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Investigation of Fly Generation During Cone-Winding Using the Image Processing Technique

Abstract
Fibre fly generation is a major problem for the textile industry, not only for health reasons but also because of quality problems associated with products. In this work, fiber fly generation during the cone-winding process was studied' emphasizing the effect of yarn spinning parameters. 100% acrylic yarns were produced with different twists and linear densities. The hairiness and hair counts of the yarns were measured using an evenness testing machine. In order to collect the fibre fly in the cone-winding process, the whole path of the yarn, from bobbin to cone, was covered with a plastic chamber so that the fly generated could be collected. The image processing technique was then used to calculate the length of flying fibres generated . The number of flies in each group length and also the total length of flies in 100 meters of yarn were calculated. The number of flies in each length group is defined as fly counts. For each yarn type 25 samples, 500 meters of yarn on each sample, were tested. The results revealed that both the twist and linear density of the yarn has a significant effect on the amount of fly generated during the winding process. As the twist of the yarn increases, the amount of fibre fly decreases. This effect is greater in higher linear densities. For all samples the total length of flies was also calculated and compared to the hairiness index of the yarn. The results showed a good linear regression between these two quantities, with a linear regression coefficient of $R^2 = 0.905$.

Key words: *fibre fly, winding machine, hairiness, hair counts, image processing, fly length.*

Introduction

Fibre fly generation is a major problem for the textile industry, not only for health reasons but also because of quality problems associated with the products. The study of fibre fly generation during a process involving the unwinding of yarns has attracted the attention of many workers, particularly after intensive work on the physical properties of yarns and studies on yarn hairiness. Over recent decades, a tremendous number of studies have been completed about the theoretical yarn hairiness models that have been used as the basis for fibre fly generation studies during production in textile mills. In literature there are many workers who have made a significant number of contributions to the investigation of yarn hairiness [1 - 4].

Fibre fly generation is receiving more attention as the production speed of machines is getting higher, which results in more fibre fly generation in the working environment. It is being considered as a bigger problem than it used to be due to the fact that it is becoming a mandatory regulation for textile mills to prepare a healthier and safer working environment for their employees. Not only does fibre fly generation cause an unhealthy working environment for people, due to the intensity of the dust, but it also affects the quality of the products because of the possible contamination of products from fibre fly. It may also cause yarn breakages during manufacturing and mechanical defects in the machines [5 - 7]. Fibre fly generation has been considered for many decades. In the past, it was not as serious a problem as it is today because of the fact that the machine speeds were not as fast as today's. However, as the speed of machines is increasing, the problem is getting more serious due to the fact that speed is one of the major factors affecting fibre fly generation.

However, neither air conditioning nor filters are reducing the total amount of fibre fly generated during the manufacturing processes in the winding process. Studies show that fabrics produced from hairy yarns generate more fiber fly during fabric finishing processes. Lawrence and Mohamed [8] studied fibre fly distribution on weft knitting machines, and reported fibre fly distribution along the thread line according to the length and percentage of fibre. In their studies, they found that most of the short fibres were removed from the yarn at the unwinding section. Most of the studies regarding fibre fly generation were conducted using ring and open end yarns in the knitting and weaving processes. There are some other parameters also affecting the amount of fibre fly coming from the yarn during the spinning processes

The fibre fly problem does not seem to be an easy task that will be solved in the

