Woollen Spinning

Woollen spinning consists of three main steps: drafting, twist insertion, and winding onto the cop. There are two major types of woollen spinning machine: mule spinning and ring spinning. The main difference between them is that these three steps are performed differently by each machine and on the mule they occur in a discontinuous way whereby the drafting and twist insertion occur separately from winding onto the cop. The ring-spinning machine combines them into a continuous sequence and so is more productive.

Drafting Against Twist

Drafting serves two purposes; firstly it straightens the fibres in the slubbing so that their extent along the yarn axis is increased and secondly it reduces the linear density of the slubbing. Straightening the fibres increases the yarn strength (slightly at the expense of extensibility) while reducing the linear density at spinning allows a heavier slubbing to be produced at carding effectively increasing the productivity of the process.

On both the mule and the ring-frame each slubbing is fed from the creel via a surface drum to a pair of nip rollers that feed it into the drafting zone. Within the drafting zone a low level of twist is inserted into the slubbing and it is stretched by being drawn to the next stage by either the relative motion of the spindle as in the mule or by another pair of nip rollers running faster than the feed rollers, as in the ring frame. Woollen draft ratios are typically 30% and almost never higher than 40%. Drafting against twist controls the rate of drafting of each segment of yarn within the draft zone. Without twist there would be a tendency for thin places to draft more than thicker places, making them thinner still; causing more unevenness in the yarn and frequent slubbing and yarn breaks. Twist tends to run preferentially to the thinner parts of a slubbing because the thinner areas have lower torsional rigidity. The relatively higher twist increases the strength of the thinner areas and so provides a stabilising mechanism to counteract their relative weakness. In theory the thicker places could be preferentially drafted over the thin and as they become lower in linear density the twist redistributes to control further drafting, in this way it is possible for the drafted slubbing to have better evenness than the parent slubbing. In practice the yarn irregularities have been shown to be mostly due (about 80%) to the web irregularities already present at the carding stage and that conversion from web to slubbing and to yarn generally only makes things slightly worse. The twist level used during drafting and the draft level itself have a marked effect on the yarn quality. The optimum draft is usually around 30 to 35 % and depends on fibre length, fibre orientation, and slubbing uniformity.

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The optimum twist level depends on fibre-fibre friction and fibre orientation and length. The twist level is often not always directly proportional to the twister speed relative to the delivery speed as the twister can slip against the slubbing once twist reaches a certain level and resist further insertion of twist. The mule spinner has much lower productivity than the ring frame due to its discontinuous action but many manufacturers believe that it produces a more even yarn and it is still popular in the woollen sector.

