

## Panel 2.8 Technology and Design

### Innovative Denim fabric Design by Color Coating Using Laser Etching and Hollowing Technologies

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#### Abstract

In this paper, the fashionable laser color water washing-like and stereo pull flower coating denim fabric with nostalgic and leisure styles design was conducted to achieve innovative denim textures by approaches for the design of combining effects of using the dynamic high-power focusing laser etching machine environmental-friendly on successive open-width, and pattern CAD software system. Meanwhile, the elastic soft feeling and the intensity of the used denim after the laser etching and hollowing can meet the requirements, such as polyester/cotton stretch denim, cotton stretch denim.

#### 1. Introduction

The artistic effect of water washing plays a very important role in denim fabric manufacture and directly influences the appearance quality of denim fabric. However, the water washing process, such as garment washing, stone washing, enzyme washing, bleaching, has shortcoming of high water consumption, low productivity, and low automation degree, etc. Not only that, the denim garment has many disadvantages in the production process, mainly is water pollution, high energy consumption and heavy metal pollution. In recent years, laser carving patterns technique has become the waterless dyeing technique which can not only meet the requirements of environmental protection, but also reflect a sustainable developing direction of the textile fabric design.

The Italy-MX Series Laser On-line Engraving Machine consists of high-power laser transmitter, advanced large-scaled high-speed galvanometer scanning system, unique operating system, tension adjustment device for materials, electronically-automatic centering device, creative material workbench, high-efficient constant voltage transport system and specified laminar flow dust emission reduction system. This engraving machine allows the laser to continuously process the material. In the manufacturing procedure, as long as the power and the focus of the machine are set appropriately, the material can be cut, holed, etched, carved and faded etc. What's more, it can even change the appearance and physical attributes of the material. The MX Series Laser On-line Carving Machine allows laser with raster or vector images, which really

realize "What You See Is What You Get". This procedure leaves out the process of plate-making, which meets the individual demands of modern people. What's more, no pigments will be used during the entire process and therefore no chemical pollution will be generated. Besides, it only cost only 20 Yuan per hour. After this procedure, the material doesn't need traditional color-fixation process, which shortens the whole manufacturing process and reduces resources consumption without any environmental pollution element

#### *CAD System for Full-width Dynamic Successive Laser Carving Machine*

BMP is the bitmap format which can be processed by Photoshop into an 8-bit grayscale image. In this software, a .BMP file will be saved as a .OTB one automatically. Figure 1 presented the user interface of BMP format. When using the .BMP file, the maximal laser speed reaches 2400m/min. This design adopted the current technology. In this research, the CAD system will be applied to accomplish the design of pattern.

PLT is the vector graphic format. Coreldraw will import the processed graphics into the PLT files, with 8 layers as the maximum. In Coreldraw, .plt files will be automatically saves as the .otp files. Figure 2 shows the user interface of PLT format. Configure the parameter when exporting the graphics: the curve fraction: 0mm; line spacing: 0.5mm; pen color: black; width of pen: 0.35mm; pen dynamics: 32cm/s. As PLT format only incorporates the linear patterns which are commonly used for fabrics clipping and hollowing, the gradient effect cannot be achieved.

This thesis designs a new combining process of the water-base polymer elastic soft glue coating, and the dynamic high-power focusing on successive open-width laser etching or hollowing environmental-friendly. Here 6 kinds of various styles of the laser water washing-like coating denim fabric were conducted.

