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Different Printing Techniques for Printing Denim Fabrics

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Abstract

The material that is used to produce jeans is known as denim. It is a highly comfy fabric that is 100% cotton twill. Throughout the world, this fabric is used to create a variety of clothing for men and women of all ages, including jeans, coats, shirts, handbags, and totes. The weft is rolled in vain under two or more rolls to create denim, which is distinguished from plain cotton by the ribbing. The process of weaving denim results in the familiar simple jeans by coloring the warp while leaving the flesh white. Denim was originally used for workers' clothing, but over time, it underwent numerous inventive modifications and additions to become the design icon it is today.

Keywords: denim fabric, printing technology, printing techniques.

Introduction

Textile printing is the process of applying certain colors to fabrics according to a specific pattern or pattern. Textile printing is related to its dyeing. In dyeing, the entire cloth is covered homogeneously with the same color, while in printing one or more colors can be used to form a specific pattern. In this study, different printing techniques were used on denim fabrics, such as laser printing and digital printing, to obtain fabrics with a faded effect in a sustainable way that is environmentally friendly.

Since the invention of denim fabrics by Levi Strauss in America in 1873 AD, which is when they first started to appear, it has been associated with the appearance of American cowboys. The denim fabric industry has since prospered, and as time has gone on, the jeans wave has swept the globe thanks to the facades of stores and exhibitions in all nations and has become a trend (for all ages).[1-31]

Denim

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Denim Jeans Chemistry

A solid cotton fabric called denim is constructed of cotton and colored indigo blue.

A long-distance thread or yarn is referred to as a "warp" in the weaving process. The chain or thread that is woven across the warp is referred to as the "weft". Denim is woven using a colored wrap and an uncolored weft. As a result, the inside of the jeans is lighter or white and the exterior is blue. This process gives denim remarkable blurring properties and protects it against various materials.

Denim chemistry

- Cellulose $(C_6H_{10}O_5)_n$ 91.00%
- Water (H_2O) 7.85%
- Protoplasm, pectin (HMDB03402) 0.55%
- Waxes and fatty substances 0.40%
- Mineral salts 0.20%

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The qualities of indigo tincture are:

- Chemical formula: $C_{16}H_{10}N_2O_2$
- The dark blue crystalline powder
- Density: 1.199 g/cm^3
- Melting point 734-738°F
- Decomposes at boiling point

The main chemicals, compounds, and components used in denim are

- cotton cellulose (C6H10O5)
- Water (H2O),
- Protoplasm
- Pectin (HMDB03402)

Types of denim

Although the original denim was composed of 100% cotton, you can today find it in several fabrics, including blends that include some uncommon elements but yet have the same fantastic look as 100% cotton denim.

Denim varieties are often categorized as follows

Dry or raw denim

Because it is neither treated nor washed while being made, this sort of denim is known as "raw denim," and it has the following characteristics: - To fit the contours of the specific body wearing it, it should be worn for 6 to 12 months without washing.

- To get rid of germs and kill them, you can freeze them rather than wash them.
- It is advised to wash the fabric before cutting it if it will be used for sewing so that it will shrink.
- With time, its color ages.

Selvedge Denim

Selvage denim is a type of denim that forms a flawless, uniform edge that does not unravel. Typically, it is introduced in an undressed or crude state.

Stretch denim

Flexible denim frequently has a 98% cotton and 2% spandex composition to acquire the slight elasticity that we all adore. This combination provides excellent mobility while also providing some support for those "problem areas" like the hips and thighs. One of the industries in which makers of women's jeans are expanding most quickly is stretch jeans.

Poly Denim

The polycarbonate blend is for people who appreciate the look of denim but would rather have a lightweight, moderately wrapped polyester blend that is quick to wash and dry.

