore pertain to wrap yarns as produced on current commercially available wrap spinning machinery, incorporating the hollow spindle principle.

### 3. PRINCIPLES OF HOLLOW SPINDLE WRAP YARN PRODUCTION

#### 3.1 False Twist

When two or more yarns are twisted between two nip points, false twist is generated (Fig. 14).

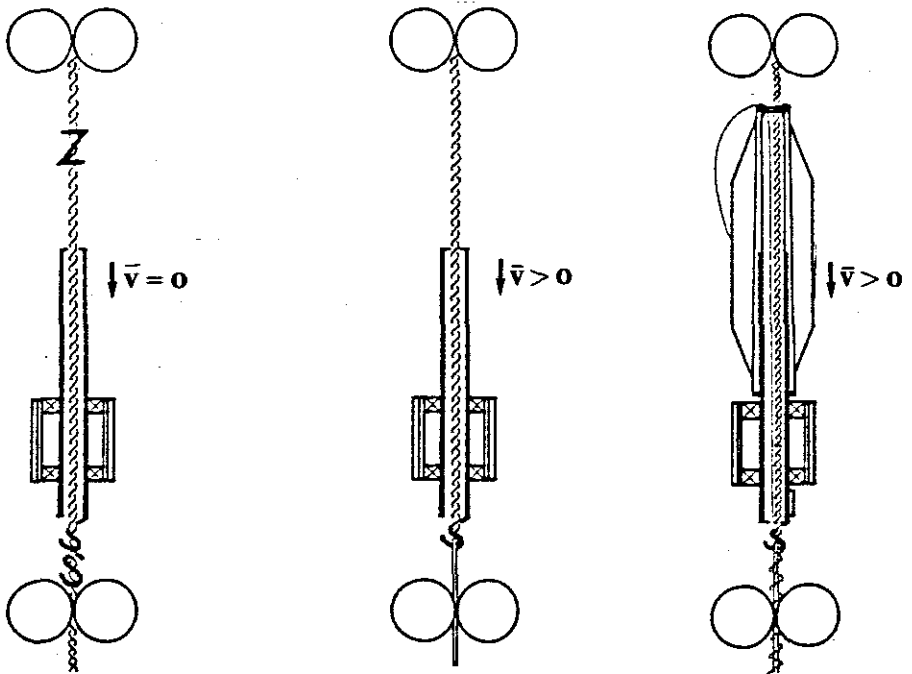


Fig. 14 – Illustration of false twist principle<sup>59</sup>.

If the draft rollers are static and the yarn delivery  $\bar{v} = 0$ , Z-twist would be obtained above the twist element and S-twist below it, i.e. assuming the spindle turns clockwise when viewed from above<sup>52</sup>. When delivery speed  $\bar{v} > 0$ , no twist can be formed below the twist point. If a bobbin with the wrapping filament is placed on the hollow spindle, and the filament is drawn together with the core through the hollow centre, the wrapping filament is nearly parallel with the other yarns up to the twist point. Only from that point on is it wrapped about the core. If a false twist unit is not used, wrapping takes place at the top of the spindle<sup>60,61</sup>. False twist is accomplished by frictional forces with or without twisting elements<sup>52</sup>. Most wrap spinning machines utilise a false twist unit, either at the top or the bottom of the spindle. In some instances, the false twist device also acts as a regulator by applying tension to the binder.

It has been suggested<sup>62</sup> that wrap yarn made without a false twist device requires about 10% more wraps per metre for the same strength than a yarn made with a false twist device. However, subsequent research<sup>63</sup> has shown that wrapping by means of a false-twisting assembly does not influence yarn strength or regularity. The use of a false twisting assembly was, however, found to lead to a reduction in fly and the number of roller lappings. An example of a false twist device is shown in Fig. 15.

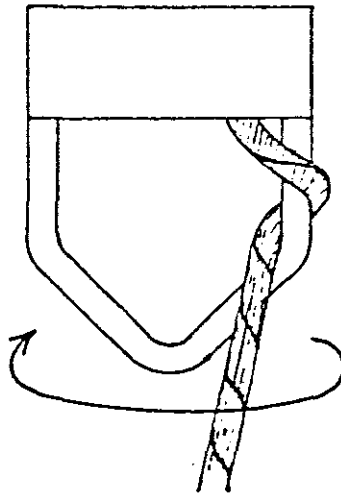


Fig. 15 – Example of a False Twist Device<sup>63</sup>.

### 3.2 Filament Tension

The relationship between the tension of the binder and that of the base material is very important.

Considerable differences in filament tension may occur as the filament unwinds during spinning. This is dependent on factors such as the shape of the package, the amount of filament on the package and spindle speed etc. These parameters also influence the position of the wrapper yarn in relation to the roving. Thus it follows that if the filament tension constantly varies, so too will the appearance and uniformity of the resultant yarn.

Optimal wrapping is achieved when the constricting effect of the filament yarn at a given elongation of the yarn, produces sufficient fibre to fibre cohesion, and when end stage elongation of the fibre structure and the filament yarn is reached simultaneously<sup>64</sup>.

