Donatas Petrulis,
*Artūras Petravičius,
Salvinija Petrulyte

Analysis of Breaking Characteristics of Tape Yarns Made from Blends of Polyolefins and Additives

**Kaunas University of Technology,
Faculty of Design and Technologies,
Department of Textile Technology,**
Kaunas, Lithuania
E-mail: donatas.petrulis@ktu.lt
salvinija.petrulyte@ktu.lt

***KLAMETA Co.,**
Kaunas, Lithuania

Abstract
Samples of experimental tape yarns of different width, linear density, and composition data, i.e. composed from blends of polyolefins, namely polypropylene (PP) with linear low-density polyethylene (LLDPE) (1-octene comonomer), and additives were produced on an extruder E10 (Barmag Saurer Co., Germany). The yarns were made from extruded film which was cut into tapes. The various tensile properties of the tape yarns were studied by applying a tensile test. In this study, values of the breaking force, breaking tenacity, elongation at break, work of break, and specific work of break of the tape yarns are presented. According to this study, the tensile behaviour of tape yarns is non uniform in the film width. The influences of the additive, namely of Granic 422 (Granic Co., Spain), on the breaking characteristics of the tape yarns are also discussed. It was found that such characteristics as the linear densities and breaking tenacities were definitely conditioned by variable quantities of the additive, but other breaking characteristics for different tape yarns were almost the same size.

Key words: *additives, blends, mechanical properties, polyolefins, tape yarns.*

Introduction

Tape yarns for textile applications can be produced from different polymeric materials, but such polyolefins as polypropylene (PP) and polyethylene (PE) are the main polymers. The first fibres from low-density polyethylene (LDPE) were produced as long ago as the 1930s. The first efforts to produce PP tape yarns are known from the middle of last century. In the recent past, significant changes have taken place in the field of tape yarn manufacturing. New blended structures as well as different components are applied in these polymeric products.

The methods of producing tape yarns are different [1 - 4], but in the more common method, a film is extruded and cooled on rollers or in a water bath [1]. The film extruded is usually slit into tapes, which are subsequently drawn, annealed and fibrillated if required [2]. In another method [3], each tape is extruded separately through an individual slit-shaped orifice. A new impulse in the field of tape yarn manufacturing is offered by coextruded tape technology [4].

Tape yarns of a flat shape, i.e. conventional tapes, may be directly applied for weaving, and tape yarns affected by fibrillating and twisting processes usually are used as sewing threads or for other purposes. Yarns with a flat shape are produced for technical textile applications, such as packing materials, and especially woven bags and sacks.

Extrusion provides an efficient and conventional way of incorporating different components into products [1 - 4]. In the manufacturing of filaments or tapes, polymer-blended structures also contain additives are used. For example, blends of different polyolefins are also produced commercially: bicomponent multifilaments containing a PP core and polyethylene (PE) sheath [1]. In addition, copolimeric polyolefins such as ethene-propene and ethene-octene copolymers [1] have some commercial significance. By means of coextruded technology, skin-core tape structures may be manufactured [4]. The choice of polymeric materials as well as additives for split-film processes affects the final mechanical properties of tape yarns [1, 5].

In tape yarns manufacturing, an important specification is the melt flow index (MFI) of polymer. For tapes, typical values of the MFI of different grades of PP are between 1 g/10 min and 11 g/10 min [1]. For instance, similar values, i.e. from 2.2 g/10 min tol 4.0 g/10 min are given [6] for grades of PP applied for manufacturing tapes and woven bags. In another study [7], for manufacturing of a series of tapes from blends consisting of high-density polyethylene (HDPE) with isotactic polypropylene (PP), the MFI value of PP was 3.0 g/10 min.

Different additives may be also applied. The additives are employed to assist the processing of fibres and to achieve the fibre properties required [1, 8]. For instance, the whiteness of tapes can be improved by additives containing calcium carbonate ($CaCO_3$). Coloured fibres are mainly obtained by the spin-dyeing technique using different pigments and colour concentrates. Ultraviolet (UV) light stabiliser is another type of additive. Without UV light stabilisers to prevent photochemical oxidation, the application of tape yarns would be severely restricted. This aspect is especially important for tapes used in carpet backings, sacks, bags, flexible intermediate bulk containers (FIBCs) and tarpaulins. The soil resistances of fibres may be enhanced by adding highly water-repellent synthetic compounds.

