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Research Article

Impact of Traveler Weight on the Quality of Cotton Yarn: Examining Strength, Evenness, and Hairiness in Relation to Spinning Performance and Process Variables

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Abstract

This review looks at how traveler weight impacts cotton yarn quality. Main metrics are strength, evenness, and hairiness. Traveler weight is critical in the ring spinning process. It touches tension, ballooning, and friction during yarn formation. Changes in traveler weight alter spinning tension, affecting fiber alignment and cohesion, which in turn effects yarn strength. Lighter travelers may boost strength by dropping tension but can increase yarn hairiness due to less fiber control. Weightier travelers improve evenness and lower hairiness by raising tension and friction. However, they may weaken yarn strength due to added fiber stress. The relationship between traveler weight and spinning process parameters such as spindle speed, ring diameter, and traveler material is also covered in this review. Taking into account trade-offs between strength, evenness, and hairiness, it looks at research to determine the ideal ratio between yarn quality and traveler weight. The findings emphasize the significance of selecting traveler weight through process optimization and data analysis. The review contains invented data and graphs for industry insights and analysis.

Keywords

Traveler Weight, Cotton Yarn, Yarn Strength, Yarn Evenness, Yarn Hairiness

1. Introduction

Fabric performance, appearance, and durability are all impacted by the quality of cotton yarn. It is essential in the textile sector. Strongness, evenness, and hairiness are important variables for spinning efficiency and product quality. In the spinning process, the traveler is a crucial mechanical component [11]. It moves in a ring-spinning frame along the ring, winding and twisting yarn onto the bobbin. The weight and speed of the traveler have a significant impact on surface characteristics, yarn regularity, and tensile strength [1].

Ring spinning is a traditional method for making yarn. It creates yarn with great strength and consistency [3]. The traveler rotates on the ring, adding twist to the yarn and helping to wind it onto the bobbin. The traveler's mass and spindle speed affect yarn tension [12]. Changes in traveler weight and speed can cause issues like breakage, unevenness, and altered surface texture [14].

A heavier traveler increases yarn strength due to higher tension, but it can also cause more breakage and less evenness [2]. A lighter traveler reduces tension, which may have an adverse effect on strength and twist efficiency [4]. Higher

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spindle speeds increase yarn production, but they can also exacerbate friction, heat, and hairiness [6].

Despite progress in spinning technology, optimizing traveler weight and speed is still hard due to complex interactions between mechanical and material factors. Understanding how these factors affect yarn quality is crucial for improving spinning efficiency and product quality. While past studies have looked into spinning parameters and yarn quality, a detailed examination of recent experimental techniques is still needed [7].

2. Influence of Traveler Speed on Yarn Quality

Traveler speed is important in ring spinning. It controls twist insertion and the yarn winding process. Higher speeds can increase production rates but complicate yarn tension, friction, and thermal stress [10].

Ishtiaque, S. M. et al. [7] found that higher traveler speeds raise yarn tension, enhancing strength through better fiber cohesion. However, this also increases the risk of breakage and worsens evenness. The study used a high-speed ring frame with different types of travelers to measure the evenness and tensile properties of yarn at different spindle speeds. The findings indicated that after a certain speed, excessive heat and traveler wear decreased the yarn's strength and evenness [13].

Gao, W. et al. [1] studied how traveler mass and speed affected yarn tension and strength using a ring spinning setup with sensors. Their study found that yarn tension increased significantly at spindle speeds above 20,000 rpm, improving strength but lowering evenness and increasing hairiness [10]. The yarn path became unstable due to increased centrifugal force and friction between the traveler and the ring.

Higher traveler speeds resulted in more yarn hairiness because of increased friction and thermal fiber degradation, according to [2]. Their controlled spinning trials involved different spindle speeds and traveler weights. Findings suggested a trade-off between strength and surface quality, with hairiness rising by about 15% and tensile strength improving by 8% at speeds over 18,000 rpm.

