(REFEREED RESEARCH)

THE EFFECT OF FIRST HEATER TEMPERATURE ON THE PROPERTIES OF FALSE-TWIST TEXTURED POLY (ETHYLENE TERAPTHALATE) YARN

BİRİNCİ FIRIN SICAKLIĞININ YALANCI BÜKÜMLE TEKSTÜRE EDİLEN POLİETİLEN TERAFTALAT İPLİKLERİNİN ÖZELLİKLERİNE ETKİSİ

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ABSTRACT

The effect of first heater temperature on the properties of poly (ethylene terapthalate) filaments was characterized through measurements of tenacity, breaking elongation, boiling shrinkage, crimp stability, crimp contraction and crystallinity. It was found that crystallinity reached a maximum at a temperature around 200 C, and then started to decrease. A similar behavior was observed in crimp stability. Tenacity and crimp contraction increased and boiling water shrinkage decreased, when the heater temperature increased.

Key Words: False-twist texturing, Heater temperature, Structure-properties, Texturing.

ÖZET

Birinci fırın sıcaklığının polietilen teraftalat filamentlerin özelliklerine etkisi kopma mukavemeti, kopma uzaması, kaynama çekmesi, kıvrım stabilitesi, kıvrım büzülmesi ve kristalinite ölçümleriyle incelenmiştir. Kristalinitenin 200oC civarında maksimuma ulaştığı ve ardından düşmeğe başladığı bulunmuştur. Kıvrım stabilitesinde de benzer bir davranış gözlenmiştir. Isıtıcı sıcaklığı arttığında kopma mukavemeti ve kıvrım büzülmesi artmış, kaynama çekmesi ise düşmüştür.

Anahtar Kelimeler: Yalancı bükümlü teksture, Fırın sıcaklığı, Yapı-özellik, Teksture.

Received: 24.11.2008 Accepted: 15.09.2009

1. INTRODUCTION

Texturing is a common commercial process which gives crimp to the flat yarns. Among the several texturing methods, false twist texturing is the most favored method.False-twist texturing process is composed of four main steps; heating the thermoplastic fibers above the glass transition temperature (T_g); twisting; cooling the fibers below T_g and untwisting (1). A second heater can be added to the system according to the end uses of the yarn.

Heater parameters, mainly heater temperature and residence time, together with fiber thermal properties influence textured yarn properties such as tenacity, crimp rigidity, dyeability, etc.

The yarn is processed at very high speeds on the texturing machines. 1000 m/min is a commercial processing speed; however the challenge is to reach over 5000 m/min (2). Because of these high processing speeds it is hard to maintain a uniform heating level on the textured yarns. Furthermore, the temperatures have to reach over T_g at very short residence time such as 0.2 sec. at the surface and center of the filament bundle. In addition, as the heater temperature increases, the temperature difference between the center and the surface of the yarn also increases (3). In heating, it must be remembered that, the temperature of the heater is not the actual temperature of the yarn.

Our earlier study, we have investigated the effects of D/Y ratio and draw ratio on some crimp properties of PET fibers (4). In the present study, the effect of first heater temperature on the tensile and crimp properties of textured PET [Poly (ethylene terapthalate)] yarn has been examined.

2. MATERIAL AND METHOD

2.1. Materials

The parent yarn used for texturing was semi-dull, poly (ethylene terapthalate) partially oriented yarn (POY) which has count of 150 denier and 96 filaments.

2.2. Methods

The simultaneous draw texturing process was carried out. The all processing parameters except first heater temperature were kept constant. The first heater temperatures were 150°C, 190°C and 230°C. The lab type texturing machine was a Barmag AFK-M with two heaters. Process speed was 650 m/min. The D/Y ratio was 2 and draw ratio was 1.60. The first heater length was 2.5 m and second heater temperature was 165°C. Disc type friction texturing unit was used.

The disc configuration was 1+6+1. The disc material was ceramic and the disc thickness was 9 mm.

SET yarns are used more widely than stretch yarns at the market, for that reason second heater was used to obtain SET yarns.

Model

One-way ANOVA model used in the experiments and results were analyzed accordingly. Test replicas were various according to parameter tested. Test numbers were given in relevant subtitle.

Measurements

Degree of Crystallinity

The crystallinity measurements were performed using a Perkin-Elmer Sapphire differential scanning calorimeter. 140.1 mJ/mg was used ΔH (fusion) for 100 % crystallinity PET. The samples were heated at a rate of 10°C/min. Two replicas have been done for crystallinity measurements for each temperature.