In practice, the breaking properties, namely the breaking force, elongation at break and work of break as the integral of force-elongation curves, are used as major parameters in technical textiles evaluation. To compare the breaking properties of yarns of different linear density, the tenacity and specific work of break may be additionally applied. The tensile properties of PE and PP fibres [1, 5, 7 - 10] are highly influenced by structure and processing conditions. However, in many cases, data are given only for filaments/fibres, and the results have not been extended to tape yarns made from extruded film. For instance, the tenacity of high-density polyethylene (HDPE) is 30 - 60 cN/tex [1]. The tenacity of different PP fibres fluctuates between 40 cN/tex and 94 cN/tex, and elongation varies between 15% and 22% [5]. In study [8], the tenacity of different PP tape yarns with UV stabiliser (1.25 wt%) and whiteness additive (2.0-3.0 wt%) is of 52 - 55 cN/tex, and the elongation at break

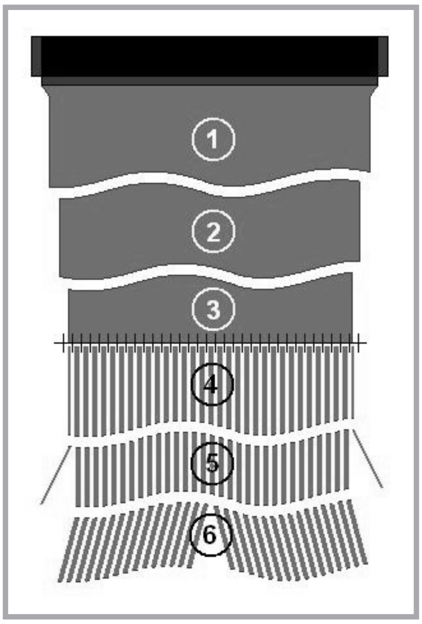

Figure 1. *Schematic diagram of tape yarns manufactured in an extruder E10: 1 – film between the slit dye of extruding device and pressing roll, 2 – film between pressing roll and deflective roll, 3 – film between deflective roll and blades of cutting device, 4 – tapes between blades of cutting device and pressing roll, 5 – tapes between pressing roll and heating device, 6 – tapes between heating device and let out roll.*

is between 18% and 19%. In another source [1], the values of tenacity and elongation at break are of 30 - 80 cN/tex and 15 - 35%, respectively. Pure PP fibres with no components added had a tenacity of 38 cN/tex [9]. In this study, the tenacities decreased to 36 cN/tex and 33 cN/tex when 5.0 wt% and 10.0 wt% poly(dimethylsiloxane) (PDMS) were added to improve soiling resistance, respectively. The tenacity of fibres to which oleamide (OA) had been added to PP was also lower than that of pure PP fibres. On the other hand, the addition of PDMS reduced the elongation at break, whereas the addition of OA increased it. Changes occurring in the tensile properties of oriented PP tape yarns were investigated following the addition of recycled process waste at various concentrations [10]. In this case, a significant loss in tape strength occurs when recycled or waste PP is added. In another paper [7], variation of the PP content in blends with HDPE affects the mechanical properties of tapes rather differently, for instance an increase in breaking stress at 9% (PP) was obtained, but comparatively lower mechanical properties occured at 50 and 80% (PP) blend composition.

This review demonstrates that despite the importance of the mechanical properties of tape yarns, the main tensile properties of tape yarns, especially those made from blends, have been variously and sparsely described. With present knowledge of these tape yarns, it is too vague to consider their main characteristics, for instance the breaking behaviour of yarns from different places tested in the film width, the influences of additives, etc. The aim of this work is to enlarge information of tape yarns basing on the study on breaking properties of tape yarns made from blends of polyolefins and additives.

