SURFACE FRICTION OF ROTOR YARN SPUN BY DIFFERENT FIBRE TYPE

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Abstract

In view of the yarn quantity distributed by spinning technology, although ring yarn always significantly lead the market (54%), it is followed by rotor yarn lately (36%). One of the reason is that rotor yarn are cheaper since process has less technological phases, considering ring spinning process. Beside the yarn structure, the type of fibre determines the properties of the spun yarn intended for the production of textile fabric. In addition to the fibre parameters, fibre fineness and length, the type of fibres from which the yarn is spun, will have an impact on the yarn friction property.

This study presents the results of yarn-to-metal friction measurements conducted on rotor spun yarns made of viscose, modal, micro modal and tencel fibres. Bright staple viscose, tencel and modal fibres of 1.3 dtex fineness and 38 mm length as well as 1 dtex and 39 mm length micro modal fibres were spun to produce single spun yarns fineness of 20 tex.

The friction property of the yarn is significant. In the production process of textile fabrics, the yarns are subjected to friction on the metal. More precisely, yarn is subject to the surface friction on different metal parts of the machines in order to produce textile fabrics for different application. If the yarn has a high coefficient of friction, breakage of yarns can occur often which slows down production and reduces the quality of the textile fabrics.

Yarn-to-metal friction, using a classical friction measurement principle by Friction Tester, was mesaured. Hairiness were determined on an Uster Tester 4-S. The coefficients of friction of rotor yarn spun by cellulose fibers range from 0.23 up to 0.27. The lowest coefficient of friction have viscose rotor yarn, wile the highest is visible for tencel rotor yarn. Since the yarns are made on the same rotor spinning machine, from fibers with the same parameters and yarns of equal fineness it can be assumed that torsional and flexural rigidities of used fibers significantly affects the yarn hairiness, respectively the rotor yarn coefficient of friction.

***Keywords**: Rotor spun yarn, Viscose, Modal, Micro modal, Tencel, Surface friction coefficient.*

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1. INTRODUCTION

Generally, yarn hairiness is characterized by the amount of fibres protruding out of the yarn body. In a spun yarn, the majority of the fibre ends are embedded in the main structure, although certain numbers of fiber ends can protrude out of the main yarn structure. Reason why ends of fiber protrude from the main yarn structure is due to their shorter length or higher bending and torsional rigidities [1]. The most significantly fibre related factors that influence the hairiness of spun yarn are torsional and flexural rigidities, fibre length and short fibre content as well fibre fineness. If the yarn is spun from longer fiber lengths the torsional rigidity of the fibre will be reduced, respectively less hairy. The shorter the fiber length is prone to protrude out of the yarn body is higher since they have preferential migration towards the surface of the yarn. The finer fibres have less resistance against torsion and bending producing less hairy yarns considering yarns spun by coarser fibres.

Since the friction is a surface phenomenon, it is expected that any difference in the surface structure of yarns will be reflected in their frictional behaviour. The surface character of the yarn determines the true area of contact with surface where friction will develop. A rotor-spun yarn is an assembly of disorderly arranged twisted fibres where the yarn surface contains tightly wrapped perpendicularly disposed fibres as well loose hairy fibres [2].

Althought many paper report about yarn-to-yarn and yarn to solid material (metal) friction, work on the frictional behaviour of rotor spun yarns spun by different cellulose fiber type including different fiber parameters appears to be limited. Hence, a comparative study of the frictional behaviour of rotor spun yarns spun in same yarn fineness (20 tex) but from different cellulose fibers (viscose, tencel, modal, micro modal) with different fiber parameters.

1. ROTOR SPINNING – TECHNOLOGY AND STRUCTURE

In view of the yarn quantity distributed by spinning technology, although ring yarn always significantly lead the market (54%), lately it is followed by rotor yarn (36%). One of the reason is that rotor yarn are cheaper since process has less technological phases, considering ring spinning process.

The general principle of open-end rotor spinning is shown on Figure 1. The sliver enters the rotor spinning machine and get pulled through the condenser by the feed roller. In the sliver cross section is aporximatelly 20 000 fibers. Considering that yarns (exits the machine) have around 100 fibers in cross section (depending on yarn count) the drafting of textile material in the machine is 200 times. Sliver is get open and draft by the rotating opening roller, which as well combs out ends of fibers. The air stream transports opened fibers via a tube to the rotor. Fibers are entering in the rotor where due to air stream and rotation of the rotor are deposing into rotor inner surface. Since the transporting tube is is tapered, air stream with fibers is accelerating and straightens the fibers. Fibers deposed to the inner surface of the rotor are beign compress due to centrifugal forces. Fibers are laying down in the layers forming fibrouse ring until required numbers of fibers are beign collected (depending on the yarn fineness). Consolidation of the fiber strand is by mechanical twisting, respectively by rotation of the rotor. After twisting, formed rotor yarn is wound into a cone.