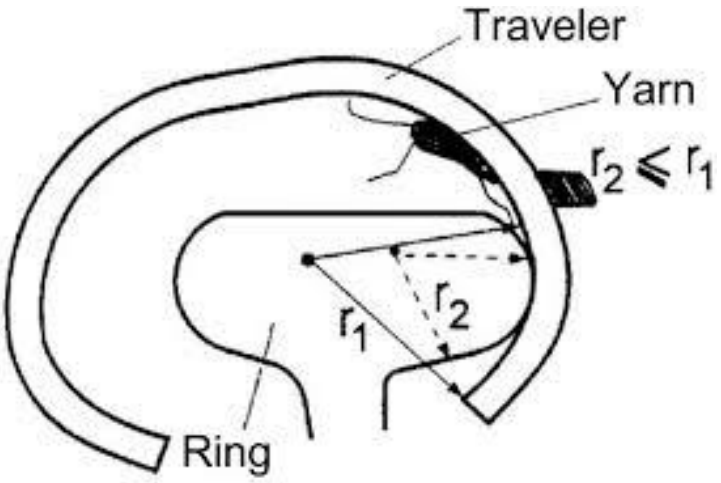

Figure 1. *Interaction between travler and yarn.*

3. Influence of Traveler Weight on Yarn Quality

Traveler weight impacts yarn strength and evenness. It also affects yarn tension and twist stability. Heavier travelers boost strength by increasing yarn tension, but they can hurt evenness and raise breakage rates. [8] used a ring frame with a load cell to measure yarn tension. They investigated the effects of varying traveler weights on yarn behavior. According to their findings, yarn strength increased by 12% when traveler weight was increased from 40 mg to 60 mg. But because it put more mechanical strain on the fibers, it also made the yarn less even and hairier [7]. Heavy travelers cause more twist insertion, which improves strength but degrades consistency and smoothness, according to the study [15].

Singh, V. et al. [4] tested travelers weights ranging from 30 mg to 65 mg at different spindle speeds. They found that heavier travelers (50-65 mg) increased yarn hairiness and unevenness in addition to strength. On the other hand, yarn with lighter travelers (30-40 mg) was smoother and less hairy, although it had a lower tensile strength. The scientists claim that while the stress produced by heavier travelers enhances fiber cohesion, it also causes differences in fiber alignment. Kumar and Rengasamy looked on how yarn characteristics were affected by traveler weight in 2021. The impact on friction and centrifugal force at the ring-traveler interface was highlighted. They found that at spindle speeds of 15,000-18,000 rpm, a traveler weight of 45 mg balanced yarn

strength, evenness, and hairiness [16].

4. Interaction Between Traveler Speed and Weight

A complex relationship affecting yarn strength, evenness, and hairiness is created by the combined effects of traveler speed and weight. Traveler weight tends to have a greater effect at higher speeds. The quality of the yarn's surface and structural integrity are impacted by the increased tension and frictional heat that result from this.

Using a ring-spinning setup with real-time tension monitoring, [5] investigated the relationship between traveler weight and speed. Traveler weight had a greater effect at higher spindle speeds (18,000-22,000 rpm), they discovered. The yarn produced by heavier travelers (50-60 mg) was rougher but stronger. At lower speeds, lighter travelers fared better, which led to better evenness and less hairiness [7]. To achieve balanced yarn properties, the authors proposed that it is essential to optimize traveler weight for spindle speed.

Spindle rotation dynamics and their impact on yarn properties were studied by [6]. According to their research, increasing traveler weight enhanced yarn strength while simultaneously increasing hairiness at constant spindle speeds [8]. Conversely, at higher spindle speeds, decreasing traveler weight improved yarn smoothness but decreased tensile strength. By observing traveler motion and yarn behavior through high-speed video analysis, they were able to gain an understanding of the mechanical interactions at play.

Figure 2. *Travler with ring.*

5. Summary of Review

The reviewed studies highlight that traveler speed and weight influence yarn quality in the following ways:

Table 1. *Traveler speed and weight on yarn quality.*

Parameter	Effect on Strength	Effect on Evenness	Effect on Hairiness	Optimal Condition
Higher Traveler Speed	Increases due to higher twist	Decreases due to tension variation	Increases due to friction and heat	18,000-20,000 rpm
Higher Traveler Weight	Increases due to higher tension	Decreases due to mechanical stress	Increases due to frictional drag	45-50 mg at moderate speeds
Interaction	Synergistic effect on strength and tension	Compromises evenness at higher speeds	Amplifies hairiness at high speeds	Optimal balance at moderate speeds and weights

Despite the comprehensive findings, gaps remain in understanding how traveler speed and weight affect yarn quality, Microstructural Analysis: Most studies look at yarn properties but ignore changes at the fiber level. Dynamic Traveler Behavior: The impact of traveler vibration and friction at high speeds is still not well studied [9].

Material Innovations: New traveler materials, like ceramics or composites, might lower friction and enhance yarn quality., Machine Learning Approaches: Using machine learning for predictive modeling could help optimize traveler settings with real-time spinning data.

Abbreviations

Rpm	Revolution Per Minute

Conflicts of interest

The authors declare no conflicts of interest.

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