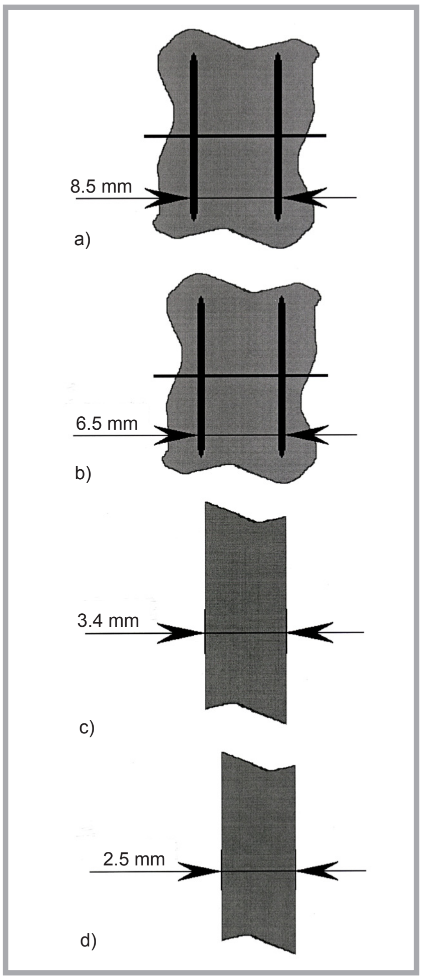

Figure 2. *Schematic diagram of tape yarns: a and b – after cutting, c and d – final view.*

Experimental

Materials and samples

Samples of experimental tape yarns of flat shape, different width and different compositions were produced on an extruder E10 (Barmag Saurer Co., Germany). In addition, samples from different places were examined with respect to film width.

Similar to other tape yarns, the samples had to undergo processes such as moulding, extrusion, thermo-acting, cutting and drawing. It is important to note that fibrillating as well as further conventional operations of manufacturing such as twisting, assembling, etc. were not used since the initial tape form, i.e. the shape of the flat yarn, may be applied for designed technical fabrics. ***Figure 1*** shows a schematic diagram of tape yarn manufacturing. The total draw ratio of the fully drawn tape was fixed at a lev-

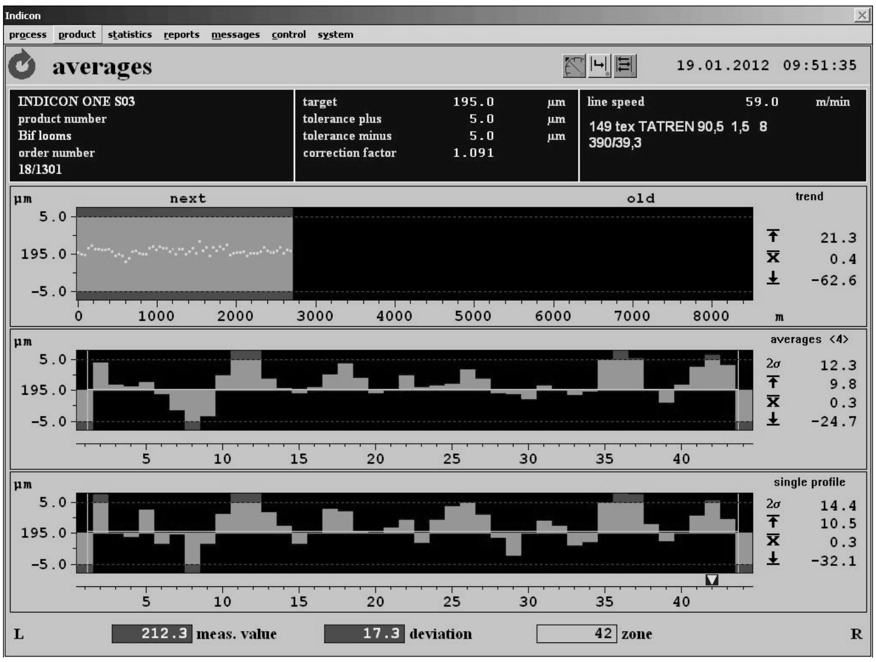

Figure 3. *Example illustrating film thickness control.*

el of 6.870. The film was then cut into tapes of 8.5 mm and 6.5 mm width (***Figure 2.a***, ***2.b***). For cutting, blades (LUTZ GmbH & Co. KG, Germany) [11] fixed between the plates (Zhengli blade Co., China) [12] were applied. Experimental conditions were adjusted so that all the tapes drawn were of 3.4 mm and 2.5 mm width, respectively (***Figure 2.c***, ***2.d***). These dimensions of tape yarns were chosen in accordance with experience of desired structural and mechanical parameters of tape yarns widely applied in the weaving of sacks. Usually tapes of 3.4 mm and 2.5 mm width are used as weft and warp yarns, respectively. For the weft, tapes of 3.4 mm width are more suitable if compared with those of 2.5 mm width because of higher weaving productivity. Since woven sacks may be of different diameter/width, narrow tapes i.e. of 2.5 mm width, have better usability in the warp direction. Betacontrol systems [13] (Betacontrol GmbH & Co. KG, Germany) were used for total process monitoring and automatic control of the thickness of the product in its width (***Figure 3***). A high-speed sensor was applied for film thickness measurement. Other experimental conditions, such as melt pump speed values (38.0 - 43.2 min $^{-1}$) were adjusted so that all drawn and relaxed tapes had nominal values of linear density of 110 tex, 120 tex, 148 tex or 215 tex. The temperatures at the extruder zones were 220 - 235 °C, and the die zone temperature was 235 °C. The film was solidified with water in the cooling unit at 35 °C. The tapes were heated in an heating oven at 173 °C, and then fixed to an annealing stand at 120 °C.

