



Research Article

## Surface Textile Design of Polar Fleece Using Laser Engraving Technique

Minnyoung Seo\* and Young Seok Koo

### Abstract

The purpose of this study is to develop textile surface design of polar fleece by using laser engraving technique. A prototype of textile design was proposed by combining selected textile design elements before making the textile design samples. The program, 4D-PLANS, was used to express the raised material and Adobe Photoshop CS6, Adobe Illustrator CS6 were used to make patterns with a dot motif. Adobe Photoshop CS6 was used for the final textile design prototypes. Its actual figures were produced by surface finishing-laser engraving. A functionality test and visual evaluation were conducted to test whether the laser engraving polar fleece is suitable as an outer textile material. As a result of the thermal test of laser-engraving polar fleece and original polar fleece, there was no significant difference in warmth when using laser engraving with less than 50% of the total area. The design evaluation indicates that the subjects are satisfied with colors, textures and patterns with over 4.0 of average on a five-point Likert-type scale. In particular, satisfaction with textile is highest. Therefore, this study will suggest diversity for the development of surface design of napping materials applying laser engraving technique.

### Keywords

Surface textile design; Laser engraving; Polar fleece

### Introduction

Developing materials and its quality and diversifying fabric designs that greatly influence clothing design and function are very important in the textiles and clothing industries. Among these, creating the new designs of fabric has the most important role in improving its added value and in order to make high-value fashion materials, fabric surface design should be developed such as printing, embroidery and laser cutting. Particularly, if the various fabric surface designs of outdoor clothing are developed and the clothes made of this fabric are comfortable and looks good, they can satisfy the elderly psychologically and visually. Today, it has been acknowledged that functional fabric is used for casual clothes and sportswear for children and adults, but there are only few functional fabrics that fit to body transformation at advanced age, so we need functional fabric which can be used for casual clothes such as leisure wears for old people who have high incomes and lots of time [1-3].

Most of textile designs that make outdoor wears look good are

combinations of colors by cutting and by DTP and a variety of lines are printed on down jackets and vests for winter by quilting. However, these fabric surface designs do not greatly affect outdoor wear designs. Therefore, if various surface designs do not affect functionality, which is a basic concept of outdoor wears, and are possible with many materials, these will stimulate emotions of people who are wearing the clothes and affect aesthetic comfort.

Materials finishing technique that may visually affect the surfaces of fashion materials include finishing by heating finishing by chemical finishing and laser finishing. Finishing by heating can be divided into embossing and pleated, which makes fabrics three-dimensional. Chemical finishing is a method that makes fabrics have patterns on their face with flame resistant for its chemical features and reactions, which includes burn out, ripple, washing and felting. One of the greatest features of the laser cutting method makes exquisite, decorative patterns, highlighting features and formativeness of fabrics. Later cutting can be divided into cutting and engraving. Laser cutting makes unique texture, three-dimensional textures, while these patterns are applied to surfaces. Also, as textile made by laser cutting casts a dramatic shadow by light, it is interactive with spaces to be applied to or users [3]. Anne Smith, a renowned designer who researching laser cutting, has conducted studies on this technique since the late 1990's. The ultimate goal of research on laser cutting is to make a textile decorating technique that can replace dyes or printing inks that may destruct our environment. One of the strong points of laser cutting is that we can make various fabrics exquisite and three-dimensional by an embossing technique. While napped fabrics need to be weaved with different lengths of threads to make three-dimensional patterns, the laser embossing method variously makes them three-dimensional because the fabrics are manipulated directly by laser and there is no limitation for patterns.

Therefore, this study aims at developing the diversity of the technique of textile design by changing the surface of polar fleece through laser engraving. It will provide the basic data that can be used more diversely for the garment fiber by the laser engraving technique.

### Theoretical Basis

#### Developing trend of polar fleece outerwear

Outdoor wear pursues comfort by using suitable functional materials according to the layering system.

The layering system is classified into a base-, mid-, and outer layer. Outdoor wear mainly concentrates on a mid-layer and an outer layer among these layers. The mid layer is the core of clothing that controls body temperature. It gives warmth as well as activity and has t-shirts and insulation. Insulation that controls body temperature to keep the warmth inside jackets. These jackets are made of high thermal insulation fillers such as polar fleece or padding / down. In addition, the mid-layer has a hybrid that is represented by two functions at once using two textile materials each. Outer layer is a jacket that wears on the outside. It has a waterproof, windproof and a down jacket. However, polar fleece jackets and vests, which are widely used for the purpose of warmth among the types of the mid layer, are also used as outerwear depending on the weather. Therefore, this

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study defines as outdoor outerwear that includes polar fleece jackets and vests of the mid layer.

