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〈研究論文(學術)〉

사이징 및 전처리 공정에서의 열처리 온도 변화에 따른 폴리에스테르 직물의 染色性 변화

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Effects of Heat Temperature in Sizing and Pretreatment Processes on the Appearance Colour of the Polyester Fabrics

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요　약－이 연구에서는 사이징 공정을 포함해서 수세, 전처리 그리고 최종 열처리 등의 염색·가공 공정에서의 습열 및 건열 처리 온도가 폴리에스테르 직물의 열응력과 염색성에 미치는 영향을 조사 하였다. 사용된 폴리에스테르 필라멘트사는 경사가 50d/24f 스파크絲이며 위사는 75d/72f semi-dull絲이다. 평직물은 셔틀직기, 주자직물은 water jet 직기로 제직하였으며, sizing dryer 온도는 90℃, 125℃, 150℃, 수세공정의 습열처리 온도는 90℃, 110℃, 120℃, 전처리 공정의 건열처리 온도는 180℃, 200℃, 220℃, 마지막 세팅 공정의 건열처리 온도는 170℃, 180℃, 200℃로 변화시켰다. 이들 습열과 건열처리 온도 변화에 따른 직물내의 필라멘트사의 열수축률과 직물의 겉보기 염색성의 변화를 조사 분석 하였다.

1. Introduction

Thermal effect in manufacturing of polyester yarns and fabrics is the most important factor among various parameters. Many works related to the thermal effects in fibre spinning and yarn texturing[1~5] have been performed until now. But there was a few work concerning the effects of wet and dry heat temperatures in dyeing and finishing on the physical properties of the polyester fabrics. Therefore, this paper examines the effects of wet and dry heat temperatures in sizing, scouring, pre-set and final set processes on the thermal shrinkage and appearance colour of the polyester fabrics.

2. Experimental

Structural parameters of yarns and fabrics prepared in this study are shown in Table 1.

Process conditions in dyeing and finishing including sizing are shown in Table 2. Specimen I in Table 2 was prepared for investigating effect of thermal shrinkage of polyester fabrics according to each process step. Specimen II was processed for examining the effects of wet and dry heat temperatures to the fabric thermal shrinkage and appearance colour of fabric.

Specimen III was prepared for investigating the effect offinal set temperature. Three warp beams treated with 90℃, 125℃, and 150℃ of dryer heat temperature in sizing were prepared. Plain fabrics were woven by shuttle loom and satin fabrics were woven by water jet loom. Each fabric woven from three warp beams was treated by 90℃, 110℃ and 120℃ in the scouring process, total nine kinds of fabrics were treated by 180℃, 200℃ and 220℃ in the pre-set process, respectively. And total twenty seven fabrics were treated with fixed 18% weight reduction and fixed dyeing, net-dry and final set conditions as shown in specimen II in Table 2.

Specimen I in Table 2 shows the processing condition of heat treatment in each process of plain and satin fabrics, respectively. Specimen III in Table 2 shows three kinds of fabrics treated with various final set temperatures and fixed conditions of other processes such as sizing, scouring, pre-set and weight reduction. Table 3 shows auxiliary used in sizing and scouring and dyestuff used in dyeing process.

3. Measurement

Various physical properties of fabrics were measured. Fabric thermal shrinkage of warp direction after each process in dyeing and finishing processes was measured by weft density of fabric. Dye-affinities of fabrics treated with various wet and dry heat temperatures, K/S, were measured by ICS-Texicon MM 9000(U.K.).

Crystallinity was calculated using following eq. (1) and eq. (2).

$$(X^{w}_{cry.}) = (\rho_c/\rho)\{(\rho-\rho_a)\}/(\rho_c-\rho_a)\} \quad (1)$$

$\rho_c = 1.457 g/cm^3$ [6]

$\rho_a = 1.336 g/cm^3$ [6,7]

$$(X^{v}_{cry.}) = (\rho-\rho_a)/(\rho_c-\rho_a) \quad (2)$$

Equation (1) is weight fraction crystallinity($X^{w}_{cry.}$) and equation (2) is volume fraction crystallinity ($X^{v}_{cry.}$). Densities of perfect crystalline and amorphous regions in equation (1) and (2) were used 1.457 g/cm³(ρ_c) and 1.336 g/cm³(ρ_a) respectively[6,7].

