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Research into the Mechanical Properties of Drawn Filament Sewing Thread

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Abstract

This study presents research into drawing conditions' influences on the mechanical properties of Polyethylene Terephthalate (PET) filament sewing thread. The thread was drawn by varying the treatment temperature and contact time on the first heated cylinder (T1, n1) and on the second heated cylinder (T2, n2), as well as by using different draw ratios (λ). The critical treatment conditions were found using the drawing process ($T1_4$=130 °C, $n1_5$=13 turns, λ_5=1.25, $T2_4$=220 °C, $n2_3$=9 turns) and the greatest improvement in the mechanical properties, respectively. Deterioration in the threads' mechanical properties was observed above the critical treatment conditions. The mechanical properties of the drawn threads were investigated under critical treatment conditions. It was found that the heat treatment conditions on the second cylinder, i.e. the treatment temperature and the contact time had the greatest influences on the improvement of the elastic modulus (D4=7.41 cN/tex, E3=7.40 cN/tex) and the breaking extension (D4=12.13%, E3=12.12%), when compared with the treatment temperature and the contact time on the first cylinder and the draw ratio between the heated cylinders. The maximal value of the breaking tenacity showed threads that were drawn at the critical draw ratio (C5=61.81 cN/tex) and the contact time of the thread with the second heated cylinder (E3=61.59 cN/tex). Simultaneously, the treatment conditions on the second cylinder affected the maximum reduction of the thread's linear density (D4=91.33 tex, E3=91.47 tex) and twist (D4=163 turns/m, E3=180 turns/m). The greatest improvement in the tension at the yield point achieved threads that were drawn at the critical draw ratio (C5=9.27 cN/tex) and the heat-treatment temperature on the second cylinder (D4=9.27 cN/tex).

Keywords: PET Filament Sewing Thread; Drawing; Treatment Conditions; Mechanical Properties

1 Introduction

During the sewing process, high tensile and heat load of the thread arise that cause deformation of the sewing thread [1-8]. The behaviour of a sewing thread during the sewing process directly influences the assurance of sewing process reliability. Thread load during the sewing process particularly influences the mechanical properties of the thread, which depend on filaments' inherent properties and on the complex arrangements of filaments within the thread's construction [4].

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Deformations are reflected by any structural changes in the thread's twisted fibres and, thereby, changes arise in the mechanical properties of the sewing threads. Perfect interaction between a thread's tenacity, extension, rubbing resistance and gliding performance provides a perfect sewing performance.

The sewing of automotive seat covers and airbags requires high-quality sewing threads. Namely, high sewing speed and thick multiple layers of the textile material cause higher thread loading when compared to the sewing of garments. Therefore, the automotive industry makes high-quality demands regarding the tenacity, extension and friction properties of their sewing threads. For this purpose, the drawing process of a commercial PET filament sewing thread for the automotive industry was carried out at an elevated temperature in order to improve the mechanical properties. For producing the drawn sewing thread it is useful to know the effect of the drawing conditions on the mechanical properties of the thread.

Studies on the drawing and heat treatments of PET filaments or PET yarns have been the subject of intense research over previous years. It is well-known that those important drawing conditions that influence any improvement in a PET yarn's structure are the winding speed, temperature, and draw ratio [9, 10]. Heat treatment is a time, temperature, and stress-controlled process. When drawing at an elevated temperature, the macromolecular motions are influenced according to the tensile force and heat treatment conditions, thus changing the filaments' mechanical properties [11, 12]. However, the presented studies did not focus on the drawing and heat treatment of the sewing thread.

In earlier research, the structure-properties relationship of the PET filament sewing thread after drawing at an elevated temperature was investigated using different draw ratios (1.05, 1.10, 1.15, 1.20 and 1.25) [13]. Dependence was confirmed between the draw ratio, structural parameters, and mechanical properties. A higher draw ratio increases the birefringence, amorphous orientation, and the degree of crystallinity, as well as breaking tenacity, elastic modulus, the tension of the thread at the yield point, and thus decreases the breaking extension. In addition, an investigation into differently-treated PET filament sewing threads was carried out by varying the treatment temperature and contact time on the second heated cylinder to a constant draw ratio, and the treatment conditions to those on the first heated cylinder. [14]. Using the drawing process, higher temperature and contact time up to the critical values (T_2=220 °C, n_2=9 turns) changed the structural parameters and, consequently, any modifications influencing changes in the threads' mechanical properties. Deterioration in the threads' structural parameters and mechanical properties was observed above the critical treatment conditions.

During this research, investigations were performed into the mechanical properties of the drawn PET filament threads under critical treatment conditions on the first and second heated cylinders, as well as at the critical draw ratio. The main aim of this research was to investigate any effects by the critical treatment conditions during the drawing process that may improve the PET filament threads' mechanical properties.

2 Experimental

2.1 Material and Sample Preparation

A PET filament sewing thread was used for this research. This thread was produced from