**Types of polar fleece outerwear’s fabric:** Polar fleece is a high emotional and functional product by rising finishing after weaving of high density polyester [4]. It has good chemical property and comfort-orientated material as well as easy fabric to application of various products by finishing. Polar fleece has the loop structure as knitted fabric such that high stretch to easy and comfort for activity of wearer. The loop structure can have large air content for good thermal property, no wrinkle and flexibility and good air permeability depending on the loop structure. Polar fleece has been originally developed by Malden Co. in USA and registered “Polartec” as a brand name and then the synthetic fiber for fleece was developed in 1981 as a trademark of “polar fleece”. In particular, the polar fleece was selected as “One of the 100 innovations in the 20th century” by the Times. Currently, the polartec has more than 400 types of fiber depending on various climate condition and more than 180 related technology and function of fiber patent. The polartec can be classified by three categories.

**Textile design characteristics of polar fleece outerwear:** A number of products made of fleece material including thermal shirts, jackets, pants, underwears, socks, gloves, hats, etc. have been on the market in general fashion market including outdoorwear, sportswear and casual wear markets. The following Table 1 is comparison analysis of polar fleece outerwears of 5 outdoor brands that are widely used for winter linings and of 5 SPA brands at reasonable prices and with practical use. The surfaces of polar fleece vary depending on finishing methods, and the kinds of polar fleece can be divided into outdoor wear and casual wear. The representative polar fleeces widely used for outdoorwears are thermal pro and high loft, which emphasize high functionality. Also, there are fluffy fleece, which has long raised yarn, and hybrid fleece that is combined with other functional materials. For casual clothes, polar fleece is used which has more general functions than high functionality such as thin, soft microfleece, fluffy fleece with long raised yarn used for outdoor wears, and hybrid fleece combined with other materials. While hybrid fleece for outdoor wears is combined with other materials at the processing of finishing, the polar fleece for casual clothes is partially combined with other

Table 1: Comparison of fleece outerwear in outdoor wear and casual wear by materials and items.

OUTDOORWEAR	FINISHING	Polartec Thermal Pro/Polartec HIGHLOFT	Fluffy Fleece	Hybrid Fleece
				
		<a href="http://www.blackyak.com/">http://www.blackyak.com/</a> Coat	<a href="http://www.thenorthfacekorea.co.kr">http://www.thenorthfacekorea.co.kr</a> Jacket	<a href="http://www.kolonsport.com">http://www.kolonsport.com</a> Vest
	ITEM			
		<a href="http://www.thenorthfacekorea.co.kr">http://www.thenorthfacekorea.co.kr</a> Micro Fleece	<a href="http://www.k2.co.kr">http://www.k2.co.kr</a> Fluffy Fleece	<a href="http://www.k2.co.kr">http://www.k2.co.kr</a> Hybrid Fleece
CASUALWEAR	FINISHING			
		<a href="http://www.hm.com">http://www.hm.com</a> Coat	<a href="http://www.uniqlo.kr">http://www.uniqlo.kr</a> Jacket	<a href="http://www.hm.com">http://www.hm.com</a> Vest
	ITEM			
		<a href="http://www.uniqlo.kr">http://www.uniqlo.kr</a>	<a href="http://www.ssfshop.com">http://www.ssfshop.com</a>	<a href="http://www.hm.com">http://www.hm.com</a>

materials at making clothes. Outerwear of polar fleece are mostly zip-up jackets and sometimes coats and vests. Among the fleece jackets in outdoor- and casual wear, the polar fleece with aesthetic surface finishing are shown in Table 2.

Polar fleece outerwear is mostly zip-up jacket, and polar fleece surface design is done by digital textile printing (DTP) technique which is one of the finishing techniques of surface textile design. Outdoor wear is designed to focus on the functionality of the material, so the surface design of the material gives a change of texture through the structural transformation of the material.

