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Influence of Ballooning on Textured Yarns Finishing properties

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Abstract: At the University of Manchester, a new texturing machine was designed and set to produce textured both Polyester and Polyamide yarns. The purposely built machine was a new method for producing bulk textured yarns using false twist process. Compared to commercial machines, friction disc been replaced by a water jet to apply twist. Steam heater also is used to maintain the needed heat energy to allow high speed texturing. Ballooning is been part of such process, especially at high speeds. Examining such physical phenomena happening with the processed yarn showed it can influence the physical properties of the finished produced polyester yarn.
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1. Introduction:

At the University of Manchester a Yarn textured machine was developed using water jet that can replace a friction disc (1). The developed Machine designed by Prof. P. W. Foster (2-6), was 1.2 meter long false twisting area, clearly shorter than any of the commercial texturing machines. The designed machine can produce Polyester yarns at speeds like 1500 and 2000 m/min which are double the commercial speeds (7). Figures 1 describes the machine parts.

It is composed of feed rollers 0.7 m steam heater, 0.5 m water cooler which includes the water jet shown in Fig. 2. A delivery rollers and Winding unit are the remaining part of the machine.

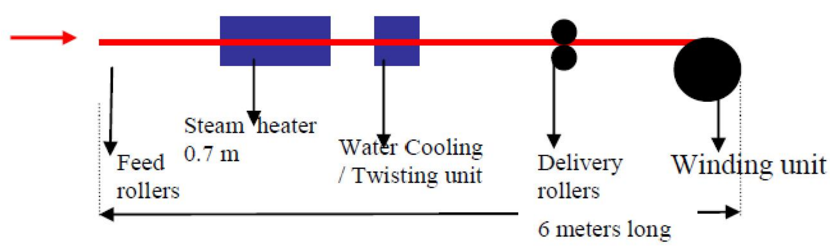

Fig. 1: False twist texturing thread path Using contact heater and water twisting jet

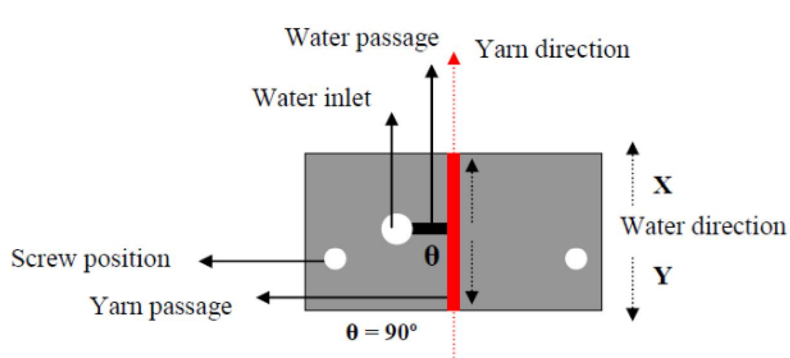

Fig. 2: 90° water jet

2. Experimental:

Bulkof the Produced POY textured 167f136 polyester yarns was measured according to Hoechst test method (9). It measures shrinkage of textured yarns in hot air. A one metre skein of 33 wraps is loaded with 1.0 gm and the initial length L1 is measured. After immersion in a 130ºC hot air oven for 5 min. then followed by 5 min. cooling, L2 is then measured after loading the skein with 1.0 kg. the bulk of the yarn is defined by the formula.

L2-L1/L1x100

Tensile properties were also measured on an Instron computerised machine for the same comparison purposes (9). The effect of ballooning is been examined and monitored. It can have a direct effect on the finished yarn properties produced (10). It was thought desirable to show the current guides position on the machine when texturing 167f136. As shown in Fig. 3, the distance between the heater and cooler is 20 cm. There are four yarn guides used mainly to adjust the yarn tension and to direct the thread through the heater and cooler.

The yarn guide A (Pigtail shape), is placed at the entrance of the water-cooling unit. The yarn guide B (Wheel shape), is placed at the exit of the steam heater chamber. Some experiments investigating altering the position of these guides were designed. The first experiment examined the current guides positions, where distance between guide A and the cooler is 2.5 cm. The second experiment examined moving A downwards. In this way A will be pressing the yarn vertically downwards. The third experiment examined decreasing the distance between the cooler and A by mean of reducing the distance between the cooler and the guide from 2.5 to 0.5 cm. The texturing conditions were as follow.

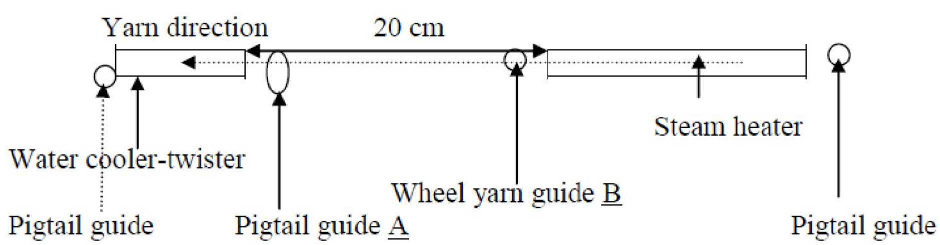

Fig. 3: Yarn guides on the university texturing machine

With such machine set the work was done producing POY 167f136 textured polyester yarns at the following conditions.