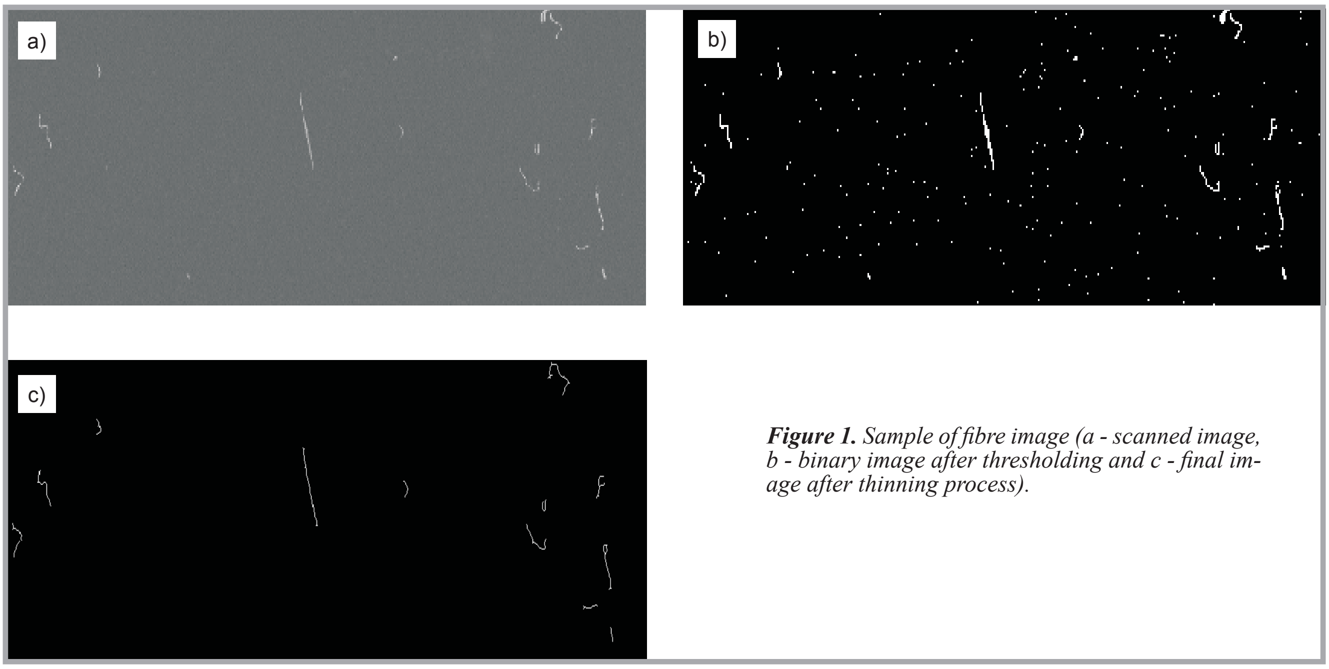


Figure 1. Sample of fibre image (a - scanned image, b - binary image after thresholding and c - final image after thinning process).

near future, but textile machinery producers are trying to reduce fibre fly generation as much as they can by adapting new technologies that reduce the amount of stress and friction introduced into the yarns on their machinery during production.

In this work, fibre fly generation during the cone-winding process is studied, emphasising the effect of yarn spinning parameters, as well as a method of calculation of fibre fly generation. In order to collect fibre fly in the cone-winding process, the whole path of the yarn from the bobbin to cone was covered so that the fly generated could be collected. The image processing technique was then used to calculate the length of fly fibres generated.

Materials and methods

In order to measure the effects of yarn parameters on fibre fly, five different linear densities, namely 29.53, 23.62, 19.68, 16.87 and 14.76 tex, of carded yarns, were chosen for experimental purposes. There were five different twists per meter associated with each yarn spun, namely 600, 670,740,798 and 862, used in the experiment.

We also measured the hairiness properties of each yarn type with a Premier machine. The hairiness (H) is defined as the sum of hairs length per one centimeter of yarn. The number of hairs in each length group was also measured, regarded as hair counts. Four bobbins of yarns, 500 m of each bobbin, 2000 meters of yarn in total, were tested for all 25 cases of the experiment.

In this study, a cone-winding machine was chosen to compile fibre fly generation. Previous studies [9] have shown that yarn speed is one of the major factors affecting fibre fly generation. We used a cone-winding machine, thus the speed of yarns was high, which generated a significant amount of fibre fly during the operation of the machine.