When yarns are spun with low filament tension, the filament yarn is wound loosely about the fibre structure and there is hardly any constriction (Fig. 16) whilst as filament tension rises the filament yarn is increasingly displaced toward the longitudinal yarn axis and the staple fibres are pressed outward (Fig. 17), producing characteristics similar to that of a ply yarn. In extreme cases the filament yarn will break before the fibres have reached their point of rupture, when the yarn is over-extended.



Fig. 16 - Wrap yarn spun with too low filament tension<sup>65</sup>.



Fig. 17 - Wrap yarn spun with too high filament tension<sup>65</sup>.

Naturally, the force-elongation properties of the fibres and the filament wrapper yarn also play an important role.

Furthermore, interference resulting from damaged spindles, packages or tubes, and the fibre accumulation in the filament balloon may cause a considerable rise in the tension acting on the filament yarn, leading to end breaks in extreme cases.

### 3.3 Wrapping Density and Filament Linear Density

The frequency of filament yarn wraps around the core influences strength, elongation and torque<sup>6</sup>. Yarn characteristics can be varied within a broad range by means of the wrapping density. It has been stated<sup>63,66</sup> that wrap yarn tenacity increases as the wrapping density increases.

Rottmayer and Brosch<sup>64</sup> have shown that the yarn tenacity increases with increasing number of wraps until an optimum, after which, increases in wrapping density result in decreases in yarn tenacity (Fig. 18). Furthermore it was stated that higher yarn tenacities can be obtained, as might be expected, by the use of stronger wrapping filaments. The largest gain in tenacity for the specified fibres, was observed in the switch from 22 dtex to 33 dtex filament. By using even coarser filament, only slight additional improvements were noted. Similar trends were found regarding elongation at break (Fig. 19). For economical reasons the finer filament yarn was given preference. The reason for this was stated to be that a longer length of filament could be wound onto the bobbin, thus longer running times could be obtained before production needs to be interrupted in order to replenish the wrapping filament.

It was stated<sup>64</sup> that optimal wrapping density with respect to tenacity and elongation properties depends on the cohesion of the fibre structure, i.e. its length, linear density, crimp, finish and on the yarn linear density.

A set of general equations from which the load extension and tenacity at break of wrap yarns can be computed for particular cases, has been developed by Grosberg *et al*<sup>67</sup>.

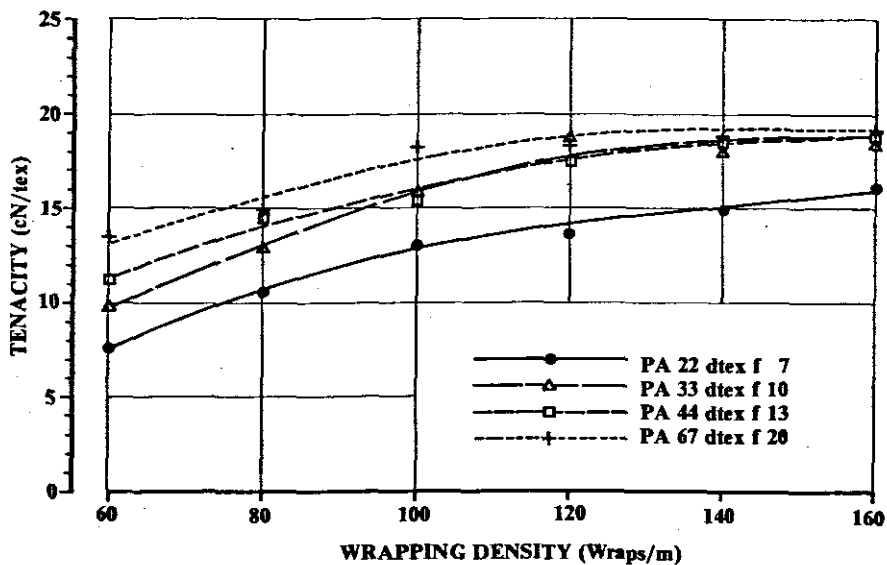


Fig. 18 - The effect of wrapping density and filament linear density on tenacity of 250 tex wrap yarns<sup>64</sup>.

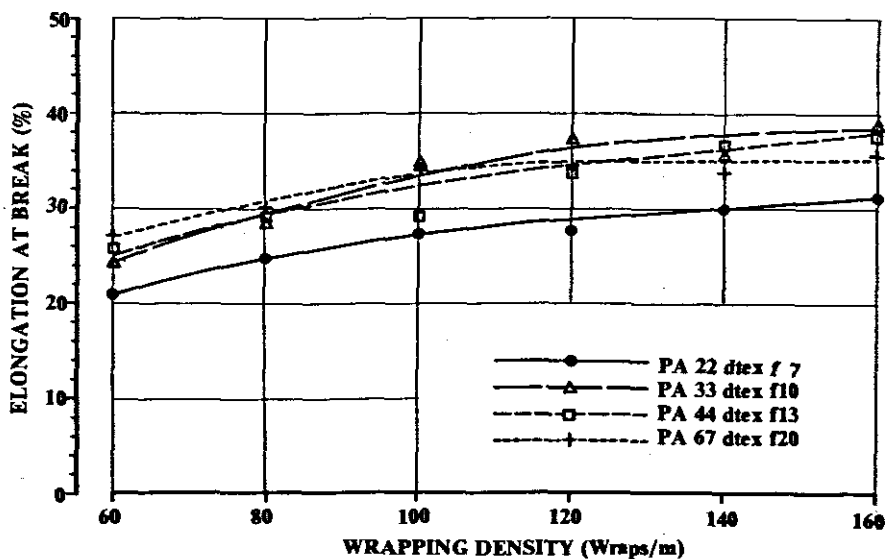


Fig. 19 - The effect of wrapping density and filament linear density on % elongation of 250 tex wrap yarns<sup>64</sup>.

