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# Dependences of Air Textured Polypropylene Yarn Properties on the Yarn Structure and Air Pressure in a Texturing Jet

**Abstract**
*In this article an investigation of air textured yarn properties dependent on the yarn structure and air pressure in the texturing jet is described. Analysis of experimental data shows that there are significant dependencies of textured polypropylene yarn properties on the structure of the yarn. Less significant dependencies on the air pressure in the texturing jet were observed. It was also observed that the hairiness of the yarn makes any differences in the fabric surface visible.*

**Key words:** *polypropylene yarns, air texturing yarn properties, hairiness.*

## Introduction

Work on air-jet texturing started in the 1950's with the development of the Taslan nozzle by Du Pont and, almost at the same time, the Mirlan Jet in the Czechoslovakia. Progressive development in nozzle design has considerably improved the productivity of the system, leading to the elimination of the need for pretwisted yarn, to increased production speeds, to reduced compressed air consumption as well as energy and water consumption rates, to improved yarn quality, and to the development of a wider range of products [1, 2].

Air textured yarns are mostly produced from thermoplastic, cellulosic or inorganic filament yarns using compressed air. Loops are formed on the surface of the filament yarn, giving it a voluminous character. Depending on the raw material, the loop structure results in a yarn with characteristics quite similar to conventional staple spun yarn [3]. But the structure and properties of air textured yarns can be very different from staple spun yarns. It is well known that the differences in the structure of yarns have a great influence on fabric geometry and herewith on its properties [4, 5].

Year after year air textured yarns are used in more and more applications, such as sewing threads, upholstery furniture, airspace, in the automotive industry, fire protection, etc. Air textured polypropylene yarns, because of their specific properties such as strength, elasticity, high wearing resistance, and hydrophobic properties are mostly used to weave carpets, fabrics for upholstery, and in the automotive industry [3, 6].

Many companies have carried out investigations of air texturing conditions and parameters, including the overfeed ratio, air pressure, different texturing jets and texturing speeds, the influence of the properties of air textured yarns made from polyester, polyamide, polypropylene or other filaments. However, there are still certain differences between their findings. Yarn structure and properties are not only controlled by texturing conditions but also related to the characteristics of the incoming filament yarn [7]. As the market for filament yarns for texturing yarns is still growing, such investigations are still important.

The tensile and dimensional properties of air-jet textured yarns are affected by the air pressure, overfeed, and different overfeed levels of the core and effect components [8]. It is necessary to analyse the effects of process variables (texturing overfeed, air pressure) and the feed material variable (yarn twist) on the important properties of air-jet textured spun yarns of different structural configurations [9]. This will allow us to decide more precisely which yarn properties are the most suitable for the final product, such as upholstery furniture, garment, decorative screens, carpets, etc. Also it will enable us to decide what possibilities there are to produce the most suitable yarn in a maximum cost efficient way. Here we investigate the dependences of air textured polypropylene yarn properties on the air pressure in the texturing jet, and on the yarn structure.

## Materials and methods

In order to study the influence of various structures and such technological parameters as air pressure in the texturing jet on the properties of textured yarn, there were some samples of yarn produced. The samples were made from 33 tex multifilament polypropylene yarns containing 72 filaments each. The same filament yarns were used as core and effect yarns. Polypropylene was chosen due to its high importance for upholstery manufacturing;it the fibre most used in such applications.

To produce textured yarn, an SSM RMT-D air texturing machine with a Hemajet – LB04 texturing jet was used.

Three different structure yarns were produced: 1 core yarn + 3 effect yarns (1c+3e), 2 core yarns + 2 effect yarns (2c+2e), 3 core yarns + 1 effect yarn (3c+1e). 3 samples of each structure yarn were produced, changing the air pressure in the jet from 0.6 to 0.7 and to 0.8 MPa. When the pressure dropped below 0.6 bar, the texturing process became impossible without changing the overfeeding and winding speed. There were no possibilities of raising the air pressure to more than 0.8 MPa because of technical reasons. Overfeeding of core yarn was constant – 11%. The overfeeding of the effect yarn was also constant – 43%. The winding speed was 209.5 m/min, the same for all samples.