Codes and composition data of the samples of 3.4 mm and 2.5 mm width are given in ***Tables 1*** and ***2***, respectively. In the codes, the first number is the current number of sample, and the second is the number of place with respect to film width. For instance, samples 1-1 and 2-1 (***Table 1***) were taken from one fixed place of the film width, and samples 3-2 and 4-2 were taken from another fixed place. The samples listed in ***Tables 1*** and ***2*** contained different portions of PP (88.5% or 90.5%) and an additive with a high content of calcium carbonate ($CaCO_3$), i.e. 8.0% or 10.0%. PP granules for manufacturing of samples were obtained from several companies, listed in ***Table 3***. MFI values of the PP granules used were between 2.84 g/10 minutes and 3.49 g/10 minutes at 230 °C. A material, type UV 01017 PP (CONSTAB Co., Germany), was applied as a UV light stabiliser. To give whiteness to the tapes, a masterbatch with a high content of treated and ultrafine $CaCO_3$ of 1.6 µm mean particle size, Granic 422 (Granic Co., Spain) [14] was used. The $CaCO_3$ content was 80 wt% and that of the linear low-density polyethylene (LLDPE, brand name LLDPE C8) was 20 wt%. In our study, LLDPE is a copolymer of ethylene and 1-octene. The MFI value of Granic 422 was 1.20 g/10 minutes at 190 °C.

Table 1. *Codes and composition data of tape yarns of 3.4 mm width; * – obtained from Rompetrol Petrochemicals Co. (Romania). ** – obtained from Lisichansk Oil Investments Co. (Ukraine). *** – calcium carbonate content – 80 wt%, LLDPE (1-octene comonomer) content – 20 wt%..*

Sample code	Portion of polypropylene, wt%	Portion of UV light stabiliser, wt%	Portion of Granic 422***, wt%
1-1	90.5*	1.5	8.0
2-1	88.5*		10.0
3-2	90.5*		8.0
4-2	88.5*		10.0
5-3	90.5*		8.0
6-3	88.5*		10.0
7-4	90.5*		8.0
8-4	88.5*		10.0
9-1	90.5**		8.0
10-1	88.5**		10.0
11-2	90.5**		8.0
12-2	88.5**		10.0
13-3	90.5**		8.0
14-3	88.5**		10.0

Table 2. *Codes and composition data of tape yarns of 2.5 mm width; * – obtained from Rompetrol Petrochemicals Co. (Romania). ** – obtained from Lisichansk Oil Investments Co. (Ukraine). *** – obtained from INEOS Co. (UK). **** – calcium carbonate content – 80 wt%, LLDPE (1-octene comonomer) content – 20 wt%.*

Sample code	Portion of polypropylene, wt%	Portion of UV light stabiliser, wt%	Portion of Granic 422****, wt%
15-1	90.5*	1.5	8.0
16-1	88.5*		10.0
17-2	90.5*		8.0
18-2	88.5*		10.0
19-3	90.5*		8.0
20-3	88.5*		10.0
21-4	90.5*		8.0
22-4	88.5*		10.0
23-1	90.5**		8.0
24-1	90.5***		
25-2	90.5**		
26-2	90.5***		

Table 3. *Melt flow index of polypropylene obtained from different producers.*

Producer	Melt flow index (MFI), g/10 min
Rompetrol Petrochemicals Co. (Romania)	2.84
Lisichansk Oil Investments Co. (Ukraine)	3.30
INEOS Co. (UK)	3.49

Test conditions methodology

The breaking properties of the tape yarns were determined on a Zwick Co. (Germany) tensile tester Z005 according to the requirements of [15]. The breaking force and elongation at break were obtained from the stress and strain graph at the breaking point. The work of break was determined as an equivalent to the area under the force extension curve [16]. Therefore this parameter was used as a source of comparison of force-elongation curves of the different samples. The tenacity and specific work of break were computed on the basis of the breaking force, work of break and linear density of the yarns. The specimen length was set at 500 mm, and a constant rate of specimen extension of 100% per minute was applied. A pretension of 0.5 cN/tex was

