University of West Hungary
Sopron

Doktoral Theses (Ph.D)

„Arrangement of the synthetic macromolecules in the textile filament yarn production”

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Program: Science of fiber technique

Discipline: Science of Material Engineering and Technology

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6./ Erdélyi János: Bei der Produktion von Polyamid 6 POY-Garn eingesetzte Spinnpraeparationen und deren Bewertung. A Schill & Seilacher és Bezema preparálószer szállítóknak átadott üzemi értékelés. 2002. április 05.

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10./ Erdélyi János (NyME): Cellulóz alapú szálak gyártásának fejlődése. Előadás az MTA Természetes Polimerek Munkabizottsága ülésén. Budapest, 2003. március 17.

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2./ Kovács Mária, Erdélyi János, Bélai Lajos: Erfahrungen über die Herstellung von gefaerbten PA-6 Feinseide mit Masterbatch-Dosierung. Svit/Szlovákia, 1998. október 8-9. Előadás

3./ Erdélyi János: Színes poliamid-6 fonalak gyártása. Sopron/Nyergesújfalu, 2000. november 10. Előadás

4./ Erdélyi János ZOLTEK Rt., Dr. Erdélyi József BMF, Gyovai Ágnes BMF, Kovács Mária ZOLTEK Rt.: A poliamid-6 POY fonalgyártás preparálószereinek vizsgálata. Magyar Textiltechnika, LIV. évf. 2001/4, 145-149.

5./ Erdélyi János, Erdélyi József, Gyovai Ágnes, Kovács Mária: A POY- fonal gyártásának preparálószerei és vizsgálata, Anyagvizsgálók Lapja 12. Évf. 1. sz. 24-27 (2002).

Abstract of the (Ph.D) theses: „Arrangement of synthetic macromolecules in the textile filament yarn production”

The type and measurement of arrangement of polyamide 6 POY filament yarns was examined and evaluated by three methods:

- The specific tenacity-elongation diagram was fitted to a quarter-degree polynomial equation and the integral and differential curves were analysed by computer. In optimal case the value of the integral is 69 mJoule/tex showing the internal energy, and corresponding with the breaking energy of POY filament yarns. The interval between the min. and max. places of the differentiated curve indicates the further possibility of structure arrangement. If the difference is too large the POY filament yarn is not apt for further normal processing.

- The examination by X-ray diffractometer shows, that the optimal crystalline mass rate is 55 %, the size of the crystallites is 6.4 nm. Greater or smaller are not convenient.

- The examination of the sonic moduls shows, that the orientation factor for amorphous mass rate is between 0.55-0.934

and the average orientation factor for POY filament yarn has to reach the value of 0.80.

Interpretation of ideas and connections used in the theses

The dissertation selected the polyamide 6 polimer out of the synthetic macromolecules suitable for production of textile filament yarn except technical or cord filament yarn quality.

The examination of the arrangement of polyamide 6 POY filament yarn macromolecules occured to the point of view of the chemical fiber manufacturer.

The intention was to find the parameter values belonging to the structural arrangement which in case of existence will result a predictable correct production and excellent quality from the POY filament yarn in the texturising process.

According to the sonic modules measured from the speed of sound and the Herman's orientation formula

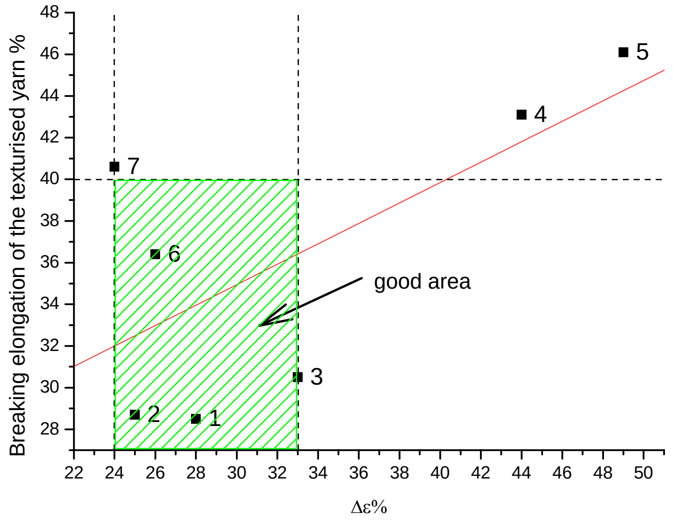

Figure 5.: Connection between the breaking elongation of the texturised filament yarn and Δε%

The optimal polyamide 6 POY filament yarn is texturised at the temperature 175± 5C°. Drawing rate in the heating zone is 1.15-1.25 with the average 1.900-2.000 D/Y rate, and the texturising speed is up to 800 m/min.