The amount of fibre fly generation for a single yarn end is usually very low and it is not an easy task to detect accurately. The study of fibre fly generation requires intensive measurements in order to have accurate test results. In the past, data were collected from a lot of primary materials, such as from a commercial weaving factory, for different types of yarns due to the fact that such data cannot be compiled in laboratory scale experiments. However, in this work we used the image processing method. A cone-winding machine at the laboratory was selected and modified in order to collect fibre fly easily for this research. Modification of the cone-winding machine was only made to collect the fibre fly easily and accurately by using a cover in the path of yarn from bobbin to cone. The cover allowed no flies to escape from the collecting chamber. Microscope slides were placed at the bottom of the collecting chamber. In this way, the flies generated fall down and lay down on the surface of the microscope slides. A very thin layer of oil was already applied on the surface of the microscope slides to provide better adhesion of flies to the slide surface. After each test the slides were removed from the collecting chamber and then covered by another slide on top. The sets of double slides were now ready for image processing.

Image processing

A preliminary study of fibre-length distribution in fly produced during weft knitting was done by Brown [10]. In this work we used the image processing technique to determine the fibre-length distribution of fibre fly generated during the cone-winding process.

Fibre flies of yarn samples during winding were collected on the microscope slides. After that the slides were scanned using a scanner (Model Canon 1200 dpi). The slides were then placed on a black paper sheet and scanned at a resolution of 1200 dpi.

In this step we used image processing from Matlab software. In the first step of image processing, images of the slides were connected together to increase processing accuracy. The images of collected fibres were enhanced by a Wiener filter as a restoration filter [11]. In the Wiener filter most of the noise pixels were removed from the image. The images were converted to binary form using a thresholding algorithm [12, 13].

For the recognition of fibre from the background after trial and error, we used a proper threshold, which was μ+σ/2. In the thresholding process some small noise pixels were generated because of a few shade factors of background light and shadows of fibres in the edge parts. To remove these noise pixels, the morphological method was used to remove additional points. For reducing thickness of fibre to one pixel we used skeletonising or the thinning method [14]. A sample of image processing effects is demonstrated in ***Figure 1*** (see page 59). Then we removed the fibres that had fewer than 10 pixel lengths. Finally we calculated the length of each fibre and drew a bar graph and histogram for each sample. The number of flies in each length group is defined as the fly count. For each yarn type 25 samples, 500 meters of yarn on each sample, were tested.

Results and discussions

Effect of twist on fibre fly generation and hairiness of yarn

Figure 2 shows the effect of twist levels on total hair counts between 3 and 10 millimeters. This result is closely related to the structure of the yarns, where more twist forces the fibre to attribute in the structure of the yarn, thus the hairiness of the yarn is reduced.

Figure 3 shows the effect of twist levels on the fibre fly generated during the winding process. As the twist level increases, the number of flies (1 - 4 mm) generated during the process decreases. The reason for this reduction in fibre fly with an increase in the amount of twist is attributed to the increase in frictional force among the fibres. Therefore it is expected to have a lower amount of fibre fly when the twist level is higher.

Effect of yarn linear density on fibre fly generation and hairiness of yarn

Figure 4 shows that as the linear density in tex of the yarn decreases, the amount of hair count (3 - 10 mm) decreases. Decreasing the linear density of the yarn results in fewer fibres in the cross section and less chance of fibre protruding along the yarn. This in turn leads to a reduction in the hairiness of yarn.

Yarn linear density is another factor for fibre fly generation. The amount of fibre flies (1 - 4 mm) decreases as the linear density in tex of the yarns decrease, as seen in ***Figure 5***. This is due to the fact that coarser yarns contain more fibres throughout their cross section and with a constant cross section the force that twist applies on each fibre decreases, leading to a reduction in interaction forces to protect fibre from pulling out.