Cotton Denim Rami

There are several different cotton denim Rami combinations available, each with a significantly different price. Rami, which are plant fibers, are frequently used because they lessen wrinkling and increase the opulence of cloth shine. To stand as denim, it must be combined with more grounded fabrics because it is not as tough as cotton.[33]

Acid-washed denim

This denim has been chlorinated and pumice stone to give it a marble look

Wrinkled denim

This type of denim has been processed so that it looks wrinkled.[34]

Fig. 1. Denim selvage and Wrinkled denim

Fig. 2. Denim Terry stretch denim

Different techniques used on denim

Printing by discharge

Discharge printing involves coloring the materials first with repositionable dyes before printing the design on them with a paste made of chemicals that react with the background dye. This dual response either leaves the colored region colorless or replaces the colored area's color with the desired color in the previously colored area.

Since most denim fabrics are made of indigo-dyed warp yarns woven into long cotton fabrics, discharge printing on denim is carried out using efficient discharge agents against indigo dyes. The

use of the discharging agent depends on the type of fibers, the nature of the dye, the depth of the shade, and the structural makeup of the fabric. For removal printing, oxidizing substances like a sodium ferrocyanide and sodium chlorate mixture or reductants can be used: formaldehyde sulfoxide sodium However, oxidants are preferred because, in the case of reducing discharge agents, the colorless reducing component may oxidise again when exposed to air and light. Typical oxidising agents include sodium hypochlorite, hydrogen peroxide (H_2O_2), potassium permanganate ($KMnO_4$), and sodium bicarbonate/percarbonate.

$KMnO_4$ was utilized as an oxidizing vacuum agent to discharge print indigo-dyed denim. Since MnO_2, which is produced when permanganate is reduced and can be easily recycled, can be recycled, the oxidation of KMnO4 is thought to be environmentally favorable.[35]

Advantages of discharge Printing

1. 1. Large areas of the earth's color are possible.
2. The best approach is to use unusual inks to print on dark clothes.
3. An excellent method for removing dye from textiles.
4. The shirt's printing is barely perceptible or nonexistent.
5. Deep color, outstanding depth, and clarity allow for the creation of delicate colors and intricate patterns.

Disadvantages of discharge printing

1. The procedure is costly.
2. A two-stage application that involves discharge and dying or printing filler.
3. A small selection of earthy hues and ornaments.
4. Demands careful process attention, with the caveat that any error will result in losses.
5. Different sizes could discharge differently. [34]

Fig. 3

Laser printing

The electromagnetic radiation known as a laser is created when certain materials' energy states cause atoms to change. Carbon dioxide (CO2), neodymium (Nd), and neodymium-coated aluminum (Nd-YAG) yttrium garnet lasers are the three main categories of lasers. Due to its low heat generation, which translates into minimal energy losses and reduced investment costs when compared to other lasers, carbon dioxide lasers are the most effective lasers for fading the color of apparel in the denim sector.[36]

The energy produced by the laser beam, which is absorbed as heat and results in the removal of the dye and a lighter shadow on the fabric's surface, is utilized in laser fade technology to burn the surface of denim fabric. A very little region is covered by the laser beam. As a result, the material can fade in a particular location where the laser beam interacts with the cloth. denim's finished visual appearance. The fabric is influenced by the fiber composition, fabric type, and color in addition to the laser beam's intensity.

The accuracy and pixel time are two factors that greatly influence laser processing. The design to be transferred is prepared on the computer before the laser beam of the selected power and density is directed to the surface of the fabric. This is necessary for laser application because the power and intensity of laser light must be adjusted according to the material to be applied.

The process of fading the laser beam depends on two factors:

1. Laser factors: such as wavelength, power, repetition rate, and pulse duration.
2. Material factors: thermal change, remodeling, reflection coefficient.[37]

Venkataraman used a laser and carbon dioxide to study the effects of denim fading and discovered that the laser intensity used altered the brightness of the treated denim cloth.

