Polyester Water Textured Yarns Examined by a Scanning Electrical Microscope

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Abstract: At the University of Manchester some work was done on yarn texturing using a new method of water twisting in order to replace the ordinary friction disc method. Such a new method would be considered an innovation in both yarn texturing and yarn finishing processes. The work done early, at the University of Manchester, proved that water jet twisting would produce yarns of better bulk and dyeing properties. Steam is the key word in such process, it not only helped to provide relatively better bulk yarn than conventional heating methods but also it help to produce better dyed yarns. This piece of work looks at the produced dyed yarns using the scanning electron microscope (S. E. M) as a visual way to asses such process. The scanning process showed that steam heater had an edge on conventional heating methods. It allowed producing textured yarns with bulk results at relatively high speeds. The results also showed that due to the use of steam good dyeing results were achieved. Steam ensures adequate heat energy that would produce new inner spaces that is created during the heating stage and is fixed during the cooling stage. In addition when using water for cooling and twisting it seems that water works as a caution for the running yarn that limits its damage compared to friction disc texturing process, which could also be the reason behind reaching high speeds.

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1. Introduction

Electron microscopic scanning of the yarns textured with a water twister and steam heater was important in giving a visual picture of what was happening and an important step to be added to the documented work done at the University of Manchester **(1,2)**. In the mentioned thesis some work was done aiming to understand the water behaviour inside different jets. In the earlier chapters, the work was focussed on the water jets and their dimensions. During these chapters a variety of jets were used and a special study of the water distribution inside the jets was made. In the route to understand the method two main comparisons were made, the first was between the steam heater and conventional heaters and the second was between the water twister and friction disc.

In this part of the work another route to understand the process and its effect on textured yarns was carried out by using the S. E. M. With the scanner it can be possible to assess different yarns. It is proposed to scan some dyed yarns textured with a variety of water jets, at different speeds and to monitor the influence of the angle of water entrance in a jet. It is a process to asses the whole process from one side and to examine the effect of dyeing as a separate process.

2. Materials and Methods

Using the water jets nominal 167f34 yarns were textured from 265f34 POY polyester yarns. The texturing process was done at the University of Manchester texturing machine under the following conditions.

- Speeds 800 - 2000 m/min.
- Water pressure 50 - 120 bar
- Draw ratio 1.63
- Steam temperature 230º and 260°C according to the speed used

The yarns were dyed with a critical Dispersol Blue B-R., using high-pressure polyester dyeing method **(3)**. Liquor ratio was 1:10. Dyeing began at 60ºC for 35 min then increased gradually to 130ºC for 40 min. pH was adjusted to 5.5 by adding acetic acid. The fabric was then rinsed in a 60ºC water bath, with 5 g/L soap and dried. The colour strength, K/S of the dyed fabrics was measured on a spectrophotometer unit, in order to assess the dye uptake.

3. Results

Results from scanning 167f34 Polyester yarns textured at the University of Manchester

Figures 1 and 2 show the scanning results of a textured 167f34 polyester yarn, made at 800, 1000 and 1200 m/min., bulk were 46 % for both 800 and 1000 m/min though at 1200 m/min bulk became 39%. The yarn tenacity was around 2.9 and 3.2 cN/dctex and elongation was around 20 %. No filament damage could be seen from the S.E.M results. When a 167f34 Polyester Yarn was textured at 800, 1000 and 1200 m/min with the water twister and a contact heater, bulk and physical properties were marginally better. In addition, when a friction disc replaced the water twister better bulk results were obtained specially at low speeds (800 m/min), where bulk was 48%.