Table 1. Structural parameters of specimen

Structural parameters	Filament		Plain		Satin	
	Wp	Wf	Wp	Wf	Wp	Wf
Tex of filament(Tex/fil)	5.5/24 (SPK)	8.3/72 (SD)				
Twist of filament(t.p.m.)	100	2240				
Density of fabrics (ends or picks/cm)			63	32.3	94.5	36.2
Width of grey fabric(cm)			134.6		167.6	
Density of dent (no./cm×ends)			15.7×4		18.5×5	
Total warp ends			8400	(SWL)	15680	(WJL)

Table 2. Process conditions in dyeing and finishing processes

Process	Heating condition	Specimen I	Specimen II	Specimen III	Remark
Sizing (Si)	90℃ 125℃ 150℃	○ △	3 pieces (1×3)	○	2 chamber & 5 cylinder (II shin m/c) Korea
Scouring & relaxation (Sc)	90℃×20min. 110℃×20min. 120℃×20min.	○ △	9 pieces (3×3)	○	Rotary type (Sam-il m/c) Korea
Pre-set (P/S)	180℃×60mpm 200℃×60mpm 220℃×60mpm	○ △	27 pieces (3×3×3)	○	Sun super (II sung m/c) Korea
Weight reduction (W/R)	18%	○△	fixed (18%)	○	CDR Onomori Co (Japan)
Dyeing (D/D)	130℃×40min.(fixed)				Rapid, Onomori Co. (Japan)
Net-dry	150℃×40mpm(fixed)				Non contact 2 chamber Onomori Co.(Japan)
Final-set (F/S)	170℃×50mpm 180℃×50mpm 200℃×50mpm	○△	fixed (180℃×50mpm)	× × ×	Ichikin(Japan) 6 chamber Victex
Remark		plain ○ satin △		○=Fixed × =Variables	

Table 3. Auxiliary and dyestuff used in dyeing & finishing processes

Process	Auxiliary and dyestuff	Maker
Sizing	Sizer : WB-800S(17%) Antistatic agent(1%) Oil agent(1.5%) After oil(8%)	Youngjin (No. 1413)
Scouring & relaxation	NaOH(50%) 4g/ℓ Desizing agent 1g/ℓ Emulsifying agent 1g/ℓ	
Dyeing	Palanil yellow 5GL : 0.55% Resolin blue K-FBL : 0.285% Resolin red F3-BS : 0.32%	BASF BASF BAYER

Density of filament(ρ) in equation (1) and (2) was measured by density gradient method using n-Heptane and CCl_4 solution under the temperature 23± 2℃, relative humidity 55± 5%. Orientations of crystalline (f_{cr}) and noncrystalline (f_a) were measured by X-ray diffraction device (Cu-Kα, Rigaku, Japan) using equation (3) and (4), respectively[8].

$$f_{cr}=\frac{3\langle\cos^2\phi\rangle-1}{2} \qquad (3)$$

$$\text{Where, } \cos^2\phi=\frac{\int^{\pi/2}(\phi)\sin\phi\ \cos^2\phi\ d\phi}{\int^{\pi/2}_0 I(\phi)\sin f d\phi}$$

$$\Delta n=X^v_{cry.}\cdot\Delta^o_c\cdot f_{cr}+(1-X^v_{cry.})\cdot\Delta^o_a\cdot f_a \qquad (4)$$

where,

Δn : Birefringence

Δ^o_c : Birefringence of crystalline (0.29)[9]

Δ^o_a : Birefringence of noncrystalline(0.20)[9]

$X^v_{cry.}$: Volume fraction crystallinity

f_{cr} : Orientation of crystalline

f_a : Orientation of noncrystalline

In equation (3), orientation of crystalline (f_{cr}) was calculated about ($\bar{1}05$) face proposed by Hermans[8]. Birefringence (Δn) was measured by Polarized Microscope (Na-lamp, Nikon, Japan) using equation (5).

$$\Delta n=\frac{\lambda\cdot R}{t} \qquad (5)$$

where,

Δn : Birefringence

R : Retardation

λ : Wave length of N_D radiation

t : Diameter of specimen

4. Results & Discussion

Fig. 1 shows fabric warp shrinkage according to the each process step under the conditions of sizing dryer temp.(Si), 125℃, rotary washer(Sc) 120℃×20min., pre-set(P/S) 200℃, 18% weight reduction(W/R), net dryer temp., 150℃(D/D), final set(F/S) 170℃×50mpm. It is shown that fabric warp shrinkage after rotary washer is about from 10% to 12%, after pre-set is 12%, fabric is relaxed by 5% after caustic reduction and next, fabric is shrunk by 5% after dryer, finally, fabric is also relaxed by 5% after final-set. But these fabric shrinkages varies largely with various wet and dry heat temperatures in each dyeing and finishing processes.

