

# A TECHNICAL STUDY ON 3D EFFECT ON DENIM JEANS

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## Abstract

Washing is considered as the final process in denim jeans production and is the core of denim finishing. It is the key to create the style in denim garments which is now becoming an art of creating fashion trends. The three dimensional (3D) effect is one of the most demandable finishing techniques for producing vintage denim jeans. Various types of 3D making equipments and methods are applied to jeans after resin application for producing such 3D effects. Denim jeans are then dried and finally cured in an oven for specific time at right temperature for getting final product.

Key Words: Three Dimensional Effect, Resin Application, Curing, Denim Jeans

## 1. INTRODUCTION

Denim jeans is 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. As with any other apparel, denim garment companies target specific market segments, however, 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 [1].

Garment finishing is one of the finishing methods applied on garment, with the use of new technologies and equipment enables to obtain the desired results [2]. For finishing of denim garments, a range of treatment methods such as enzymatic treatment [3-5], bleaching treatment [6-7], acid

treatment [8], silicone treatment [9] etc. are being used widely. They all are aimed at new possible effects of fabric appearance. Particularly the dry finishing creates many effects on denim fabric, it will stimulate the customers to buy, and also it increases the market potential of the denim market [10].

### 1.1 3D Effect and Resin

There is a big demand in the market for 3D effects (Permanent wrinkles on denim surface, also known as crinkle effect) on jeans. Resin application is done on denim to retain this effect even after wash [11-12].

It is the fabric deformations based on its viscoelastic properties, meaning a slight depression in the smoothness of a surface [13-15]. It gives fabric a vintage and aged appearance. The wrinkled-jeans look is created with chemicals and machines that manipulate the denim fabric and wrinkle it in the desired areas [16].

Resins are viscous liquids that are capable of hardening permanently [17]. Resins mainly fall into two groups, one is deposition type of resins. This type of resins is deposited on the fabric as Surface coating. No reaction will take place between the fiber and resin. They include Phenol formaldehyde

resins, Urea formaldehyde resin, Alkyd resins, Ketone resins, Vinyl resins etc. Another is Cross linking type of resins. These types of resins chemically react with the fiber and cross link the fiber molecules. The type of finish obtained is durable and much better than deposition type. They are also known as N-Methylol compounds as the Methylol groups (-CH<sub>2</sub>OH) are attached to the nitrogen. The cross linking compounds are commonly called resins but the term pre condensate is correct. The pre condensates further polymerize to form resins [18-19].

## 2. PRINCIPLE OF 3D EFFECT FORMATION

Cotton is a cellulosic fiber and its polymer is linked by many hydroxyl (-OH) groups. The structural units of cellulose contain crystalline region, amorphous region and intermediate region. In the crystalline region, the cellulose chains are closely packed and the mobility of the chains is low. However, for the amorphous and the intermediate regions, the molecular chains are temporarily held together with weak hydrogen bonds and the bonding could be broken easily when distortion force is applied. After the force is applied, the temporarily bonds would reform into a new position and the chains are failed to return to their original positions. As a result, wrinkle or crease is formed [20].

## 3. HOW RESIN WORKS

Since the forming for wrinkle is because of the weak intermolecular bonding, crosslinking resin could build a memory into fiber to allow it to return to its original size and shape. Resin finishing for wrinkle resistant is to enhance the "memory" of the cellulosic chain so that they could return to its original position. The resin finishing forms covalent bonds crosslinking to replace the weak hydrogen bonds between the cellulose chains. Therefore, the stability of the bonding would be improved and the molecule chains would more likely to return to its original position. When cellulose cotton fiber is treated with resin agent, intermolecular crosslinks would be strengthening because of the bonding. As a result, cellulose chains would be able to hold the adjacent molecular chains and return into its original position. An example of Crosslinking of cellulose

with DMDHEU is shown at figure 1. [20]