Checked, diagonal and geometric patterns are used for casual wear. Snowflake-, geometric-, and diagonal patterns are used for outdoor wear. Generally, geometric motifs are mostly used, and the size of the motifs is small. The small motifs give calm and comfortable feeling by being arranged one way and two ways. Because the polar fleece is dyed well, there are various types of polar fleece products in casual wear. Tones are used for bright tone and vivid tone.

On the other hand, outdoor polar fleece products are used dark and light tones, and the variety of colors is limited compared to casual wear. The pattern is mostly geometric patterns similar to casual wear, the size and arrangement of the motifs are arranged in a one way and all over with small and medium motifs. Polar Fleece of the outdoor brand focuses on functionality, so it lacks a variety of designs than polar fleece of the casual brand.

Therefore, the aesthetic sensibility in casual wear needs to be reflected in outdoor wear.

Methods

Textile material selection









Based on the previous research [5], we selected polar fleece fabric, which has soft texture with raised surface. In addition, this fabric meets the needs of new senior women who values it practicality and economically.

Selection of components for textile design

The components of the textile pattern design is based on the previous researches [6-8]. The previous researches of geometric patterns can be divided into two types (Table 3). One is the theoretical analysis of geometric patterns, and then the researcher expresses them as his works. The other was analyzed qualitatively and quantitatively by selecting specific patterns such as a circle or a stripe in geometry types. The criterion for dividing the type of geometric patterns varies according to the criteria of the researcher. Also it can be seen that the detailed types of geometric patterns are divided on various criteria. Because the researchers classified the types according to the purpose of the research.

Geometrical patterns are classified into a line and a shape, and a line represents an illusion caused by a rule and a repetition due to a mathematical structure, and a shape represents the reproducibility

Table 2: Polar fleece outerwear of casual wear and outdoor wear.

Casual wear		Outdoor wear	
Plain	Color combination	Plain	Color combination
			
<a href="http://www.uniqlo.kr">http://www.uniqlo.kr</a>	<a href="http://www.uniqlo.kr">http://www.uniqlo.kr</a>	<a href="http://www.thenorthfacekorea.co.kr">http://www.thenorthfacekorea.co.kr</a>	<a href="http://www.blackyakmall.com">http://www.blackyakmall.com</a>
Diamond pattern	Check pattern	Surface Effect	Abstrct diagonal pattern
			
<a href="http://www.uniqlo.kr">http://www.uniqlo.kr</a>	<a href="http://www.uniqlo.kr">http://www.uniqlo.kr</a>	<a href="http://www.blackyakmall.com">http://www.blackyakmall.com</a>	<a href="http://www.mehmall.com">http://www.mehmall.com</a>
Fairisle pattern		Fairisle pattern	
			
<a href="http://www.uniqlo.kr">http://www.uniqlo.kr</a>	<a href="http://www.uniqlo.kr">http://www.uniqlo.kr</a>	<a href="http://www.blackyakmall.com">http://www.blackyakmall.com</a>	<a href="http://www.uniqlo.kr">http://www.uniqlo.kr</a>

**Table 3:** Types of geometric patterns based on previous research.

	Researcher	Classification
Geometric motif	Ha, Lim & Park	Check, Stripe, Circle, Polygon, Geometric complex
	Baek	Dot, Check, Stripe, Other geometric patterns
	Jung	Dot, Ellipse, Rectangle, Stripe
	Kim	Triangle, square, circle
Geometric pattern	Jo	Geometric line, Geometric curve
	Oh	Classified as line, curve, or mix by the shape of the line

**Table 4:** Types of geometric patterns.

Category	Type	Characteristic
Line	Curve	Optical illusion due to repetition and rule by the mathematical structure
	Spiral, Circle	
Shape	Straight line	Reproducibility of natural plants and animals as a motif
	Zigzag, Grid, Diagonal line	
Shape	Animals and plants	Reproducibility of natural plants and animals as a motif
	Animals and plants	

**Table 5:** The selected textile design elements of outerwear.

Elements of outer textile design			
Fabric	Polar fleece	Function	Insulation
			Lightweight
Color	Chromatic	Texture	Soft
	Achromatic		Soft
Pattern	Geometric	Texture	Soft
	Arrangement		Soft
Textile finishing	Laser cutting	Texture	Soft
			Soft

of motifs of animals and plants in nature (Table 4). The line can be divided into a curved line and a straight line, and a shape can be divided into a circle and a polygon. In other words, the geometric patterns can be expressed in clothing by optical illusion and reproducibility. Therefore, the selected textile design elements for outdoor outerwear are shown in Table 5.