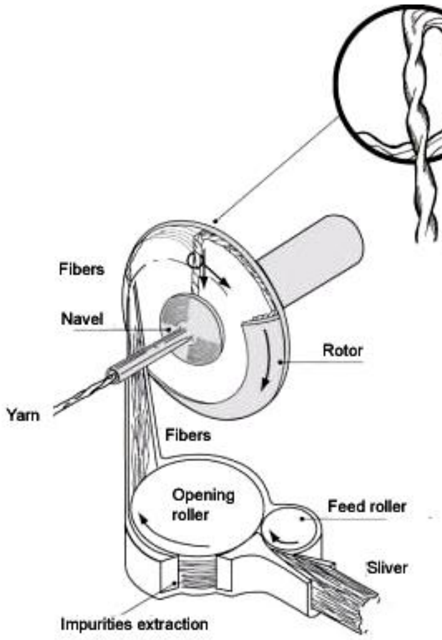

Fig. 1: Principle of rotor spinning system [X]

Formed rotor spun yarns consist of three-part structure, e.g. wrapper of fibers, sheath fibers and core fibers (Figure 2.). The core contains densely packed fibres, sheath fibres are loosely packed round the yarn core at a low angle to the yarn axis while the wrapper fibres are wrapped around the outside of the yarn at a very large inclination to the yarn axis [3].

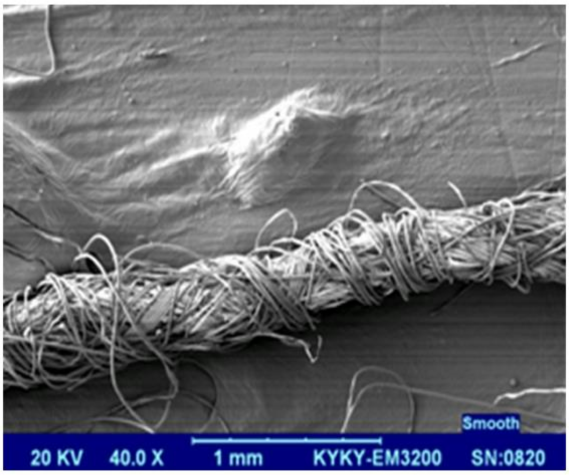

Fig. 2: Rotor spun yarn [4]

Generally, conventional and unconventional yarn properties are comparing related to different spinning techniques. As it mention in the beginning, ring spun yarns always lead the market where rotor yarns are following. For the above, rotor yarn properties will be compared related to ring yarns. Due to significant difference in the ring and rotor yarn structure, especially their inner structures, these differences are reflects in their different performance characteristics. Rotor yarns tend to be more even in appearance and in linear density considering ring yarns. Rotor yarns have better evenness they are more extensible, fuller, softer and less hairy. The main disadvantage of rotor yarns is lower yarn strength related to ring yarns. Maximum tenacity of rotor spun yarns is at least 10–30% lower than ring yarns of same count. The products for which rotor spun yarns are suitable includes dress materials, denim and jeans, sheeting, leisure wear, industrial wear, interlining, towels, furnishings and warp knits [3].

2. EXPERIMENTAL PART

2.1. Materials

For the purposes of this study, rotor yarns were spun with a nominal count of 20 tex (Nm 50). Rotor yarns were spun from viscose, tencel and modal fibres of 1.3 dtex fineness and 38 mm length as well as 1 dtex and 39 mm length micro modal fibres. Besides testing of yarn fineness, yarn-to-metal friction and yarn hairiness were tested.

In table 1, yarn designation and yarn count is given.

Tab. 1: The rotor spun yarn count

Yarn designation	Fibre type	Yarn count, tex	Standard deviation, tex	Coefficient of variation, %
CV	Viscose	20.5	0.5	1.0
T	Tencel	20.2	0.2	0.3
M	Modal	20.2	0.4	0.7
MM	Micro modal	20.1	0.3	0.8

Yarn count or yarn fineness is a numerical value which tells how fine or coarse yarn is. It refers to the thickness of a yarn and is determined by its mass per unit length, i.e. it is a weight of yarn in grams length of 1000 m expressed in tex.

2.2. Yarn friction measurement

Yarn-to-metal friction was measured using a friction measuring apparatus made by Uster Zweigle Friction Tester according to the standard ASTM D3108-95. The principle of the testing device is based on the force required to move a yarn horizontally through a metal disk tensioner.

