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〈研究論文(學術)〉

The Crystal Structure and Mechanical Properties of Thick & Thin yarn According to Production Condition

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제조조건에 따른 태세사(Thick & Thin yarn)의 구조와 물성

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Abstract— 시료는 POY사 104/192로 Draw-Winder(독일 Zinser)를 이용하여 기존의 태세사 제조장치의 부분적인 개조를 통하여 길이방향으로 강제적인 태세사가 형성되도록 하는 제조기술을 이용하여 Thin-thick yarn(T&T사) 6종류를 제조하였으며 제조 조건에 따른 구조변화와 물성에 대하여 연구 검토한 결과 다음과 같다.

결정화도의 변화는 Draw-winder의 R2 roller 온도가 상온인 경우보다 100℃인 경우가 높게 나타났으며 태세사의 세(thin)부분의 복굴절률은 연신비가 높고 Draw winder의 roller(R2)의 온도가 높을수록 복굴절 값은 선형적으로 증가하였다.

T&T사 제조시 연신 온도가 상온인 경우는 Thin부분만 연신이 진행되고 Thick부분은 원사인 POY사의 성질이 그대로 유지하고 있음을 알 수 있고 R2 roller 온도가 상온에서 제조된 시료의 초기탄성률은 약 1.5-2.0kgf/denier 정도로 높게 나타났으나 100℃로 제조된 시료는 약 0.2-0.8kgf/denier 정도로 낮게 나타났다.

Keywords : *Thick & thin yarn*(태세사), *T-T device, Shrinkage* (수축), *Crystallinity* (결정화도), *Birefringence*(복굴절률)

1. Introduction

These days polyester has been a major manmade chemical textile. This is because polyester has excellent physical and chemical properties as a yarn as well as its low production cost. Accompanied by the rapidly developed textile manufacturing technologies, various polyester textile products have manufactured including so-called "singosen." Since the high glass transition temperature and melting point make polyester stable enough to various physical and chemical modification processes, polyester has been a good textile material practiced various ways for the development of new textile products.

Recently developed thick & thin polyester (T-T) yarn is widely used to manufacture sense-differentiated textiles because of its ability to show light and dark coloring difference in a single mono filament yarn. T-T yarns consist of a series of alternative thick and thin filament parts in the single

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mono filament yarn. Therefore, when the yarns dyed, the coloring of thick parts appears dark and that of the thin parts light in the mono filament.

Currently, T-T yarns developed are having their mono filament fineness over 1 denier. In fact, the formation of the thick & thin part is achieved by making use of the structure difference naturally resided in polyester polymer at the glass transition temperature. In practice, the manufacture of T-T yarns has been accomplished by using a drawing machine or a false twister by utilizing the necking phenomenon occurring in the natural drawing process. When the monofilament becomes the thinner, the difference in the thickness between the thick parts and the thin parts in the fiber becomes less obvious and to obtain a deep coloring is difficult.

In spite of many efforts, to T-T yarns with finer than 1 denier monofilament is largely not yet successful.

In this study, sample T-T yarns were prepared under various conditions by a partially modified commercially available T-T yarn manufacturing machine and the structure and various physical properties were examined.

2. Experiment

2.1 Preparation of sample

Sample T-T yarns were prepared by using POY 104/192 with a Draw-winder (German Zinser) under the conditions given in Table 1, Here, R2 is set to 650m/min. The fineness of the prepared T-T yarn samples were shown in Table 2.

In Fig.1, a schematic description of the Draw-winder used was given. In Fig. 2, the schematic of T-T device (Bell) attached on the hot plate in the Draw-Winder was given in

As can be seen in Fig. 2, the T-T device consists of two parts, the upper and lower parts. As the upper and the lower parts rotate, the yarn contact the hot plate surface in a periodic pattern to produce a series of successive thick and thin parts in the yarn.