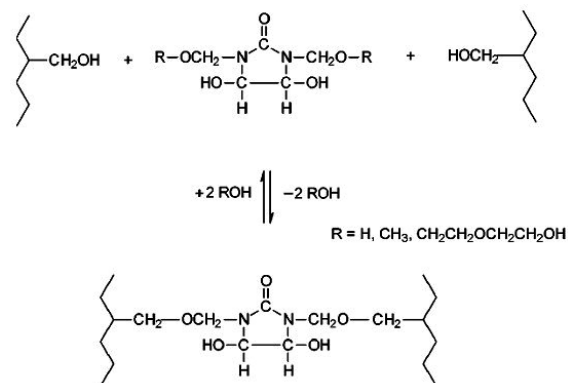


Figure 1. Crosslinking of cellulose with DMDHEU

## 4. RESIN APPLICATION

Resin is applied on finished garment where 3D Effect has to be made then wrinkles are created manually or semi automatically [21]. Low formaldehyde or formaldehyde free catalyst integrated crosslinking N, N-dimethylol 4, 5-dihydroxy- ethylene urea (DMDHEU) type resins along with support auxiliaries are being used in a large scale in denim industry[22,23]. Support auxiliaries are used for various purposes such as improving resin penetration into thick fabrics and seams, creating creases at low temperatures, improving handle when used as a softener in last bath, imparting extra shiny look etc. [24]. Different types of resin application systems are described below.

### 4.1 Garment-Dip Method

In the garment-dip method, garments constructed from non-resinated fabric are impregnated with a resin solution, extracted to about 65 percent wet pick-up and then tumble dried to 8-10 percent moisture content, a critical factor that is determined using a moisture meter [25].

### 4.2 Spray and Chemical Application Cabinets

Spray method is a latest technology of wrinkle finishing, the resin is applied by spraying it onto the garment during tumbling in an enclosed rotational device, or on spray booth where garments being hung to inflated balloons & sprayed a measured

quantity of resin solution. A microprocessor is used to meter the exact amount of chemicals and to control the rotation time, desired wet pick-up, spray rate and process time. The garments are then treated for different 3D effects, crunched or whatever designed intended to produce, used for both menswear and women swear with the market moving towards washed-down looks and softer handles [26]. A Spray and Chemical Application Cabinets is shown in figure 2.

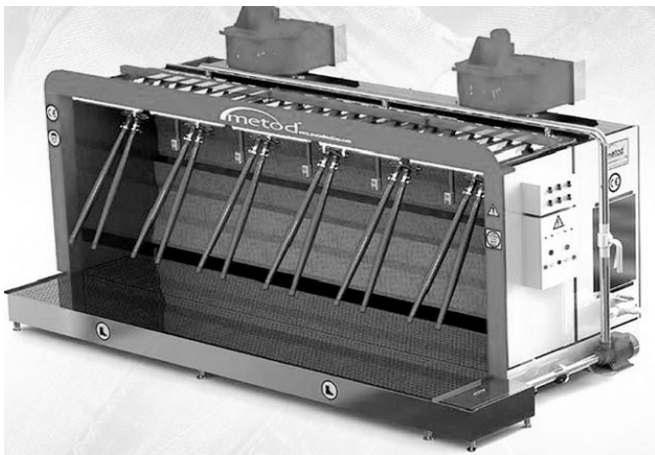


Figure 2. Spray and Chemical Application Cabinets [26]

#### 4.3 Spray and Chemical Application Cabinets with Conveyor

Spray Cabinets with Conveyor (Figure 3) allows to apply chemical application to robots dressed up with jeans while, they are moving on the conveyor and is a system that makes easy and increase the workflow and daily capacity [26].

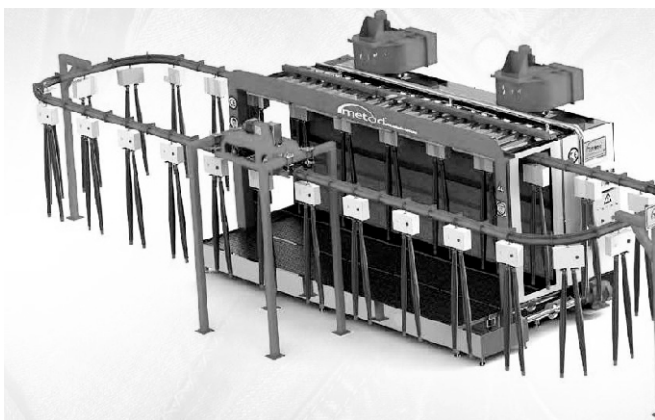


Figure 3. Spray and Chemical Application Cabinets with Conveyor [26]

## 5. TECHNIQUES OF 3D EFFECT FORMATION

3D effects give fabric a vintage and aged appearance. The wrinkled-jeans look is created with chemicals and machines that manipulate the denim fabric and wrinkle it in the desired areas [16]. Some industrial wrinkle making techniques are described below.