Table 4. Properties of tape yarns of 3.4 mm width; – nominal linear density is given in brackets.*

Sample code	Linear density*, tex	Breaking force, N	Tenacity, cN/tex	Elongation at break, %	Work of break, J	Specific work of break, J/tex
1-1	150 (148)	80.5	53.7	21.8	5.653	0.03769
2-1	155 (148)	79.4	51.6	21.3	5.438	0.03508
3-2	150 (148)	79.1	52.7	19.6	4.853	0.03235
4-2	153 (148)	77.1	50.4	19.4	4.707	0.03076
5-3	146 (148)	76.1	52.1	19.6	4.674	0.03201
6-3	150 (148)	77.2	51.5	19.9	4.864	0.03243
7-4	146(148)	78.9	54.1	20.2	5.030	0.03445
8-4	149 (148)	80.5	54.0	20.5	5.219	0.03503
9-1	213 (215)	106.3	49.9	20.6	7.182	0.03372
10-1	215 (215)	106.9	49.7	20.5	7.157	0.03329
11-2	207 (215)	104.7	50.6	20.2	6.983	0.03373
12-2	212 (215)	101.7	48.0	19.7	6.547	0.03088
13-3	210 (215)	107.3	51.1	19.8	6.910	0.03290
14-3	217 (215)	103.5	47.7	19.4	6.539	0.03013

*Table 5. Properties of tape yarns of 2.5 mm width; * – nominal linear density is given in brackets.*

Sample code	Linear density*, tex	Breaking force, N	Tenacity, cN/tex	Elongation at break, %	Work of break, J	Specific work of break, J/tex
15-1	124 (120)	68.3	55.1	19.7	4.270	0.03444
16-1	126 (120)	69.2	54.9	21.4	4.827	0.03831
17-2	122 (120)	66.3	54.3	18.3	3.755	0.03078
18-2	125 (120)	64.5	51.6	18.1	3.649	0.02919
19-3	124 (120)	68.2	55.0	19.3	4.152	0.03348
20-3	128 (120)	70.0	54.7	20.3	4.558	0.03561
21-4	120 (120)	66.5	55.4	20.1	4.308	0.03590
22-4	126 (120)	66.3	52.6	20.1	4.244	0.03368
23-1	112 (110)	62.5	55.8	19.9	3.928	0.03507
24-1	110 (110)	61.3	55.8	19.8	3.854	0.03504
25-2	110 (110)	61.8	55.7	20.2	3.982	0.03620
26-2	110 (110)	60.7	52.7	21.4	4.191	0.03810

used. During the tensile test, the slippage of specimens was checked as described in [15], and the conventional atmospheres for testing were as specified in [17]. To determine the values of linear density, the samples were weighted by means of an EW 150-3M electronic balance (Kern & Sohn GmbH, Germany).

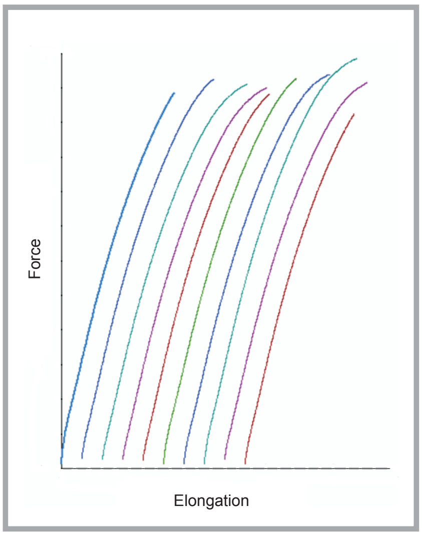

Figure 4. Typical force-elongation curves of tape yarns.

Results and discussion

Values showing the properties of the tape yarns of 3.4 mm and 2.5 mm width tested are given in ***Tables 4*** and ***5***, respectively. In addition, ***Figure 4*** shows some typical examples of force-elongation curves of tape yarns.

It is worth noting that there is very small variability in the force-elongation curves, as illustrated by the sets of repeated tests (10 curves from a set of 50 repeated tests) shown in ***Figure 4***. The behaviour of a tape yarn at break expected is similar to so-called catastrophic rupture if the tape yarn is assumed as a monofilament of uniform structure. In our opinion, the tapes, especially those made from blends, may have another nature of rupture which is similar to the break of low-twist multifilament yarns, i.e. the tape yarns tend to fibrillate during tension testing, and therefore the force-elongation curves end in a series of steps. However, when the transverse forces are sufficient to hold the whole tape yarn structure up to rupture, this case of rupture is less appropriate.