Tensile Properties of the Multifilament Yarn

Breaking elongation and breaking strength of the yarns were tested according to ISO 2062 using SDL universal tensile tester having 2500 N load cell. 15 replicas were done for the yarns produced with each temperature.

Crimp Properties of the Yarn

Crimp stability and crimp contraction tests were performed according to DIN 53840 standards by using Textechno Texturmat ME. The experiment conditions were given in Figure 1. Crimp contraction and crimp stability values were calculated according to the following equations:

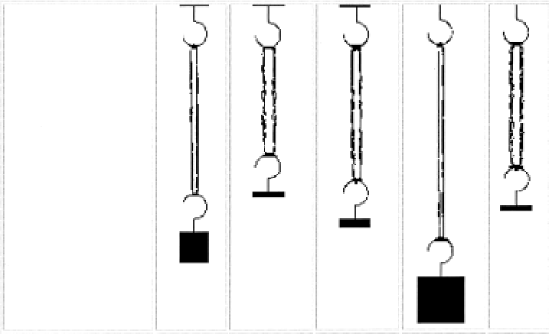
Crimp contraction = $[(l_g - l_z)/l_g] \times 100(\%)$ (1)

Crimp stability = $[(l_g - l_b)/(l_g - l_z)] \times 100\ (\%)$ (2)

Shrinkage force and crimp force tests were done using Textechno Dynafil ME. Dynafil ME was arranged for tests as following: The applied pre-load was 13 cN, the heater temperature was 250 °C. The shrinkage force test was done at 90 m/min testing speed and the crimp force test was done at 220 m/min testing speed. The yarn length was 50 m for shrinkage force and 100 m for crimp force.

Boiling Water Shrinkage of the Yarn

Boiling water shrinkage test was executed using a special device which



Load (cN/tex)	2	0,01	0,1	10 or 20	0,01
Duration of load	10sec	10min	10sec	10sec	20min
Length of hank	lg	lz	lf		lb

Figure 1. Experiment conditions of DIN 53840

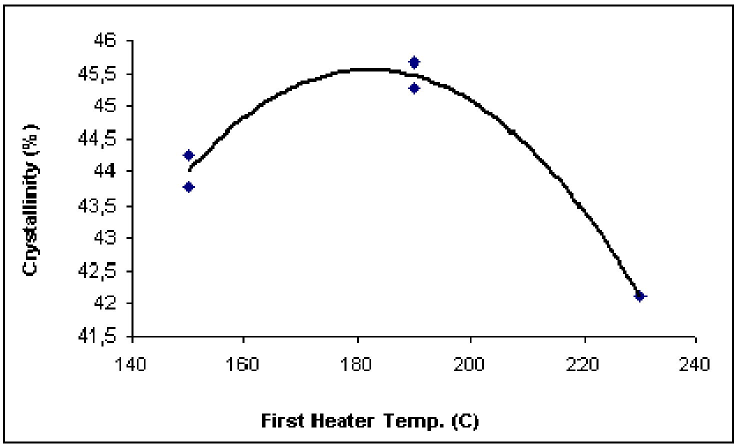


Figure 2. The relationship between first heater temperature and crystallinity

was designed by Tubitak (Bursa). Six replicas have done for each temperature. Tensioning weight equivalent to 0.125 cN/tex was applied to the yarn which was 1 m length and hank form. The first length recorded on this condition as l_1.Then load was removed. The yarn was wetted in a soap solution (1 l water/1 g soap) and left in the solution at 100 °C for 15 min, dried an hour at 60 °C, hanged the device again and waited one hour. Then same weight applied to the yarn and the length was recorded as l_2. Boiling water shrinkage was calculated from Equation 3

Boiling water shrinkage (%) = $[(l_1 - l_2)/l_1] \times 100$ (3)

3. RESULTS AND DISCUSSION

Degree of Crystallinity

When the heater temperature increases the crystallinity percentage of the textured filaments also increases. It is due to the re-crystallization process at elevated temperatures (4). The rate of crystallization is high around 180-190 °C for PET yarn (6).

Figure 2 shows that the maximum crystallization temperature is about 200°C. However, in our study, crystallinity started to decrease, after peak point. It must be also remembered that crystallinity and as usual non-crystalline regions are also affected by tension and twist level during the heating (7).

