Worsted Spinning

1 Process Description

Worsted spinning is the conversion of combed top into yarn.

The top sliver is progressively thinned by drafting the strand by a larger amount than the number of input slivers (doubling). The doublings help to reduce any irregularity present in the input material or introduced in the drafting process. When the sliver is thick the control of fibres is achieved using pins and as it thins better control is provided by balloon rollers and/or aprons. A minimum of 3, and up to 7, gilling stages are used.

The drawing stages are followed by one or two roving stages. A flyer rover consolidates the output strand by inserting a small amount of twist. A rubbing rover consolidates the strand by rubbing between reciprocating aprons.

The roving packages are mounted (creeled) on the spinning frame and drafted (by a factor of 14 to 30) before twist is inserted. For pure wool strands the drafting is achieved using 3 pairs of rollers with the middle pair having a central recess and driving a pair of aprons which lightly grip the strand. Twist is inserted in the drafted strand by having the forming yarn pass through and pull a metal loop (traveller) which slides around a lubricated ring. The whole package rotates within the balloon formed by the yarn. Each turn of twist in the yarn requires a complete rotation of the package (bobbin) and, for a fine weaving yarn, it is typical for 500 to 1000 turns/m to be inserted. The speed of rotation is limited by the tension that the forming yarn can withstand, with the tension coming from the friction of the traveller. Higher speeds require smaller rings and lighter travellers but the tension must also be enough to control the balloon.

Full yarn packages are removed (doffed) and fed to a winder either directly or after a steaming operation to reduce the twist-liveliness of the yarn. During the winding operation the yarn from successive small bobbins is joined to form a large package and thick, thin and coloured places can be removed (cleared). The clearer sensors cut the yarn when a fault is detected and then the two ends are located, overlayed and rejoined with a splice (or knot).

In order to produce a yarn that can survive weaving it is normal to twist two singles yarns about each other in the opposite direction (or the same direction if a stiffer crepe yarn is desired). Two or more yarns can be assembly wound onto the one package in preparation for this twisting operation or several packages can be directly mounted on the twister. For knitting a number of yarns may be wound and twisted together to produce a bulkier or torque-balanced yarn. The older method was to use another ring/traveller machine (ring twisting) but it is now more common to use a 2-for-1 twister in which the component yarns rotate around the suspended package(s) and 2 turns of twist result for each rotation. The final yarn may be steamed or conditioned before dispatch to the weaver or knitter.

For further information on spinning and associated equipment the following links are useful:

Wool drawing and combing machinery:
NSC: www.nsc.fr then look under Products
Finlane: www.finlane.com then look under Sant'Andrea

Worsted spinning frame and component manufacturers:
Saurer: www.textile.saurer.com then under Zinser (or Schlafhorst for winders and Allma Volkmann for twisters)
Suessen: www.suessen.com
Finlane: www.finlane.com then look under Cognetex
TEXParts: www.texparts.de then look under Products
Murata: www.muratec.net/tex also includes winders and air-jet spinners

2 Recent Developments

It has become almost standard for the spinning mill to re-comb tops of fine (<21µm) wool irrespective of whether the top is dyed. Although expensive the improved spinning performance is claimed to outweigh the cost. Re-combing is also much better than gilling for achieving a uniform blend of different colours or with synthetics. On modern drawing machinery only 3 or 4 gillings of the top are required and any extra doubling and drafting stages (other than needed for blending) are better carried out when the sliver is thin and fibre control better, that is, at the roving rather than early stages.
It is possible to produce a singles yarn that is directly weavable without two-folding by spinning two separated strands (**Sirospun**) or by splitting the one strand into multiple components (**Solospun**). The latter allows slightly finer yarns than two-folding but the main advantages are in cost savings from removing a twisting step. The resultant yarns are leaner than two-fold yarns and still have uni-directional twist but the surface fibres are more strongly bound than for a singles yarn.

Yarns of lower hairiness and slightly higher tenacity can be produced using compact or condensed spinning. Here the strand is compacted with air in an additional zone after drafting but before twist is inserted. This gives improved spinning performance but the yarn is not sufficiently abrasion-resistant for use as a warp yarn in weaving.

Collapsed balloon spinning is also available in which the yarn balloon is caught by a crown or bent finger on top of the spindle and winds partly around the bobbin. This greatly reduces the tension on the forming yarn above the spindle although the tension is higher at the traveller. Higher spinning speeds are possible but the empty bobbin tubes need to be of larger diameter and doffing is more complex.

Smaller diameter rings are used for finer yarns and diameters have reduced over time because smaller rings allow higher speeds but less yarn fits on the bobbin and so more doffing, piecening and splicing are required.

Automation has steadily increased with automatic doffing now routine. Ends-down detection is available as well as roving stop motions and spinning speeds can be adjusted according to the level of end-breakage. The bobbins can be automatically conveyed to a linked steamer and/or winder and such systems can monitor and report on which spindles are producing faulty yarn using clearer sensors which can measure evenness and hairiness. Splicing has generally replaced knotting on the winder with hot air splicing (**Thermosplicer®**) being particularly effective.

Synthetic filaments such as polyester and acrylic can be blended after being cut or broken to a similar length to the wool although they may be dyed separately before blending. Bi-component blends can be made on the spinning frame using Sirospun and attachments are also available to feed a continuous filament, such as an elastomer to impart stretch, behind the front roller.

Although slow, ring spinning is dominant for wool yarns. Self-twist spinning has a small presence for hosiery yarns. Open-end or rotor spinning is used for some wool/cotton blends but the fibre must be shortened to match the size of the cotton rotors and fibre handling systems. Air-jet, including Vortex, spinning has been tried but is not in widespread use. Friction or DREF spinning is used for some coarse multi-fibre blends. In general, these competing systems cannot produce yarns which are as strong or with as few fibres in the yarn cross-section.

3 Processing Problems

The drawing of the top sliver down to roving should be straightforward using standard loadings and pinnings for the diameter of the wool and making small adjustments according to the mean fibre length. The quality at each stage can be checked in terms of the Index of Irregularity. Lapping of rollers can arise if the wool is too dry or if there are wet patches, or there is insufficient lubricant/antistat, or if scouring left excessive residuals, or if the rollers have become dirty or degraded.

The generic problem is one of suspected inferior yarn quality and excessive ends-down which have to be compensated for by slowing the spinning speed and, possibly, increasing the twist. The first thing to realise is that yarn properties and spinning performance are quite sensitive to small changes in fibre properties (see information sheet on Top Properties) but expected performance can be predicted. However, if performance is below expectations then it can be due to a myriad of causes, for example, machine maintenance (worn rollers, rings, pig-tails or aprons, eccentric spindles, slipping drives, misaligned components, missing ring lubrication etc.) or machine settings (wrong apron spacer, wrong back-draft etc.) or faulty input material (fibre damaged in dyeing, irregular roving, slubs, bad joining etc.) or low moisture content (due to low RH%). Establishing the actual cause of underperformance can take considerable time but firstly requires the ability to measure yarn and fibre properties under standard conditions.

Problems can also become apparent in downstream processing but most should be picked up early if sliver and yarn properties are monitored. Excessive faults in winding can arise from as far back as faulty output webs in combing. Even at winding and two-folding care must be taken because faulty splice settings, or bad knots in two-fold yarn, may show up in weaving.

4 Useful References

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