- **Speeds** **800 m/min.**
- **Water pressure** **85 bar**
- **Draw ratio** **1.63**
- ***B* jet, 60º water entrance.**
- **Steam temperature** **230°C.**

The yarn ran for 30 min. before being wound up. Bulk and twist levels were measured and are shown in Table.1. From visual observation no broken filaments were detected in any of the produced yarns.

3. Results and Discussion

Table 1: ***Effect on ballooning as a result of repositioning yarn guides on texturing 167f136***

Experiment number	**Guides place and visual observations**	**Bulk %**	**Tenacity cN/dtex**	**Elongation %**	**Twist tpm**
1	Straight path, 2.5 cm distance between A and the water twister **Ballooning was seen in the space between the heater and the cooler**	12	2.3	18.3	2070
2	Guide A pressing on the thread line **No ballooning**	4	2.0	16.9	1760
3	Guide A moved towards the cooler 0.5 cm **Bigger size Ballooning**	13	2.1	17.6	2190

As shown in Table 1, the degree of ballooning appears to affect the efficiency of the process. The bigger the balloon the higher the bulk achieved. The reason for the experimental correlation is unclear. It could be that the ballooning upstream leads to better heat transfer in the steam heater. Visual observations would suggest this is unlikely, because ballooning upstream of guide B is not visible to the naked eye. Alternatively ballooning downstream could enable the water twister to hold the thread more effectively and so impart more twist. The measured twist results may need to be treated cautiously, as the act of catching the yarn for twist measurement may destroy the ballooning. However, if the hypothesis of water twisting being non-effective with a ballooning yarn were true, then a question of how to increase ballooning would arise.

The following experiments were carried out in order to get a better picture of the influence of guide position. In experiment 4, it was proposed to use three guides in the space between the heater and the cooler. A was 0.5 cm away from the cooler and B was 0.5 cm away from the heater. Guide D was located 10 cm away from both the heater and the cooler in order to make it exactly in the middle.

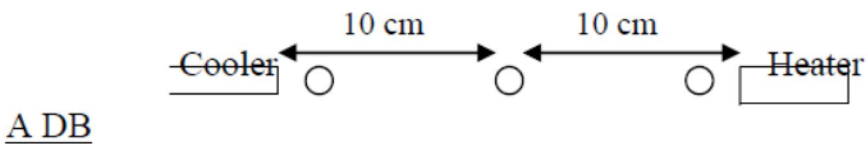

Fig. 4: ***Yarn guides repositioning on the university texturing machine***

In experiment 5 two yarn guides were again used, though this time guide A was dropped. Guides B and D were used where the distances from the heater were the same as in experiment 4.

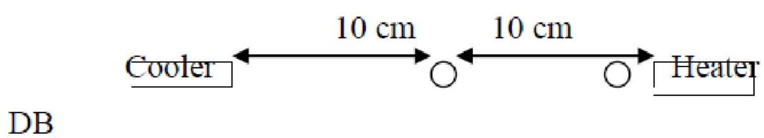

Fig. 5: Yarn guides repositioning on the university texturing machine

In experiment 6, the distance between D and the heater was altered to become 12 cm instead of 10 cm.

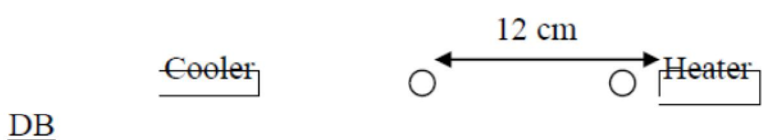

Fig. 6: ***Yarn guides repositioning on the university texturing machine***

Experiment 7 was designed to examine the possibility of producing textured yarns with only one yarn guide present at the exit of the heater (B). If it was possible, then it may be useful to try producing textured yarn while using no yarn guides as will be shown in Experiment 8.

In experiments 1 – 8 tension in threadline was assessed visually. In experiment 8, the yarn being textured was under lower tension compared to experiments 2 and 3. Overall the balloon shape, in experiment 8, was unstable. Tight spots were observed in textured yarns, which could be due to low tension.

From the results the length of balloon could be playing a big role. Perhaps if ballooning were extended from the heater to the cooler it would benefit the textured yarn. The other important aspect of ballooning is its size. According to observations, ballooning of bigger size resulted in better bulk levels.

II.1. Influence of Twist on Ballooning

It was thought that identifying the character of ballooning would benefit our understanding of the process. Accordingly, 167f136 polyester yarn was textured under the following conditions.