## Sample making of textile design

A prototype of textile design was proposed by combining selected textile design elements before making the textile design samples. The program, 4D-PLANS, was used to express the raised material and Adobe Photoshop CS6, Adobe Illustrator CS6 were used to make patterns with a dot motif. Adobe Photoshop CS6 was used for the final textile design prototypes. For real production, textile design was developed using laser engraving technique for polar fleece material. The laser cutting machine used to the polar fleece fabric was VLS6.60, the largest platform in the VLS platform line. VLS6.60 has a wide, deep slice area that can accommodate a variety of materials. It provides the selection of the six laser cartridges within 10-60-watt output range.

## Suitability evaluation of textile design samples for outerwear

**Thermal test:** The thermal of the fabric was measured (KS K 0560). Measuring method for warmth keeping property of cloth is as follows. As a general rule, two specimens are to be taken from the surface of the fabric at least 1/10 of its width and at least 1 m from both ends of the fabric. Each specimen shall not contain the same warp and weft or weir course. The specimen is conditioned for at least 4 hours under the standard condition of KS S ISO 139. The test piece was sampled at a size (about 50 cm × 50 cm) that completely covered the constant temperature heating element.

**Evaluation of visual satisfaction of new senior women:** A visual satisfaction test was performed on the new sister women of the developed textile samples. Three textile design elements (color,

pattern, texture) and the visual sensibility adjectives of 26 materials based on the previous researches [9,10] were selected.

## Textile design process for outerwear





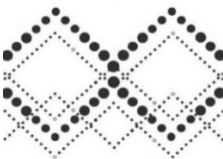
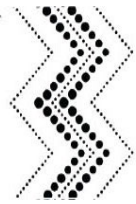


**Prototype process of outerwear's textile design:** This study was suggested a textile design prototype before developing a polar fleece fabric for new senior women based on the results of the design preference of outdoor wear.

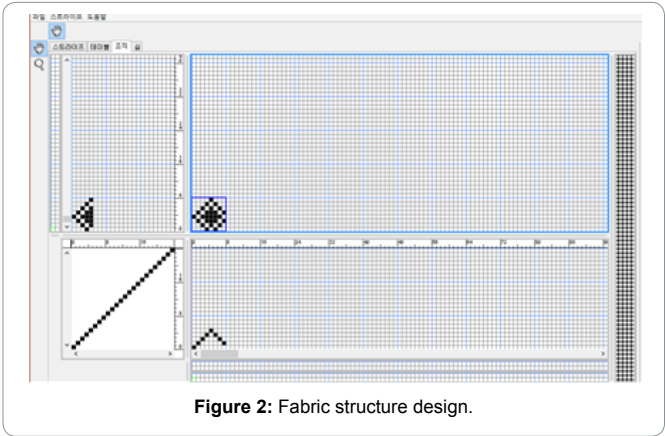
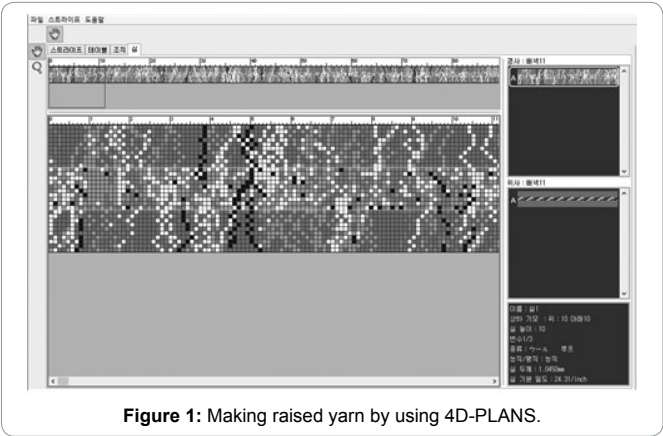
**Making raised fabric:** The raised fabric was made using the 4D PLANS program. First, the number of yarns is set to 1/3, the thickness of the yarns is 1.0450 mm, and the basic density of the yarns is set to 24.31 / inch. The color was set in the color panel and the inside of the yarn section circle was clicked and placed. The basic yarn is made by setting the number of times and direction (S: right, Z: left) between 1m. After making the basic yarn, the melange yarn was selected for the raised expression, and the lengths of the top and bottom of the raised yarn was set to 10 in in the raised pattern setting item. The fabric structure was selected from 5001 structure of weave 500E in fabric structure 500 kinds. The warp was 62 / 64.78mm, the warp count was 62, and the weft was used the loop structure set to 88 (Figure 1).