Breaking Strength and Breaking Elongation

Although Hardegree and Buchanan (8) and Gupta et al. (5) found that tenacity decreased when the first heater temperature was increased, tenacity increased when the first heater temperature was increased according to Gosh and Wolhar (9) and Pal et al. (10). Gupta et al. used fully drawn yarn, the others were used POY as a feeding material. In the present study it was also observed in Figure 3 that, tenacity increased slightly when the temperature increased.

According to ANOVA results also, temperature has an effect on tenacity for 95 % (α=0.05) significance level. Tensile strength and breaking elongation are extremely depended on amorphous and crystalline orientation factors. However these factors could have not been measured. Since POY was fed to the texturing machine, an increase in orientation because of drawing may be expected.

A decrease was anticipated according to tenacity results, however any significant difference in breaking elongation for the chosen temperature range was not observed as shown in Figure 4.

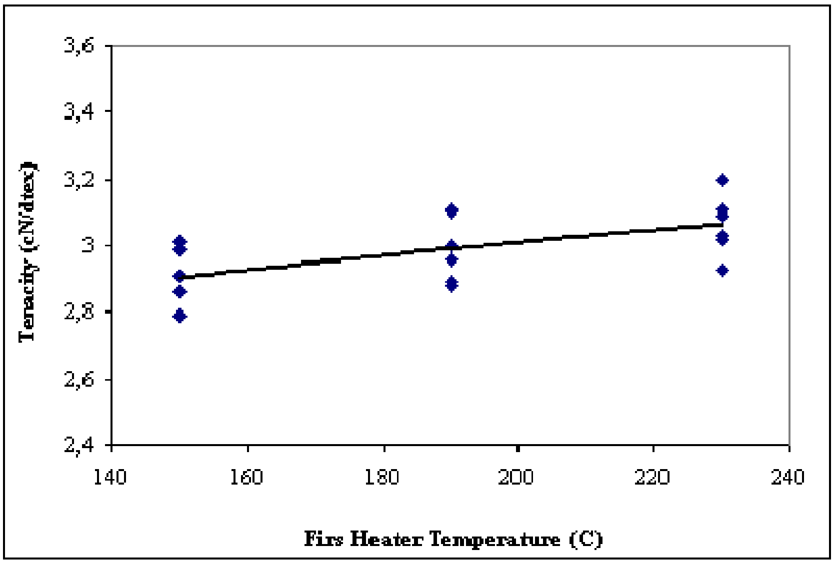


Figure 3. Effect of first heater temperature on tenacity

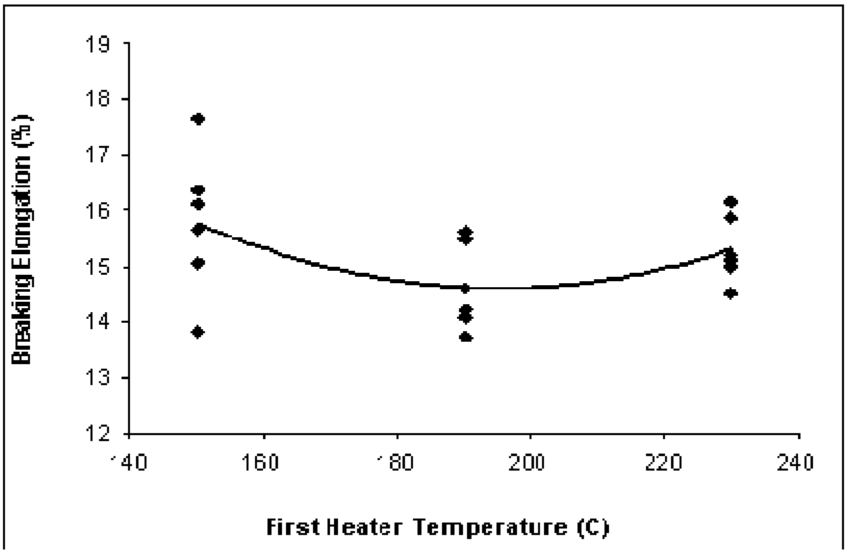


Figure 4. Effect of first heater temperature on breaking elongation

Boiling Water Shrinkage and Shrinkage Force

Boiling water shrinkage drops as a function of the increased crystallinity (11, 12); according to another comment shrinkage is a unique function of the product of amorphous volume fraction (13). Larger crystallites and a lower degree of orientation in the amorphous zone lead to reduce shrinkage (13, 14). According to Gupta and Kumar's study (5), crystallinity increases with an increase in heater temperature and amorphous orientation factor decreases with an increase in heater temperature. Boiling water shrinkage was decreased when first heater temperature increased as shown in Figure 5 in the present study. Shrinkage force measurements were also supported the results as shown in Figure 6. Maximum shrinkage value calculated from the curve was 230°C. Crystallinity also increased up to 200°C as mentioned above. The temperature range used in this study was between 150-230°C, higher temperatures must be studied to make the correlation obvious.

