

FIBRE CONSOLIDATION AND AGGLOMERATION IN V-GROOVE ROLLER WRAP SPINNING

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Abstract. *This theoretical study examines the fibre consolidation and agglomeration mechanisms in a novel wrap spinning system employing a V-grooved roller positioned directly after the front rollers. The spinning triangle—the critical region where individual fibres converge and receive twist—is fundamentally transformed by the V-groove geometry, which forces all fibres to converge at a single point, the groove apex. In contrast to conventional systems where edge fibres travel longer paths, creating uneven tension and poor fibre integration, the V-shaped channel induces lateral compression that reduces path-length differences and increases fibre-to-fibre friction. The narrowing groove walls promote enhanced agglomeration through geometrical confinement, compression forces, friction-based consolidation, and single-point twist insertion. Theoretical analysis indicates that yarn packing density can be increased from 70–75% in conventional wrap yarns to 80–85% with the V-groove system, yielding stronger, more uniform yarns with fewer voids. The groove apex angle, optimally maintained between 60 and 90 degrees, provides the best compromise between effective compression and fibre integrity. Expected improvements include more circular yarn cross-sections, lower hairiness, superior dye uptake, and enhanced abrasion resistance. The system demonstrates significant potential for industrial adoption with appropriate material selection (ceramic or hardened steel) and precise surface finishing to ensure consistent fibre convergence and product quality.*

The quality of a spun yarn depends largely on what happens in the spinning triangle – the region just after the front rollers where individual fibres come together, become consolidated, and receive twist [1]. In conventional wrap spinning, fibres follow different path lengths and experience uneven tension, leading to a loose structure with high hairiness and variable packing density [2, 3]. The newly proposed spinning method uses a V-grooved roller placed directly after the front rollers to fundamentally change how fibres converge and agglomerate [4].

In the conventional system, fibres spread out after leaving the rollers and converge gradually over a relatively long distance. This allows edge fibres to travel longer paths,

creating uneven tension and poor integration into the yarn body. The V-groove changes this by forcing all fibres to converge at a single point – the apex of the groove [5-7].

As the fibre bundle enters the V-shaped channel, the narrowing walls gently push the fibres inward. This lateral compression has two important effects:

- It brings edge fibres closer to the centre, reducing path-length differences;
- It increases fibre-to-fibre friction, which helps to consolidate the bundle before twist is applied.

The result is that all fibres – whether they started at the centre or the edge of the bundle – arrive at the convergence point at almost the same time and under similar tension. This creates a much more uniform and dense yarn structure.

Agglomeration refers to the process by which individual fibres are brought together and packed into a compact yarn cross-section [8]. In the V-groove system, agglomeration is enhanced in several ways:

- Geometrical confinement – the V-shape physically narrows the fibre stream;
- Compression forces – the groove walls press fibres towards the centre;
- Friction-based consolidation – increased fibre-fibre contact helps fibres stay together;
- Single-point twist insertion – twist is applied exactly where the fibres are most concentrated.

As a result, the packing density of the yarn – the fraction of the yarn cross-section occupied by fibres – is expected to increase from about 70–75% in conventional wrap yarns to 80–85% in the V-groove system. Higher packing density means stronger yarns with fewer voids, better abrasion resistance, and lower hairiness.

The V-groove geometry plays a key role in this. If the groove angle is too narrow (below 60 degrees), fibres may be damaged by excessive compression. If it is too wide (above 120 degrees), the agglomeration effect is minimal. An angle between 60 and 90 degrees provides the best compromise, giving good compression without fibre damage. The improved fibre agglomeration achieved by the V-groove is expected to produce yarns with:

- More circular cross-sections – better for weaving and knitting;
- Fewer protruding fibres – lower hairiness and smoother surface;
- Better dye uptake – due to more uniform fibre arrangement;
- Higher abrasion resistance – because fibres are less likely to be pulled out.

The roller material (ceramic or steel) should be selected for low friction and high durability. The groove surface must be smooth to avoid fibre breakage, and the apex should be precisely shaped to ensure consistent convergence.

Conclusions. The V-grooved roller wrap spinning system significantly improves fibre agglomeration by forcing all fibres to converge at a single point. This reduces path-length differences, increases fibre-fibre friction, and enhances packing density. The result is a stronger, more uniform, and less hairy yarn compared to conventional wrap spinning. The groove angle should be optimised between 60 and 90 degrees for best results. This theoretical analysis provides a solid basis for experimental work and industrial adoption of the new spinning method.

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