#### 4. TYPES OF WRAP YARNS

Wrap yarns can be categorised into three groups:

1. Flat parallel yarns
2. Structured parallel yarns
3. Fancy yarns

##### 4.1 Flat Parallel Yarns

These yarns are also referred to as "straight"<sup>50,68,69</sup>, "regular"<sup>70</sup> or "smooth"<sup>52, 71-74</sup> yarns, and consist of a core of parallel, untwisted fibres helically wrapped with a fine filament yarn<sup>75-86</sup>. In addition, wrap yarns of this type, which have been produced on the "LEESONA" range of wrap spinning machinery, have been termed "Cover Spun" yarns<sup>66,87</sup>.

In the manufacture of flat parallel wrap yarns it is the function of the wrapping filament to exert radial pressure on the staple fibres and thus increase the frictional forces acting between the individual components.

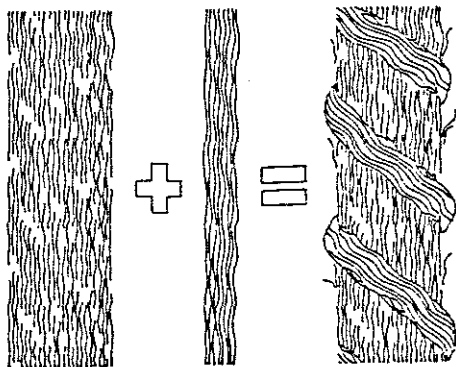
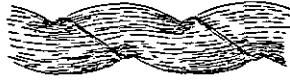


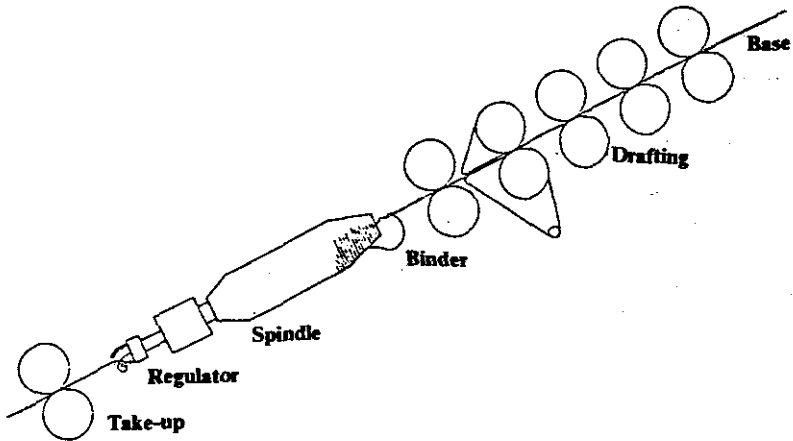
Fig. 20 - Schematic representation of wrap yarn formation<sup>66</sup>.

In contrast to ring spun yarn, the fibre structure is held together not by twist, but by the wrapping thread. The individual fibres lie parallel but may be deformed due to the helically distributed radial forces of the wrapping filament. This effect is shown in Fig. 21.



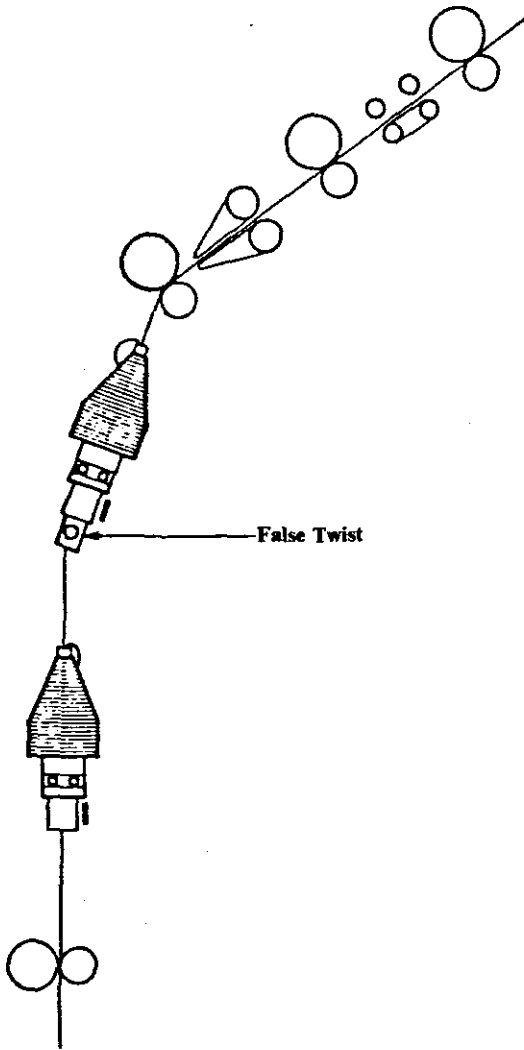
*Fig. 21 – Deformation of yarn due to radial forces of the wrapping filament<sup>65</sup>.*

Fig. 22 shows a typical arrangement of a wrap spinning unit for the production of flat parallel yarns<sup>62</sup>. The fibre mass is drafted in a conventional drafting unit, it then passes through the hollow spindle which carries the filament package. By the rotation of the filament package, the filament is wound around the fibres, each filament wrap requiring one full turn of the filament package<sup>88</sup>.