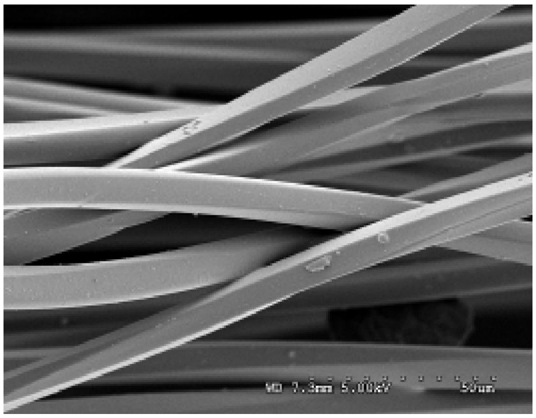

Figure 1: 167f34 yarns textured at 800 m/min, using steam heater and the water cooler/twister

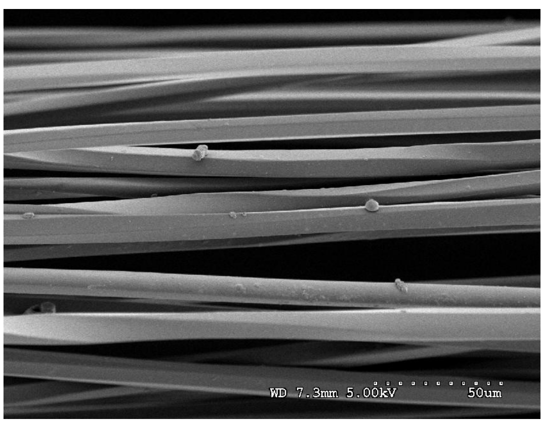

Figure 2: 167f34 yarns textured at 1000 m/min, using steam heater and the water cooler/twister

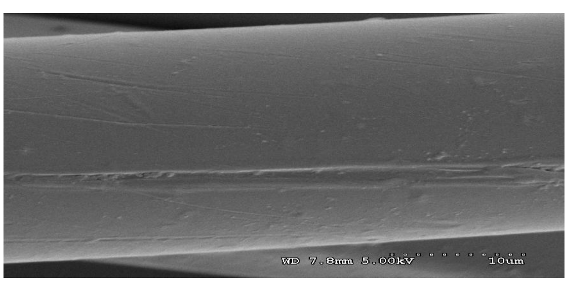

Figure. 3: 167f34 textured at 1000 m/min using a friction disc and a contact heater

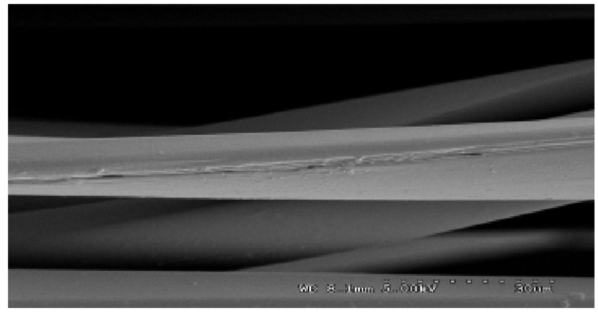

Figure 4: 167f34 textured at 1200 m/min using the water twister and a contact heater

Figure 3 shows the damage caused as a result of high strain applied to the filaments. That damage was regularly repeated in the filaments but at long intervals. At 1200 m/min the damage occurrence was repeated at shorter intervals in a more severe form as shown in figure 4.

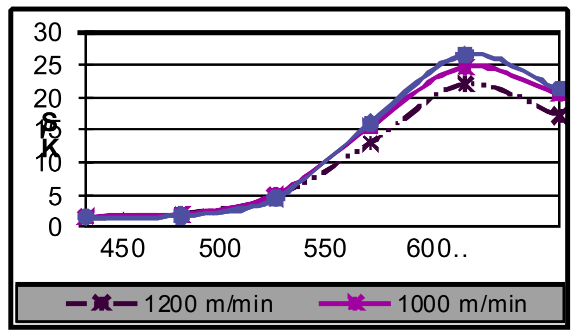

Figure 5: Dyeing results achieved at 800, 1000 and 1200 m/min speed texturing Using steam heater

According to the dyeing results achieved when using a steam heater, the best colour strength was achieved at low speeds. That is due to the effect of steam as a heater **(2)**. It could be noticed that twist insertion (made by water twisting jet in the form of water pressure) combined with good amount of heat would produce good textured yarns with less fatigue or yarn damage. That was clear if compared to the similar yarns textured with friction disc and contact heater, such results were illustrated in figure 6.

