

The Effect of Using Laser Engraving on Seam Properties of Weaving Denim Products

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Abstract:

Laser engraving can be used for quick and easy of diverse textiles and fabrics. Textiles suitable for engraving with a laser include materials as different as linen, cotton, silk, felt, and more. Laser engraving refines the surface of the material, thus increasing the quality of the fabric. Unlike in printing, laser engraving additionally produces a haptic effect. Particular benefits when working with the laser on textiles are its speed, flexibility and precision. Moreover, the nesting feature included in the laser software ensures economical use of the fabrics.

In this study three different seam types were used to sew denim fabric. Seam type1 is superimposed seam type (SSa), seam type2 is lapped seam type (LSb) and seam type3 is lapped seam type (LSc) by using two different stitch types (Stitch type 516 and Stitch type 301). Flatbed laser machine was used to engrave shapes on denim fabric before and after sewing by using two different speeds (speed1 180 m/s, speed2 400 m/s). Tests were applied to determine the seam properties like thickness, breaking force, seam pucker and appearance. All tests were done according to standards and took place into conditioned atmosphere of 21°C and 65% RH. Comparisons have been made among the three different seam types and two different machine speeds; this was done with reference to durability, efficiency and appearance.

Keywords

- *Laser engraving,*
- *Laser machine,*
- *Laser beam,*
- *Denim fabric.*

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Introduction

The classic denim is strong, durable, comfortable and fashionable. Manufacturers are keeping this classic on the fashion radar by stoning, icing, burning and drilling the beloved denim to create novel and unique effects. There's a new technology that is producing some amazing looks on denim. With the popularity of special effects surging, it's a good time to check-out laser engraving.⁽¹⁾

The laser technology utilizes a beam of light, to produce a non-contact mark on the denim fabric. When engraving denim, the laser burns away the indigo dye to produce a worn look.⁽²⁾ Designs can be strategically placed anywhere on the denim fabric even over pockets, naps and seams. Patterns can be matched at the seams to create an all over design. A number of parameters such as speed, frequency, power and spot size can be tweaked to produce different degrees of degradation, detailed effects and even holes. Laser engraving is faster than many conventional methods used to distress jeans. Depending on the intricacy of the design, a pair of jeans can be engraved in minutes. By using a laser it is possible to create a worn look on denim, which could be an alternative method to conventional processes.⁽³⁾

Laser engraving

Laser engraving is one of the most promising technologies to be used in rapid prototyping in

order to engrave or mark an object. In this method, a laser beam is used to ablate a solid bulk, following predetermined patterns. The desired pattern is created by repeating this process on each successive thin layer. There are many advantages of this method compared to traditional machining, such as: no mechanical contact with the surface, reduction in industrial effluents, a fine accuracy of machining and an excellent quality and detail on the final product. The laser engraving method has many applications in industry, such as: creation of molds and dies, direct engraving of the expiry date on food package, engraving of an image beneath the surface of a solid material, direct engraving of flexographic plates and cylinders.⁽⁴⁾

Laser engraving is the practice of using lasers to engrave or mark an object (it is also sometimes incorrectly described as etching, which involves the use of acid or a similar chemical). The technique can be very technical and complex, and often a computer system is used to drive the movements of the laser head. Despite this complexity, very precise and clean engravings can be achieved at a high rate. The technique does not involve tool bits which contact the engraving surface and wear out. This is considered an advantage over alternative engraving technologies where bit heads have to be replaced regularly. The impact of laser engraving has been more pronounced for specially-designed "laserable" materials. These include polymer and novel metal

alloys.⁽⁵⁾

In situations where physical alteration of a surface by engraving is undesirable, an alternative such as "marking" is available. This is a generic term that covers a broad spectrum of surfacing techniques, including printing and hot-branding. In many instances, laser engraving machines are able to do marking that would have been done by other processes.⁽⁶⁾

There are two kinds of laser engraving cutting software. One is based on the direct output software of CorelDraw; the other is based on the direct output software of AutoCAD.⁽⁷⁾

Laser engraving machines

The laser engraving machine of series is made up of five parts: machinery platform, optical system, transmission system, control system, and accessory system.