*Fig. 22 – Wrap spinning assembly for the production of plain wrap yarns<sup>62</sup>.*

A further method<sup>89–96</sup> involves the use of two hollow spindles in tandem as shown in Fig. 23.



*Fig. 23 – Double wrap spinning assembly using two hollow spindles fitted in tandem<sup>91</sup>.*

By rotating the spindles in opposite directions, the drafted sliver is wrapped by a filament in "S" direction followed by a second filament in "Z" direction of *vice-versa*. The resultant yarn is shown in Figure 24.





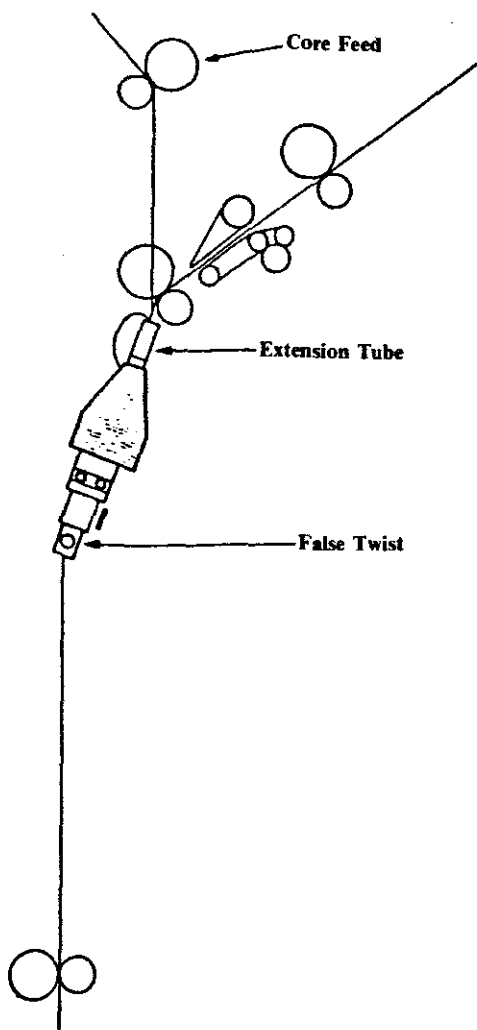
Fig. 24 - Double wrap yarn<sup>65</sup>.

#### 4.2 Structured Parallel Yarns

Structured or engineered yarns can be created to give the finished product improved performance, enhanced aesthetics, softer handle, lower unit mass, greater bulk and cover etc.<sup>75,60, 97-102</sup>. An example<sup>75</sup> of such a process is to use a filament yarn which contracts when the wrap yarn is dyed or steamed. The contracting filament exerts pressure on the staple fibre core, thus squeezing the staple fibres in a bow out of the yarn axis. A spiral appearance is therefore generated, which grows to a string-of-pearls pattern as volume builds up to a maximum.

In another example, a filament is introduced as a core<sup>97,103</sup> and is surrounded by staple (Fig. 25). By selection of the properties of the third component, i.e. the core, speciality yarns can be produced, such as elastomeric (Fig. 26), or high-strength yarns<sup>66</sup>.

In principle all kinds of staple fibres can be combined with the most versatile types of filament yarns to form parallel yarn. For practical purposes it is advisable to select combinations where the properties of the yarn components compliment each other, for example according to shade or dyeability and/or shrinkage properties.



*Fig. 25 - Wrap spinning assembly illustrating the introduction of a filament<sup>1</sup>.*

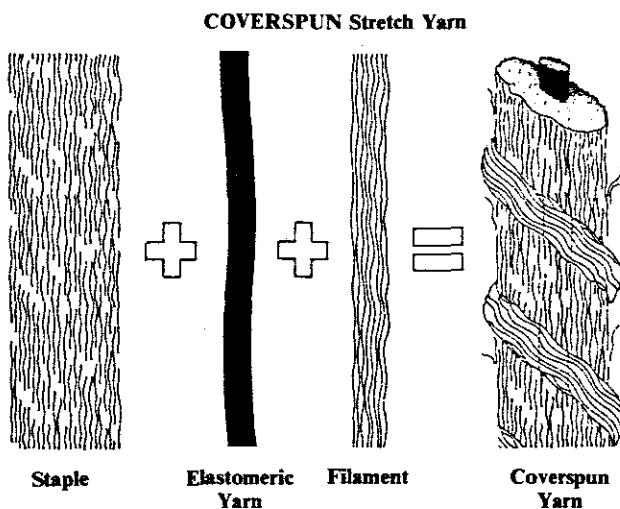


Fig. 26 – Example of a structured yarn with an elastomeric yarn in the core to produce a stretch yarn<sup>104</sup>.

