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Yarn Hairiness Affecting Fluff Generation

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Abstract: Fluff (lint, fiber fly) generation, especially related to yarn structure, was investigated. Research centered on the fiber length related to fluff generation during the knitting process. Short fiber length composing yarn structure was a main source of the fluff shedding. High quality spun yarn with longer length of fiber was recommended to the high speed knitting industry in order to reduce process troubles such as yarn breakage, etc. but the cost is doubtable to the manufacturers. A trial to reduce the fluff trouble by using chemicals to hold the short fiber on the surface of the yarn was suggested and the research showed a positive effect to the problem. However, another factors including a by-product of chemical residue and searching more feasible material need to be concerned for the future research.

Keywords: Fluff, Hairiness, Fiber length, Coating, Chemical residue

Introduction

Fluff generation is one of the parameters that should be controlled to reduce processing faults and to increase production efficiency in the circular knitting industry. There are many processing parameters that affect fluff shedding in the circular knitting.

As the production speed of knitting machinery increases, fluff become a major cause to lead to serious process troubles in the case of cotton spun yarn. In particular, as yarn comes into contact with many elements in the knitting machine and as knitting speed increases, fluff generation also has been increased. All contact points of the yarn on the circular knitting machine are potential causes of fluff shedding. Researches [1-7] have been carried out on fluff shedding with the mentioned parameters. Most of the investigators concluded that a fluff generation is caused by the fiber properties of the yarn and it is also related to the processing parameters in the production of fabric.

From the standpoint of yarn morphology, factors in the yarn production include many aspects of physical and chemical characteristics of textile products. One of the factors in the yarn structure impinging on the knitting process is the fiber length of yarn, which should be taken into account for fluff generation in the mainly high-speed circular knitting manufacturing.

Fiber length is a basic factor in the textile processing and is also one of the main factors influencing fluff shedding. Like all other physical properties of natural fibers, fiber length varies considerably within any one sample. A research [8] showed that the variability in terms of the coefficient of variation in fiber length might be as high as 40 % for cotton. It also showed that man-made staple fibers are, generally, much more uniform and they may have a coefficient of variation of as much as 10 %. This variation is partly caused by faulty stapling or fiber breakage during processing.

Synthetic filament yarn does not produce these troubles due to its manufacturing characteristics, but spun yarn such as especially cotton has these troubles in all areas of textile processing.

In order to avoid these troubles the mean fiber length of the yarn should be increased. Lawrence and Mohamed [9] has studied the relation between mean fiber length and fluff shedding and obtained the result that the amount of fluff decreased as the mean fiber length increased. By increasing these mean fiber lengths, there would be many finer fibers in the cross section of the yarn which should increase the friction between the fibers, resulting in better fiber cohesiveness. In addition to the increase of mean lengths, there would be a greater contact length between fibers, thereby reducing the degree of fiber slippage when the yarn is placed under stress.

Yarn hairiness [8] is defined as the fibers in the outer layer of the yarn where cohesion to the core of the yarn is small. A certain number of fiber ends rooted in the core of the yarn are entangled with other fibers, whereas the other end protrudes as a consequence of the mechanical properties of the fiber. Yarn hairiness affects the appearance, handle, and attractive characteristics of yarns. However, the hairiness diminishes the production efficiency with fluff shedding in the knitting process.

As the spinning speed increases, yarns are under great stress regardless of open end or ring spun. A side effect of these increased speeds is to make hairy fibers on the surface of the spun yarn. Hairiness is an undesirable property and gives

- An increase in surface friction and geometrical roughness
- Dying troubles and color difference
- Entanglement of warp threads during sizing and weaving
- A higher propensity to pill in the finished fabric.

Furthermore, one important factor of fluff shedding is the hairiness of the yarn and the distribution on the surface of the spun yarns of hairy fibers.

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With respect to fiber length addressed so far, it seems to improve the fluff problem by increasing mean fiber length in the yarn structure. However, it influences on not only increase of production cost but also property change of following products. Therefore, in this research, a possible way of reduction of fluff generation was approached with yarn produced in the ordinary process by coating some chemicals on the surface of yarn. The main concern of the study is to find possibility of chemical use to hold the hairs on the surface of yarn during knitting.

Experimental

Device

Tests were compared with the number of hairs and fluff amount. To determine the number of hairs or fibers over a specific length, protruding from the yarns, SDL (Shirley Development, Ltd.) friction/hairiness tester was used. This tester provides variable input tension, measuring head adjustable from 0-10 mm, electronically measuring interruptions to an LED (Light Emitting Diode) beam set at a specific height protruding from the surface of spun yarns or broken filaments on filament yarns.