- Machinery platform: composed of fittings such as machine cover, guide rail, base frame, reflector mount, etc.
- Optical system: composed of laser tube, laser power supply, three reflecting mirrors and one focus head.
- Drive system: composed of three imported balanced straight line guide rails of high accuracy, belt, two step motors and several gears.
- Control system: composed of high speed DSP control card, two sets of switching power supply and two step motor drivers.
- Accessory system: composed of circulating cooling water pump, air blowing compressor and smoke suction machine.^{(8),(9)}

Laser style software bundled with the laser engraving machine which provides full freedom of design and preparation of your job for laser engraving. It combines the best and most useful elements of a CAD and an illustration program. In addition to importing all common file formats, creating and manipulating graphical design elements and full typographic capabilities, the software can generate barcodes, drill patterns, process photos for realistic layered images, make rubber stamps, create dials and scales, handle variable lists and serialization.⁽¹⁰⁾

CO2 laser treatment

The CO2 laser treatment has been used in different areas of textile industry for several years because it allows short time surface designing of patterns with good precision, desirable effects, various sizes and intensity without causing much damage to the bulk properties of the textile materials.⁽¹¹⁾

Denim fabric

Introduction about denim fabric

Among all the textile products, no other fabric has

received such a wide acceptance as denim. It has been used extensively by people of all ages, classes and genders. Denim jeans can be considered as the most widely used garment in the fashion business. It is well known that denim and jeans have had a major influence on the lives of consumers since their inception. Jeans have become symbols for cowboys, women, youth and economic status. Through the ages, jeans have evolved from work wear to casual wear and then to premium wear and functional wear. Consumers evaluate jeans based on style, brand, country of origin and company ethics. No other garment can claim the social culture that denim has already set. Designer jeans as well as premium jeans first influenced a small group of luxury consumers, but now consumers from all social and economic classes embrace them. Challenges faced by denim apparel manufacturers and fashion designers include the need for reinventing products for niche markets, and meeting consumer demands for better apparel sizing.⁽¹²⁾

Denim is a study cotton warp-face twill textile in which the weft passes under two or more warp threads. This twill weaving produces the familiar diagonal ribbing of the denim that distinguishes it from duck. It is a characteristic of most indigo denim that only the warp threads are dyed, whereas the weft threads remain plain white. As a result of the warp-faced twill weaving, one side of the textile then shows the blue warp threads and the other side shows the white weft threads. This is why blue jeans are white on the inside.⁽¹³⁾

Types of denim fabric

Demand for fashion variants of classic denim will continue to grow. The most popular variants are:

- Stone-washed and double stone-washed denims.
- Chambrays.
- Fancy multi-color denims.
- Denim with metal-effects yarns.
- Elastic denims.
- Printed denims.
- Jacquard-patterned denims.
- Denims with fancy yarns.

Lightweight denim fabric are used for shirts and blouses. Heavy, classic denims are made up into trousers or coats. Besides classic indigo blue, the fabric is dyed in other fashion shades and colors, the most popular being black denim.⁽¹⁴⁾

End uses of denim fabric

In modern world, the apparels made from denim have become very popular among wearing. Denim goods are now being used among almost all type of people. Denim wears crosses the line of fashion boundary. It may be used in various ways as

follows:

- Baby wear, men's trouser, shirts, ladies wear are also made from denim fabric, and day by day, its acceptability is increasing among consumers.
- In the past, it was used by workers as a safety wear. Now it is used for making decorative cap, and ladies hand bag, school and college bag, and travel bag.