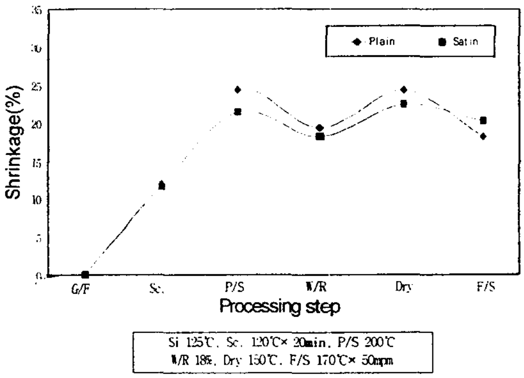

Fig. 1 Fabric warp shrinkage on each process step.

Fig. 2 shows fabric shrinkage variations with various wet and dry processing step and sizing as well as pre-set temperatures. It was investigated by authors[10] that these shrinkage variations with the heat temperature affect yarn and fabric mechanical properties and thus fabric hand is changed. For surveying appearance colour of fabric in relation with fabric thermal shrinkage by the various wet and dry heat temperatures, apparent concentration of dyestuff on the fabrics was measured and discussed.

In Fig. 2, after final set, fabric shrinkage is changed from about 8% to 23%. And shrinkage variation of fabrics treated with 200℃ of pre-set temperature according to the each process is the largest, shrinkage itself is the highest. Therefore, for surveying appearance colour of fabric in relation with fabric thermal shrinkage to the various wet and dry heat temperatures, apparent concentration of dyestuff on the fabrics was measured and discussed.

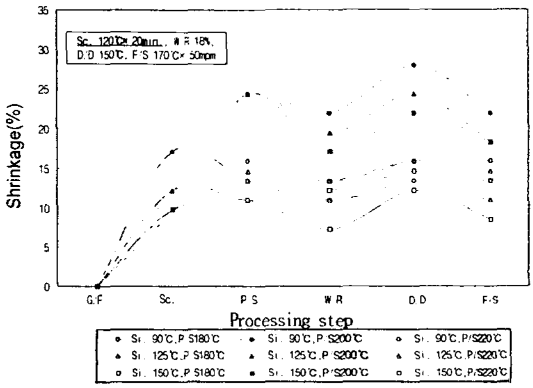

Fig. 2 The variation of fabric warp shrinkage on each process step.

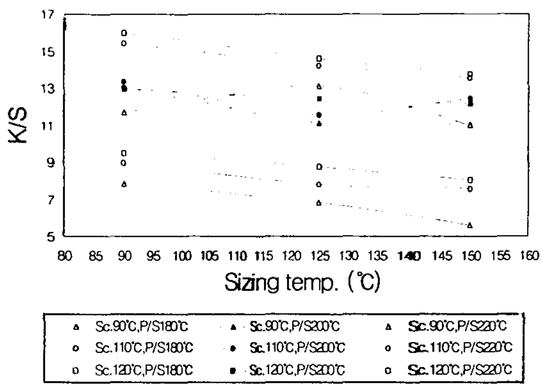

Fig. 3 Appearance colour of fabric to the sizing temperature.

Fig. 3 shows K/S of fabric according to the sizing temperature with various scouring and pre-set temperatures. K/S is decreased with increasing sizing temperature. These phenomena are due to decrease of fabric shrinkage with increasing sizing temperature, it is confirmed by no change of crystallinity to the sizing temperatures and no change of amorphous orientation in the temperature range from 90℃ to 150℃. Next figures demonstrate the evidence of these phenomena.

Fig. 4, 5 and 6 show fabric shrinkage, crystallinity, crystalline and amorphous orientation according to the sizing temperature, respectively. Fig. 4 shows fabric shrinkage with the sizing temperature. Fabric shrinkage is decreased with increasing sizing temperature. On the other hand, as shown in Fig. 5, crystallinity does not show any change with increasing sizing temperature. Fig. 6 shows relationship between crystalline and amorphous orientation factors of polyester and various dry heat temperatures of polyester filament treated on the AIKI texturizing machine(TH312). This experiment was performed for analysing the change of internal structure of polyester filament with various dry heat temperatures. And as shown in Fig. 6, orientation factor of the amorphous region of the polyester, f(a), which is measure of penetetating of dyestuff, does not change so much from 90℃ to 150℃ in the range of sizing temperature.