The yarn passes through the two metal plates where constant force is applied to the upper plate (20 cN), which in turn produces a defined force on the yarn (Figure 3). During the measurement, an area of "zero" force is developed between two rollers because the yarn first passes in one and then in another direction with constant speed of 200 m min^{-1}.

As force F1 applied on the yarn is known and the force F2 is measured, coefficient of friction can be calculated by dividing force of friction (F2) with a normal force (F1) according to the equation 1.

$$F_2 = \mu \times F_1 \quad (1)$$

Where F_1 is known force of 20 cN; F_2 is measured force, cN; μ is coefficient of friction

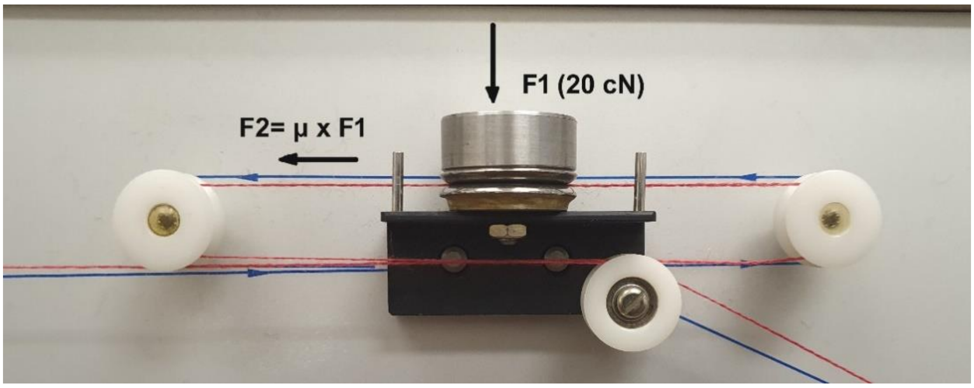

Fig. 3: The friction measuring principle by Uster Zweigle Friction Tester

2.3. Yarn hairiness measurement by Uster Tester 4-S

The hairiness measuring principle is based on evaluation by parallel beam of infrared light (Figure 4). A constant infrared light from laser (transmitter) is falling on the fibers protruded from the body of yarn. Individual protruded fibers scatters the parallel light which appears to be luminous. Yarn itself is dars since is not transparent. The amount of scattered light from the optical sensor (receiver) is converted to an electrical output signal and considered as a measure of hairiness.

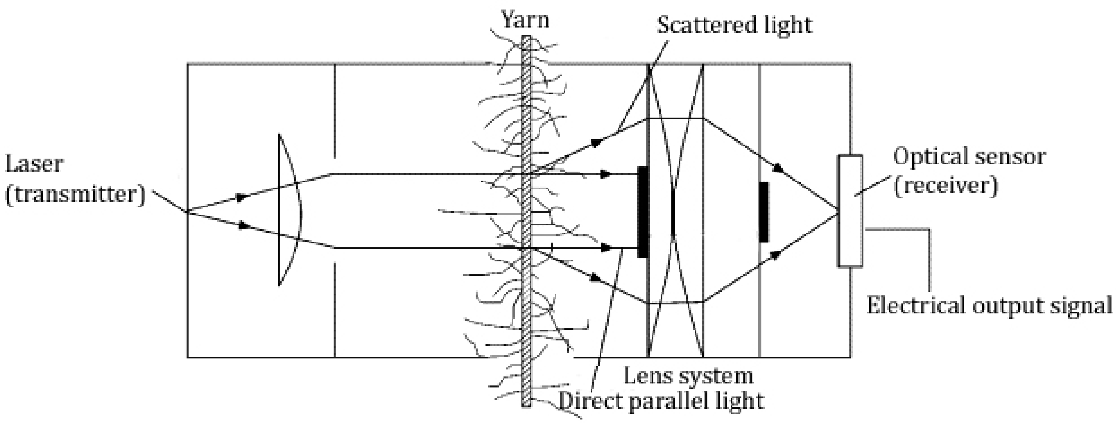

Fig. 4: Hairness measuring principle by Zweigle Uster Tester [1]

Hairiness index H is defined as the total length of all fibre ends protruding out of the yarn body in cm, i.e. total hairiness related to a yarn section of 1cm in length.

$$Hairiness\ index = \frac{Total\ length\ of\ protruding\ fibres\ (cm)}{Total\ lenght\ of\ tested\ yarns\ (cm)} \quad (2)$$

Hairiness were determined on an Uster Tester 4-S with a yarn throughput speed of 400 m/minute through the measuring field during 2.5 minutes. One measurement of each cross-wound package of each sample was performed [5].