### 5.1 By Tying Specific Area with Thread

After resin application, tying is done with thread at the specific area where 3D effect is desired. The garments is then sent to oven for curing [27].

### 5.2 By Using Clip

In this process the small areas of the garment are bound by using clips on the required areas for desired effect and then garment is put in the oven for curing [22]. Wrinkle Formation Using Clip is shown in figure 4.



Figure 4. Wrinkle Formation Using Clip [22]

### 5.3 By Using 3D Wire Crinkle Machine

There are 3 operation heads and 3 stations in this machine. The operation time is around 30 seconds. One person can control and work with this machine. Desired 3D effect can be easily and quickly made by this system [26]. A typical 3D Wire Crinkle Machine is shown in figure 5.



Figure 5. 3D Wire Crinkle Machine [26]

#### 5.4 By Using Garments Crushing Machine

It is a scrunch/ crushing machine (figure 6) of steam system, achieving different levels of wrinkle and/or pressing. This machine is used for scrunch applications and making wrinkle all over the garment. The effects can be adjusted depending on the pressure, steam and chemical level [22].



Figure 6. Garments Crushing Machine [28]

#### 5.5 By Using 3D Bendable Leg

This machine (figure 7) is used to give some crinkle effects on the denim jeans during the washing process. This flexible hanger consists of one station and one flexible hanger. There is no energy consumption in this system. It works just with air. [26].



Figure 7. 3 D Bendable Leg [26]

#### 5.6 By Using Crinkle Press Machine

The Crinkle press machine (figure 8) consists of 2 application stands and one head that will press the trousers to be given effect on these stands. The system works with air and electricity. The air is used for creating pressure force of the air pistons, while electricity is used for feeding resistances of the heating group. The system is sliding and the product can be prepared on one stand while the pressing procedure is carried out on the other [26]



Figure 8. The Crinkle press [26]

#### 5.7 By Using Octopus Crinkle Machines

This machine (Figure 9) has double header 6 heads, 6 legs, and separate heating system in down of each leg. 6 Location can be operated on same time. Two user can operate whole system. Machine gives natural 3D effect. All 6 legs and heads can be controlled separately. Front pocket with regions and next fractures can be made at same time [29].



Figure 9. Octopus Crinkle Machine [29]

### 5.8 By Using Knee Effect Machine

This machine is being used for getting loose the knee area of the denim jeans. The temperature and the processing time can be easily adjusted from the control panel. It is shown in figure 10. [26].



Figure 10. Knee Effect Machine [26]

### 5.9 By Using Net Machine

This machine is based on pneumatic system with 6 Bar that requires very few air with no electricity requirement. There are 6 liters air consumption per jeans. The main tube was made from stainless steel [26]. It is shown in figure 11.



Figure 11. Net Machine for wrinkle formation [26]

### 5.10 By Using Double Head Crinkle Machine

Double Head Crinkle Machine (Figure 12) is used to obtain permanent 3D effects on various parts of the garments. Due to its usage ease it is highly preferred. Regardless of the garment size, with the help of

double creasing frame of the machine, it is easy to give the 3D effects on desired parts of garments [26].



Figure 12. Double Head Crinkle Machine [26]

### 5.11 By Using Crinkle Machine with Spiral

The Crinkle Machine with Spiral, having 6 heads, is a highly effective wrinkling machine (Figure 13) due to its high running speed, fast workflow and as it enables low cost production. The garments to be given 3D effects before and as well as after the washing process are located on the heaters and treated by the heads of the machine respectively. The crinkling process time is around 30 seconds if the garments are treated before the washing process, whereas it is 20 seconds if the garments are treated after the washing process [26].