### 4.3 Fancy Yarns

Fancy yarns can be produced by feeding an effect yarn together with the drafted sliver through the hollow spindle so that both the sliver and the effect yarn are wrapped by the filament<sup>105–112</sup>. Fancy yarns are also produced by employing overfeeding<sup>113–115</sup> and intermittent<sup>52,105</sup> feeding of the effect yarn or drafted sliver. The basic structure of a fancy yarn is shown in Fig. 27.

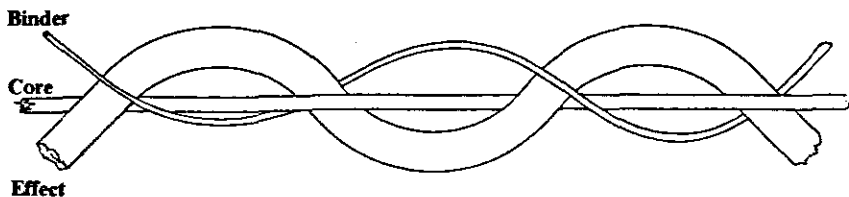


Fig. 27 – Basic structure of a fancy yarn<sup>115</sup>.

The principles upon which a fancy yarn machine<sup>62</sup> is based is illustrated in Fig. 28. The fibres are drafted either with or without aprons. The core yarn is brought through a groove in the front draft roller and therefore runs at the speed of the delivery roller, permitting overfeeding at the front roller. The materials then pass through the hollow spindle, where they are wrapped with the binder.

According to one manufacturer<sup>114, 116</sup> a "virtually unlimited" range of novelty yarns can be produced. On some fancy yarn machines<sup>117 - 119</sup> relevant processing data can be stored on a computer and recalled when required.

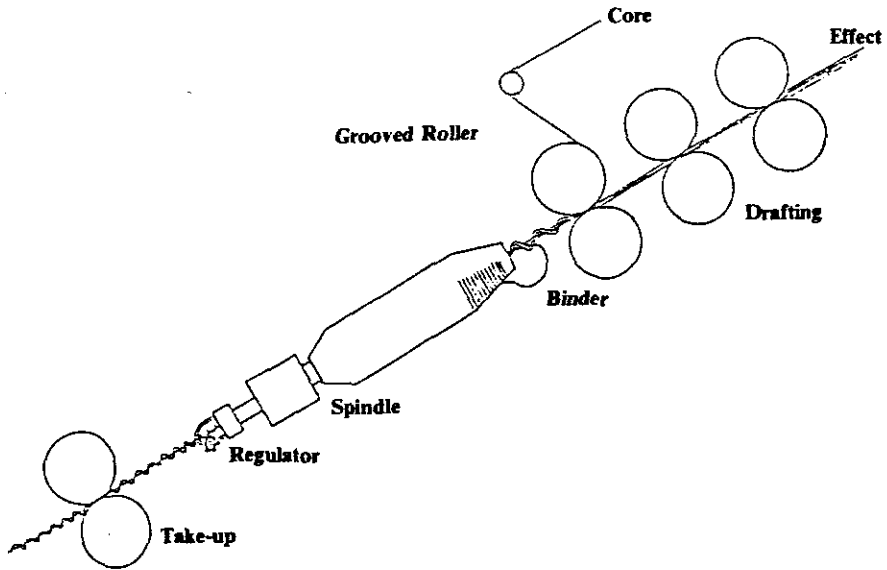


Fig. 28 - Wrap spinning assembly for the production of fancy yarns<sup>62</sup>.

## 5. WRAPPING FILAMENT

### 5.1 Filament Types

Initially only nylon filaments were used as binders, but these were later supplemented by polyester and subsequently by others. The most important filaments used are<sup>62,120</sup>.

Filament type	Linear density (dtex)
Nylon	17-228
Polyester	17-167
Polypropylene	78-330
Acrylic	78
Acetate	220-330
Water Soluble	62
Glass	110-440
Silk	33-88
Elastomeric	22-156
Staple yarns	50-2000

In many cases, particularly when spinning plain wrap yarns, the strength of a filament is more important than its linear density. This may result in the introduction of strong, fine binders.

In practice both monofilaments and multifilaments in a broad range of linear densities can be used<sup>64</sup> (Fig. 29).

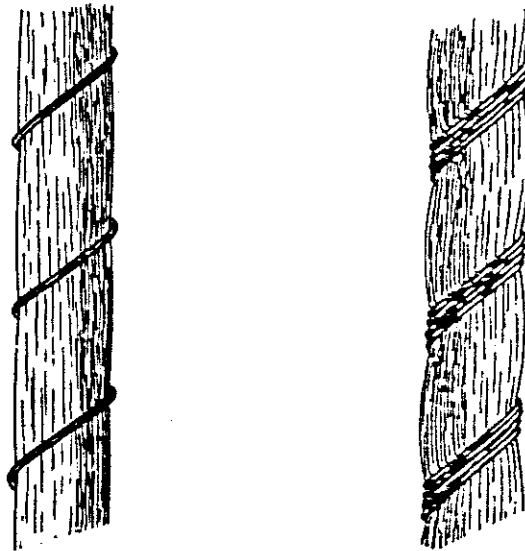


Fig. 29 - Wrap yarns with multi- and monofilament as wrapper yarns<sup>65</sup>.