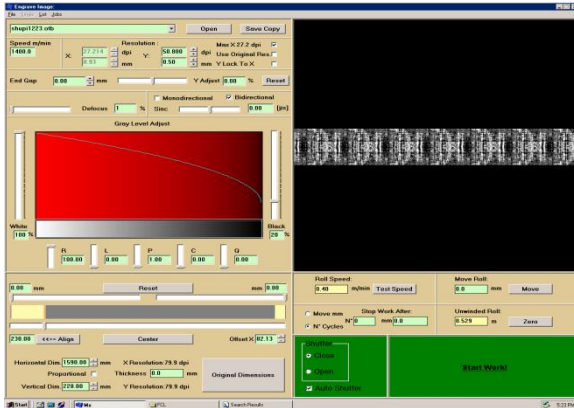


Figure 1 BMP Format Interface

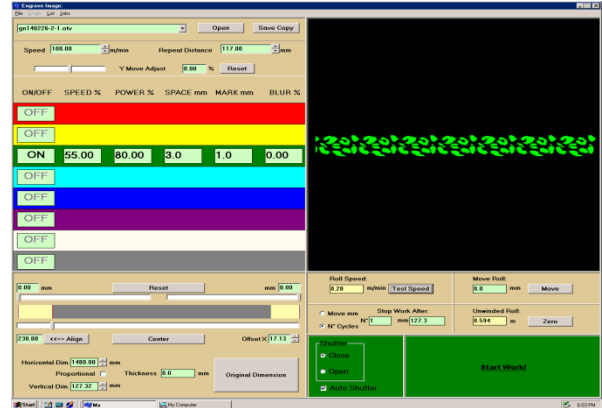


Figure 2 PTL Format Interface

## 2. Methodology

**Approach 1** Making laser color water washing-like denim on the surface of the color coated using polymer glue film (Such as sample 1, sample2).

**Approach 2** Making laser color water washing-like denim on the surface of the multi-color coated using polymer glue film (Such as sample 3, sample4).

**Approach 3** Making laser color water washing-like denim printing on the base of denim by color coating polymer glue film (Such as sample 5).

**Approach 4** Making laser hollowing the single surface of the coated fabric with the polymer film (Such as sample 6).

### The Laser Etching Technical Parameters

Sample	V (m/min)	Y (mm)	W (%)	B (%)	the Etching Effect					Speed (m/min)
					R	L	P	C	Q	
1	1400	0.5	100	20	100	0	1	0	0	0.40
2	600	0.48	100	0	0	0	33	0	100	0.18
3	600	0.48	100	0	0	0	33	0	100	0.20
4	500	0.55	100	15	100	5	5	0	0	0.21
5	1400	0.50	10	100	100	0	10	1	0	0.42

**Notes:** V- the laser velocity, Y- the laser vertical spacing, Speed- the operating speed of the machine W-White, as Figure 1 showed, when the value of w is equivalent to zero, the white lines and white area will not be etched by the laser. Yet, when the value of W is 100%, the white lines and area will be etched by the laser with maximal energy.

B-Black, as Figure 1 showed, when the value of B is zero, the black lines and area will not be affected by the laser. However, when the value goes to 100%, both the lines and area will be corroded by the laser with maximal energy.

Etching Effect: Figure 5 presented the figure with gray gradient lines and areas. Figure 4 is the quadratic curve for gray degree adjustment corresponding to pattern in Figure 5. "R, L, P, C and Q" in Figure 4 represent the range of empirical value of the adjustable gray degree of Curve R, L, P, C and Q which are corresponding to the quadratic curve for gray degree adjustment from the left to right. Notably, the empirical values of R, L, P, C and Q must not be zero simultaneously.

### Laser Hollowing Technical Parameters

Sample	V (m/min)	the Speed (%)	the Power (%)	the Space (mm)	the Mark (mm)	the Blur (%)	Speed (m/min)
6	100	55	80	3	1	0	0.28

**4. Design illustration**  
**Sample 1**



Figure 3

The laser color water washing-like blue denim (Shown as figure3)

The Design of the Technical Process:

Making the single-sided laser color watering-like fabric by the PU blue color coating before laser etching pattern

The Design of the Pattern: Shown as figure 1, figure 4, figure 5

- ①The texture of the pattern has a sense of regular layers.
- ②The grayscale of the stripe pattern is adjustable, which makes it seem to have a gradient texture.

③Since the color of the PU coating is less different from that of the base fabric, we choose the pattern of bark texture with texture of layers.

Based on the above design ideas, we gain the PU color coating etched pattern .BMP file (shown as figure 5), and the corresponding quadratic curve of image gray value for the pattern(shown as figure 4).