**Pattern development:** The geometric pattern was developed using a dot motif with high preference in the pattern preference result of previous research. Geometrical patterns are often expressed in sportswear and outdoor wear, and they are used to express modern and active feelings. Geometric patterns were divided into shapes expressing the optical illusion and lines expressing reproducibility in terms of morphological structure. The line was divided into a curved line and a straight line, and the shape was composed of a circle. The optical illusion was designed based on the principle of optical pattern formative factor- concentric circle type, rhythmic type, diamond type, wave type, radial type (Table 6). In detail, curved patterns were designed with spiral pattern (Type -①), a wave pattern (Type -②), a



Table 6: Motif development.

Category		Type	
Line	Curve	Spiral (Type -①)	Wave (Type -②)
			
	Straight	Circle (Type -③, ④)	
			
		Grid (Type -⑤)	Zigzag (Type -⑥)
			
Shape	Circle	Plant (flower) (Type -⑦, ⑧)	
			



circular pattern (Type -③, ⑥), The line patterns were designed with a grid pattern (Type -⑤) and a zigzag pattern (Type -⑥). The shape patterns were designed with floral patterns (Type-⑦, ⑧) among the plant motifs using dots. Finally, eight kinds of patterns were developed (Table 4). The size of the motif was expressed that dots are gradually increased or decreased to give a slight change in calmness without using dots of the same size. The size of the dot was designed within a range not exceeding 2 cm at maximum (Figures 2 and 3).

**Preferences evaluation of developed patterns:** To determine the preference of the pattern, the color was designed with a black pattern

on a white background, so that it was not affected by other design factors. The proposed pattern designs were printed with 8 patterns on 20 cm \* 20 cm paper. The results of the pattern preference evaluation of 10 new senior women were shown in Table 5. New senior women preferred Type ①, Type ③, Type ④ over 4.0 on an average. Therefore, the pattern textile of two types (Type ①, Type ④) with high preference was applied to the final textile design (Table 7).

**Suggestion on prototype of textile design for outdoor outdoorwear:** Two final patterns were applied to raised fabric (H \* W = 20 cm × 20 cm) using the 4D PLANS program. The size of the dots

Table 7: Preference difference on pattern design of the new senior.

Types	Mean	Types	Mean
Type ①	4.70	Type ⑤	3.40
Type ②	3.90	Type ⑥	3.40
Type ③	4.20	Type ⑦	3.30
Type ④	4.70	Type ⑧	3.20

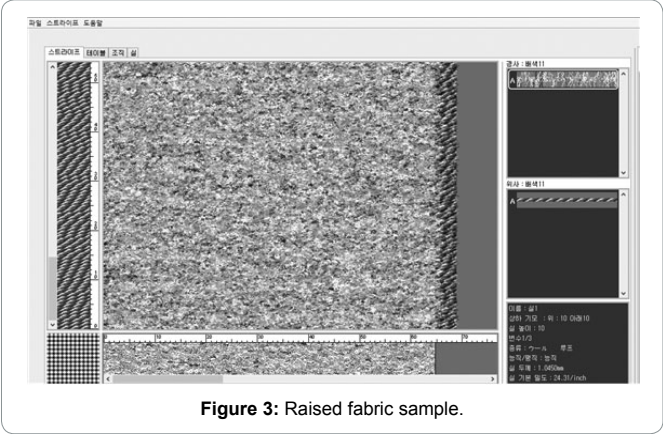


Table 8: Outer textile design prototypes.

	Type ①	Type ④
Motif Size	Large (H:15 cm, W:15 cm)	Small (H:5 cm, W:20 cm)
Pattern	One pattern	Repeat pattern
Pattern arrangement	All over	1 way
Color	Gary	Gary
Textile Design Prototype		

gradually changed within a maximum size of 2 cm. Looking at the size of the final motif, the spiral pattern Type ① was set within a large size of 15cm because one motif becomes a pattern. Zigzag pattern Type ④ was set small size, a length of diagonal is 5cm, because one motif is repeated. Based on the result of the color preference, the fabric color was set to achromatic gray, which excluded the chromatic color, in order to see only the effect of the pattern applied to the raised fabric. The color of the pattern was set to black in consideration of the fact that the tone of the fabric was thicker than the original color of the fabric by laser finishing (Table 8).