In another stage of the current research, the effect of the place with respect to the film width was examined. Tape yarn samples of fixed width (3.4 mm) and composition (***Table 1***) but from four different places in the film width, named as 1-1, 3-2, 5-3, and 7-4, were compared.

It was obtained that the linear density of the above-mentioned samples fluctuated from 146 tex to 150 tex (***Table 4***) i.e. the range of variation is 4 tex. Thus the values of linear density and the thickness of the tapes in the case of a fixed width and density differed from corresponding average values by no more than 1.4%.

The breaking forces of the same tape yarns (***Table 4***) equalled 76.1 - 80.5 N, and the average value was 78.7 N. The following deviations from this value were determined: for sample 1-1 – 2.3%, for sample 3-2 – 0.5%, for sample 5-3 – 3.3%, and for sample 7-4 – 0.3%. Thus the breaking forces varied more if compared with those of linear density. It is possible that the increased deviations were related to additional variations in the internal unevenness of the structure across the width of the extruded film. The tenacity obtained was in the range of 52.1 cN/tex to 54.1 cN/tex (***Table 4***). These results differed from the average value (53.2 cN/tex) in the range of 0.9% (samples 1-1 and 3-2) and 2.1% (sample 5-3). As a result of the study, the values of tenacity had a narrower range compared with the results of breaking forces.

The above-mentioned samples, i.e. 1-1, 3-2, 5-3, and 7-4 possess an elongation at break from 19.6% to 21.8%, and a measured average value of 20.3%. The maximum deviation from the average values (see sample 1-1 in ***Table 4***) was 7.4%. Thus, in general, the results obtained by an even greater change were comparable with those previously mentioned.

However, the greatest impact of the measuring place in the film width was observed in data of the work of break. For samples 1-1, 3-2, 5-3, and 7-4 this parameter, given in ***Table 4***, differs from the average value from 0.5% (sample

7-4) to 11.9% (sample 1-1). Similarly the values of specific work of break differed from the average value from 0.9% to 10.4%.

One more series of samples from the same places of the film width were studied for 2.5 mm tape yarns. The results for tape yarns 15-1, 17-2, 19-3, and 21-4 from ***Table 5*** were used here. In this case, fluctuations of the resulting breaking characteristics such as the breaking force, elongation at break and work of break were less compared with those of tape yarns of 3.4 mm width (***Table 4***). However, these changes were conditioned mainly by the differences in linear densities. For tapes of 2.5 mm width, the specific values, such as the breaking tenacity and specific work of break, were at the same level, as observed for tapes of 3.4 mm width. It is possible that the fixed total draw ratio and other fixed conditions, i.e. the same portions of all components, were the main reasons for the stability of the breaking characteristics.

In our opinion, the main possible reasons for the above-mentioned differences in mechanical properties with respect to the film width were connected with the problems adjusting the extruding device of slit dye, and possibly because of dirt unevenly accumulated in the slit dye.

In a further study, the effects of the additives were tested, and corresponding data from ***Tables 4*** and ***5*** were used again.

The influence of the portion of material, whose brand name is Granic 422, on the breaking characteristics was examined. For instance, summarised values of four samples (1-1, 3-2, 5-3, and 7-4) with a portion of Granic 422 of 8.0 wt% were compared with other summarised values of four samples (2-1, 4-2, 6-3, and 8-4) containing 10.0 wt% of Granic 422. The trends for these two series (***Figure 5***) are as follows:

The linear density (***Figure 5.a***) of the tape yarns of the first series (with 8.0 wt%) is slightly lower compared with those of second series (with 10 wt%). This difference is about 2.6%, which can be caused by the different densities of PP (0.90 - 0.92 Mg/m^3) [18] and Granic 422 (1.80 Mg/ m^3) [14].

Figures 5.d, ***5.e & 5.f*** show that the summarised values of elongation at break, work of break, and specific work of break for the two series mentioned above were almost of the same magnitude. This trend also applies to the breaking forces (***Figure 5.b***). Therefore the breaking tenacities (***Figure 5*.c**) for samples containing a smaller portion of additives (8.0 wt%) were higher because of the existence of the linear density difference between samples. Thus for samples with 8.0 wt% of additives, a positive synergistic improvement in the tenacity was observed. It should be noted that the trend of tenacity when a tape yarn has an 8.0 wt% or 10.0 wt% of Granic 422 was also confirmed for the other tape yarns from ***Table 4***, i.e. from 9-1 to 14-3. This feature is also typical for yarns with a width of 2.5 mm (***Table 5***), i.e. for samples from 15-1 to 22-4.