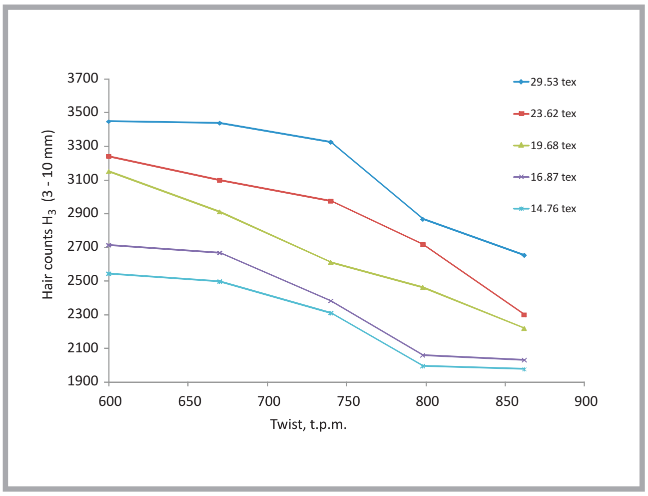


Figure 2. *Effect of yarn twist on hair counts H3 (3 - 10 mm).*

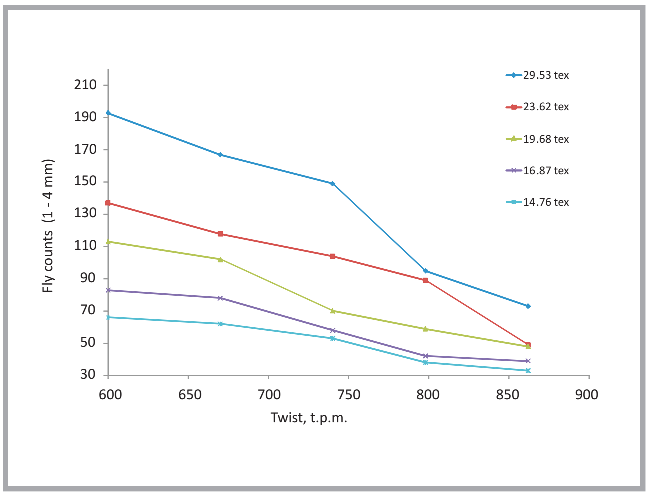


Figure 3. *Effect of yarn twist on the total number of flies (1 - 4 mm) in 100 meters of yarn.*

