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Sustainable and Ecological Finishing Technology for Denim Jeans

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Keyword

Denim Jeans, Ecofriendly Finishing, Laser, Ozone, Water Jet

Denim Jeans finishing is an important operation for value addition of the final products in the apparel business. There are numerous operations exist for fulfilling of this treatment. This paper deals with the recent developments of the sustainable, environment friendly and emerging industrial approaches (Laser, Ozone and Water Jet) for the finishing treatments of the denim jeans. It is observed that finishing with laser and ozone is a reduced water treatment while water jet fading system though consumes water but assembling of water recycling system makes it ecological and economic. The adoption of these finishing technologies has brought about a radical transformation in the garment finishing industry, which is changing from an artisanal, labor intensive industry towards an industry based on knowledge and technology that feels more responsible for the environment and for workers.

Introduction

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 [1].

Denim Jeans finishing is one of the most extensively used finishing treatments that have enormous practice, because of its effects on appearance and comfort [2]. There are almost countless variations of dry and wet processing techniques used by designers and textile chemists to achieve fashionable looks that are distinctive and desirable [3-6]. With the increasing awareness about and concern for environmental issues, such as large amounts of effluents produced and high consumption of water and energy, wet processes related to denim washing are considered as not environmentally friendly. To address the environmental concerns, some finishing techniques (Laser, Ozone and Water Jet) have been introduced as an alternative to the conventional wet processing [7-14].

Ecological Finishing Technology

Laser Finishing Technology

The CO_2 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 [15-16]. The popular uses of lasers are Laser Marking (Only the surface of the fabric is processed, fading), Laser Engraving (Controlled cutting to a depth), Laser Welding (A molten material joins or welds

two or more layers of fabric together), and Laser Cutting (Cutting through a fabric) [17]. Among these Lasers, fading (Marking) is a popular dry process for denim now a day. It has been used extensively as the replacement of some conventional dry processes like sand blasting, hand sanding, destroying, and grinding etc. which are potentially harmful and disadvantageous in some manner. Apart from this, Laser systems are used in fashion design [18], pleating, cutting and modification of fabric surface to impart some special finish [19]. Laser fading works with better precision and higher productivity but also have some drawbacks.

A laser is a device that emits light through a process of optical amplification based on the stimulated emission of electromagnetic radiation. The term "laser" originated as an acronym for "light amplification by stimulated emission of radiation" [20-21].

The laser works by creating extensive heat. Within the focused region, the material is subject to very intensive heating within a very small region. Laser energy is absorbed as heat and the material rapidly heats leading to melting as a phase change from solid to liquid takes place. Some of the molten liquid tries to move, driven by surface tension of the liquid. The remaining liquid heats very rapidly, boiling and releasing vapors another phase change takes place from liquid to gas [22]. Laser Fading Mechanism is shown in figure 1.

Figure 1. *Laser Fading Mechanism on Denim Jeans [17, 22].*

If we compare laser fading with manual dry processes, we get some points [17] such as

a) Effect quality is comparatively finer in Manual system than laser.

b) Hand feel is comparatively finer in Manual system than laser system.

c) Hairiness is comparatively less in Laser system

d) Production cost is higher in Laser system

e) Working space required is less in Laser system

f) Design consistency is high in Laser system

g) Tearing strength is higher in Laser faded denim (May differ in case of stretch denim)

h) Rejection rate is 0% in Laser system whereas around 5% in Manual system

i) Manpower required – Laser: Manual= 1:3 (Approximately)

j) Power Requirement is higher in Laser system (approximately 7.5 Kilowatt hour)

k) The laser beam would be harmful if it came into contact with skin or eyes.

Ozone Fading Technology

Ozone typically acts as a mild bleaching agent as well as a sterilizing agent. In this technique of denim washing, the garment is bleached (Figure 2) with ozone dissolved in water in a washing machine. However, this technique can also be carried out in a closed chamber by using ozone gas. The advantages of this method are: (a) a minimum loss of strength and (b) it is a simple method (c) water- and chemical-free that is environment friendly (d) processing low energy costs (e) short treatment time. The

ozonized water after laundering can easily be deozonised by ultraviolet radiation. Nowadays, ozone fading can also be achieved by plasma equipment [23-25, 31]. Under the influence of plasma treatment, high energy electrons are formed. Some of the high energy electrons react with moisture in air and a mixture of radicals is generated [26]. During the generation of ozone plasma, a combination of charged particles, free radicals and ultraviolet light is generated. The ultraviolet light, being the by-product of the plasma treatment process, also contributes to production of the •OH radical. Hydroxyl radical •OH is the most oxidative radical among radicals generated in the plasma process and is the main radical responsible for degradation of indigo dye in textile materials. The •OH can oxidize indigo dye molecules (RH) producing organic radicals R•, which are highly reactive and can be further oxidized [27-28]. As a result, the color fading effect of the indigo dyed textile is achieved. The K/S (in which K is the absorption coefficient at a specific wavelength and S is the scattering coefficient) values of different treated denim fabrics are shown in Table 1.

Table 1. *Color properties of different denim fabrics [29].*

Fabric sample	K/S value
Untreated	430.58
Plasma induced ozone treated	382.18
Enzyme desized	425.46
Plasma induced ozone treated followed by cellulase treatment	365.32
Enzyme desized followed by cellulase treatment	378.90

From the results, it is noted that the differently treated denim fabrics have lower K/S values than the untreated denim fabric. The K/S value is linearly related to concentration of the colourant in the medium and it can be concluded that a paler shade is obtained after different treatments. Without the cellulase treatment, the plasma induced ozone treated denim fabric has a paler shade than the enzyme desized denim fabric because during the plasma induced ozone treatment, ozone oxidises indigo dyes on the denim fabric surface leading to a colour fading effect [29-30]. However, in the case of enzyme desizing, the enzyme only reacts with the sizing material at the fibre surface and no breakdown of indigo dyes molecules occurs. Therefore, no significant shade change takes place. In the case of cellulase treatment, cellulase in the aqueous medium can penetrate effectively into the denim fabric. The enzymatic hydrolysis induced by cellulase in the plasma induced ozone treated denim fabric is more severe than the enzyme desized denim fabric. As a result, the cellulase treatment for plasma induced ozone treated denim fabric gives a paler shade than the enzyme desized denim fabric.

Figure 2. *Range of Bleachdown on Jeans with ozone finishing. [Ozone Denim Systems].*

Water Jet Fading Technology

Figure 3. *Water jet fading effect on denim jeans [35].*

Hydro jet treatment has been developed for patterning and/or enhancing the surface finish, texture, durability and other characteristics of denim garments [32]. Hydro jet treatment generally involves exposing one or both surfaces of the garment through hydro jet nozzles. The degree of color washout, clarity of patterns and softness of the resulting fabric are related to the type of dye in the fabric and the amount and manner of fluid impact energy applied to the fabric. Particularly good results are obtained with blue indigo dyed denim. As this process does not involve any chemical, it is pollution free. A water recycling system can make this a very economical and environmentally friendly way of denim processing. Color washout of dye in the striped areas produces a faded effect without blurring, loss of fabric strength or durability, or excessive warp shrinkage [33-34]. An example of water jet fading effect on denim jeans is shown in Figure 3.

Conclusion

The finishing of denim garments give them self-identity and therefore add value for the final consumer. These reduced water techniques are those that can obtain a washed look and excellent handle using a minimum quantity of water. The integration of such technologies into the conventional washing lines will ensure that vintage looks and other fashion effects can be created on jeans with much less water. In such cases, the effluent output is reduced to a negligible quantity, thus transforming denim washing to an environmentally friendly process.■

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