Therefore, apparent concentration of dyestuff

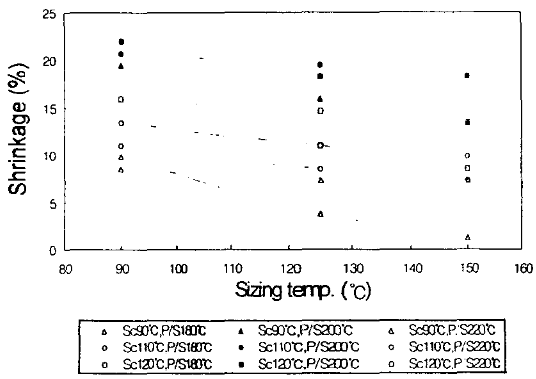

Fig. 4 Fabric warp shrinkage to the sizing temperature.

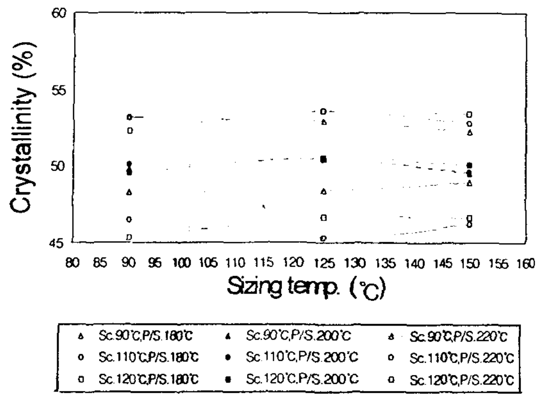

Fig. 5 Diagram between crystallinity and sizing temperature.

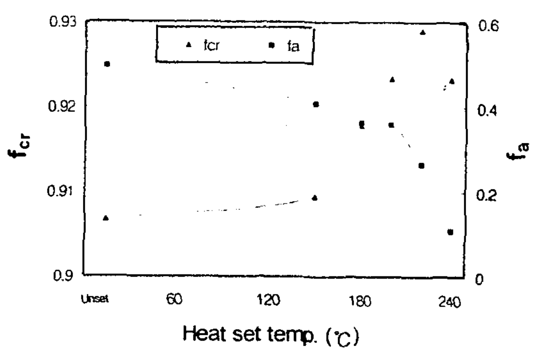

Fig. 6 Diagram between orientations of amorphous and crystalline and heat temperature.

on the fabric decreased with increasing sizing temperature is only due to decrease of fabric shrinkage without any change of appearance colour on the fabrics.

Fig. 7 shows appearance colour(K/S) of fabric to the scouring temperature with various sizing and pre-set temperatures. Appearance colour of fabric is increased with increasing scouring temperature. These phenomena can be also explained the same as a result of sizing temperature.

Fig. 8 shows fabric shrinkage to the pre-set temperature. A little differently to the sizing and scouring processes, fabric shrinkage is increased at the 200℃ of pre-set temperature and then decreased at the 220℃. The reason why maximum fabric shrinkage is shown at the pre-set temperature, 200℃ seems that maximum thermal stress of polyester is shown at the range of 200℃, which is originated from recrystallization of polyester at the vicinity of 200℃, this thermal stress makes the fabric shrinkage high. The appearance colour according to the pre-set temperatures is shown in Fig. 9. Fig. 9 shows fabric appearance colour to the pre-set temperature. Appearance colour of fabric is increased with increasing pre-set temperature. But, these phenomena could not be explained by increase of fabric shrinkage such as the results of sizing and scouring.

Fig. 10 explains the reason why the dye take up of the fabric is increased with pre-set temperature even though fabric shrinkage is decreased at the 220℃ of pre-set temperature. Fig. 10 shows the dye take up of tube knitted fabric treated with the various heat-set temperatures, as explained in Fig. 6, which thermal experiment of filament was also performed on the AIKI texturizing machine(TH312). Dye take up is largely increased at the 220℃ of heat temperature even though the density of knitted fabric is same. It is confirmed as the orientation of the amorphous region is decreased with increasing heat temperature from 180℃ to 220℃ as shown in Fig. 6.