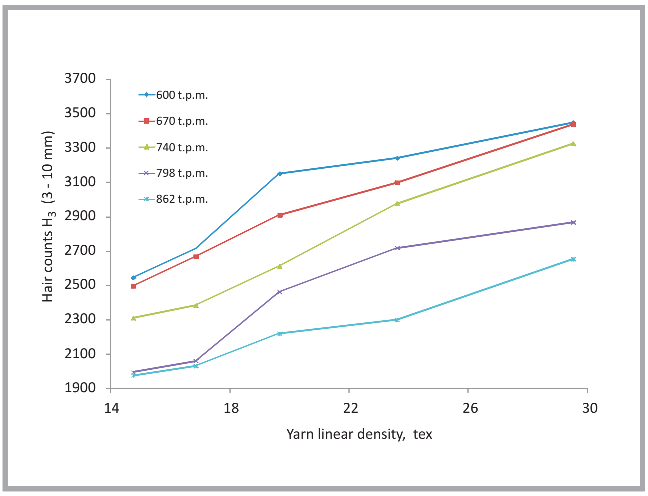


Figure 4. *Effect of yarn count on hair counts (H3).*

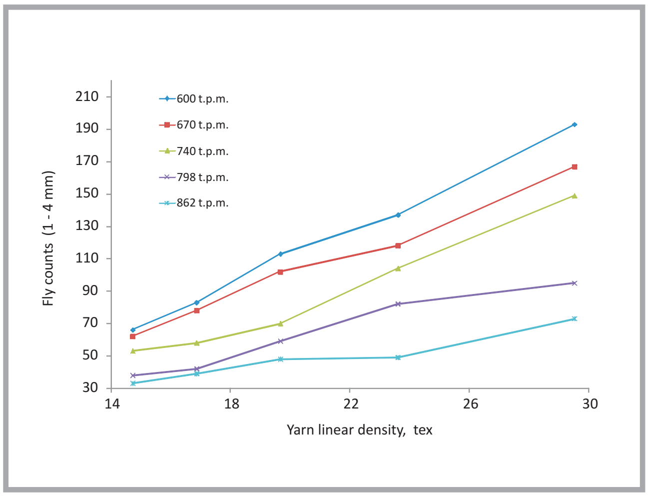


Figure 5. *Effect of yarn count on fly counts (1 - 4 mm).*

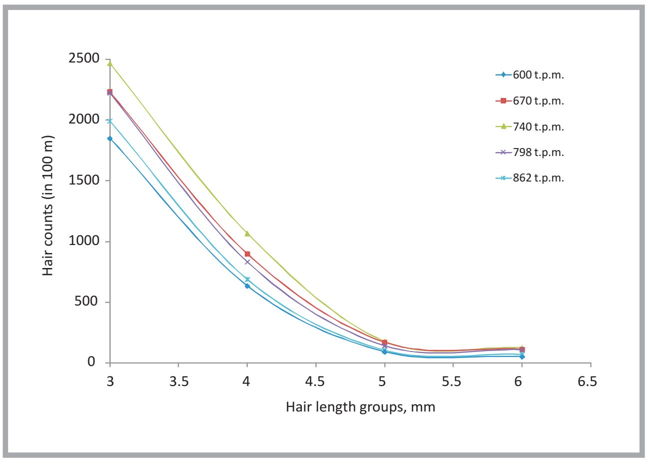


Figure 6. *Effect of yarn twist on hair length distribution (29.53 tex).*

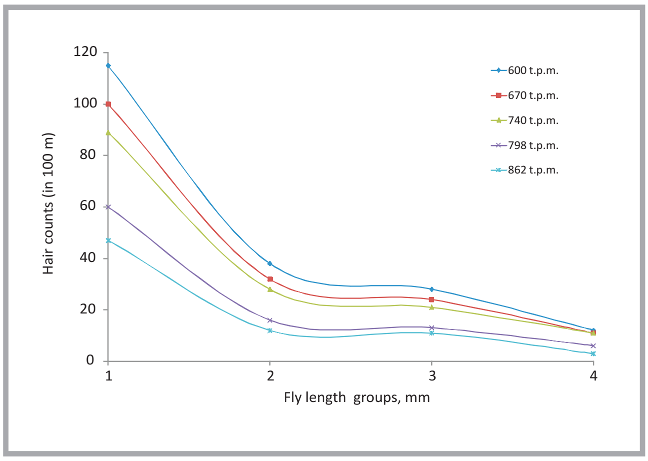
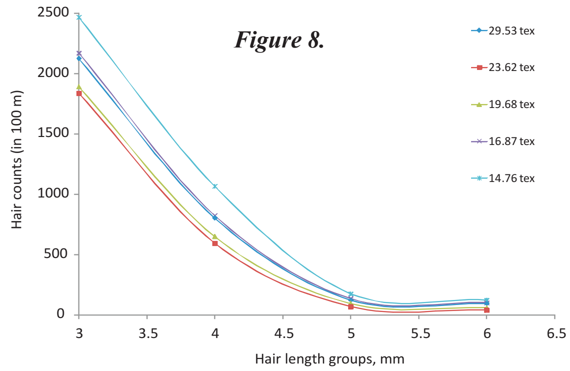
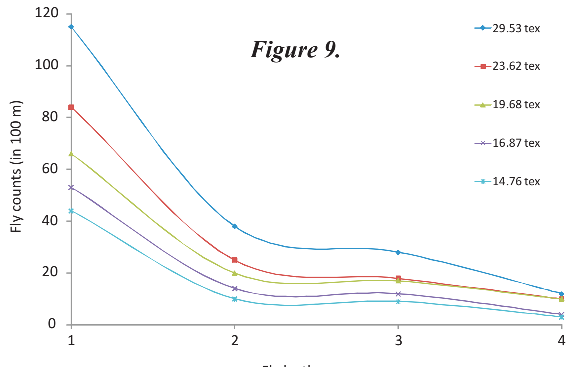


