

ENHANCING TWIST UNIFORMITY IN WRAP YARN SPINNING USING A V-GROOVED ROLLER: A THEORETICAL ANALYSIS

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Abstract. *This study presents a theoretical investigation of a novel wrap yarn spinning method incorporating a V-grooved roller positioned immediately after the front drafting rollers to address the persistent challenges of uneven twist distribution and excessive roller wear in conventional ring spinning systems. In traditional wrap spinning, yarn passes through multiple contact points between the roller nip and ring-traveler system, creating a non-twist section and twist gradient that compromises yarn strength and uniformity. The proposed V-groove configuration guides the emerging fibre bundle to a single convergence point—the groove apex—where twist is concentrated and uniformly propagated along the yarn length. The groove acts as an effective twist stopper, preventing twist migration toward the drafting rollers. Key geometric parameters including apex angle (optimised at 60–90°), vertical distance (below 20 mm), and horizontal offset (within 30 mm) were identified as critical factors influencing fibre compression and twist effectiveness. Theoretical analysis predicts that twist variability, typically 5–10% in conventional systems, can be reduced to 2–4% with the V-groove approach. Anticipated improvements include higher yarn tenacity, better evenness, reduced hairiness, enhanced abrasion resistance, and extended roller service life. The system can be retrofitted to existing ring spinning frames with minimal modification, offering a practical, cost-effective solution for industrial implementation.*

Wrap yarns are composite structures consisting of a core fibre bundle bound by a continuous filament. They are widely used in technical textiles, protective clothing, sportswear, and composites due to their excellent strength-to-weight ratio and abrasion resistance [1, 2]. In conventional wrap spinning on ring frames, the yarn passes between the output rollers, which creates a non-twist section, uneven twist distribution, and causes rapid roller wear due to continuous friction at multiple contact points [3, 4].

To overcome these limitations, a novel spinning method has been proposed. In this system, a V-shaped grooved roller is placed immediately after the front drafting rollers. The V-groove guides the emerging fibre bundle to a single point – the apex of the groove – where the twist is inserted by the ring–traveler system. This configuration

eliminates the non-twist zone and ensures that twist propagates uniformly along the yarn length. The V-groove acts as an effective twist stopper, preventing twist from migrating back towards the drafting rollers [5-8].

In the conventional system, twist must travel through several contact points between the roller nip and the ring-traveler. This results in a twist gradient, meaning that some sections of the yarn receive more twist than others. The non-twist section near the rollers also reduces yarn strength and increases irregularity [9].

The proposed V-groove system changes this fundamentally. Since the yarn is guided at only one point, the twist inserted by the spindle is fully concentrated at that point and does not spread unevenly. The V-shape of the groove also compresses the fibre bundle laterally, ensuring that all fibres are equally exposed to the twisting action. As a result, the twist per unit length becomes nearly constant along the entire yarn.

The key geometric parameters of the V-groove are:

- The apex angle of the V-shape;
- The vertical distance from the front roller nip to the groove centre;
- The horizontal offset of the groove relative to the roller nip.

These parameters determine how effectively the groove compresses the fibres and stops twist propagation. Based on theoretical analysis, an apex angle between 60 and 90 degrees provides the best balance between fibre compression and smooth yarn passage, while keeping the vertical distance short (below 20 mm) and horizontal offset within 30 mm ensures that twist reaches the roller nip effectively.

The uniform twist distribution achieved by the V-groove system is expected to bring several improvements:

- Higher yarn tenacity, because all fibres share the load more equally;
- Better yarn evenness, with fewer thick and thin places;
- Reduced hairiness, since fibres are better integrated into the yarn body;
- Improved abrasion resistance, due to a more compact and uniform structure;
- Longer roller life, because yarn contact is limited to a single point, reducing wear.

In conventional wrap spinning, twist variability (measured as coefficient of variation) is typically 5–10%. The V-groove system is predicted to reduce this to 2–4%, representing a substantial quality improvement.

The V-grooved roller can be manufactured from ceramic or hardened steel, both of which offer low friction and high wear resistance. The groove surface should be smooth to avoid fibre damage, and the apex should be precisely machined to ensure

consistent yarn guidance. The roller can be retrofitted to existing ring spinning frames with minimal modification, making the technology accessible for industrial adoption.

Conclusions. The proposed V-grooved roller spinning system offers a simple yet effective solution to the long-standing problems of uneven twist and roller wear in wrap yarn production. By guiding the yarn to a single convergence point, the V-groove eliminates the non-twist section and ensures uniform twist distribution. The geometric parameters of the groove can be optimised to maximise yarn quality. This theoretical analysis provides a strong foundation for experimental studies and industrial implementation.

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