The yarn linear density was determined using a Zweigle L 232 reeling machine and Branca Idealair Mark 160 scale. To determine the linear density of the yarn, 5 specimens of 100 m yarn length were prepared, from which an average value taken.

The yarn breaking load, tenacity and elongation were determined by an Uster Tensorapid yarn tensile tester using a gauge length of 500 mm



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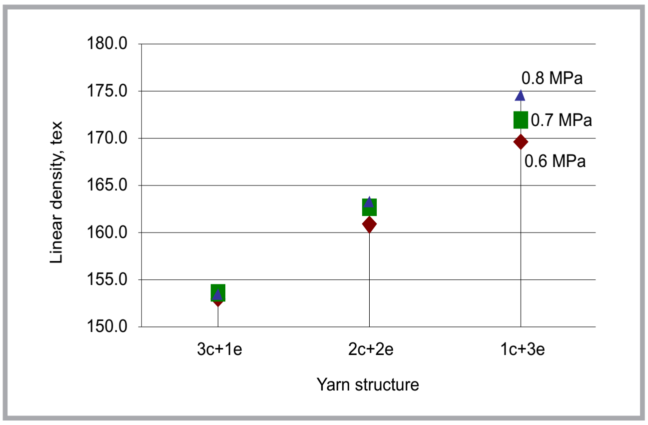