Figure 7. *Effect of yarn twist on fly length distribution (29.53 tex).*





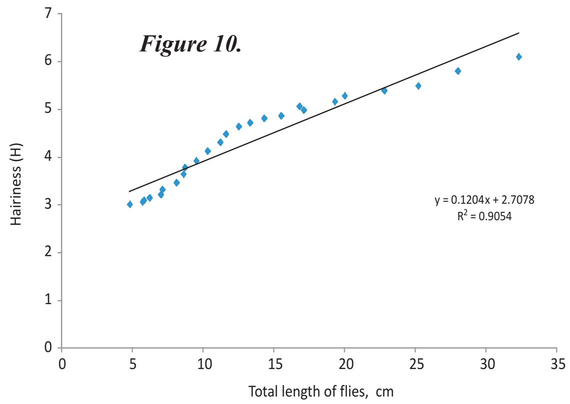


Figure 8. *Effect of yarn count on hair length distribution.*

Figure 9. *Effect of yarn count on fly length distribution.*

Figure 10. *Correlations between hairiness (H) and the total length of flies in 100 meters of yarn.*

Effect of twist on the length distribution of fibre flies

Figure 6 shows the effect of twist levels on hair length distribution. This result is closely related to the structure of the yarns that more twist force fibre to attribute in the structure of the yarn, leading to a reduction in the amount of hairs in each length group.

Figure 7 shows the effect of twist levels on the length distribution of fibre fly generated during the winding process. As the twist level increases, the number of fibre flies generated in each length group decreases. The reason for this reduction in fibre fly with an increase in the amount of twist is attributed to the increase in frictional force among the fibres. Therefore it is expected to have a lesser amount of fibre fly when the twist level is higher in each length group.

Effect of yarn linear density on length distribution of flies

Figure 8 shows that as the linear density in tex of the yarn decreases, the amount of hairiness in each length group decreases. Decreasing the linear density of the yarn results in fewer fibres in the cross section and the chance of fibres protruding along the yarn is reduced. Therefore the hairiness of yarn in each length group is reduced.

Figure 9 shows the effect of linear density on the length distribution of fibre fly generated during the winding process. As the linear density decreases, the number of fibre flies generated in each length group decreases. The reason for this is attributed to the increase in frictional force among the fibres. Therefore it is expected to have a lesser amount of fibre fly in each length group when the linear density is lower. Also in coarser yarn we have a lot of protruding fibres and thus more hairiness.

Correlation between hairiness and fibre fly

In this study we calculated the correlation between the hairiness (H) of the Premier machine and the amount of the total length of flies (1 - 4 mm). As is known, hairiness is the total length of hairs (cm) in one centimeter of the yarn length. The total length of flies in cm in one hundred meters of yarn, regarded as the total fly length, was calculated from the following equation:

$$\text{Total fly length} = \sum_{i=1}^{n} i \times n_i$$

where i is group length in centimeters and n is the number of flies in an i^{th} group length. For all cases of twist and yarn count the values of hairiness and total fly length, as explained above, were measured and then the linear correlation between the two quantities were calculated. ***Figure 10*** (see page 61) shows plots of the total fly length (1 - 4 mm) versus hairiness. A linear regression coefficient of $R^2 = 0.905$ was found between these two quantities, which can be regarded as an acceptable linear correlation. We can conclude that the hairiness (H) can be used as a significant criterion to predict the amount of flies generated during cone-winding

Conclusions

The main aim of this study was to calculate the fly length generated during con-winding. The image processing technique was used to calculate the length of fibre flies. Calculating individual fibre flies allows us to obtain the number of fibre flies in each group length as well as the fibre length distribution. 100% acrylic yarns with different twist and linear densities were produced and re-wound on a con-winding machine. The fly fibres generated during the process were collected. Using the image process technique, the length of flies and fibre length distribution were calculated. The results showed that both the twist and linear density of the yarn have a significant effect on the amount of fly fibres generated during con-winding. The fly length parameters were also compared to the hairiness and hair count of the yarn, measured by an evenness testing machine. The results showed an acceptable linear regression between the number of flies and the hairiness index of the yarn. It can be concluded that the twist of yarn can be a reasonable criterion to predict the hairiness and fly generated during the con winding

Acknowledgment

The authors would like to express their sincere thanks and gratitude to the deputy of research of Isfahan University of Technology for the financial support.

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Received 24.10.2011 Reviewed 15.02.2012