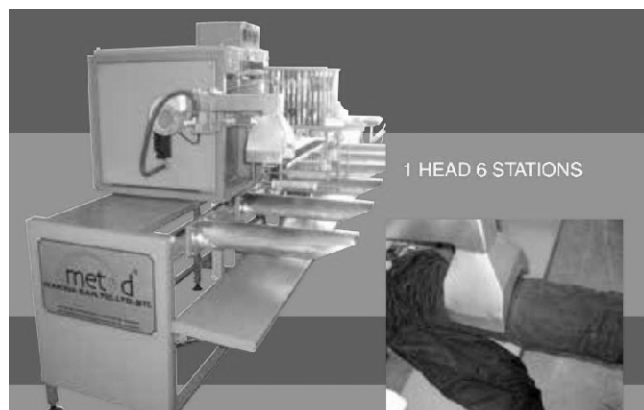


Figure 13. Crinkle Machine with Spiral [26]

## 6. CURING

Curing is the process to place the fabric at high temperature for allowing the chemical to carry out the reaction process [16]. For high quality 3D crunching / wrinkles, the two most important

criteria are temperature and control of cycle [10]. Oven curing is needed to reach right temperature (145– 160°C) & time (7–22 min) as per Resin tech bulletin advice [12]. Description of some typical industrial ovens are given below.

### 6.1 Automatic Type Ovens with Conveyor

Automatic Type Ovens with Conveyor can be U-Turn Type or Tunnel Type in accordance with the customer demands based on the layout of the plant as well as their workflow. Thermo block (heating unit) is designed as a separate section attached to one side of the oven. The inner part of heating unit is made of high-quality stainless steel and provides long-term operation without any problem. The air canals are located on the base of oven. As all the jeans are conveyed through the oven and be passing from each point of the oven, there is no shade difference between the jeans of one batch. The temperature measurement taken from different points –mostly from 7 different points- of the oven are indicated on the control panel in digital form so that the temperature of each point is controlled and seen by the operator easily. The burner operation is cut in and out by the control panel according to the average values of measured temperatures within the oven. The conveyor used in our ovens is specially designed Cardan Shaft model conveyors. The trolleys on monorail is freely moving and running while the gap between the jeans hung is 400 mm. The engine of the gear drive system is low revolution DC and reduction gear type. The conveyor speed can be changed by the frequency adjustment device. The speed adjustment can be done between 0.5 m/min–3 m/min thus the curing time can be adjusted according to the process requirements [26]. A typical automatic type ovens with conveyor is shown in figure 14.

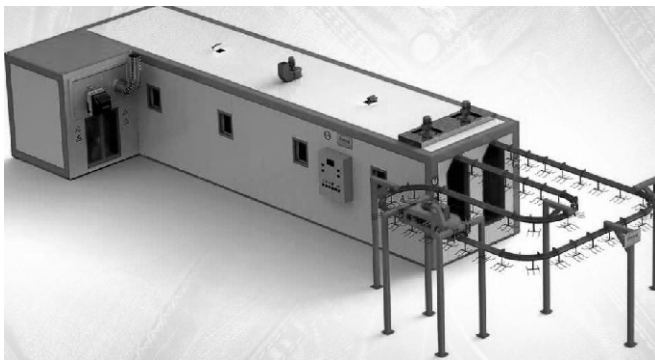


Figure 14. Automatic Type Ovens with Conveyor [26]

### 6.2 Box Type Curing Oven with Trolley

Box Type Ovens (Figure 15) with Trolley consist of demounted sandwich type panels. The insulation material used between the panels is 60 kg/m<sup>3</sup> rock wool and glass wool. The heating unit is assigned according to the type of the oven and mounted at the backside of the oven. The heating unit is made of stainless steel as the heating system is provided by Natural Gas, Diesel or LPG. As the burning chamber is separated and insulated inside the oven, there is no flame, fire, soot, black, pollution, dust coming up to the jeans so there is no mark, shade or smell etc. on the jeans. There are special air ducts and blowing vents inside the oven in order to assure homogeneous distribution of hot air through the oven. The oven can be easily installed and used on a plain ground. The rail system on the floor of the oven allows an easy entrance and movement for the trolleys. The oven reaches to set temperature 160°C at start-up within 25-30 minutes. The maximum temperature difference between all the points inside the oven is 3°C. As reaching the set temperature, the automatic temperature limiter is activated so that the set temperature remains constant. Thus, the most suitable working circumstances are obtained [26].