Finally the properties of tape yarns made from PP with different values of MFI were compared. In this study, the summarised values of linear densities and mechanical parameters from ***Tables 4*** and ***5*** were applied to check the possibility of coherent mechanical behaviour of several series of tape yarns.

In one case (see ***Table 4***), the summarized values of samples 1-1, 3-2, and 5-3 (series I) were compared with those of samples 9-1, 11-2, and 13-3 (series II). ***Table 1*** shows that PP granules for samples of series I and II were obtained from Rompetrol Petrochemicals Co. (Romania) and Lisihansk Oil Investments Co. (Ukraine) with MFI values of 2.84 and 3.30 g/10 min (***Table 3***), respectively. Since the linear densities are rather different, the values of tenacity, elongation at break, and specific work of break were used in the current study. It should be mentioned that these characteristics for series I were 52.8 cN/tex, 20.3% and 0.03402 J/tex, and for series II – 50.5 cN/tex, 20.2%, and 0.03345 J/tex, respectively.

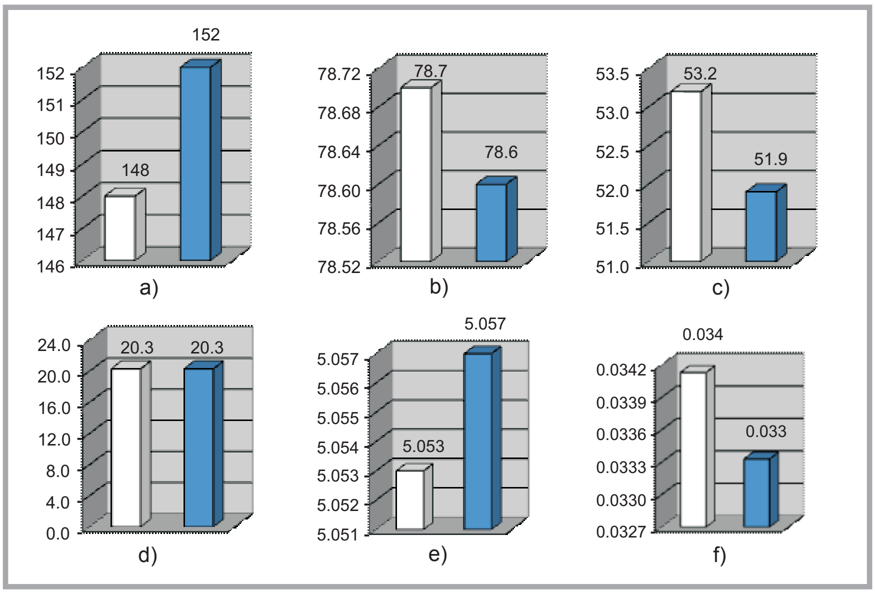

Figure 5. *Summarized values of characteristics of samples 1-1, 3-2, 5-3, and 7-4 (white column) and samples 2-1, 4-2, 6-3, and 8-4 (marked column): a – linear density in tex; b – breaking force in N; c –tenacity in cN/tex; d – elongation at break in %; e – work of break in J; f – specific work of break in J/tex.*

In another case (see ***Table 5***), the summarised values of samples 15-1, 17-2 (series I), 23-1, 25-2 (series II), and 24-1, 26-2 (series III) were studied. From ***Table 2*** it can be seen that PP granules used for series I, II, and III were from Rompetrol Petrochemicals Co. (Romania), Lisihansk Oil Investments Co. (Ukraine), and INEOS Co. (UK) with MFI values of 2.84, 3.30, and 3.49 g/10 min (***Table 3***), respectively. In this case, the summarised values of tenacity, elongation at break, and specific work of break fluctuated in the ranges 54.3 - 55.8 cN/tex, 19.0 - 20.6%, and 0.03261 - 0.03657 J/tex.

Thus in the first case differences in the tenacity, elongation at break and specific work of break were 4.4%, 0.5%, and 1.7%, respectively. In the second case, the differences for these mechanical parameters were 2.6%, 7.8%, and 1.7%, respectively. Although the current values are similar to those of the case previously mentioned, the elongation at break varied more and the tenacity fluctuated less.