3. RESULTS AND DISCUSSION

The coefficients of friction of rotor yarn spun by cellulose fibers range from 0.23 up to 0.27 (Table 2). The lowest coefficient of friction have viscose rotor yarn, while the highest is visible for tencel rotor yarn. Since the viscose, tencel and modal rotor yarns were spun from fibers having same fibre fineness, length and cross section, on same spinning machine and same yarn count influence of different raw material on friction coefficient of rotor yarns is notable.

Tab. 2: The rotor spun yarn coefficient of friction

Yarn designation	Mean value	Minimal value	Maximal value	Standard deviation	Coefficient of variation, %
CV	0.23	0.18	0.26	0.04	15.6
T	0.27	0.25	0.29	0.01	5.5
M	0.25	0.23	0.28	0.02	6.4
MM	0.24	0.20	0.26	0.02	7.6

As it previously mentioned, the main fiber-related influences on yarn hairiness and thus on coefficient of friction are torsional and flexural rigidities, fibre length and short fibre content as well fibre fineness. Since the viscose, tencel and modal fiber used for spinning rotor yarns have same fibre parameters the influence of hairiness is tested.

The influence of hairiness on friction coefficient is clearly visible (Figure 5). As the hairiness of the rotor yarns increases, the friction coefficients increases too.

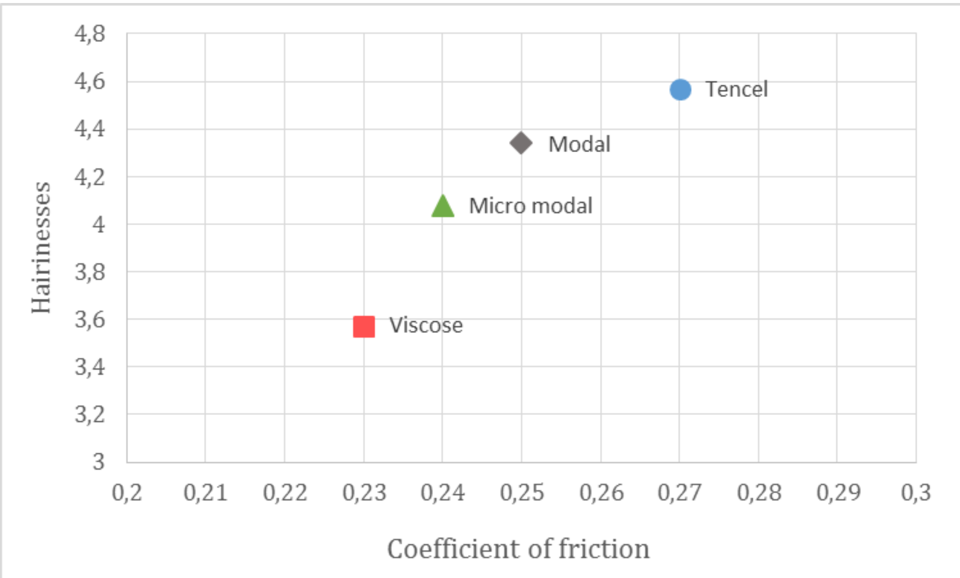

Fig. 5: Dependence of yarn friction coefficient on yarn hairiness

According to the theory, the hairiness of the yarn is a consequence of torsional and flexural rigidities, fiber length and fiber fineness. As the rotor yarns are spun from fibers of equal length and fineness, it can be assumed that the coefficient of friction depends on the torsional and flexural rigidities of the fiber itself since this property significantly affects the yarn hairiness.

The finer fibres have less resistance against torsion and bending producing less hairy yarns considering yarns spun by coarser fibres. The micro modal rotor yarns are spun by finer and longer fibers related to the modal yarn having lower friction coefficient. The obtained result is in accordance with the theory, respectively the longer and finer fibers with same cross-section have lower resistance to bend, and lower hairiness of yarn is obtained consequently reducing coefficient of friction.

4. CONCLUSION

The study of surface friction of rotor yarns spun by viscose, tencel, modal and micro modal fibers shows clear influence of raw materials. The viscose, tencel, modal fiber parameters of rotor yarns are equal but difference in yarn friction coefficient is detected. One of the main parameter influencing coefficient of friction is yarn hairiness. The yarn hairiness is results of fibre torsional and flexural rigidities, fibre length and short fibre content as well fibre fineness. As the yarns are made on the same spinning machine, from fibers with the same parameters and yarns of equal fineness it can be assumed that torsional and flexural rigidities of used fibers significantly affects the yarn hairiness, respectively the rotor yarn coefficient of friction.

Additional confirmation of the above is detected at the micro modal rotor yarns that are spun by finer and longer fibers related to the modal yarn, having lower friction coefficient.

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