INVESTIGATION OF STAPLE FIBRE TO FIBRE COHESION BY TENSILE TEST OF WEB

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Abstract

Friction and cohesion forces have great influence on the processability of a fibre as well as causing fibre breakage during mechanical recycling of textiles. Through pre-treatment of the fibres or textiles with a lubricant, the friction and cohesion forces can be decreased. However, the measurement of friction coefficient on staple fibres is challenging and needs special machinery. With the development of a new test method of the fibre cohesion force we can measure the effect of a treatment on fibre cohesion, predict the spinnability of a fibre as well as see the effect of a lubricant on the tearing efficiency in textile mechanical recycling.

Introduction

Fibre to fibre cohesion is an important property for staple fibres, from the spinning process to finished fabric. In the fabric, it influences the strength of the textile as well as hand feeling and the drapability. In spinning, fibre to fibre friction and cohesion needs to be controlled in all steps; from carding, drafting, roving and spinning. As well as influencing textile manufacturing processes, inter-fibre friction and cohesion can cause heat to build up and breakage of fibres in the carding process [1] and textile tearing process during mechanical recycling. To reach suitable fibre cohesion for a controlled textile process or efficient tearing of textiles, fibres can be treated with finishing agents. The choice of finishing agent and loading of the same are often drawn from experience.

Fibre-fibre cohesion is defined as the interaction between fibres [1] or as the force required to separate fibres [2]. Fibre cohesion is mainly influenced by the fibre surface morphology and fibre crimp. Further, long fibres have higher surface area between fibres which increase the influence of inter-fibre cohesion.

Measurement of the coefficient of friction between fibres requires the normal load to be known, which makes a measurement on short-staple fibres challenging. There have been some advances on the measurement of friction coefficient between staple fibres, however, the methods involve special or even custom-built machinery [3]. Often, fibre cohesion is used as an indirect measurement of fibre friction [1]. The work at hand has investigated a simple method to measure fibre-fibre cohesion for staple fibres using a tensile tester. This method can be used to analyse the effect of e.g. a finishing agent or treatment on a specific fibre.

Experimental

The test method was performed on polyester staple fibres with and without finishing treatment. Treatment of fibres was made with lubricant polyethylene glycol (PEG) with average molar weight 10000, supplied by Merck. The lubricant was added in different fibre

weight percentage, as seen in Table 1. After a first carding, the treatment was added using a high pressure spray gun, after which the fibres were dried in room temperature for 2 hours. Subsequently the fibres were carded twice and then conditioned in 65% humidity and 20°C for minimum 24 hours.

Table 1 Fibre and lubricant concentration tested.

Fibre	**PEG 10000 (wt.%)**
PES 1.3 dtex/38mm	0.0, 0.25, 0.50, 0.75, 1.0

The specimens were cut to size just before testing, 9 samples were taken from each carded web. The specimens were also weighted prior to testing for normalization of the test results. The fibre web specimens were tested in a 3 kN Mesdan lab tensile tester equipped with a 100 N load cell and pneumatic yarn grips. Gauge length was 75 mm and deformation rate was 300 mm/min.

The tensile test results were analysed and cohesion force was extracted from the maximum force. Further, software MiniTab 18 was used to calculate Tukey's simultaneous test with 95% confidence interval on the result to show if there was any statistical significance between the treatments.

Results

The result of tensile testing of carded webs with and without treatment is shown in Figure 1. With treatment of PEG10000 the cohesion force between fibres seems to decrease. Further, the Tukey simultaneous test showed that treatment had a significant effect on the cohesion force, while the loading of treatment didn't show a significant effect, see Figure 2. The concentrations 0.5 and 0.75 of PEG 10000 showed largest decrease in cohesion force, mean values were more than 30% lower than untreated polyester.