Conclusions

Tape yarns composed from blends of polyolefins, i.e. polypropylene (PP) with linear low-density polyethylene (LLDPE) (1-octene comonomer) and additives such as ultraviolet (UV) light stabiliser and calcium carbonate ($CaCO_3$) were manufactured into tape yarns using an extruder E10. The yarn samples were drawn at a fixed draw ratio, and a fixed temperature regime was also used. The final width of the two types of samples manufactured was 3.4 mm and 2.5 mm, and four levels of nominal linear densities from 110 tex to 215 tex were chosen for the samples.

Examining the tape yarns, it was found that they have rather different ranges of different characteristics with respect to the place in the film width. For instance, for samples of 3.4 mm width, the values of linear density fluctuated by only 1.4%. The greatest influence on the measuring place was observed in data of the work of break i.e. 11.9%. The tape yarns of 2.5 mm and 3.4 mm width exhibited changes conditioned mainly by the differences in their linear densities. It should be mentioned that the fixed conditions of manufacturing are the main reasons for the stability of the breaking characteristics, but problems connected with the adjustment of the slit dye may aggravate the situation.

The effects of additives are as follows: The linear density of tape yarns with 8.0 wt% of Granic 422 is lower, and tenacity is higher compared with the samples containing 10.0 wt% of Granic 422. This linear density trend can be caused by different densities of PP and Granic 422, and the tenacity trend is additionally conditioned by differences in the composition, i.e. by the highest portion of PP in the tape yarns. Summarised values of the elongation at break, work of break, specific work of break, and breaking force for the above-mentioned two series were almost of the same magnitude.

The tape yarns made from PP granules with different melt flow index (MFI) values exhibited very similar breaking characteristics.

References

1. Mather RR. Polyolefin fibres. In: *Synthetic fibres: nylon, polyester, acrylic, polyolefin*. Editor J.E. McIntyre. Woodhead Publishing Limited, 2005, pp. 235-292.
2. Crangle A. Types of polyolefin fibres. In *Polyolefin fibres. Industrial and medical applications*. Editor Samuel C.O. Ugbolue. Woodhead Publishing Limited, 2009, pp. 3-34.
3. Schmenk B, Miez-Meyer R, Steffens M, Wulfhorst B, Gleixner G. Polypropylene fiber table. *Chemical Fibers International* 2000; 50: 233-253.
4. Alcock B, Cabrera NO, Barkoula N-M, Loos J, Peijs T. Interfacial properties of highly oriented coextruded polypropylene tapes for the creation of recyclable all-propylene composites. *Journal of Applied Polymer Science* 2007; 104: 118-129.
5. Kim Y. The use of polyolefins in industrial and medical applications. In: *Polyolefin fibres. Industrial and medical applications*. Editor Samuel C.O. Ugbolue. Woodhead Publishing Limited, 2009, pp. 133-153.
6. http://www.sca.com.sg/ (Sumitomo chemical Asia Co., Japan).
7. Mahajan SJ, Deopura BL, Wang; Y. Structure and properties of drawn tapes of high-density polyethylene/ethylene-propylene copolymer blends. *Journal of Applied Polymer Science* 1996; 60: 1527-1538.
8. Petravicius A, Petrulis D. Manufacture and properties of tape yarns. In: *Gaminiu technologijos ir dizainas* (in Lithuanian). Technologija, 2008, pp. 34-37.
9. Takahashi T, Kimura Y. Improved soiling resistance of polypropylene fibers on the addition of synthetic compounds. *Textile Research Journal* 2012; 82; 8: 789-800.
10. Horrocks AR, Richards AF, Ghosh S. Influence of waste polymer inclusion on the performance of oriented polypropylene geotextile tapes. Part I: Effect on tensile properties. *Textile Research Journal* 1995; 65, 10: 601-606.
11. http://www.lutz-blades.com (LUTZ GmbH & Co. KG, Germany).
12. http://www.roundknives.com/ (Zhengli blade Co., China).
13. http://www.betacontrol.de/ (Betacontrol GmbH & Co. KG, Germany).
14. Granic 422 product description (Granic Co., Spain).
15. International Standard ISO 2062.
16. Saville BP. *Physical testing of textiles*. Woodhead Publishing Limited, 2000.
17. International Standard ISO 139.
18. Petrulis D.; Models of fibres and yarns geometry. *Technologija*, 2009.

Received 14.04.2012 Reviewed 27.06.2012