***Figure 1.*** *Dependence of yarn linear density on the structure of the yarn.*

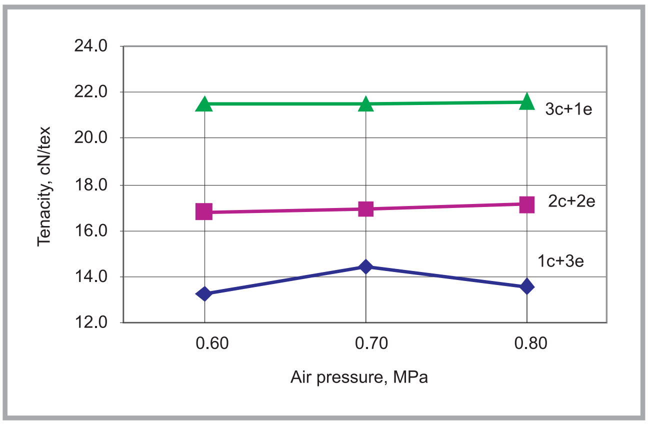


***Figure 3.*** *Dependence of breaking tenacity on the air pressure and structure of the yarn.*

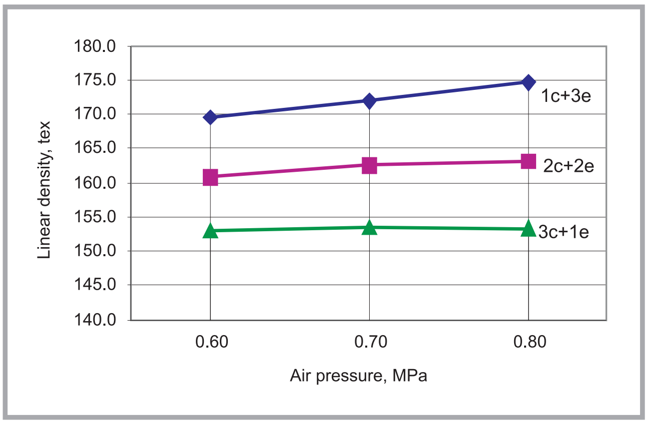


***Figure 2.*** *Dependence of yarn linear density on air pressure.*

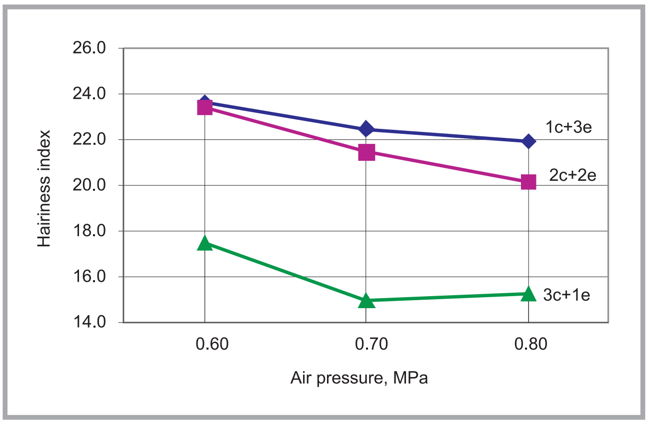


***Figure 4.*** *Dependence of yarn hairiness on the air pressure and structure of the yarn.*

and extension rate of 500 mm/min. 20 tests were made for each sample.

The yarn hairiness index H was determined for 400 meters of yarns samples using an Uster Tester 3 machine with a hairiness measuring device at a speed of 400 m/min. The hairiness index gives the average length of the fibre ends or loops in a 1 cm length of yarn.

In order to observe the influence of yarn hairiness on appearance of fabric, two samples were woven on a Somet Thema 11 rapier weaving loom. For both samples the same warp was used, but for the weft 1c+3c yarn with a hairiness index of H = 21.9, and 3c+1e yarn with a hairiness index of H = 15.27 were used. Both samples were woven under the same conditions (weft density, warp tension, weave, loom speed).

## Results and discussion

During the investigations, it was stated that the variation in yarn linear density caused by air pressure was less important than the variation caused by the yarn structure, which is evident taking into account that the overfeeding of the effect yarn is significantly larger than for core yarn (43% to 11%). The linear density in dependence on the structure is changes from 153.3 tex in the case of 3c+1e yarn, to 162.2 tex in the case of 2c+2e yarn, and to 171.9 tex in the case of 1c+3e yarn. The difference is around 12 % between the 3c+1e and 1c+3e yarns. The linear density of yarn with the same structure in dependence of the air pressure changes by around 3% (see ***Figures 1*** & ***2***). Yarn manufacturers and their customers can accept a linear density variation of up to 3%. Such a small variation has not got any important impact on the visual and mechanical properties of the fabric.

During dynamometrical tests of the yarns produced, it was observed that the tenacity of the yarn depends more on the yarn structure than on air pressure. The Difference in tenacity between the 1c+3e and 3c+1e structure yarns is around 30%, while the air pressure in the nozzle has no influence on the tenacity (see ***Figure 3***).

It is vital to state that the tenacity, breaking force and elongation at break in yarns produced with the same air pressure are higher for the 3c+1e structure yarn than for the 1c+3e structure yarn despite its smaller yarn linear density (see ***Figure 3***). This proves that more core filaments give a higher resistance, and effect yarn filaments have a much lower influence on the tensile properties of textured yarn. In the case of 3c+1e structure yarn, there are 3 times more core filaments, which have a more even tension distribution than effect filaments in 1c+3e structure yarn. Most probably it is because the force applied is distributed to the core yarn filaments first, and when the core filaments are broken, the effect filaments are in disordered, loopy state. In this way they begin to break in sequence because of non -uniform tention distribution in the separate filaments.