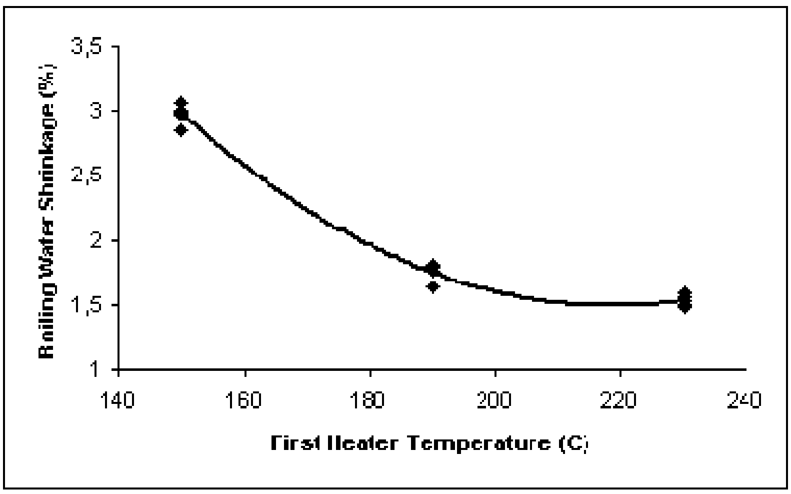


Figure 5. Effect of first heater temperature on boiling water shrinkage

Crimp Properties

Crimp contraction is the reduction in length of textured filaments after the crimp is developed (1). As shown in Figure 7, crimp contraction increased sharply when heater temperature increased. Crimp force measurements have also supported this increase as given in Figure 8.

In Gosh and Wolhar's (9) and Pal and co-worker's (10) studies, crimp contraction was also increased with increasing heater temperature. In twisting process, filaments follow a helical path around the yarn axis. In the idealized helical structure, a yarn is considered as consisting of a core