In view of processing and final product quality the samples 1-2-3 were stated very good, the 6-7 as good. The qualification of samples 4-5 were poor.

The 4-5. Figures show the connection between the mechanical parameters of the final texturised filament yarn, and Δε%.

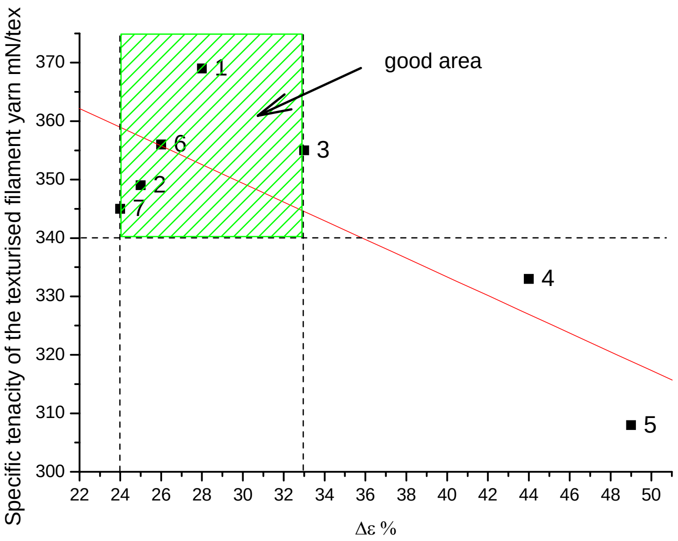

Figure 4.: Connection between the specific tenacity of the texturised filament yarn and Δε%

$$f_x = \frac{3\cos^2\theta - 1}{2}$$

we stated the orientation factor for the amorphous part and the average orientation factor for POY filament yarn.

The θ (theta) is the angel between the polimer chain and the direction of orientation (fiber axis).
The orientation of the amorphous and crystallic part results the average orientation in the mass rate of the two phases.

One of the most important parameter for the texturising is the D/Y rate, which is the ratio of circumference speed of the friction discs and the speed of the filament yarn.

The theses are as follows:

Thesis 1.

I stated, that the optimal processibility of polyamide 6 POY filament yarn, with minimal waste and guaranteed best quality of final filament yarn product concerning the mechanical parameters, has a crystalline mass rate of 55%. The optimum size of crystallites is 6.4 nm. The orientation

factor of the 45% amorphous part of POY filament yarn is between 0.55-0.934 and the average orientation factor for POY filament has to reach the value near of 0.80.

If the filament yarn is characterized by greater or smaller values than listed above, then this is unconvenient for further processing, which is followed by an increased waste.

The Figure 1. shows the connection between the waste quantity and Δε% derived from the differentiated breaking curve.

