
# Analysis of the Properties of Air-textured Sewing Threads

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**Abstract**
*The aim of this research was to assess how certain mechanical characteristics of sewing threads varied while different parameters were changed during the manufacturing process. Air-textured technical sewing threads are a relatively new product on the market. The applications of the end product could be selected depending on the mechanical characteristics of the product during usage. Some applications require very high tenacity, others require very low friction forces during the sewing process. Air texturing appears to be a technology which can accommodate the manufacturing possibilities of threads with different end characteristics and also allow the usage of different types of fibre filaments. Two types of yarns were manufactured during this research: high-tenacity PES yarns were used in both core and sheath elements in one case; in the other case, the same high-tenacity PES yarns were used in the core while Polytetrafluorethylene (PTFE) was used in the sheath elements. The threads were manufactured in the Department of Textile Technology at Kaunas University of Technology, using a Stahle Eltex air-texturing machine and a Heberlein HemaJet texturing nozzle. In addition, tensile and friction tests were performed during the research. Different manufacturing parameters were changed during air-texturing, including air pressure and overfeeds of effect & core yarn. The results clearly showed the good mechanical characteristics of the sewing threads manufactured.*

**Key words:** *air-texturing, sewing thread, polytetrafluorethylene, high tenacity, mechanical characteristics, manufacturing parameters.*

## Introduction

Sewing technology has entered the new millennium with its familiar needs, and is waiting for new solutions from textile technology. Sewing threads have been used for many centuries, and are used in the same manner even now, but demand for sewing threads is another matter. Polyester yarn and multifilament threads have almost replaced cotton sewing threads in the market [1]. The main reason for the increasing demand for polyester threads is their higher breaking force, low degree of shrinkage while washing, and good wearing properties in comparison to cotton threads. Polyester sewing threads have one negative feature: at high sewing speeds and high friction with the metal parts of a sewing machine, these threads heat up and start melting at ~250°C.

Texturing is the process where filaments are entangled by various methods which impart softness and bulk to the product [2]. Loops made in this manner may be fixed by thermo-setting depending on the origin of the raw material processed, i.e. if a thermoplastic polymer is under texturing. Non-thermoplastic polymers are not fixed by thermo-setting. For each polymer, an adequate thermo-setting temperature must be selected [3].

Due to their high strength, good chemical properties, acceptable elasticity and good dye fastness, polyester multifilament yarns are considered a perfect raw material for sewing threads. Due to its even surface and circular cross-section, polyester is more lustrous than natural threads. Irrespective of their origin and manufacture method, all sewing threads must meet certain requirements. In order to obtain high sewing efficiency and good end-quality of articles, it is necessary to ensure low breakage of sewing threads and suitable stitch formation. Textured polyester threads are the most economical option available today, and their introduction into the clothing industry is one of the best ways of reducing production costs. Air-jet textured threads are produced by feeding polyester yarns through a turbulent region of compressed air [4]. The yarn is opened, loops formed and are then closed. The loops are locked inside and on the surface by applying heat under tension. Such a thread is often referred to as an entangled thread. Air-jet texturing enables the production of sufficiently thick sewing threads which ensure the stability of the seams. Due to their circular cross-sections and smooth surface, polyester multifilament sewing threads are more lustrous than those from natural yarns. Polyester is the best fibre for most sewing thread applications, as it costs little, shows high strength, good chemical properties, favourable elastic characteristics and good dye fastness [1].

One of the most desired properties is strength, which depends on the raw material, processing (finishing), manufacture method, and linear density of the threads. Among traditional sewing threads, polyamide and polyester multifilament sewing threads have the highest strength. The strength of a multifilament sewing thread is always higher when compared to the yarn of the same fibre [5].