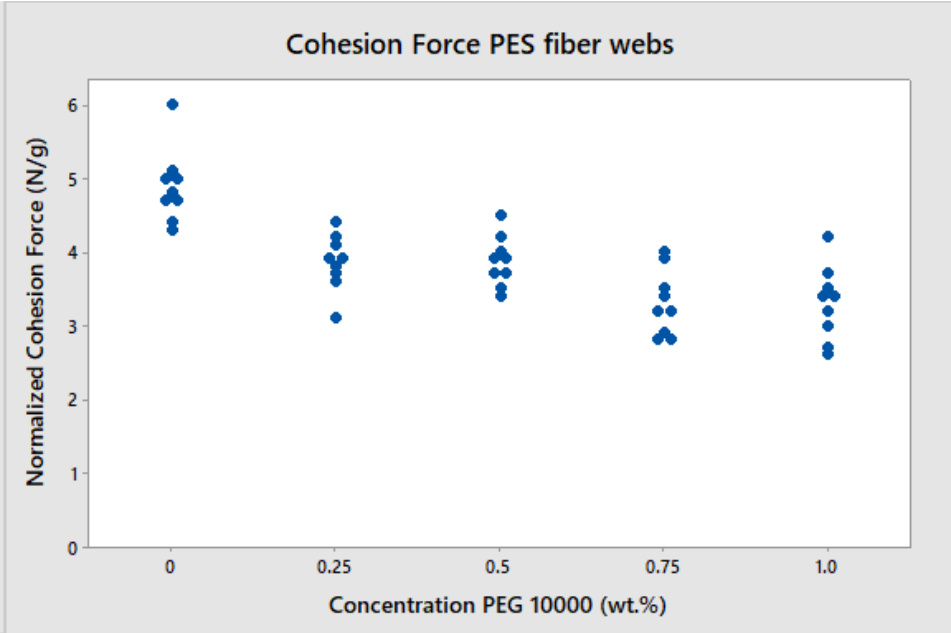

Figure 1 Tensile test result of carded webs.

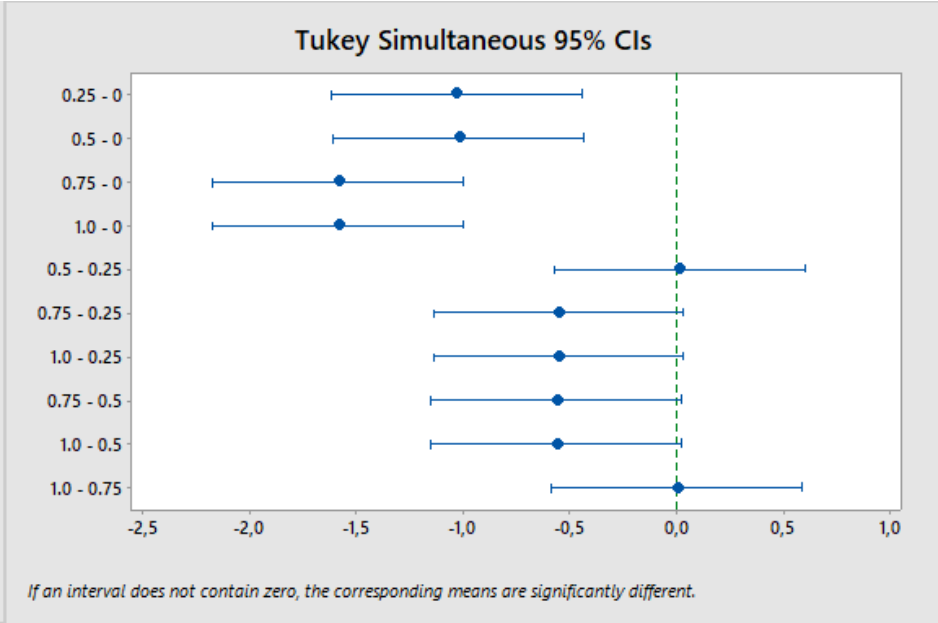

Figure 2 Statistical calculation of Tukey Simultaneous test.

Discussion and Conclusion

The high friction and cohesion forces between fibres during carding and mechanical recycling tearing process damages fibres and causes fibres to break. With the use of lubricant pre-treatment it may be possible to lower this effect. By measurement of inter-fibre cohesion force on a carded web, it is possible to find an appropriate lubricant for a specific fibre as well as the optimum loading of the same. Further, the result can estimate the spinnability of a fibre or the recyclability of a textile by mechanical recycling.

The result showed that polyethylene glycol 10000 made a significant decrease (30%) of the inter-fibre cohesion on polyester fibres.

Acknowledgements

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