- Denim is used for jacket, pant, shirt, denim wine bags, denim pencil case, denim apron, denim pillows and denim quilt.⁽¹⁵⁾

Experimental work

Fabric specifications

The following table1 illustrates the specifications of the tested fabric

Table1 Fabric specifications

Fabric type	Fabric structure	Yarn warp/cm	Yarn weft/cm	Mass(gm/m ²)	Thickness(mm)
Denim 100% cotton	Twill 2/1	25	20	370 ± 5	0.57

Sewing specifications

Three different seam types were used to sew denim fabric. Seam type1 is superimposed seam type (SSa), seam type2 is lapped seam type (LSb) and seam type3 is lapped seam type (LSc) by using two different stitch types (Stitch type 516 Over edge stitch shall be formed with five threads, two needle threads, one looper thread and two cover thread forming a purl on the edge of the seam. It has great stretch and high elongation

along edge of fabric. It's ideal for medium to heavy stretchy fabrics such as sportswear and denim fabric. Stitch type 301 Lock stitch shall be formed with two threads one needle thread and one looper thread. It's used for seaming on common fabrics) and intermediate foot pressure. The following table2 illustrates the sewing specifications of seam type1, table3 illustrates the sewing specifications of seam type2 and table4 illustrates the sewing specifications of seam type3.

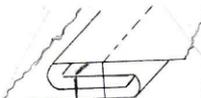
Table2 Sewing specifications of seam type1

Seam type1	Thread type	Thread size	Needle size	Stitch type	Stitch density/cm
Superimposed 	100% spun polyester	Ne 22/3	16	Over edge stitch 516	3

Table3 Sewing specifications of seam type2

Seam type2	Thread type	Thread size	Needle size	Stitch type	Stitch density/cm
Lapped seam 	100% spun polyester	Ne 22/3	16	Over edge stitch 516 and Lock stitch 301	3

Table4 Sewing specifications of seam type3

Seam type3	Thread type	Thread size	Needle size	Stitch type	Stitch density/cm
Lapped seam 	100% spun polyester	Ne 22/3	16	Lock stitch 301	3

Laser machine specifications

Co2 flatbed laser machine for engraving different materials was used to engrave shapes on denim fabric using two different speeds (speed1 180 m/s, speed2 400 m/s) the following table5 illustrates the specifications of the laser machine

Experimental tests

Tested samples examined before and after making seam types. All tests were done by standard test methods in conditioned atmosphere of 20°C ± 2 and 65% ± 2 RH. Tests included thickness test

which was carried out by using Erazier Precision Instrument, according to (B.S.-2544).⁽¹⁶⁾ Thickness before and after sewing was obtained from average of four readings. Breaking force was carried out before and after sewing the fabric according to (AS 2001.2.20)⁽¹⁷⁾; average of three readings has been obtained for each property. Seam pucker has been evaluated according to (AATCC 88B-1978)⁽¹⁸⁾ and seam appearance; average of five readings has been obtained for each property.

Results and Discussion

Effect of laser engraving at different seam types on seam properties of denim fabric

Effect of laser engraving at different seam types

on thickness

Table6 illustrates the effect of laser engraving at different seam types on thickness

Table5 Specifications of laser machine

Working Area	laser type	Model no.	Laser power (watts)	Speed1	Speed2	power supply
60 x 40 cm	CO2 laser, flatbed	BS6040	60w	180 m\s	400 m\s	AC220V, 50Hz

Table6 Effect of laser engraving at different seam types on thickness

Machine speed	Thickness (mm)			
	No seam	Seam type1	Seam type2	Seam type3
speed1	0.53	2.05	2.22	2.15
speed2	0.55	2.07	2.25	2.17

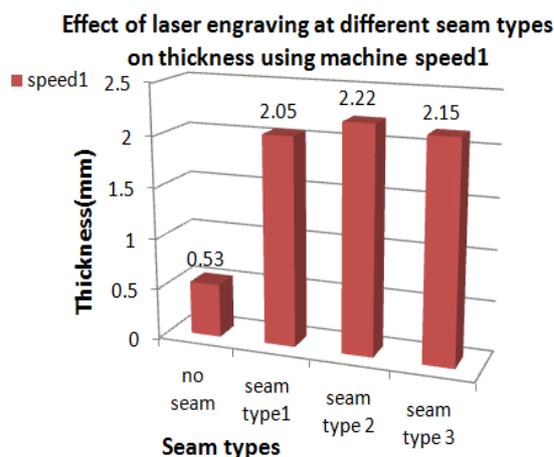


Fig.1. Effect of laser engraving at different seam types on thickness using machine speed1