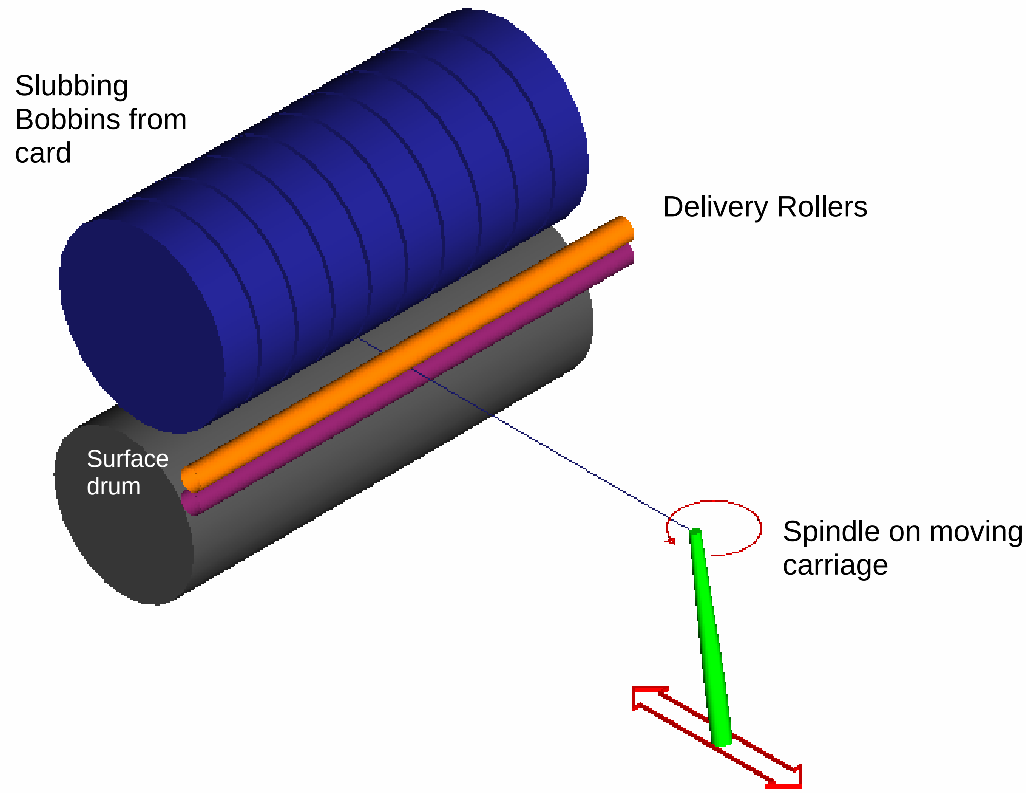

Figure 1 Schematic diagram of the Mule Spinning Frame

The mule frame is a horizontal machine and has a much longer draft zone in which the twist is inserted via the spindle. The spindle axis is almost perpendicular to the slubbing plane but is tilted forward slightly. During drafting and twist insertion as the spindle rotates the yarn flips over the top of the spindle inserting twist into the slubbing rather than winding it onto the cop. The flicking action is believed by some to help redistribute twist and set up vibrations that assist the drafting process.

In the first stage of the cycle slubbing is delivered from the creel via surface drums and the carriage moves back at the delivery speed while the spindles rotate to insert a small amount of twist. At a predetermined point in the carriage progress backwards the delivery rollers stop while the carriage continues so that the length of twisted slubbing starts to draft while twist continues to be inserted. At the end of the draw the spindle speed increases to its maximum to insert the final yarn twist and then the yarn is wound onto the package as the carriage returns to the start. During winding a bar holds the slubbing down so that the spindle rotation causes the twisted yarn to be wound onto the cop. It also controls the yarn package build pattern. The longer draft zone on the mule may contribute to a better drafting action since the extra length allows a larger range of density fluctuations to exist within the draft zone simultaneously. Since the draft against twist mechanism is a competitive one, longer scale-length fluctuations can be handled in a longer draft zone.

A schematic diagram of the woollen ring spinning system is shown in figure 2. The “False Twister” is so called because it inserts twist temporarily. It rotates as slubbing is drawn through it and so twist propagates up-stream. As each section of twisted slubbing passes through the point of twist insertion the sense of rotation of the twister relative to it reverses and each turn that was inserted up-stream is removed as it passes downstream of the twister. The slubbing is therefore only twisted up stream of the twister and the draft is only controlled in the upstream region. The twister is designed and positioned to minimise the untwisted length between it and the nip of the draft rollers, if this length is much less than the fibre length then little

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uncontrolled draft is can occur