Table 1. Texturing Methode of Thin-thick Yarn

Sample No	Texturing Methode
1	R1: Room temp., TT-Device: 200℃, R2: Room temp., Draw ratio: 1.29
2	R1: Room temp., TT-Device: 200℃, R2: Room temp., Draw ratio: 1.34
3	R1: Room temp., TT-Device: 200℃, R2: Room temp., Draw ratio: 1.39
4	R1: Room temp., TT-Device: 200℃, R2: 100℃, Draw ratio: 1.29
5	R1: Room temp., TT-Device: 200℃, R2: 100℃, Draw ratio: 1.34
6	R1: Room temp., TT-Device: 200℃, R2: 100℃, Draw ratio: 1.39

Table 2. Denier of Thin-Thick Yarn

Sample NO	1	2	3	4	5	6
Draw-ratio	1.29	1.34	1.39	1.29	1.34	1.39
Denier	81.5	78.6	75.6	81.2	78.5	75.6

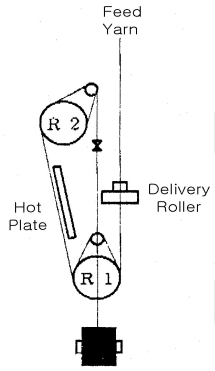


Fig. 1 Draw-Winder.

Fig. 2. TT-Device(Bell).

2.2 Shrinkage

The T-T samples prepared were cut to 30 cm and tensioned under 1g/d of tension. After the tensioned samples processed in 100℃ water for 20 min and dried in 150, 170 and 190℃ of dry air for 20 min, the shrinkage rates were measured.

$$\frac{l'-l}{l}\times 100 ,$$

l : Initial sample length, l': Treated sample length,

2.3 The Structure and the physical Properties

The structure and the physical properties were examined by processing the samples in 100℃ water for 20 min and drying in 150 and 180 ℃ of dry air for 20 min.

2.3.1 Crystallinity

The crystallinities were calculated by measuring the density of the samples. For the calculation, the crystalline region density value used was the Bunn value 1.455g/cm^3 and the non-crystalline region density value used was 1.335g/cm^3.

2.3.2 Birefringence rate

For the calculation of the birefringence rates, the sample retardation values were measured by a 546. 1 nm monochromatic polarizing microscope (Zeiss, mf-AKs Automatic-2) and the sample yarn diameters were measured by an optical microscope.

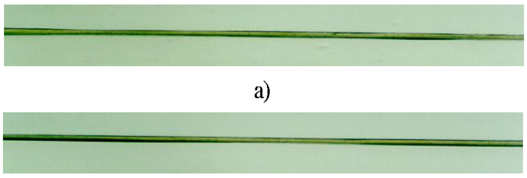
$$\Delta n = \frac{R}{d}$$

Δn : Birefringence rate, R : retardation,
d : Diameter of fiber

2.3.3 Initial Elasticity Modulus

The initial elasticity values were measured by using S-S curves measured by UTM (U.K., Hounsfield). The measuring condition used were

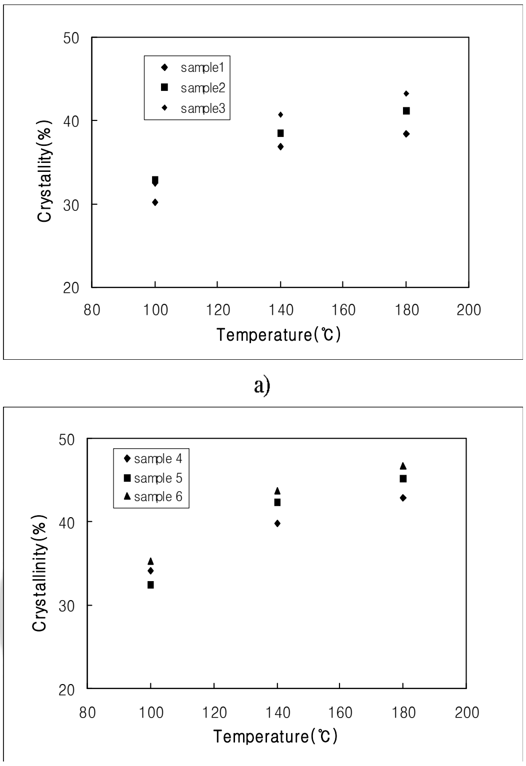
Full scale: 10 kgf, Load cell: 50kgf
Sample length: 5 cm, Extension speed: 3 cm/sec



a)

b)

Fig. 3. Microphotograph of textured yarn(mono filament).
a) Sample 3 b) Sample 6



a)

b)

Fig. 4. Crystallinity of samples against various treated temperature.
a) Draw-winder roller(R2) at room temperature
b) Draw-winder roller(R2) at 100 ℃

3. Results and discussion

The representative pictures of the microphotographs of the prepared sample T-T yarns are shown in Fig. 3. In Fig.3, the thick and thin parts of the T-T yarns are clearly identified. Here, one may identify the general feature of the thick and the thin parts of the T-T yarn.