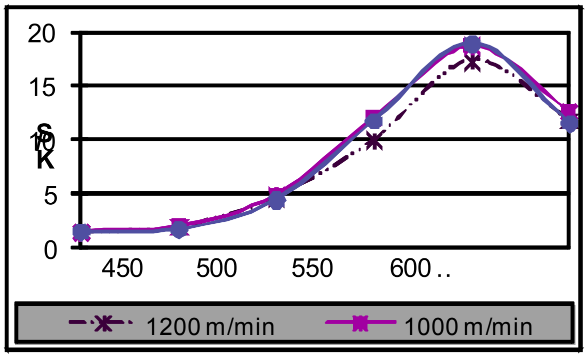

Figure 6: Dyeing results achieved at 800, 1000 and 1200 m/min speed texturing Using contact heater

From figure 6 colour strength results showed that yarns textured at 800 and 1000 m/min were of similar k/s results possibly due to the effect of using a contact heater. It is well known that a contact heater transfer heat energy by direct contact. That could have affected the yarns running at low speeds if compared to a steam heater. In addition a friction disc would have a firmer grip on the yarn which would be the reason for yarn strain and damage seen in figures 3 and 4.

High Speed Texturing

167f34 yarns textured at 1500, 1800 and 2000 m/min, with the water cooler/twister and the steam heater, were scanned, the results obtained can be seen in figures 7 – 9.

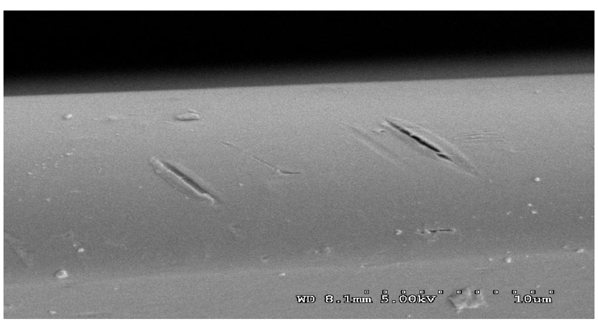

Figure 7: 167f34 textured at 1500 m/min using the steam heater

The cracks seen in figure 7 show the influence of increasing the water pressure, which in turn caused a relative increase in the yarn tension. The cracks seen are usually obtained before a real damage would occur to the filaments, which could be a sign of high strain and a notice before filaments break. It is expected these cracks would certainly affect the tensile properties of the yarn.

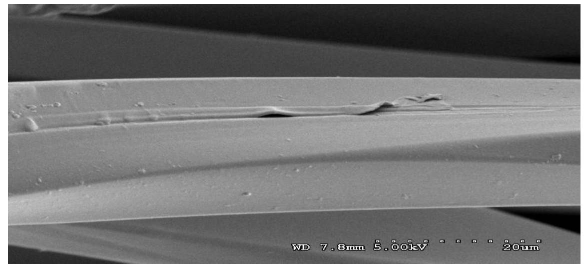

Figure 8: 167f34 textured at 1800 m/min using the steam heater

Figure 8 shows the damage and cracks seen in the yarn textured at 1800 m/min. The detected damage was seen to repeat regularly at 1800 and 2000 m/min. Figure 9 shows another filament damage detected at 2000 m/min. These cracks and filaments damage could be the reason behind the significant decrease of the yarn tensile properties at high speeds.