Measurement

Yarn is transported through nip rollers driven by an electronic drive with variable speed by 50-300 m/min. and air suction removes the tested yarn to waste. However, yarn speed is set to 60 m/min during the test to prevent any disturbance from air dragging. The number of hairs on the surface of yarn are usually measured with 3 mm distance of the measuring head but the distance was varied to 2-5 mm to investigate distribution of hair length.

Coating

In order to apply chemicals on the surface of yarn, the dipping method was used in this research. The method was determined to be quite suitable for the coating machine used in this test. The coating machine consisted of several parts namely, yarn feeding, yarn coating and yarn winding. In the yarn feeding part, the package of yarn was set on the yarn holder unwinding from the package. There was also a tensioner between the yarn holder and yarn-coating vessel to feed the yarn uniformly. In the coating part, one pair of rollers called pads, usually used for finishing a fabric, were used for yarn coating in this research. The two rollers were used to apply a thin coating onto the yarn surface. The rollers can be revolved in the range of 1-10 m/min. The maximum revolution speed of 10 m/min was used to increase coating speed and prevent any possible penetration of the coating material into the yarn. The rollers were also used to remove excess coating liquid from the yarn and to lay the surface fibers down to the yarn body with a consistent pressure of 0.3 bar. In the winding part, the coated yarn was wound onto another package for further tests. This yarn package is supported by a holder which is connected to a motor, so the winding speed of the package was controlled by the motor speed. The winding speed of the package was adjusted depending on the roller speed on the coating part to give the necessary tension on the yarn for good winding.

Table 1. Characteristics of the yarn used

Fiber type	American cotton
Spinning method	Ring-spinning
Yarn twist (tpi)	16.8
Yarn count (tex)	20
Hairiness (>3 mm)	3.88

Chemicals

The coating chemicals (C1 and C2 thereafter) tried in this research were provided by a company producing lubricant and softener for textile processing. C1 is manufactured as a finishing agent to provide excellent lubrication between fiber/metal and fiber/fiber friction thus reducing needle damage and improving the process. C2 is produced as a knitting lubricant to improve yarn knittability, which imparts low fiber to metal coefficient of friction whilst giving a medium to high fiber to fiber coefficient of friction where it effectively overcomes troubles due to needle damage. The two materials have different compositions as a blending of softener or lubricant, which is not exactly specified from the manufacturers for their business aspect. However, they suggested the materials are proper ones for the research with holding effect of the hairiness, easy removing by washing, etc. A combed ring-spun American cotton yarn was used in the study. The yarn coated with 4 different concentrations (5 %, 10 %, 15 %, 20 %) of chemicals (C1, C2) and compared with uncoated yarn.

The yarn was conditioned in a standard atmosphere of 65 ± 2 % relative humidity and a temperature of 20 ± 2 °C for 1 day, prior to all coating tests. To measure fluff shedding, a test rig was specially designed and constructed which is addressed in the former paper [10]. The amount of fluff was calculated with difference of yarn weight before and after coating and drying. The surface morphology of the coated yarn was studied using microscope images.

Results and Discussion

It is possible that the yarn would get stiffer as the coating material penetrated the yarn. One of the properties of the coating materials used in this research is their ability to bind the surface fibers on the yarn body. Therefore, if the coating materials penetrate the yarn structure, the component fiber inside yarn can be stuck together. As a result, the yarn will be stiff and will lose its pliability. In order to prevent this penetration, the rollers were revolved at the maximum and constant speed of 10 m/min.

Figure 1 showed the results of hairiness tests for two different uncoated yarns, carded and combed. The results show that carded yarn has more hairy fibers than combed yarn. As expected, this can be accounted for by the removal of a significant amount of short fibers during the spinning process. This result was compared to tests for yarn hairiness on coated yarns and the amount of fluff.

Figures 2 and 3 showed the number of hair decreased with the both coating chemicals as the concentration increased.

From the results, it is considered that the two chemicals have positive effect to lay down the short fibers on the surface of the yarn. However, as can be seen from the Figure 4, the amount of fluff was not largely decreased except the yarn coated with C1-10 %.