The crystallinities of the T-T yare obtained as a function of temperature are shown in Fig. 4. In over all, the crystallinity increases with increasingthe temperature and at the temperatures high than 140℃ the increasing rates show a tendency to decrease.

By comparing a) with b) in Fig. 4. Thecrystallinities in b) is slightly higher then those in a) at all temperatures examined. This is due to the higher roller (R2) temperature. That is, the higher the R2 temperature the more heat fixation arises to increase the surface crystallinity of the sample.

The birefringence values obtained are shown in

Fig. 5. Similar to the crystallinity case, the birefringence increases with increasing temperature.

Also, the increasing rate of the birefringence decreases at the temperatures higher than 140 ℃. a) at all temperatures examined. This is due to the crystallinities in b) is slightly higher then those in higher roller (R2) temperature. That is, the higher the R2 temperature the more heat fixation arises to increase the surface crystallinity of the sample.

When R2 temperature increases to 100 ℃ the birefringence increases at all temperatures. This isdue to the heat fixation effect of R2. At higher R2 temperatures, the non-crystalline region polymer surface partially crystallizes to increase the tension in the non-crystalline chain to increase the bire

In Fig. 6, the shrinkages as a function as temperature are shown. The general tendency of the shrinkage is to decrease with increasing the heat treatment temperature and to increase with increasing the draw ratio.

By comparing the shrinkage data set shown a), where R2 is at room temperature with that shown in b), where R2 temperature is 100 ℃, it is noticed that the shrinkage dada in a) is much higher than that in b). Numerically speaking, in a) the shrinkage data are 10-55% and in b) 7 9 %. This is because only the thin part of the T-T yarn is drawnand the thick part is of the T-T yarn is not effecatively drawn by the T-T device when R2 is at room temperature The lower shrinkages in b) whenshown, where the initial modulus increases with

In Fig. 7, the initial elasticity modulus data sets are

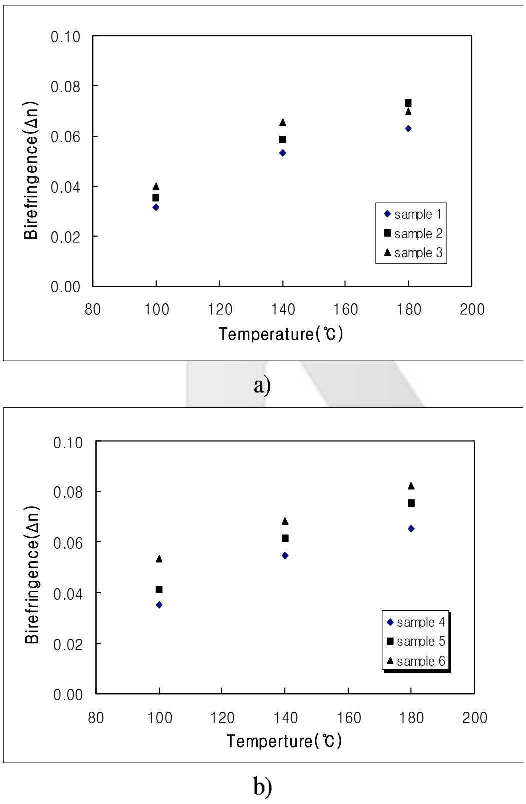


Fig. 5. Birefringence of samples(thin part) against various treated temperature.
a) Draw-winder roller(R2) at room temperature
b) Draw-winder roller(R2) at 100 ℃fringence.