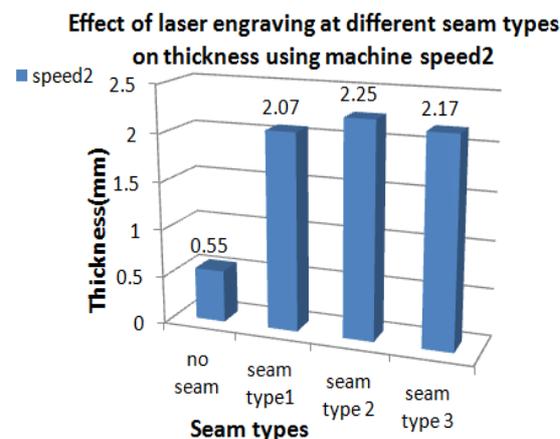


Fig.2. Effect of laser engraving at different seam types on thickness using machine speed2

- As shown in table6, fig.1, 2 seam type2 gives the highest thickness then seam type3 then seam type1 while sample of no seam gives the lowest value as thickness of tested samples by using machine speed1 and speed2 too. It is due to seam construction. Seam type2 consists of two stitches (Stitch type 516 and Stitch type 301) which increases its thickness while seam type1 consists of one stitch (Stitch type 516) which decreases its thickness. (More threads and more layers of fabric increases the

thickness).

- It can be noticed that using machine speed2 gives higher thickness than machine speed1. This can be attributed to machine speed1 is slower than machine speed2 it burns more layers of fabric than machine speed2 which is faster than machine speed1 and burns less layers of fabric.(Burns more layers of fabric decreases fabric thickness). There is a direct relationship between machine speed and thickness when machine speed increases thickness increases and vice versa.

Effect of laser engraving at different seam types on breaking force using machine speed1

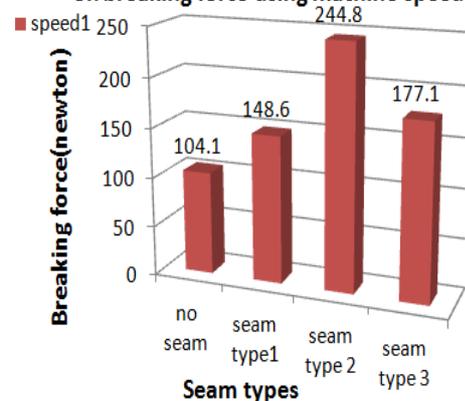


Fig.3. Effect of laser engraving at different seam types on breaking force using machine speed1

- Sample of no seam gives the lowest value as thickness of seam types by using machine speed1 and speed2. It is due to seam construction, and gives lower thickness by using machine speed1 than using machine speed2. It is due to the high machine speed2 which burns less layers of fabric and increases fabric thickness.

Effect of laser engraving at different seam types on breaking force

Table7 illustrates the effect of laser engraving at different seam types on breaking force

Table7 Effect of laser engraving at different seam types on breaking force

Machine speed	Breaking force (newton)			
	No seam	Seam type1	Seam type2	Seam type3
speed1	104.1	148.6	244.8	177.1
speed2	455.5	501	595	527

Effect of laser engraving at different seam types on breaking force using machine speed2