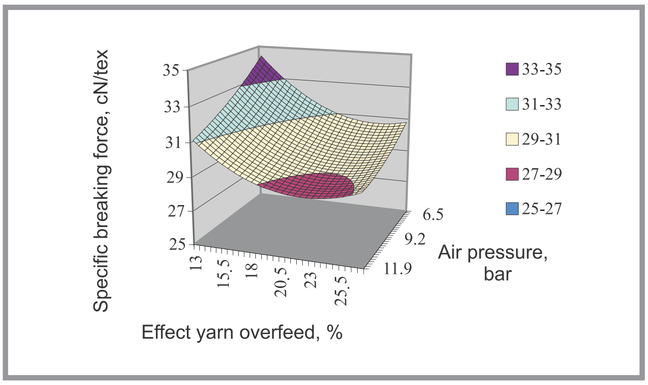


*Figure 1. Variation of tenacity (specific breaking force) when changing air pressure and overfeed of the effect component PES/PES.*

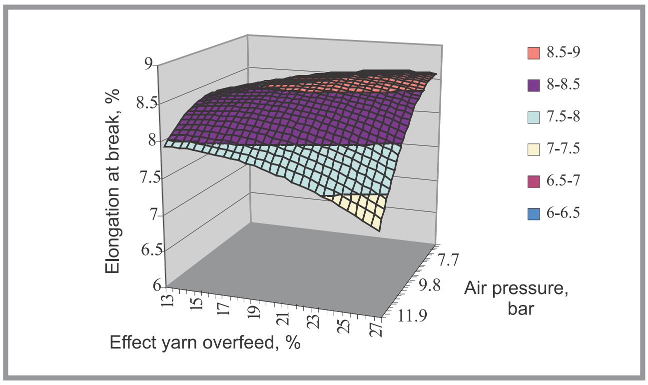


*Figure 2. Variation of elongation at break when changing air pressure and overfeed of the effect component PES/PES.*

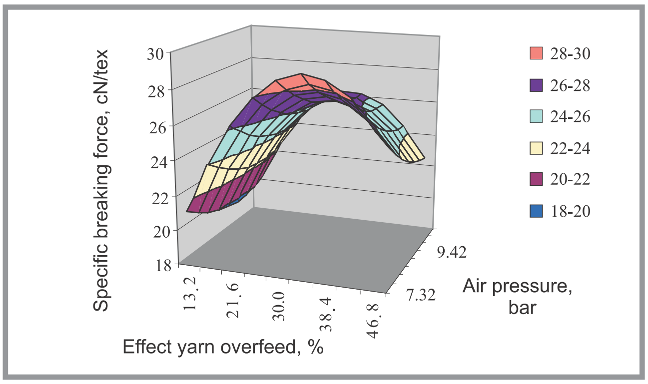


*Figure 3. Variation of tenacity (specific breaking force) when changing air pressure and overfeed of the effect component PES/PTFE.*

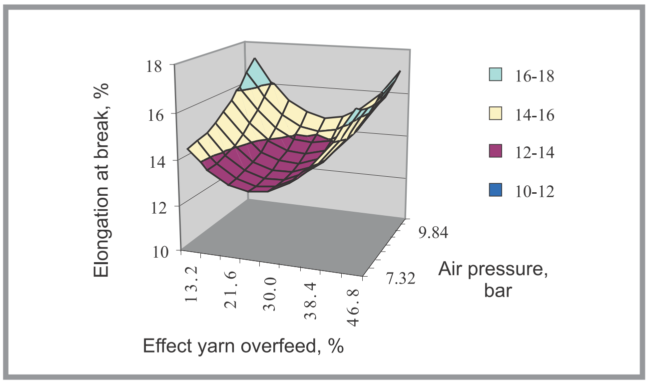


*Figure 4. Variation of elongation at break when changing air pressure and overfeed of the effect component PES/PTFE.*

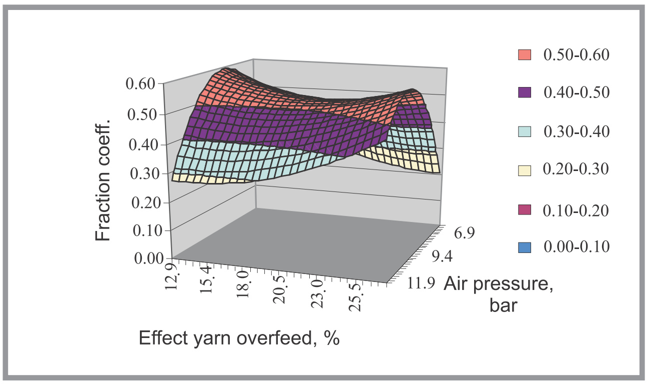


*Figure 5. Variation of friction coefficient when changing air pressure and overfeed of the effect component. PES/PES yarns without heat setting.*