Figure 15. Box Type Curing Oven [26]

### 6.3 Semi-Professional Curing Ovens with Conveyor

Semi Professional Curing Ovens (Figure 16) with conveyor allows easy usability, high production capacity and low operational costs. Thermo-block (Heating Unit) is mounted to the back side of the oven. There is a burner system in the heating unit, which turns the fuel into flame and exchanger system is made from stainless steel, turns the flame into heat and also fan system dispatches the heating

air through the oven. The surface of the panels inside the oven is made from 1 mm Galvanize Sheet Metal, and the surface of the panel outside the oven is made from 1 mm Painted DKP Sheet Metal. There is an insulation material between the panels consists of the mixture of rock wool and glass wool preventing the loss of the heat. The air canals in the oven are specially produced from galvanize sheet and designed in order to distribute the heating air homogenously through the oven. The conveyor system is the mechanism called by Webb Type (I – Beam Type). The conveyor trolleys mounted on the chain are freely move on the NPI 80-100 profile. The carrying capacity of unit burden on the conveyor is 140 kg/m. There are 600 mm gaps between the each trolleys. 4 jeans easily can be hung in every 600 mm gap on the conveyor. In this system, the electrical materials using in the control box are Siemens or Telemecanique. Heat balance in the oven can be easily adjusted by taking the heating measurement from one point of the oven. According to the temperature in the oven, burner system cuts out and exhaust system cuts in automatically. By this way the heating balance in the oven can be controlled and also prevented maximum energy consumption [26].

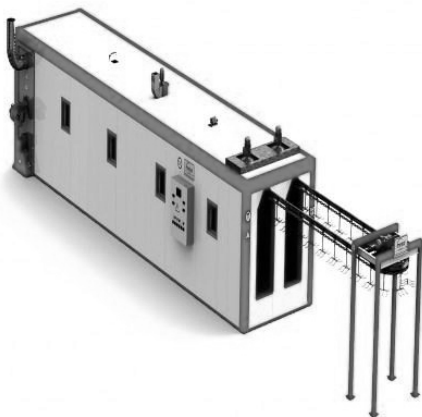


Figure 16. Semi-Professional Curing Ovens with Conveyor [26]

## 7. PARAMETERS IN CHOOSING DENIMS FOR RESIN APPLICATION

The garment finisher usually does not manufacture his own fabric and he may be faced with unacceptable losses in tensile strength, tear strength and abrasion resistance in the fabric when cross-linking. Because of the added value, garments rejects due to low strength may prove to be more expensive than fabric rejects [25]. For producing an

acceptable 3D effects Denim, several precautions must be taken in fabric selection: The base fabric must have sufficient strength to withstand 40-60 per cent loss in tensile and tear strength and still maintain sufficient strength to provide a garment of acceptable wear life and durability. It must also have excellent absorbency to allow resin to penetrate into the very interior of the fibers and form crosslink's. Surface adhering resins do not serve any useful purpose and are inefficient and wasteful. If the fabric is dyed the dye must be fast to acid catalysis and high temperatures. Sulphur dyes, which are known to generate acid upon storage, are to be strictly avoided & Lycra/Spandex based fabric also should be tested on elongation before mass production. Residual extractable on the fabric (like starch from size) can react with resin and lower its effectiveness, a high degree of size removal is thus essential. Fabric pH should be between 6.5 to 7.0. [25].

## 8. ADVANTAGES AND DISADVANTAGES

It creates unique & vintage looks that makes the garments more fashionable thus adding value to denim garments & improves its salability in market. It prevents the intermolecular slippage in the fiber core and it may not harmful if we use formaldehyde free resin.

It decreases the tensile & tear strength, abrasion resistance. It gives an unpleasant odor and unwanted harsh & stiff feel. It turns the fabric yellow after chlorine bleaching. Sometimes it is difficult to remove unfixed resin.

Moreover, if the resin is applied to elastic denim products, the elasticity of the fabric may be damaged, and for this reason the fabrics must be tested before applying resin.

## 9. CONCLUSIONS

The three dimensional effect (also known as 3D whisker or crinkle effect or wrinkle effect) is one of the most important and aesthetic designs of used and rigid look in denim jeans. It is necessary to use formaldehyde free resin in this process for environmental sustainability. It is also noted that if 3D effect is not permanent, it can cause skin irritation to the wearer. So highly skilled operators

are needed to execute this process in order to get consistency and uniformity.

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