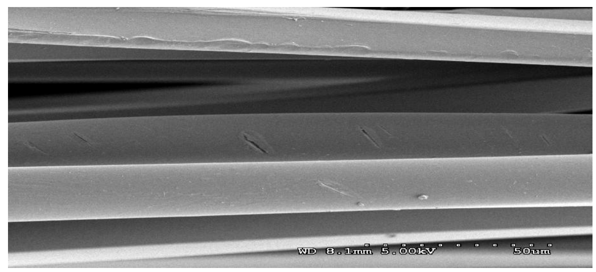

Figure 9: 167f34 textured at 2000 m/min using the steam heater

Figure 10 is a photograph of a scanned 167f34 yarn, textured at 1500 m/min and 150 bar water pressure. Figure 11 is another photograph of a similar yarn but textured at 800 m/min and 90 bar. The individual filaments in the latest figure, appears to be highly twisted than filaments in Figure 10, as expected. In both the photographs, the individual filaments appear to be more twisted compared to figure 9. The low twist levels could possibly be due to the high yarn tension at high speeds as a result of the water pressure increase. Significant low twist level could be the reason for lower bulk levels produced at high speeds.

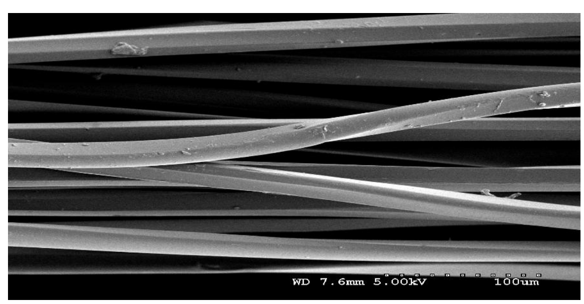

Figure 10: Textured 167f34 yarn at 1500m/min

It was thought that a water twister could only twist a bunch of yarns. Though, from figure 11 it appeared that the water twister was capable of twisting individual filaments. It is an indication of its high twisting efficiency, which could the reason for higher bulk levels achieved relative to friction disc.

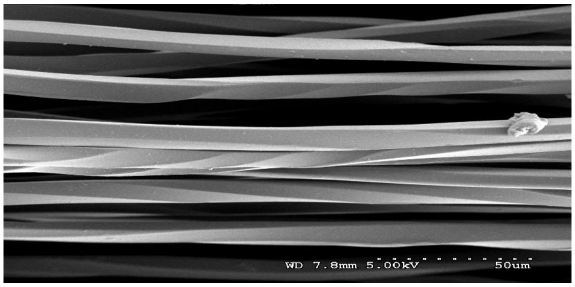

Figure 11: Textured 167f34 yarn at 800 m/min

At high speeds the k/s proved to be lower than low speeds, though it was never possible to texture such yarns with a contact heater or a friction disc. The damage and the yarn strain showed in scanning results photograph were due to the high twist levels inserted and the low heat energy transferred if compared to low speeds. That reason would be the reason behind lower bulk and k/s results achieved.

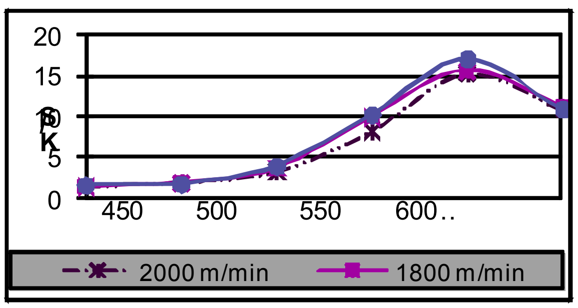

Figure 12: Yarns textured at high speeds using a steam jet

Twist level effect

The process made at the University of Manchester mainly depends on both amount of heat transferred to the textured yarn and the amount of twist inserted in the running yarn. Figures 13 and 14 express the role of twist insertion in such texturing process.

Some cracks or filaments damages were detected in the scanned 167f34 yarns textured at 800m/min speeds at 90 bar. The scans showed that the damage was regularly occurring. It is expected that due to the use of high water pressures, yarn tension increased perhaps causing filament damage due to the friction force applied.