While the monofilament winds about the fibre structure in a wire-like fashion, the multifilament takes the shape of a ribbon wound about the fibre structure. This may affect the stiffness and hairiness of the yarn and may also become apparent in the fabric<sup>64</sup>.

The colour of the filament may also be important<sup>65</sup> depending on the type of yarn being produced. For example, a certain shade of core fibres may warrant the use of a clear or dark coloured filament, in order to disguise the wraps.

Fabrics can be produced by employing a water soluble filament as wrapper yarn<sup>121</sup>. The latter is dissolved during subsequent washing, thus leaving a fabric free from filament. This method has been successfully employed in the production of tufted carpets<sup>122</sup> and cotton terry towels<sup>123</sup>.

For most end uses, the relationship between yarn linear density and wrapper filament linear density and proportion as stated by Haldon<sup>60</sup>, is shown in Fig. 30.

## 5.2 Filament Packages

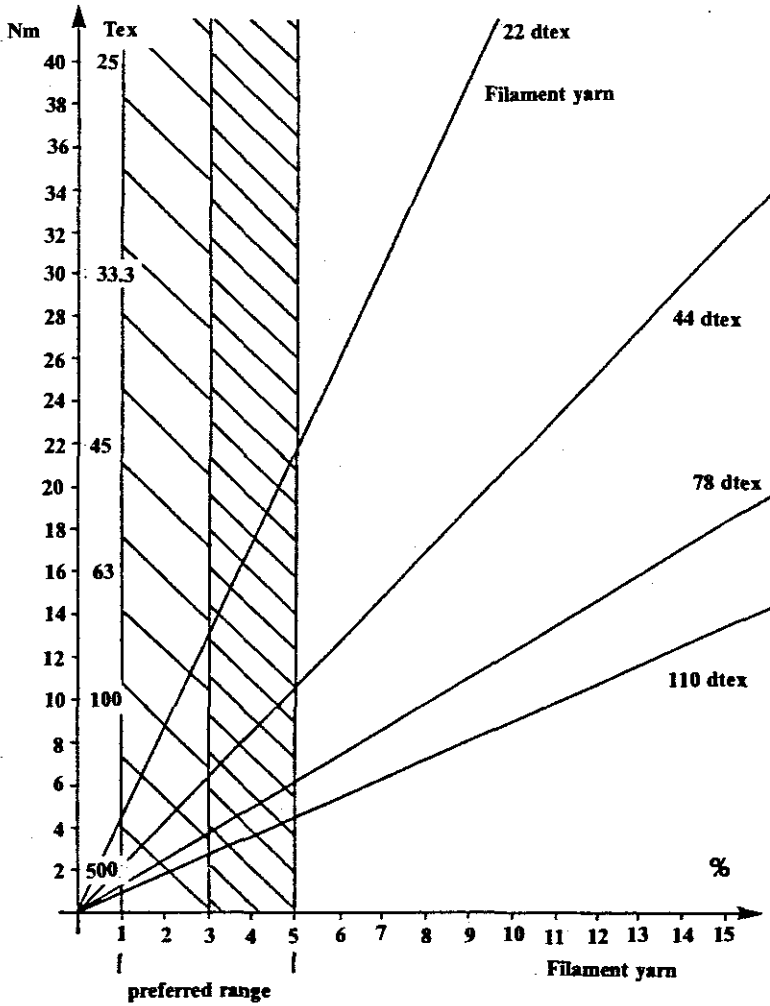
The wrap spinning process fails to be a continuous system of yarn production due to the fact that once the available filament yarn is consumed, the process has to be interrupted<sup>124</sup>. For this reason, much attention has been given to the amount of filament which can be contained on the filament package, although a point may be reached, where the additional power required to drive a heavily laden spindle, will outweigh any advantage gained in machine efficiency. It is extremely important that great care is taken during package winding. A badly wound package may result in problems during wrapping.

There are several principle types of filament packages in current use on hollow spindle machinery<sup>125,126</sup> some of which are illustrated in figures 31 — 35<sup>130</sup>.

Fig. 32 shows a flanged package which is wound in a parallel fashion. The flanges allow a large quantity of filament to be wound onto this type of package. During unwinding the filament tension is relatively constant. A disadvantage is that, when producing the package, the movement of the yarn guide must be synchronised with the position of the flanges. If bulges or gaps are formed at the flanges during winding, individual yarn layers are overwound or trapped. This may result in filament breakages during unwinding.

The energy consumption associated with this construction is considerably higher due to the extra mass of the flanges, and the length/diameter ratio of approximately 1:1. Furthermore, the initial cost of the flanged packages is higher than that of tubes.

**YARN COUNT**



*Fig. 30 – Relationship between yarn linear density and wrapper yarn linear density<sup>60</sup>.*

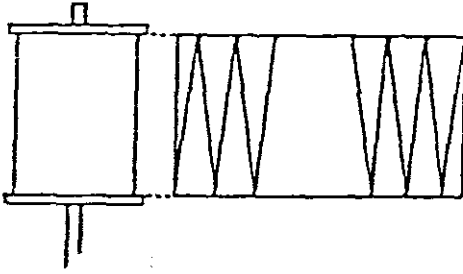


Fig. 31 - Flanged bobbin with parallel winding<sup>130</sup>.