Furthermore, C1-20 % showed more amount of fluff than

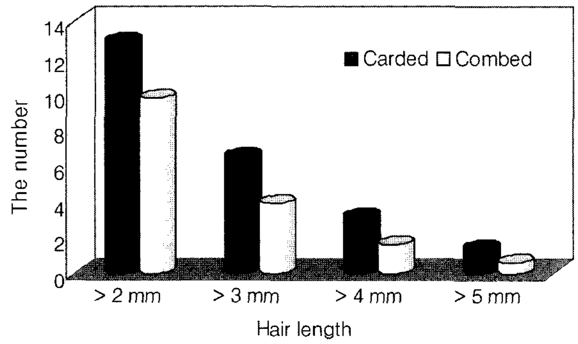


Figure 1. The number of hair of carded and combed yarn according to a measuring length.

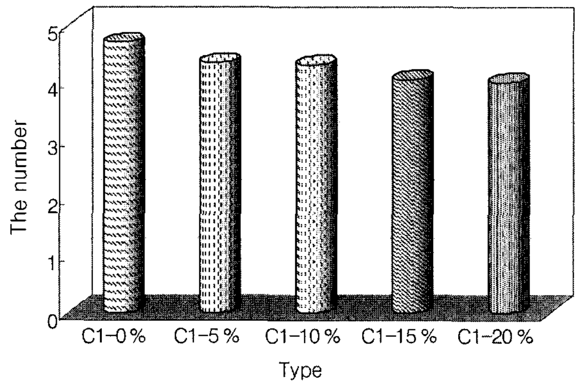


Figure 2. The number of hair of yarn coated with C1 and uncoated.

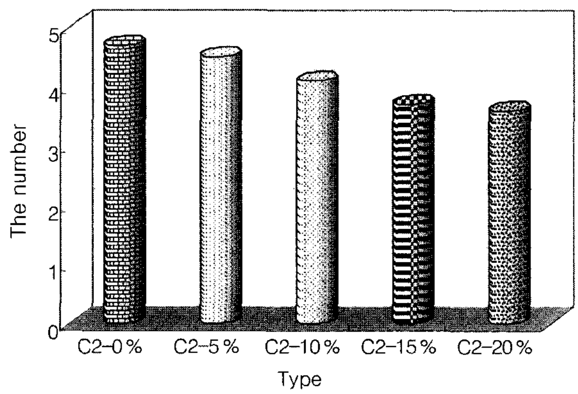


Figure 3. The number of hair of yarn coated with C2 and uncoated.

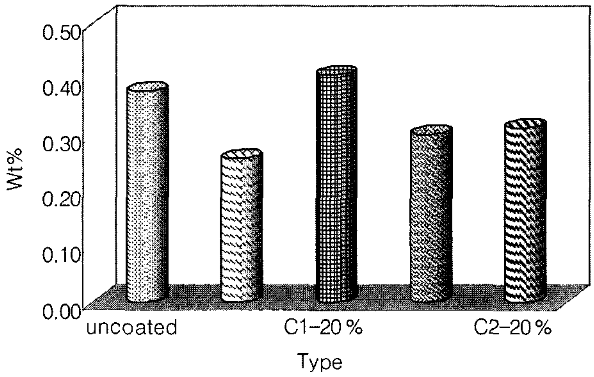
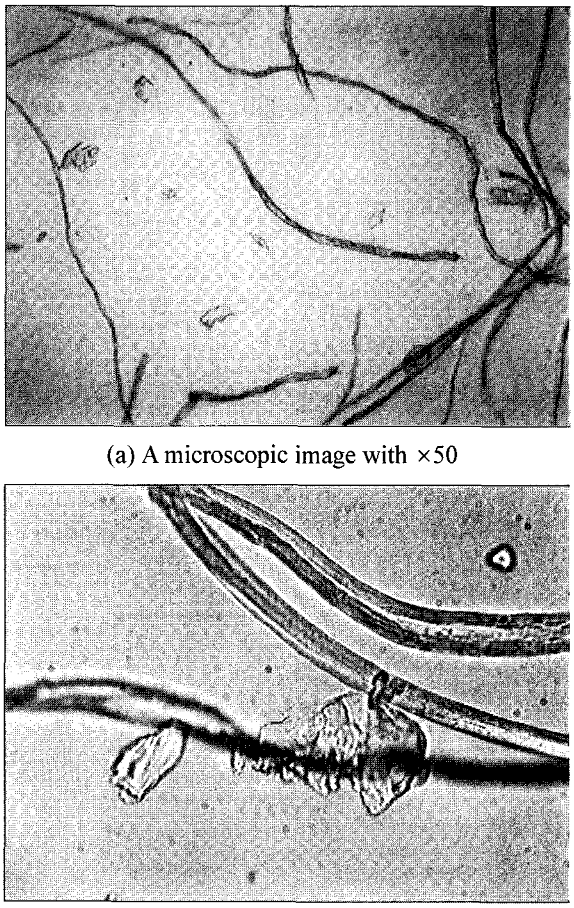


Figure 4. The amount of fluff of coated and uncoated yarn.