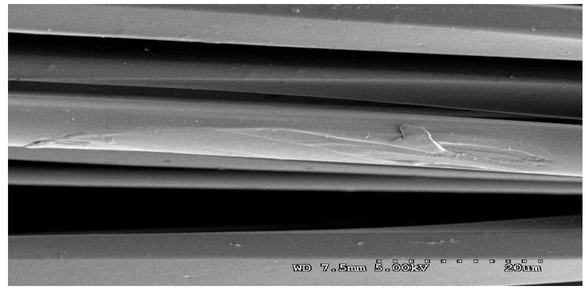

Figure 13: Some detected damage in 167f34 textured with at 800 m/min

Figure 14 illustrates the twist levels in a 167f34 polyester yarn textured at 800 m/min. Clearly, the individual filaments are not twisted as in figure 13, when 80 bar were used at the same speed.

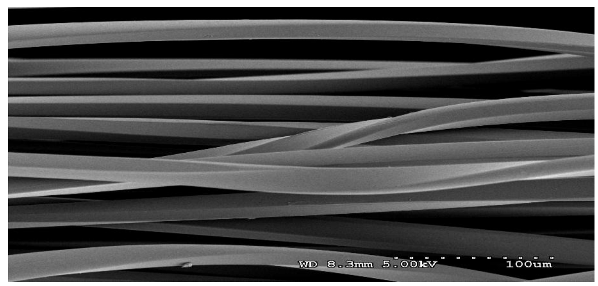

Figure 14: Good textured yarn produced at 800m/min with a perfect water pressure 80 bar

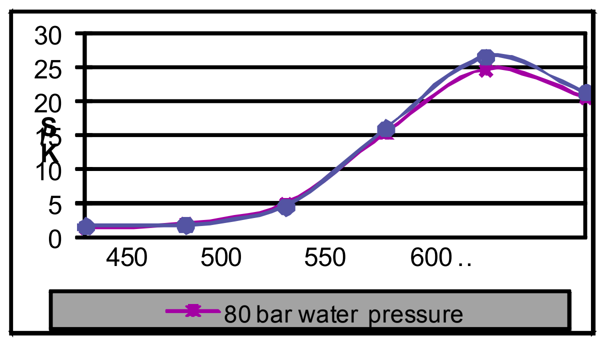

Figure 15: Yarns textured at 800 /min using 80 and 90 bar water pressure

According to the achieved results it became clear that twist levels do have a direct effect on dyeing properties of the yarn processed. Where twist level if inserted while good heat energy transferred to the running yarn would produce new inner spaces that would guarantee good dyeing properties.

4. Discussion

From the S.E.M. results there appeared to be some cracks, which appeared to be due to twist, as in figure 4. In other scanned yarns there were some filaments damage, which was probably due to the yarn friction, as in Fig. 5. Both the damage and the cracks ended in some weak points, which concentrated the tensions at these points resulting in lowering the yarn tenacity.

Hearle (4) discussed damages and cracks occurring in yarns as a result of applied mechanical force. In his book, he concluded not unreasonably that whatever the reason for the crack or the damage, which he named as fiber fatigue, would end up in decreasing the tensile property of the yarns, with no real effect on bulk. Similarly was the case with dyeing properties where yarn fatigue or damage did not have a real effect on dyeing properties. Though, dyeing properties were affected by twist insertion and heat energy transferred to the running yarn. It is known that heat helps release the inner forces and the twist inserted help create new inner properties which would improve the dyeing properties. That was clear from dyeing properties results achieved and illustrated in figures. 5, 6, 12 and 15.

The filament cracks seen in figure 4, can be classified as biaxial rotation fatigue, as described by Hearle. Whether the filament would completely split or remain as one part depends on the amount of twist inserted and the diameter of the filament in use. That was the case, with some of the filaments scanned where these cracks were seen at regular intervals, which could be correlated, to the amount of twist inserted in the yarn. Figs 1 and 3 illustrated the twist inserted in the yarns, which is believed to be efficient enough to severely twist the individual filaments.

It is understood the shear fatigue, similar to figure 5, could be caused by friction of filament-to-filament or of filaments to a hard body. With the scanned yarn it is probable that the shear fatigue, in these cases, is probably caused by filament friction with the guides or the aluminum jet body. Fig. 3 also shows how individual filaments can leave stamps on each other when they get in contact with each other, possibly in certain occasions causing some damage.

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