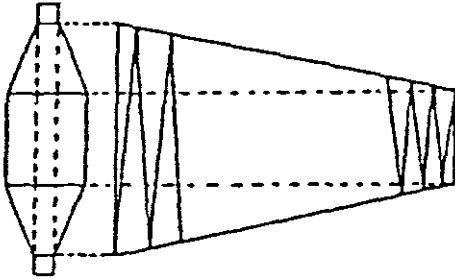


Fig. 32 - Tube with flyer type winding<sup>130</sup>.

Fig. 32 shows a tube with a flyer winding. The angle of slope necessary in this case is achieved by progressively reducing the traverse. This type of package is relatively easy to produce and unwinds well. However, it is easily damaged, as a light blow in the axial direction will cause displacement of the layers and make unwinding impossible.

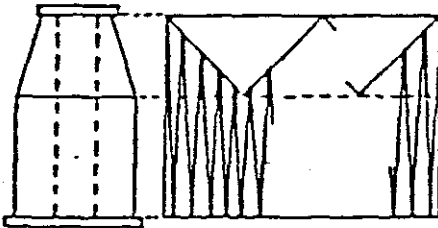


Fig. 33 - Flanged package with alternating traverse<sup>130</sup>.



Fig. 33 shows a flanged package with alternating traverse. In this case the diameter of the upper flange can be kept smaller, thus contact between the filament and the upper flange will be less. The angle of slope of the winding can be kept sufficiently small to prevent the formation of bulging layers.

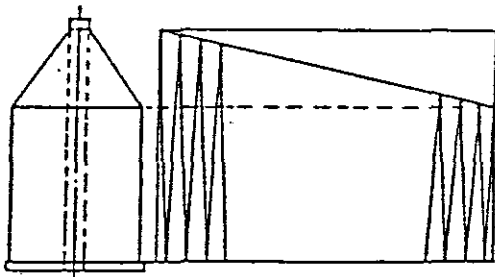


Fig. 34 - Modified flanged package and simplified winding<sup>130</sup>.

In Figure 34 the top flange has been completely removed. The yarn is displaced with a decrease in the length of the traverse on one side.

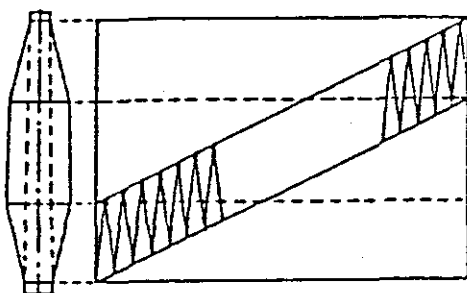


Fig. 35 - Tube with cop type winding<sup>130</sup>.

Figure 35 shows a tube with a cop winding. On this type of package, the angle of slope at the cop tip must be very shallow to prevent the risk of bulging layers. In addition, unwinding is improved by a tube which is slightly conical towards the top.

Irrespective of the shape of the tube, it must be produced as a precision component. The surface must be very carefully machined, and because of the high operating speeds, the tube must be made from high strength lightweight material. It must also be well balanced. These factors naturally have a marked effect on the cost of production<sup>130</sup>.

Information on hollow spindles offered by certain manufacturers is given in Fig. 36.

	Gemmill & Dunsmore	Mackie	Saurer-Allma	Suessen	Weller
Type of winding	Cop	parallel conical	Cop	Parallel biconical	Any
Capacity (cN)	150-200	250 to 430	200	230-275	-600
Filament carrier	Tube	Bobbin with flange at one end	Tube	Tube	Flanged bobbin
Maximum speed, min -1	30,000	35,000	30,000	35,000	22,000
Filament encapsulation	No	Yes	No	Yes	No
Winding machines	Schweiter	Hacoba	Schweiter	Hacoba	Own design

Fig. 36 - Details of some available hollow spindles <sup>126</sup>.

## 6. CORE FIBRES

### 6.1 Fibre Types

Virtually all textile raw materials can be successfully converted into wrap yarns including asbestos and glass <sup>62,64,66,127,128</sup>. The system is considered suitable for both the long staple, and short staple sectors of the industry. It is said that any fibres that can be drafted can be wrap spun<sup>50</sup>.

### 6.2 Range of Yarn Linear Densities

Yarns of a very wide range of linear densities can be spun on the hollow spindle system and it is said that restrictions on linear density range are economical rather than mechanical<sup>50</sup>.

The suitability of a particular machine to spin a yarn of a specific linear density is dependent on the type of drafting unit employed<sup>61</sup>. Various drafting systems are available depending on requirements. An important aspect of the system is that the traditional concept of requiring a certain number of fibres per yarn cross-section can be discarded. The factors imposing limitation on ring yarns no longer apply<sup>129</sup>. For example, coarse grade wools are being wrap-spun to finer counts than is normally possible by ring spinning<sup>62,75</sup>. This means that yarns of relatively low linear density can be spun from coarse fibres, the significance of which being the lower cost of the latter fibres<sup>129</sup>. It has been noted<sup>130</sup>, however, that when producing yarns of low linear density, the cost of

the wrapping filament is proportionally more than when producing yarns of high linear density.