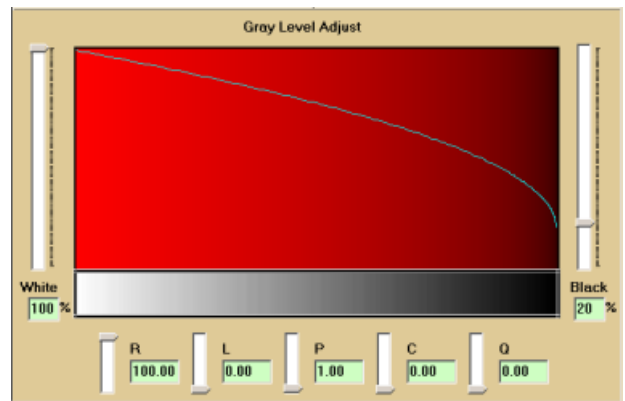


Figure 4

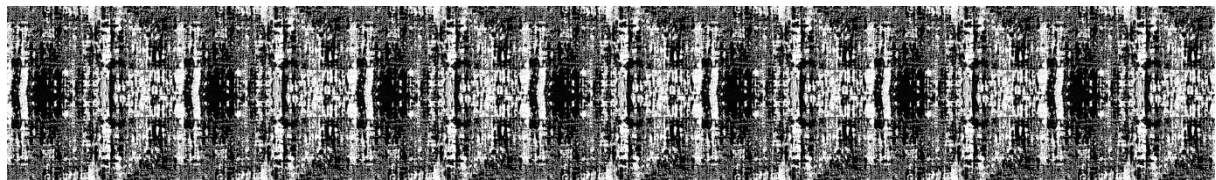


Figure 5

Contents		Before Being Coated and Etched	After Being Coated	After washing
Tensile Strength/LBF	Warp	200.2	197.8	186.8
	Weft	239.3	248.8	175.0
Rate of Decrement /%	Warp		-1.0	-6.69
	Weft		+3.8	-26.87
Tear Strength /LBF	Warp	11.3	9.0	>14
	Weft	13.6	13.0	12.6
Rate of Decrement /%	Warp		-20.9	+19.28
	Weft		-4.4	-7.35

*Strength Tests*

- a. ASTM D5034-95 Standard Test Method for Breaking Strength and Elongation of Textile Fabrics —DESC fabric strength tester
- b. ASTM D1424-96 Standard Test Method for Tearing Strength of Fabrics by Falling-Pendulum Type — M008 falling-pendulum strength tester
- c. Washing conditions: 50°C, 15 minutes
- d. The test results show that after being etched by laser, the warp tearing strength of the coated fabric mixing with cotton and polyester and spandex denim fabric has increased by 19.29%.

These increments together make the breaking strength and the tearing strength of the fillings and warps tend to be equalized to less than 30% loss, which reduces the impact on the loss of the fabric strength caused by laser etching on the whole.

e. REACH (EC No.1907/2006) test analysis: 144 SVHCs<0.1% (W/W) , conforming to the limited range.



### Sample 2

The laser color water washing-like black blue denim (Shown as figure 6)



Figure 6

*The Design of the Technical Process:*

Making the single-sided laser color watering-like fabric by the PU black color coating before laser etching pattern

*The Design of the Pattern:* Shown as figure 7

- ① The texture of the pattern has a sense of regular layers.
- ② The grayscale of the stripe pattern is adjustable, which makes it seem to have a gradient texture.
- ③ Since the color of the PU coating is more different from that of the base fabric, we choose the pattern of compact bark texture with texture of layers.

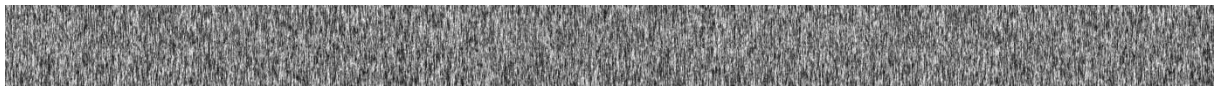


Figure 7

### Sample 4

The laser color water washing-like purple blue denim (Shown as figure 9)

*The Design of the Technical Process:*

Making the single-sided laser color watering-like fabric by the PU multi-color coating before laser etching pattern consisted of the first layer of black and the second layer of light purple.

*The Design of the Pattern:* Shown as figure 10

- ① The texture of the pattern has a sense of regular layers.
- ② The grayscale of the stripe pattern is adjustable, which makes it seem to have a gradient texture.
- ③ Since the color of the PU coating is more different from that of the base fabric, we choose the pattern of geometry of the circle texture with thick closed outline.