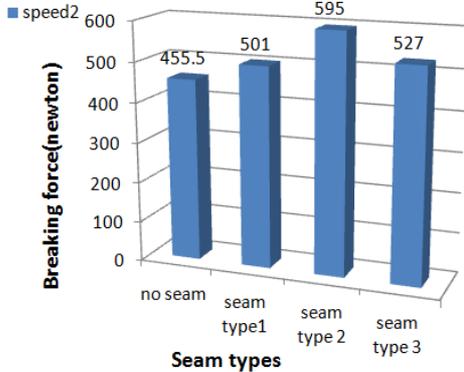


Fig.4. Effect of laser engraving at different seam types on breaking force using machine speed2

- Seam breaking force is the maximum stress, measured as force that a material can withstand before breaking. As shown in table7, fig.3, 4 seam type2 gives the highest breaking force then seam type3 then seam type1 while sample of no seam gives the lowest value as breaking force of tested samples by using machine speed1 and speed2 too. It is due to seam construction. Seam type2 consists of two stitches (Stitch type 516 and Stitch type 301) which increases its break force while seam type1 consists of one stitch (Stitch type 516) which decreases its break force. (More threads

and more layers of fabric increases the breaking force).

- It can be noticed that using machine speed2 gives higher breaking force than machine speed1. This can be attributed to machine speed1 is slower than machine speed2 it burns more layers of fabric than machine speed2 which is faster than machine speed1 and burns less layers of fabric.(Burns more layers of fabric decreases fabric breaking force). There is a direct relationship between machine speed and breaking force when machine speed increases breaking force increases and vice versa.
- Sample of no seam gives the lowest value as breaking force of seam types by using machine speed1and speed2. It is due to seam construction, and gives lower breaking force by using machine speed1 than using machine speed2. It is due to the high machine speed2 which burns less layers of fabric and increases fabric breaking force.

Effect of laser engraving at different seam types on seam pucker

Table8 illustrates the effect of laser engraving at different seam types on seam pucker

Table8 Effect of laser engraving at different seam types on seam pucker

Machine speed	Seam pucker (level)			
	No seam	Seam type1	Seam type2	Seam type3
speed1	5	4.8	4.4	3.6
speed2	4.8	4,6	4.2	3.4

Effect of laser engraving at different seam types on seam pucker using machine speed2

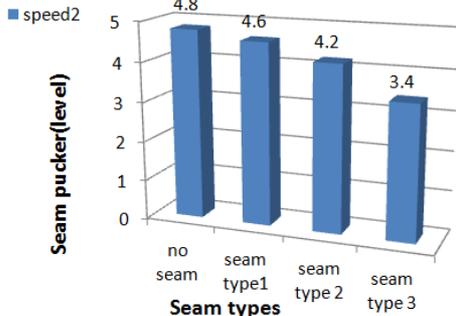


Fig.6. Effect of laser engraving at different seam types on seam pucker using machine speed2

- Seam pucker evaluated (from 1 to 5) where 5 means no pucker and 1 means severely pucker.

As shown in table8, fig5, 6 sample of no seam gives the lowest seam pucker (highest level) then seam type1 then seam type2 while seam type3 gives the highest value (lowest level) of tested samples by using machine speed1 and speed2 too. It is due to seam construction. (More threads and more layers of fabric increases the seam pucker).

- It can be noticed that using machine speed1 gives lower seam pucker (higher level) than machine speed2. This can be attributed to machine speed1 is slower than machine speed2 it burns more layers of fabric than machine speed2 which is faster than machine speed1 and burns less layers of fabric.(Burns more



layers of fabric makes the shape engraving more clearly and decreases seam pucker). There is a direct relationship between machine speed and seam pucker when machine speed increases seam pucker increases and vice versa.