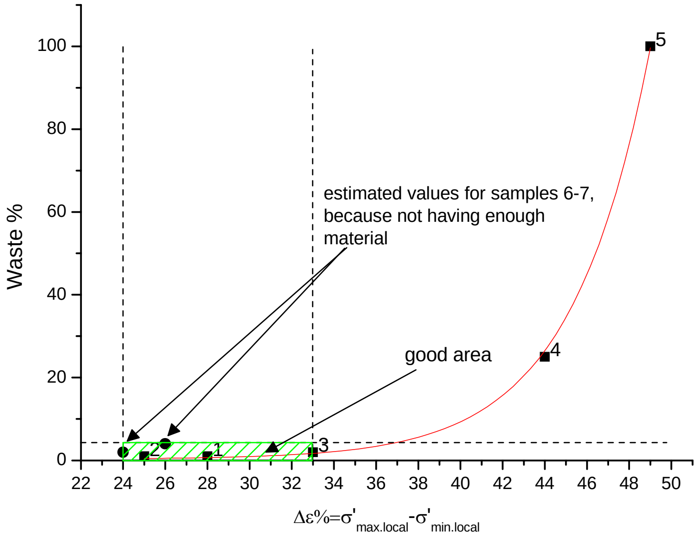

Figure 1.: Connection between the waste quantity and Δε%

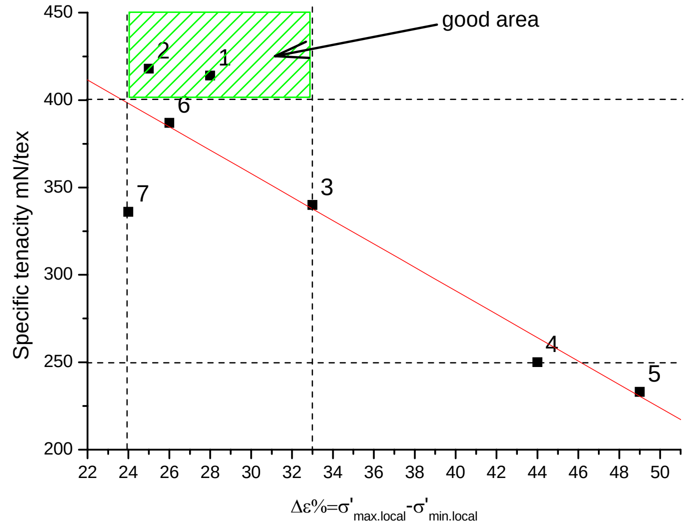

Figure 3.: Connection between the specific tenacity of POY filament yarn and Δε%

If the distance difference between the min. and max. places is larger than 24-33 % , we can count during processing with several technical problems, and a big quantity of waste up to 25-30 %.

The POY filament yarns with elongations of 90-100 % and tenacities of 250 mN/tex (or lower) are not considered to be processable.

Thesis 4.

I stated, that the specific tenacity of the optimal POY filament yarn is 400-420 mN/tex, the elongation at breake is 60-65% in the usual controll tests of production.

If these parameters are not provided and the specific tenacity is between 250-400 mN/tex and the elongation is between 65-100%, it is necessary to controll the POY filament yarns suitability according to theses of 2-3.

If the distance difference of the min. and max. points of the differentiated breaking diagram is between 24-33%, the proper technological parameters of texturising can be set.

The Figure 3. shows the connection between the specific tenacity of the POY filament yarn and Δε% derived from the differentiated breaking curve.

The Figure 2. shows, that the orientation factor of amorphous part is much depending from the linear density of the elementary filament of the POY filament yarn. Therefore his value cannot be the only deciding factor for the mechanical parameters of the POY filament yarn.

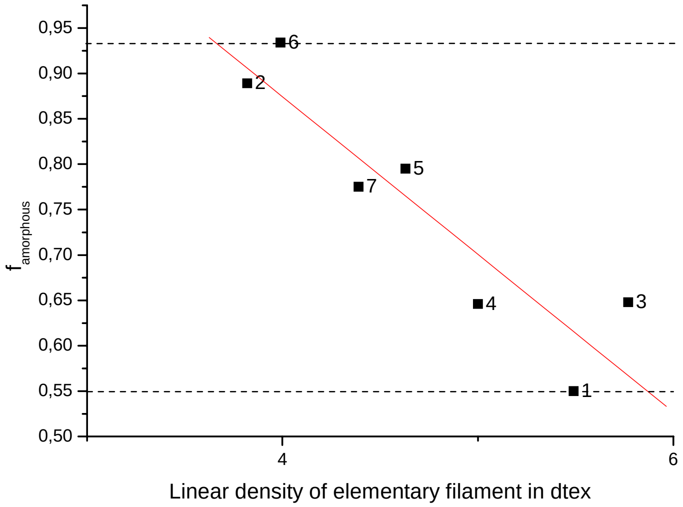

Figure 2: Connection between the linear density of elementary filaments and $f_{amorphous}$

If the orientation factor for the amorphous mass rate is big enough and according to this the average orientation factor is acceptable, although the specific tenacity of POY filament yarn is very low and the breaking elongation is very high, then this clearly indicates, that the arrangement of macromolecules into the crystallic phase happend not in a proper degree and the size of crystallites is also not convenient.

This wrong structure of POY filament yarn is not worth or cannot be modified reasonably, but the forming of such a structure has to be avoided.

In this case one surely has to calculate during processing with a big waste quantity.

Thesis 2.

I stated, that after evaluating the controll tests of breaking diagrams during production, we can make quicker and simplier a decision for processing.

The initial modulus, which is the value of the differentiated breaking curve belonging to the elongation of ε = 0, has to reach 800-1200 mN/tex to have a good processing.

If this is realised, all conditions of the Thesis 1. are fullfiled.

The specific tenacity-elongation diagram, (F-ε) can be fitted to a quarter-degree polynomial equation. The value of the R-Square (COD) is 0.999.

From the value of the integrated polinom and the form of the differential curve, a conclusion can be derived for the structure and further processibility of the POY filament yarn.

Thesis 3.

I stated, that the specific tensile energy of the POY filament yarn, determined from the integral breaking diagram of the Thesis 2., has to reach the value of 69 mJoule/tex ± 1.5%.

In this case the conditions of the Thesis 1. and the good processing are guaranteed.