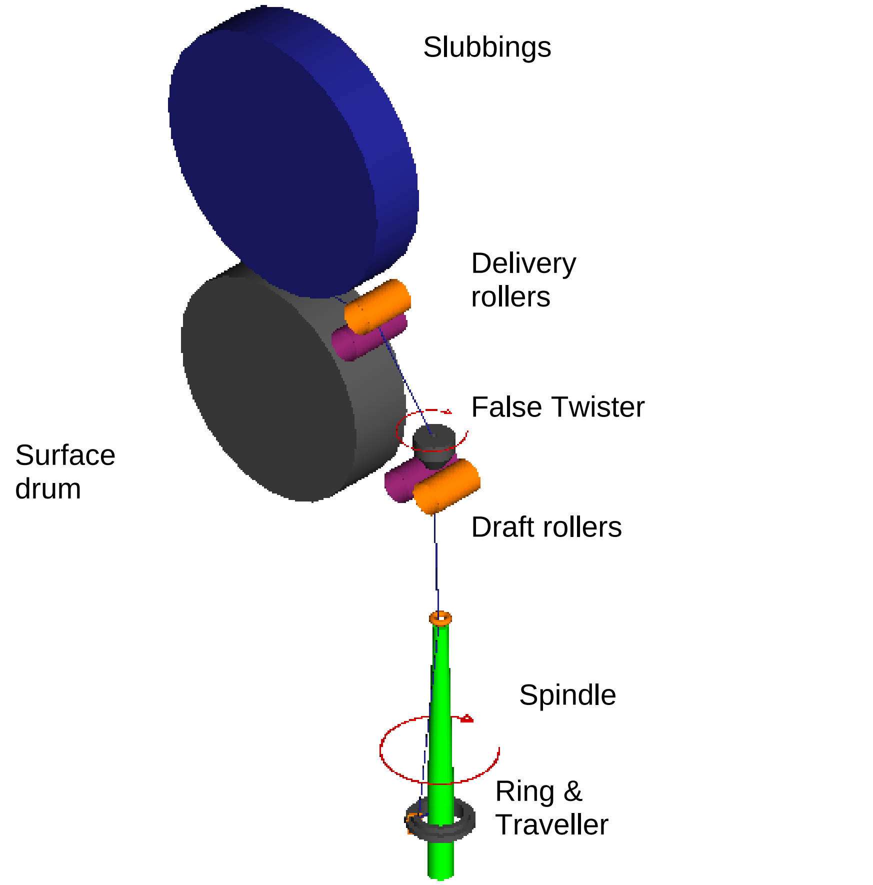

Figure 2. Schematic diagram of Ring Spinning Frame

Some uncontrolled drafting will still happen. This is another difference between the mule and the ring frame and the most likely reason for better drafting behaviour on the mule; the mule-spun slubbing is twisted along its entire length during drafting. A system has been devised (and was commercialised by the Delpiano company of Italy) whereby the front draft rollers are housed in a cage which itself rotates so that the twist insertion point is nip of the front draft rollers and there is no region of zero twist. It has the added advantage that the drafting twist is completely controlled; a frictional false twister can slip and so the actual twist level inserted is unknown. This was shown to produce a more even slubbing than conventional drafting and was claimed to be at least as good as mule-frame drafting. The system was more complex than conventional frames and some difficulties could arise with end breaks and roller wrapping. A wide range of false twisters have been used but they all seem to produce similar yarn qualities. Some twisters have knobs on their top surfaces designed to imitate the flicking behaviour of the mule. In these types the angle of the slubbing with respect to the twister axis is sometimes adjustable to vary the degree of flicking. It also changes the interaction between the twister and the slubbing and friction around it and so it is not known which effect is prominent when the angle is changed.

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In ring-spinning the yarn twist insertion and the winding steps are combined. The ring has a lightweight traveller clipped to it through which the yarn passes on its way to the spindle cop. The traveller is dragged around the stationary ring by the rotating yarn and the friction between the traveller and ring means that the traveller turns slightly slower than the spindle so that yarn is wound onto the cop. As the spindle speed increases, the traveller-ring friction increases and centrifugal force on the yarn increases and so yarn tension increases. The traveller weight must be chosen so that the tension it generates overcomes the centrifugal forces on the yarn at all speeds, otherwise it will fail to wind properly and a large "balloon" of yarn will form. If the traveller is too heavy then the tension may frequently exceed the local yarn strength at high speeds and the yarn will break at the thinnest places. Woollen ring-frame spindles usually have castellated tops and spiral loops positioned close to them so that the yarn balloon collapses onto the spindle before departing it again towards the traveller. The smaller yarn balloon this generates compared to a free balloon reduces the spinning tension and allows higher speeds. The castellated spindle tops can generate extra yarn hairiness especially if spindle tops are damaged with knives when cleaned. Because the ring-frame is a continuous process it is much more productive than the mule-frame at the same spindle speed as the mule spindle is only spinning part of the time. However the mule frame is still quite popular with some traditionally minded spinners of fine woollen yarns. In worsted spinning and cotton spinning the mule has been completely superseded by the ring-frame and other newer systems such as rotor and air-jet. The woollen yarn has a completely different and aesthetically pleasing character compared to worsted spun yarns. The fibres are less parallel and the yarns are hairier and so bulkier knitwear and flannels can be obtained from the woollen system. The woollen system can handle shorter fibres than the worsted system and is highly amenable to processing multiple fibre blends including large proportions of recycled fibres. The woollen card provides excellent intimate fibre blending but the speed is limited so that as the yarns go finer, the kilograms per hour produced drops and costs go up. Because of the disoriented conformation of the fibres in the woollen yarn a greater number of fibres in the cross-section is needed compared to worsted yarns. The spinning limit for woollen is about 90 fibres whereas for worsted it is 35 to 40 fibres. The finest yarns spun routinely on the woollen system are about 50tex, although 25tex woollen yarns are spun by some fine spinners from high quality fine wool inputs, eg 17 micron diameter and 60mm long lamb's wool.

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