- Sample of no seam gives the lowest value (highest level) as seam pucker of seam types by using machine speed1 and speed2. It is due to seam construction, and gives lower seam

Table9 Effect of laser engraving at different seam types on appearance

Machine speed	Appearance (level)			
	No seam	Seam type1	Seam type2	Seam type3
speed1	10	9.6	9.2	8.4
speed2	8	7.6	7.2	6.4

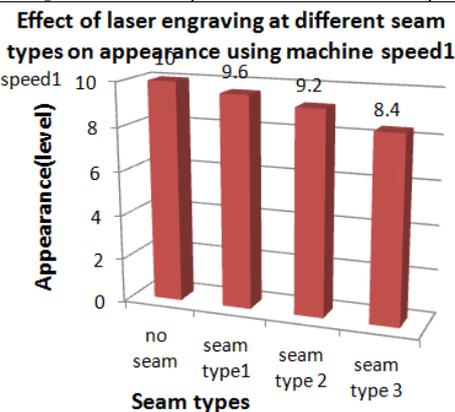


Fig.7. Effect of laser engraving at different seam types on appearance using machine speed1

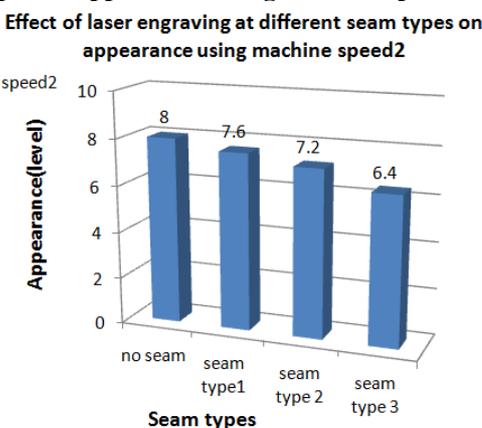


Fig.8. Effect of laser engraving at different seam types on appearance using machine speed2

- Appearance evaluated (from 2 to 10) where 10 means best appearance and 2 means worst appearance. As shown in table9, fig7, 8 sample of no seam gives the highest appearance then seam type1 then seam type2 while seam type3 gives the lowest appearance of tested samples by using machine speed1 and speed2 too. It is due to seam construction. (More threads and more layers of fabric decreases the appearance). There is an inverse relation between appearance and seam pucker as appearance increases when seam pucker decreases.
- It can be noticed that using machine speed1

pucker (higher level) by using machine speed1 than using machine speed2. It is due to the low speed1 which makes the shape engraving more clearly and decreases seam pucker.

Effect of laser engraving at different seam types on appearance

Table9 illustrates the effect of laser engraving at different seam types on appearance

gives higher appearance than machine speed2. This can be attributed to machine speed1 is slower than machine speed2 it burns more layers of fabric than machine speed2 which is faster than machine speed1 and burns less layers of fabric. (Burns more layers of fabric makes the shape engraving more clearly and decreases seam pucker so increases the appearance). There is an inverse relation between machine speed and appearance when machine speed increases appearance decreases and vice versa.

- Sample of no seam gives the highest value as appearance of seam types by using machine speed1 and speed2. It is due to seam construction, and gives higher appearance by using machine speed1 than using machine speed2. It is due to the low speed1 which makes the shape engraving more clearly and increases appearance.

Conclusions

- Laser engraving can be used for quick and easy of diverse textiles and fabrics.
- Laser engraving has a significant effect on seam properties of denim fabric.
- Laser engraving machine speed has a significant effect on seam properties of denim fabric.
- There is a direct relationship between Laser machine speed and thickness when machine speed increases thickness increases and vice versa.
- There is a direct relationship between Laser machine speed and breaking force when machine speed increases breaking force increases and vice versa.
- There is a direct relationship between Laser machine speed and seam pucker when machine speed increases seam pucker increases and vice versa.
- There is an inverse relation between Laser machine speed and appearance when machine

speed increases appearance decreases and vice versa.

- Seam types has a significant effect on seam properties of denim fabric.
- More threads and more layers of fabric at seam type increases the thickness, breaking force and seam pucker
- More threads and more layers of fabric at seam type decreases the appearance.
- The author recommend choosing Laser engraving machine speed₂ and seam type₂ to achieve seams with needed durability.
- For aesthetical seams the author recommend choosing Laser engraving machine speed₁ and seam type₁ to increase the performance and appearance.

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