**Making of textile design samples for outdoor outerwear**

Textile design samples (20 cm × 20 cm) were made based on the textile design prototype. The color of fabric was selected navy and gray which were high in color preference results. A laser engraving technique was used for surface finishing of the fabric by applying Type ① and Type ④ to the selected color polar fleece fabric. Each sample showed visual effect as cutting the pattern of the raised fabric through laser engraving technique (Table 9).

**Suitability evaluation of textile design for outdoor outerwear**

**Thermal test:** Table 10 showed the result of thermal test.

Table 9: Polar fleece applied Type ① and Type ④.

Color	Type ①	Type ④
Gray		
Navy		

Table 10: Measuring method for warmth keeping property of cloth.

Test item	Temperature
Room Temperature	(20 ± 1)°C
Tester Temperature	(35 ± 0.5)°C
Original	56.6°C
Finishing textile	55.7°C

Table 11: The visual evaluation of textile design of the new senior (n=10).

Element	Mean
Color	4.10
Texture	4.80
Pattern	4.60

Table 12: The visual evaluation of a textile sampling's sensibility adjectives (n=10).

Element	Mean
Chic	4.70
Urban	4.80
Neat	4.70
Emotional	4.00
Natural	4.10
Comfortable	4.30
Simple	4.60

Temperature of the unfinished fabric was 56.6°C and it of the finished one (50% surface finishing in total) was 55.7 °C in the test condition of 20 ± 1°C and tester temperature of 35 ± 0.5°C. The difference between the tested fabrics was 0.9°C (1.6% in percentage conversion) which showed no significant difference of thermal function in the surface finishing.

**Visual evaluation:** The results of the new senior women's textile designs satisfaction are the same as Table 11. New senior women were satisfied with a color, texture, and pattern more than 4 points on average. Especially, satisfaction of the texture was the highest. Therefore, the results show that the developed textile samples are suitable for outerwear that can be used as a daily wear for new senior women. As a result of the visual sensitivity of the developed material,

the sensibility adjectives of modern images were higher (Table 12). New senior women considered this developed textile design as a sensibility textile with modern and comfortable. The results show that the developed textile samples are suitable for outerwear outer that can be used as a daily wear for new senior women.

## Conclusion

In this study, research on preferences for functional materials and design was conducted with the new senior women who pursue comfort and aesthetics of clothing and outer textile design was developed and evaluated.

Thermal polar fleece with napping and soft materials is selected among comfort materials and three chromatic colors (navy, violet and purple) and one achromatic color (gray) are selected based on previous studies in order to develop outdoor wear textile design. Geometric patterns are separated into lines and shapes based on dotted patterns; 8 types of patterns are developed and evaluated to select two patterns; and the motives of these two patterns are reorganized for patterning. Through this process, textile prototypes and samples were produced. The following is the results of thermal tests of the sample textile and design evaluation and visually emotional evaluation by the new senior women: The difference between the tested fabrics showed no significant difference of thermal function in the surface finishing. The design evaluation indicates that the subjects are satisfied with colors, textures and patterns with over 4.0 of average on a five-point Likert-type scale. In particular, satisfaction with textile is highest.

It is very significant that emotional textile design was developed in combination of practical use, functionality and aesthetics for the new senior women who pursue graceful sensibility of clothes. In addition, applying laser engraving that is not used for napping materials shows diversity of surface finishing.

Only vivid colors were considered to study on their preferences for colors of functional materials based on the colors of functional clothes on the market and previous studies, but studies on various tones, color combinations and colors by item for casual clothes are necessary. In addition, using both DTP for polar fleece and laser processing will give visible effects more.

The limitations are that the napping materials of polar fleece were not expressed visually when textile design prototypes were produced with CAD and patterns were made by printing as they were not expressed by laser engraving. This is also a threshold that patterns on napping materials engraved by laser were not expressed visually due to surface of napping fabrics processed by computer, when the first textile design of outerwear was suggested with CAD.

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