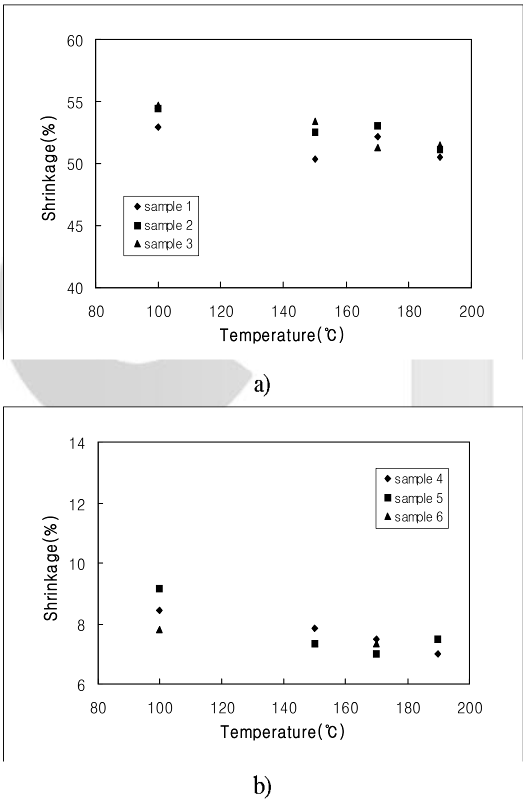
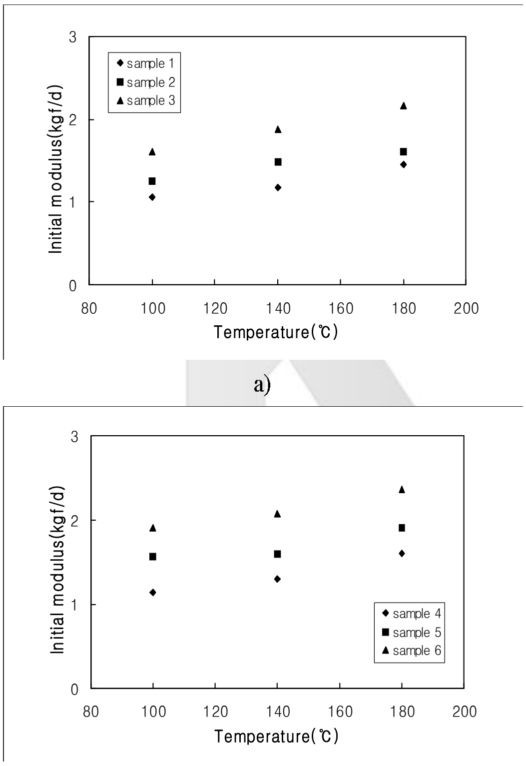


Fig. 6. Shrinkage of samples against various treated temperature.
a) Draw-winder roller(R2) at room temperature
b) Draw-winder roller(R2) at 100 ℃

R2 temperature is 100℃ is due to the heat fixation effect at higher temperatures. The increased crystallinity due the heat fixation effect at higher temperature may decrease the shrinkage of the T-T yarn. increasing the draw ratio and the heat treatment temperature. In the case of a) where R2 is at room temperature the initial elasticity modulus values obtained are 1.5-2.5 kgf/denier and in the case of b) where R2 temperature is 100℃ the initial elasticity values obtained are 0.2-0.8 kgf/denier.

The higher the R2 temperature, the lower the initial elasticity. This is due to the increased coil behavior at lower temperatures. As shown in Fig. 6, the shrinkages are higher when R2 is at room temperature It is generally known that the coil behavior increases with increasing the shrinkage.



a)

b)

Fig. 7. Initial modulus of samples against various treated temperature.
a) Draw-winder roller(R2) at room temperature
b) Draw-winder roller(R2) at 100℃

4. Conclusion

By using POY 104/192, T-T yarns were prepared. The device used for the preparation was partially modified Draw-Winder (German, Zinser). The structure and the physical property changes, such as the crystillinity, the birefringence, and the initial elasticity modulus at various T-T yarn preparation conditions were examined. The results are as follows:

1. The crystallinities of the T-T yarns prepared with the 100℃ of R2 were higher than those under with room temperature R2.
2. The birefringence of the thin part in the prepared T-T yarn increased with increasing the draw rate and the R2 temperature.
3. When R2 is at room temperature, it appeared that only the thin part of the T-T yarn is drawn and the thick part of the T-T yarn is not effectively drawn by the T-T device.
4. When R2 is at room temperature the initial elasticity modulus values observed were 1.5-2.5 kgf/denier and when R2 temperature 100℃ the initial elasticity values obtained were much lower 0.2 - 0.8 kgf/denier.

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