- Speeds	**800 m/min.**
- Water pressure	**85, 90 and 100 bar**
- Draw ratio	**1.63**
- *B* jet, 60º water entrance.	
- Steam temperature	**230°C.**

Table 2: Bulk and yarn property results achieved when no, two and three yarn guides were used

Experiment number	Guides place and visual observations	Bulk %	Tenacity cN/dtex	Elongation %	Twist tpm
4	Three yarn guides A, D and B Ballooning appears at both sides of middle guide **Relatively small size balloon**	5	2.0	15.6	1800
5	Two yarn guides D and B **Ballooning was recognised in the middle and at the heater outlet** **Bigger than experiment 4**	6	2.1	16.6	1893
6	Two yarn guides D and B **Smaller balloon size than experiment 3**	4	2.0	15.9	1788
7	One yarn guide B at heater outlet **No ballooning**	5	2.1	17.6	1850
8	No yarn guides used **Balloon size smaller than experiment 2 and 3**	8	2.0	16.2	1936

Table 3: ***Water pressure influence on ballooning***

Experiment number	Water pressure in bar	Bulk %	Tenacity cN/dtex	Elongation %	Twist tpm
9	85	6	2.0	16.5	1923
10	90	7	2.1	17.2	1940
11	100	10	2.0	16.9	1995

It appears that an increase in water pressure leads to an increase in bulk levels. As expected this could be due to increase in twist inserted in the yarn as a result of increasing water pressure. However, from visual observation with increasing water pressures yarn tension increased in response. When yarn was textured using 85 bar the ballooning size was variable. It varied between 0.7 and 1.0 cm in size. By increasing the water pressure to 90 bar it stopped varying and stabilised to become 1.0 cm during the period of production. When the water pressure became 100 bar, a relative increase in its size to 1.2 cm could be seen.

II.2. Influence of Steam inside the Heater on Ballooning

In another attempt to investigate the influence of steam on the processed yarn, 167f136 was textured under the following conditions.

- **Speeds** **800 m/min.**
- **Water pressure** **85 bar**
- **Draw ratio** **1.63**
- ***B_{w1}*** **jet, 60º water entrance.**
- **Steam temperature** **230°C.**

Steam was stopped from flowing inside the steam chamber. It was observed that balloon size decreased in response to steam flow decrease. When there was no steam flowing inside the chamber yarn was seen vibrating heavily, and a very unstable thread path was detected. That can be a result of stopping the counter current steam flow inside the chamber, which seems to be acting as a physical force. These are all predictions and more work needs to be done in that field in order to understand the phenomena.

167f136 yarn was textured and a package was made within five minutes after closing the steam pipes. This ensured the temperature inside the chamber was 230ºC. The produced yarn had a 10 % bulk, twist and yarn property results are shown in Table 4.

From the results achieved, decreasing the steam decreased both balloon size and bulk levels. It could be possible that steam flow might be affecting the twist levels as well. However, at this stage of the work the decrease in bulk is most probably due to the decrease in heat energy transferred to the yarn due to stopping the steam flow.

Another hypothesis, describing the relationship between steam and ballooning (steam act as a physical force), could be that flowing steam when it comes in contact with a moving yarn may be increasing the yarn tension. The idea could be similar to that when water puts twist in processed yarn resulting in a certain amount of tension. Increasing water pressure when texturing yarns at constant speed seems to lead to bigger balloon size and to better bulk. In order to prove the idea, the amount of pressurised steam inside the steam chamber was varied in a series of experiments. It was expected that bulk would increase as more heat energy was transferred to the yarn and will be accompanied by a bigger balloon size.

167f136 POY polyester yarn was textured under the following conditions.

- Speeds 800 m/min.
- Water pressure 85 bar
- Draw ratio 1.63
- B_{w1}, 60º water entrance.
- Steam temperature 230°C.
- Steam pressure No steam, 1.5, 2, 3 bar

Table 4: ***Steam pressure influence on ballooning***

Experiment number	Steam pressure	Bulk %	Tenacity CN/dtex	Elongation %	Twist tpm
12	No steam	10	2.0	16.8	2190
13	1.5	12	2.2	17.4	2190
14	2	13	2.1	17.6	2190
15	3	13	2.1	16.9	2190

Visual observations showed that balloon size was virtually the same when there was steam flowing inside the steam chamber. It was almost 0.9 to 1.0 cm width. Yet when the steam flow was stopped and there was no steam inside the chamber, the temperature was 230ºC, ballooning could not be seen.

It would appear that an increase in the steam inside the heating chamber leads to an increase in bulk levels. However, such a conclusion is based on relatively small changes in the levels of bulk.

4. Conclusion

It needs to be born in minds that yarn guides may act as twist stops as well as increasing the yarn tension. This appeared in experiment 2, where low bulk was achieved as a result of using a pressing guide. In experiment 6, the decrease in balloon size could be another aspect of high yarn tensions. On the other hand when yarn is free and under no tension it can lead to other undesired effects that cause tight spots and broken filaments. Increase in surging occurrence would be more likely in that case. It is also assumed that due to that yarn instability twist insertion would be inconsistent and would vary from one place to another along the yarn. This could be the reason behind seeing different balloon size while texturing this yarn with no guides.

There would appear to be a relationship of sorts between ballooning and bulk levels achieved. This relationship seems to be an indirect relationship suggesting that ballooning is a phenomenon that describes the yarn thread path instability. To control it a certain amount of tension should be added to the thread during texturing. If that tension exceeds a certain level ballooning becomes suppressed. This could be the reason the water jet at the University is seen working as a slipping clutch at certain occasions when water pressure is increased.

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