(a) A microscopic image with ×50

(b) A microscopic image with ×250

Figure 5. Chemical residues from the coated yarn.

uncoated yarn. From the results, several aspects can be arrived. Firstly, even though the chemicals showed a good effect to reduce the number of hairs on the surface of yarn, it may not be enough to hold the fibers against the friction on the needle hook. Usually, the friction causes fluff shedding against needles in a large portion during the knitting process. Secondly, in terms of the increased amount of fluff from the yarn coated with C1-20 %, the coating chemicals might be detached from the yarn surface during the test. That is, the coating chemical was another contamination and added to the total amount of fluff. This was confirmed from the microscope images in Figure 5. Besides the short length of fiber, chemical residues were found in the accumulation of fluff. This may be explained by the property of a thick polymer film to crack and fall away from the yarn surface when it becomes too thick. In this respect, thinner films are more advantageous as they are more flexible, because thicker films may end up contributing to the amount of fly generated during processing. However, from the results, C1-10 % showed positive results to decrease fluff amount and was regarded to an optimum concentration among the tested concentrations.

In order to confirm whether the C1-10 % is the best concentration, lower concentration of C1-5 % was employed. As seen in Figure 6, the number of hairs has no significant

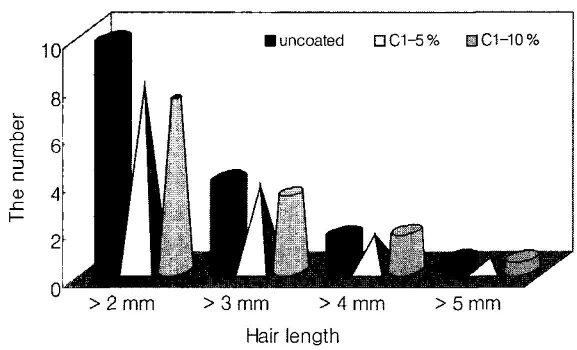


Figure 6. The number of hair of coated and uncoated yarn according to a measuring length.

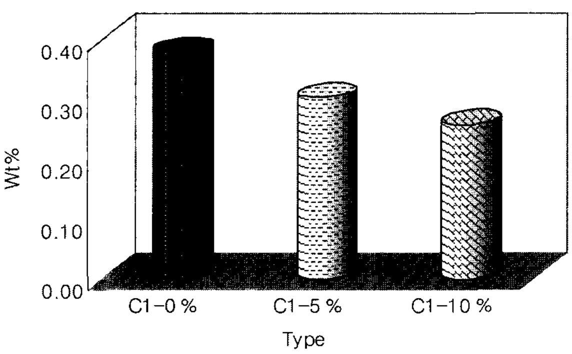


Figure 7. The amount of fluff of yarn coated with the low concentration of C1 and uncoated.

difference but the amount of fluff showed a slight increase than C1-10 % from the Figure 7. It maybe explained that 5 % of concentration was not enough to hold the short fibers against friction of needle.

In order to maximize the coating effect, further tests are necessary to search more reliable chemical and its optimum concentration. Furthermore, it should be concerned that the chemical should not affect to the yarn in any negative aspect such as yarn stiffness or contamination.

Conclusions

Side effects of short fiber length of spun yarn to fluff generation was tested with a specially designed test rig. It is found that the number of short fiber affects to the fluff shedding. In order to reduce the amount of fibers on the surface of yarn, coating yarn with two chemicals were carried out. The chemicals showed a positive effect to reduce the number of short fibers on the yarn surface but coating strength was another point that should be considered to reduce the fluff. Although they all showed good results to reduce the number of short fibers depending on types and concentrations of the chemicals, extent of fluff shedding was different. The reason is that holding force of the chemical to the short fibers on the yarn body should be different against friction of needle during knitting process. In addition, as increasing concentration of the coating chemicals, fluff generation became another contamination due to chemical residues on the yarn body. The residue was considered as the chemicals that have a weak resistance against friction. Therefore, with above results, yarn should be coated with the lowest concentration of coating solutions feasible for holding the short fibers and to maintain the holding force of the short fibers during the knitting process so that the knitting process will not be adversely affected. In this research, C1 (10 %) showed a positive effect to reduce the number of short fibers and the amount of fluff.

Acknowledgement

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