## **7. PHYSICAL PROPERTIES OF WRAP YARNS AND RESULTANT FABRICS**

As previously stated, wrap yarns can be successfully produced with less fibres per cross-section than normal ring-spun yarn. One report<sup>131</sup> suggests that only half the number of fibres are required. The reason for the possible use of fewer fibres per cross-section is due to the fact that very little tension is exerted on the yarn during wrapping, therefore, the spinning limit is clearly lower than in ring spinning. Consequently, fine yarns can be wrap-spun from relatively coarse fibres. The fewer fibres there are in the cross-section of a yarn, the higher is the theoretical limit of irregularity<sup>64</sup>, therefore process control becomes more critical as the number of fibres per cross-section becomes smaller.

Yarn uniformity was found to be equal to or better than that of conventional ring spun yarns<sup>66,131,132</sup>, the wrap yarns also being smoother and less hairy<sup>132</sup>. Wrap yarns were found to be very voluminous<sup>66,72,132</sup> and therefore effect a better cover<sup>75</sup> in fabrics, with a resultant saving of yarn.

Yarn tenacity was reported to be higher than that of conventional yarns<sup>66</sup>. The reason for this was stated to be as a consequence of the higher level of interfibre friction due to the better contact between the parallel staple fibres bound and compressed by the wrapping filament. Furthermore, when spinning yarns of low linear density, the percentage of filament present is proportionally increased, resulting in a relative increase in tenacity<sup>64,66</sup>.

Elongation at break was found to be higher in the case of wrap spun yarns than in the case of conventional ring spun yarns<sup>66,131</sup>.

A further important property possessed by wrap spun yarns is a lack of torsion<sup>65,133</sup>. Twist-lively yarns usually cause spirality in the knitted construction, the latter being the reason for the use of two-ply spun yarns in most styles of knitwear, and the reason conventional singles yarns require special attention in knitting and/or finishing. The zero twist of wrap spun yarns reduces problems of spirality.

## **8. ECONOMICS OF WRAP YARN PRODUCTION**

Although it is extremely difficult to directly compare the cost of wrap yarn production with that of ring spun yarn production, a qualitative comparison has been made by Maag<sup>130</sup>. He noted that the costs of package doffing during wrap spinning are lower than in ring spinning due to the longer running lengths in the former case, even when the handling times, occurring as a result of filament replenishment, are taken into account.

Due to the lower yarn tension and the even distribution of the wrapping

twist, the yarn breakages during wrap spinning are lower than for ring spinning by a factor of 2 to 3. Here, too, the costs should be lower. During wrap spinning, patrolling and supervision is more conveniently carried out due to the lower number of spindles employed. It is therefore, reasonable to assume that wage costs will be lower for wrap spinning.

In the production of yarns of a high linear density, the ratio of spindle price to production — and hence also the capital costs — are more favourable in the case of wrap spinning. However, it is stated, that smaller spindles are used in ring spinning for the production of fine counts; these are less expensive and also reach higher speeds. This is not possible in the case of wrap spinning at least as far as the higher speeds are concerned<sup>130</sup>. In the production of fine yarns, therefore, the spindle cost to production ratio does not favour wrap spinning. The increase in raw material costs attributable to the filament component when yarns of a high linear density are produced, is negligible. When producing finer yarns, however, the percentage filament content is greatly increased as the yarn linear density decreases.

In conclusion it was stated<sup>130</sup> that, when producing yarns of a relatively high linear density, wrap spinning can compete with ring spinning economically. However, this does not necessarily follow in the case of fine yarns.

## 9. ADVANTAGES AND DISADVANTAGES OF WRAP SPINNING

### 9.1 Advantages

Many advantages are claimed for wrap-spun yarns when compared to conventional ring-spun yarns<sup>87,134-151</sup>, the most important of which are the following:

- Greater bulk
- Improved cover in pile fabrics
- Softer handle
- Higher absorbency
- Greater strength
- Higher elasticity
- Less hairy
- Ability to "engineer" specific requirements
- Requires fewer fibres per cross-section, therefore, coarse fibres can be spun into finer linear densities.
- Increased production
- Favourable costs per unit of production
- Lower energy costs
- Lower overall investments
- Less floorspace required

Greater scope and versatility  
Less spinning waste  
Simplicity of operation  
Higher efficiency

## 9.2 Disadvantages

It seems clear that wrap spinning has much to offer in many areas, and has been receiving much attention in recent years.

However, not all reports have been positive. Topf<sup>152</sup> suggests that there are two purely textile facts limiting the filament yarn spinning technology for articles made of flat yarns. In the first place it is noted that the filament share of a flat fabric surface becomes visible to a variable extent and leads to glazing effects which are considered unpleasant. This weakness could be compensated for by using fancy yarns, but they are very dependent on fashion.

Secondly it is stated, that according to certain textile labelling acts<sup>153-154</sup>, the type and content of the filament has to be stated, which is a psychological hindrance with the result that technically superior fabrics fail to be accepted by the consumer. This can be overcome, however, if for example wool or even more precious fibres are combined with silk as filament yarn, or by employing a water soluble filament wrapper.

## USE OF PROPRIETARY NAMES

The names of proprietary products where they appear in this report are mentioned for information only. This does not imply that SAWTRI recommends them to the exclusion of other similar products.

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