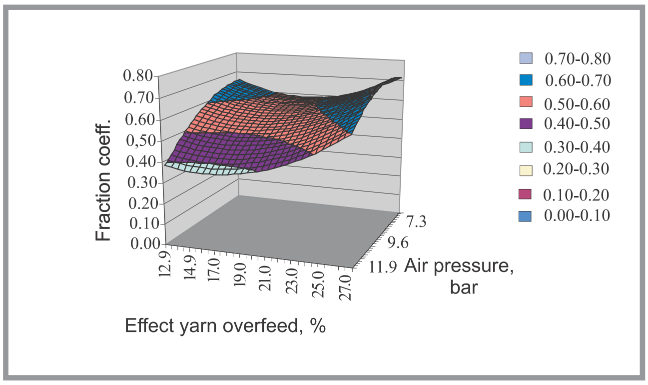


*Figure 6. Variation of friction coefficient when changing air pressure and overfeed of the effect component. PES/PES yarns with heat setting.*

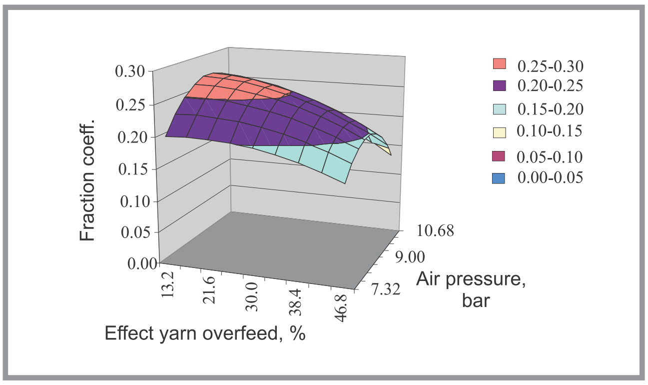


*Figure 7. Variation of friction coefficient when changing air pressure and overfeed of the effect component PES/PTFE yarns.*

In the course of the research, polyester air-jet textured threads were manufactured and analysed in the Department of Textile Technology at Kaunas University of Technology. The purpose of the research is to analyse to what extent the properties of air-jet textured sewing threads designed for sewing various outfits and clothes depend on the parameters of the manufacturing process. Three parameters were changed; air pressure, wrapping thread overfeed, and thermo-setting.

## Experimental Results and Discussions

The threads manufactured and analysed in the Department of Textile Technology at Kaunas University of Technology have not up-to-now been used in the sewing industry. Threads of the following two types were manufactured:

- 100% PES air-jet textured threads designed for sewing outwear;
- PES/PTFE air-jet textured threads designed for sewing different articles by high-speed sewing machines.

When manufacturing pure PES and PES/PTFE threads, the following two parameters, which have an essential impact on the quality of the end product, were changed: the effect (wrapping) thread overfeed and the pressure of air fed to an air-jet textured nozzle.

In the process of thread manufacture, two multifilament threads (PES in both cases) were fed to the core, and one (PES in the first case and PTFE in the second) consists of the effect thread. On the whole, three multifilament threads were fed. Core threads were dampened in all cases. The effect thread overfeed was varied from 15 to 27%. Furthermore, the pressure of air fed to an air-jet textured nozzle was alternated from 6 to 12 atmospheres. When manufacturing the air-jet textured threads, a HemaJet® T321 air-jet textured nozzle was used.

The raw materials used were:

- 'Torlen FY HT' polyester multifilament threads with increased strength.
- Polytetrafluorethylene multifilament threads. As the PTFE component is resistant to high temperatures, heterogeneous air-jet textured sewing threads may be suitable for working clothes that are exposed to high temperatures.

The main parameters of HT-PES and PTFE used raw material are given in Table 1.

Tensile tests were performed on a ZWICK stretching machine. The tests were implemented according to DIN EN ISO 2062, 05/1995 standard for thread stretching established by the International Standardisation Organisation. The test conditions were as follows: distance between clamps 500±1 mm; stretching speed 500 mm/min; initial thread stretching 0.5 cN/tex; number of tests per one package 20, stretching until thread break.