During the tests of the yarn produced, it was stated that the physical properties of

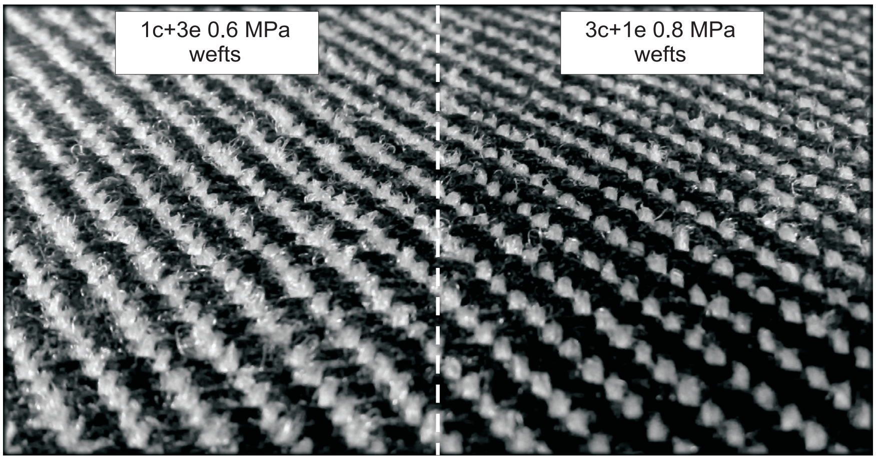


***Figure 5.** Influence of yarn hairiness on the fabric pattern.*

the yarn really depends on the air pressure in the nozzle and on the structure of the yarn itself. The dependence of such properties as the breaking force, tenacity, and elongation at break on air pressure was not as important as for hairiness. If the tensile properties changed up to 10 % because of the air pressure dropping, then the hairiness of the same structure yarn increased by 16% when the air pressure dropped from 0.8 to 0.6 MPa. The dependence on the yarn structure was much stronger than on the air pressure regarding all properties.

Due to the hairiness of the yarn, some defaults in the fabric may appear [10]. The hairiness of the yarn is perhaps not so important when yarns are used in uniform colour fabric. When contrasting colour yarns are used in fancy fabrics with a 1+1 or 2+2 pattern, it becomes very important. If hairy yarn is woven into such fabric, the pattern will be not regular, but with some shadow in places where two contrasting yarns work together. The term hairiness is mostly used for staple fibre spun yarns. As regards air textured filament yarns, we refer to the loopiness of the yarn,because there are loops of filament protruding on the surface of the yarn instead of single fibre ends, as it is in the case of staple spun yarns.

As is seen from ***Figure 4***, the hairiness of different structure yarn changes from 26%, when the air pressure is 0.6 MPa, up to 33% when the air pressure is 0.8 MPa. For same structure yarn, because of the air pressure, the hairiness changes from 7% in the case of 1c+3e structure yarn to 16% in the case of 3c+1e structure yarn. Such a big difference in yarn hairiness can completely change the pattern of the fabric, which is demonstrated in ***Figure 5***.

Depending on the lightning angle, the difference in the fabric can be clearly seen, which can be treated as a defect in quality. Thus it is necessary to state that the hairiness of yarns can change some properties of the fabric, for example air permeability, piling, friction resistance, etc. Such variation is not acceptable in final applications, such as upholstery furniture, garment making, etc. To estimate the influence of yarn hairiness on fabric properties, additional investigations are necessary, which will be detailed described in further articles.

## Conclusions

A significant dependence of the yarn linear density on the air pressure in the jet was not observed. The variation in linear density caused by the air pressure in the jet is less than 3%. The linear density is more dependent on the structure of the yarn. The variation in linear density caused by the yarn structure is more than 10%.

Yarn tenacity, breaking strength and elongation at break depend significantly on the structure of the yarn, i.e. on the number of core and effect filaments and much less on the air pressure in the jet. The variation in the absolute breaking force and tenacity caused by the yarn structure is more than 30%, whereas that caused by air pressure is less than 10%.

Better tensile properties are possible to achieve by changing the yarn structure to have the same linear density of the yarn.

The hairiness index of the yarn depends on the following parameters: the air pressure in the jet, and the yarn structure, but the dependence on the yarn structure is more significant. The variation caused by air pressure is around 15%, whereas that caused by the yarn structure is between 26 and 33%.

The influence of the hairiness of the yarn on the fabric surface is visible, which can have an influence on the wearing properties of the fabric.

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