### Sample 3

The laser color water washing-like brown blue denim (Shown as figure 8)



Figure 8

*The Design of the Technical Process:*

Making the single-sided laser color watering-like fabric by the PU multi-color coating before laser etching pattern consisted of the first layer of black and the second layer of purple.

*The Design of the Pattern:*

Same as the sample 2



Figure 9

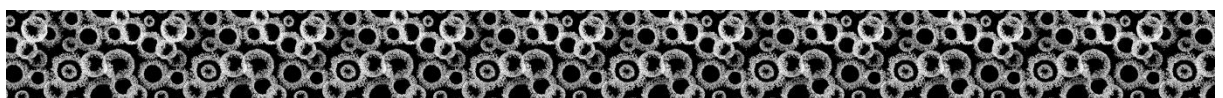


Figure 10

**Sample 5**

The laser color water washing-like printing-like denim fabric base with a gradient color line texture of perspective (Shown as figure 11)



Figure 11

The Design of the Technical Process:  
Making the single-sided laser color printing-like fabric base by the PU red color coating before laser etching pattern.

The Design of the Pattern: Shown as figure 12  
① The pattern texture is geometric stripes.  
② The grayscale of the stripe pattern is adjustable, which makes it seem to have a gradient texture.  
③ Since the color of the PU coated denim is more different from that of the surface. We choose the pattern of color-gradient geometric stripes with a texture of layers.

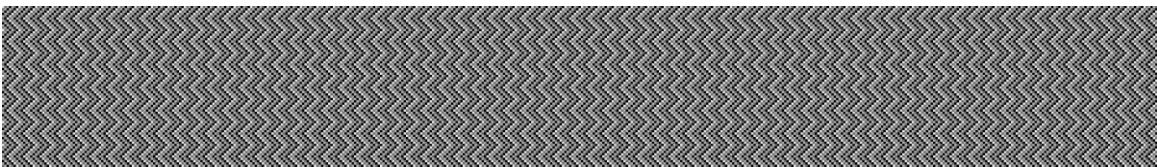


Figure 12

**Sample 6**

The laser stereo pull flower cotton stretch denim fabric with a gloss skin texture (Shown as figure 13)

The Design of the Technical Process:  
Making the single-sided laser stereo pull flower fabric by the transparent PU coating before laser hollowing out



Figure 13

The Design of the Pattern: Shown as figure 14  
① The laser hollowing adopts the linear pattern of PLT format. The effect is out of gradient.

② The regular pattern constituted by small holes was selected as the hollowing pattern.



Figure 14

<i>Sample Specification</i>						
Sample	Color	Composition	Yarn Count: (root/inch)	Density (root/inch)	Weight (g/m <sup>2</sup> )	Width (cm)
1	Blue	70%C., 28%P., 2%S.	10s+10s(Slub-yarn) *300/40D+30D/70D	86×56	359	148
2	Black Blue	Same sample 1	Same sample 1	86×56	360	148
3	Brown Blue	Same sample 1	Same sample 1	86×56	375	148
4	Purple Blue	Same sample 1	Same sample 1	86×56	378	148
5	Red Blue	98%C., 2%S.	10*16s/40D*16s/40D	79×50	282	151
6	Dark Blue	Same sample 5	Same sample 5	79×50	282	151

## 5. Conclusion

By using the modified water-base polyurethane (PU) resin glue color or multi-color coating, this process not only makes the cloth elastic soft, but also solves the problem that the cotton-polyester woven jeans will encounter the tearing and reduction issue during the laser corrosive engraving. In addition, the multi-color layers settles down the problem caused by the fact that laser engraving only have the single color and therefore the color water washing-like and stereo pull flower with a gloss skin texture by color coating denim with nostalgic and leisure styles design can be produced. This undoubtedly makes contributions to enrich the technical approaches and design ideas regarding the laser technology applied to produce the top-class leisure jeans and clothes.

## 6. References

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## 7. Authors



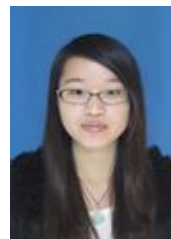
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