***Table1.** The main parameters of HT-PES and PTFE used raw material.*

| Parameter | Unit | PES | PTFE |
|---|---|---|---|
| Linear density of one thread | dtex | 133 | 133 |
| Amount of filaments | - | 32 | 32 |
| Tenacity | cN/tex | 54 | - |
| Elongation at break | % | 16 | - |
| Filament cross-section profile | - | circular | circular |

The results of tests were analysed in terms of measurable and computable quantities. The absolute breaking force and elongation at break were selected as the main computable parameters, which above all determine the quality and behaviour of a ready-made thread in the process of sewing.

The friction coefficient of the threads was determined on a Rotschield 'F-meter' friction tester at a convex angle of the friction roll of 180° and a thread speed of 150 m/min.

The linear density of both obtained threads was measured and the following amounts assessed: 44.5 tex for the first type of threads (PES/PES), whereas 42.94 tex for the second type of threads (PES/PTFE).

Dependencies between the following indicators were analysed: the effect component overfeed and the air pressure in the air-jet textured nozzle. The following mechanical properties of the air-jet textured threads were analysed and forecasted: breaking force $F_{tr}$ in cN, tenacity (specific breaking force) $f_{tr}$ in cN/tex, elongation at break $\varepsilon_{tr}$ in % and coefficient of friction $\mu$. As is known, all the parameters mentioned should both ensure the steady processing procedure and condition the mechanical properties of further textile articles sewn by air-jet textured threads.

The diagrams (Figures 1-7) demonstrate the dependence of the properties of the threads considered according to the manufacturing parameters.

Air-jet textured threads break differently than simple plain threads do. It has been established that mechanical properties are determined by the core component, which is particularly important for stretching [6]. A core component is the axis of an air-jet textured thread, and other components with this axis only form a certain angle defined by the overfeed quantity; therefore when stretching an air-jet textured thread, firstly a core component breaks, and then an effect component starts to deform and break. Besides, the character of break is affected by the fact that an effect component is usually arranged by irregular filaments, and in the process of stretching this component affects the core component by radial pressure. The indicator of the tenacity of air-jet textured threads is not very precise, since it is computed by dividing the breaking force by the linear density of the air-jet textured threads. At the moment of break, a given thread breaks at the weakest point, and when computing the tenacity the total linear density of threads with complex structure is considered. Specific elongation at break of air-jet textured threads especially depends on the elongation of a core component. An effect component determines the strength only when high elongation is reached.

In the process of sewing, the same place on a sewing thread repeatedly touches the parts of a sewing machine. The thread is under mechanical impact cyclically, and that is why friction properties become a key factor determining the thread's quality in the process.

The polyester threads used have been characterised by increased stretching resistance; traditional polyester multifilament threads have a lower tenacity, i.e. c. 30-40 cN/tex. Polyester multifilament threads with increased resistance were selected in order to upgrade the mechanical properties of the ready-made product. PTFE threads were used to improve the friction qualities of the sewing thread in the sewing process.

## Summary

This paper describes the chosen manufacture method of sewing threads and their research methodology. The ranges of linear density, overfeed, thermosetting, and air pressure, as well as the raw material of the threads manufactured were selected. Air-jet textured threads were manufactured in the Department of Textile Technology at Kaunas University of Technology using Eltex, a state-of-the-art laboratory texturing machine with a Heberlein air-jet texturing nozzle and a dampening system.

To summarise the results of the tests performed during this research, we may state that by changing the parameters of the manufacture process, the properties of a desirable thread, i.e. elongation at break, tenacity and the absolute breaking force, may vary within certain limits. In industry, both types of threads may be used, due to their good properties and the maintenance of these properties in the sewing process.

## Conclusions

The tensile tests of threads enable us to come to the following conclusions:
- using higher pressure in the process of air-jet texturing allows a decreasing elongation at break of a ready-made thread to be achieved;
- in individual cases, it may be assumed that the force required to untwist elementary filaments is higher than their breaking force;
- a decrease in air pressure and effect thread overfeed increases the tenacity of a ready-made thread.

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