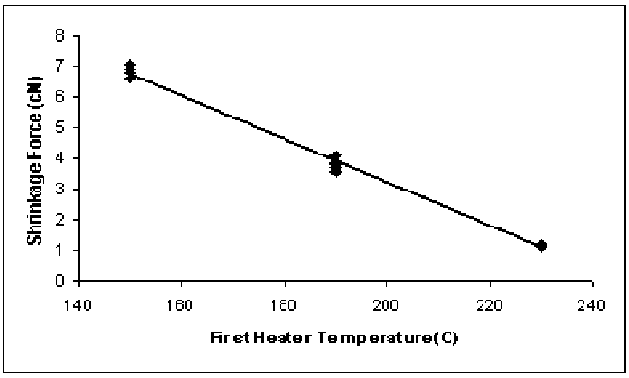


Figure 6. Effect of first heater temperature on shrinkage force

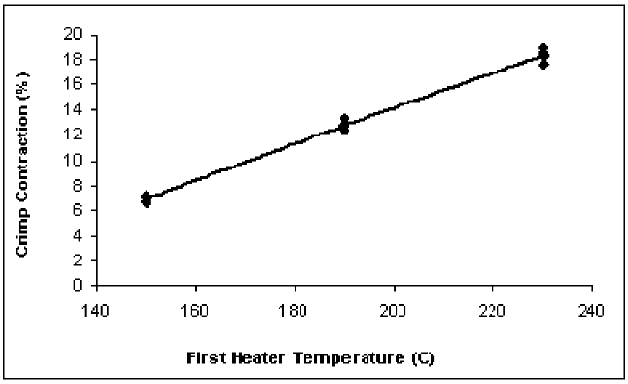


Figure 7. Effect of first heater temperature on crimp contraction

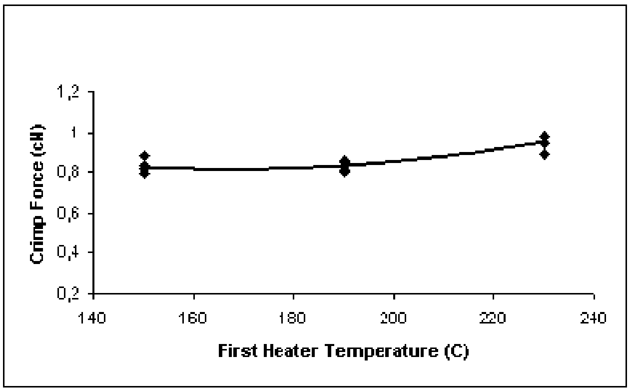


Figure 8. Effect of first heater temperature on crimp force

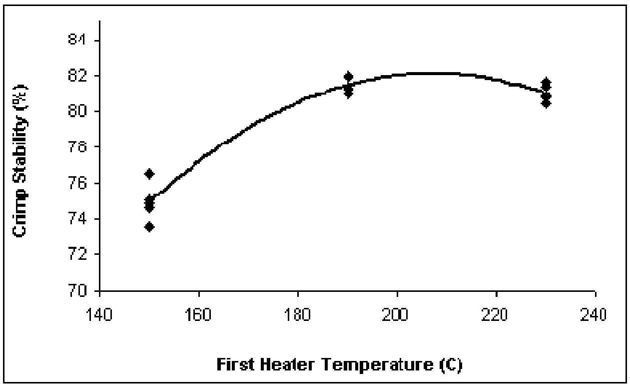


Figure 9. Effect of first heater temperature on crimp stability

straight fiber surrounded by coaxial cylindrical layers of other fibers, each forming a perfect helix. However, the path of a fiber in a yarn is in fact a helix of which the radius is alternately increasing and decreasing along its length (14). "Denton has shown that the helical coils of the twisted yarn reduce in diameter due to better heat setting. Therefore, by increasing heater temperature, the helical coils are expected to reduce in diameter and also produce higher recovery force in yarn, because the retractive power of a stretched helical spring is inversely proportional to the square of its diameter" (9,15).

Crimp stability determines the crimp level left after load application. As shown in Figure 9 crimp stability was also increased about 200 C, then started to decrease. Pal and co-workers investigated the first heater temperature effect on crimp stability (9); they also observed an increase in crimp stability. However the applied maximum first heater temperature was 200 ^{0}C in their study. They associated this increase with an increase in crystallinity. In the present study crimp stability value was started to decrease at about 200 ^{0}C where crystallinity also started to decrease.

4. CONCLUSIONS

Simultaneous draw texturing process is one of the very complicated textile processes where fibers are drawn, heated and twisted simultaneously. Some molecular rearrangements and cross sectional deformations are also happened. Therefore, it is hard to explain the effect of process parameters on the yarn properties exactly. Detailed fine structure analysis must be done. However it is evident that, first heater temperature has a significant effect on the crimp properties. Percentage crystallinity, boiling shrinkage and crimp stability values have presented a sharp variation around 200 ^{0}C for textured PET POY.

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Bu araştırma, Bilim Kurulumuz tarafından incelendikten sonra, oylama ile saptanan iki hakemin görüşüne sunulmuştur. Her iki hakem yaptıkları incelemeler sonucunda araştırmanın bilimselliği ve sunumu olarak ***"Hakem Onaylı Araştırma"*** *vasfıyla yayımlanabileceğine karar vermişlerdir.*

NANO PARTİKÜLLÜ İÇ ÇAMAŞIRLARI

Amerikan Silah Teknolojisi, askerleri için sık aralıkla değiştirme gerektirmeyen kendi kendini temizleyebilen giysi türleri üzerinde çalışmaktalar. Bu gelişen nano teknoloji endüstrisi ile birlikte yapılabilecek bir çamaşır ve giysi türü. Nano Partiküller mikro dalga yayarak kir ve deri atıklarının, bakterilerin giysi lifleri üzerinde tutunmamasını sağlıyorlar. Bu prensiple çalışan çamaşırlar 3-4 hafta yıkanmadan giyilebiliyor.

Amerikan Savunma Sanayinde geliştirilen her gelişme sonuçta mutlaka genel piyasada da yerini alır. Bundan hareketle çok yakında bu çamaşır ve giysileri mağazalarda da görebileceğiz. Bu mikro dalgaların derimizde ne gibi sakıncaları olacağı ise henüz açıklık kazanmamış durumda. Yani yan etkileri henüz tam olarak bilinmiyor. Belki sadece bazı kişilerde görülebilecek kısmi alerji olabilecek diye düşünülüyor. Ancak genel olarak düşünüldüğünde deterjan ve kansorejen zararları sık temizlikte harcanan su miktarı, deterjan v.b. giderlerde düşünülünce bu teknoloji kendisiyle birlikte yanında ekonomi ve sağlığı da yanında getirecek gibi görünüyor. (internet)