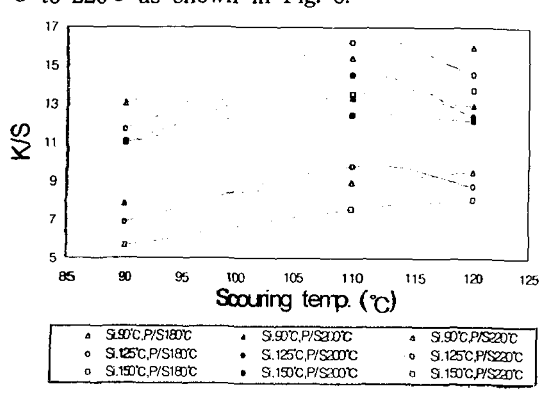

Fig. 7 Appearance colour of fabric to the scouring temperature.

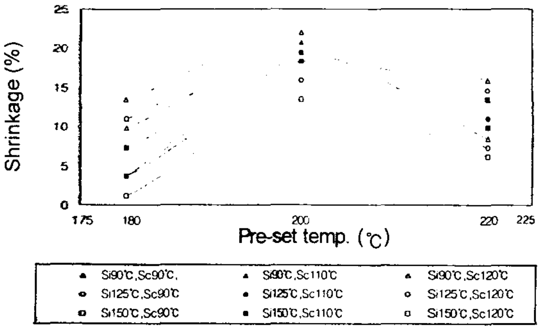

Fig. 8 Diagram between fabric shrinkage and pre-set temperature.

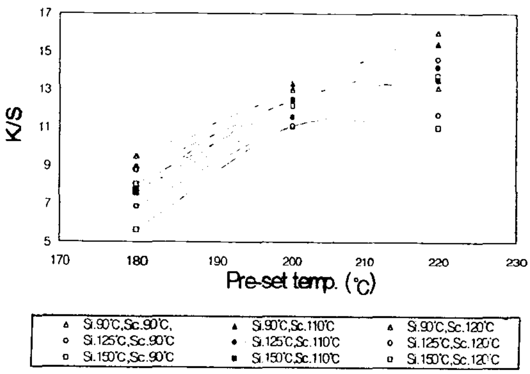

Fig. 9 Diagram between appearance colour and pre-set temperature.

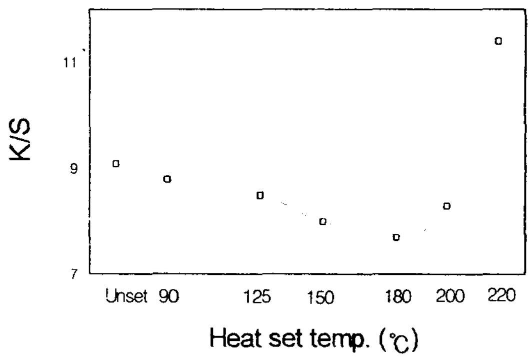

Fig. 10 Appearance colour of tube knitted fabric to the heat temperature.

Fig. 11 shows the appearance colour and the shrinkage of the fabric to the various final set temperatures. Appearance colour and fabric shrinkage show no change with variation of final heat temperatures. It seems that dry heat treatment in final-set process after excessively treated by dry-heat in the pre-set and net-dry processes makes fabric shrinkage no change, and thus no change of appearance colour of fabric is shown.

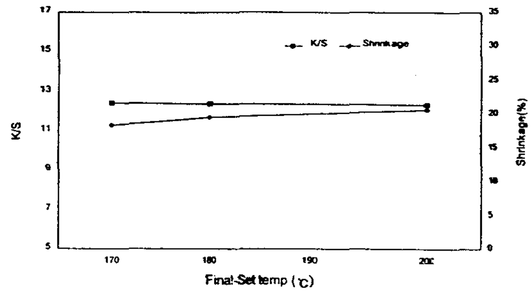

Fig. 11 Diagram between appearance colour and fabric shrinkage and final set temperature.

5. Conclusion

1. Low drying temperature in sizing chamber makes polyester fabrics high fabric shrinkage and appearance colour.
2. High scouring temperature in scouring and relaxation process makes appearance colour of polyester fabric high as fabric shrinkage is large.
3. Appearance colour of polyester fabric is increased with dry heat temperature in the pre-set process. It is due to fabric shrinkage in the vicinity of before and after 200℃, then above 200℃, it is due to orientation of amorphous region.
4. There was no effect of final set temperature to the appearance colour of polyester fabric.

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