The Denim fabric's brightness has diminished as laser power has increased due to color fading. Additionally, the surface color of the fabric is impacted by the laser power used.[38]

Chi-wai Kan researched how laser therapy influenced denim fading and compared the outcomes to stone washing. The laser treatment was shown to save time and water during processing. The laser requires only half as many steps as traditional stone washing, which requires seven. While the laser only needed two rinses, the stone-washing approach required three. Stone cleaning took place at a temperature of 55–60 °C for 45–60 minutes. At room temperature, the laser fading was completed in 3 minutes.

As a result, this process requires less time, energy, and effluent, making it sustainable. The denim-cleaning technique called laser pro washing, created by Jeanologia, is 40% quicker than existing types of laser technology.142 It makes the industry sustainable and lowers energy expenses as a result.[39]

Advantages of laser printing

1- Environmental benefits: There is no environmental pollution because the laser-dry method uses no water and has no issues with chemical use or water recycling.
2- Economic benefits: The use of the laser reduces the amount of water and energy needed to produce the same thing and effect, which helps to lower the cost. The application also uses very few consumables, such as inks, chemicals, and auxiliary materials, and the laser uses less time to operate—only two minutes as opposed to the 30-to-45 minutes required by the conventional process.
3- Social benefits: Since the laser's intensity can be easily changed by varying the force, applying lasers eliminates the health dangers associated with older methods' use of chemicals, making it simpler to change the characteristics of designs.
4- Other benefits: A little piece of fabric or even already-made garments can be subjected to the laser process. By using lasers, 3D features can be created, which is not achievable using conventional techniques since lasers make high-resolution designs.[36]

Fig. 4. laser-engraved jeans

Digital printing of denim:

The lack of color restrictions depends on the type of ink, and what's more intriguing is that digital printing gives designers more artistic freedom to develop their creative vision. When compared to traditional methods, digital printing is one of the cleanest processes for coloring textiles because it allows for rapid production, multiple variables, and printing on demand.

Additionally, an infinite number of motifs and designs can be created and printed on denim materials. These printers enable the creation of a variety of images using a variety of tools and techniques, as well as the creative exploration of millions of colors in a single process, which is not possible with analogue printing techniques. However, the most well-known drawbacks of digital printing are the high cost of inks and lengthy print times, though manufacturers are currently working to address these issues.

Regarding denim, the usage of inkjet or digital printing has increased significantly in the same manner that it has for other fabrics, particularly for ornamental printing, which reflects current fashion trends like floral, animal, and cosmic patterns.

Since the type of ink and fabric interact in a variety of ways to produce a high-quality print, textile properties are one of the main factors to consider. Ink characteristics, fiber types, fabric structure details, and pretreatments used before printing on a textile substrate all have an impact on how printing ink diffuses over the surface of the printed object. The color gamut, which varies with different textile materials, is another issue to be considered. Considerations for textile properties include yarn size, fabric structure, and the fabric's hydrophilic/hydrophobic makeup.

Because fabric is a three-dimensional substrate as opposed to paper, fabric structure has the biggest impact on print quality.

The finest printers for denim fabrics are those using reactive dyes or pigments since classic blue denim is a warp-faced cotton fabric with an indigo-dyed warp and a slightly grey weft.

DTP can be systematically categorized according to the intended use of the product, as follows: shown in Figur8

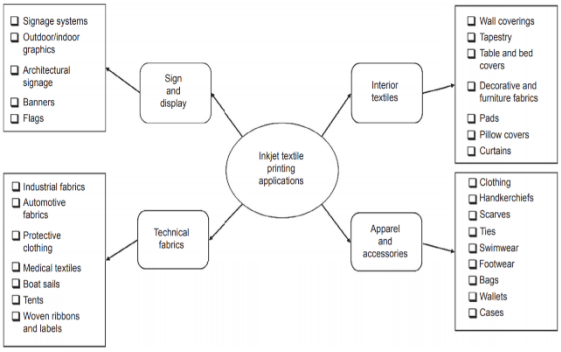

Fig. 5

The end product of a process involving one or more inspiration, creative, technical, and design sources as well as hardware and software add-ons is digitally created denim, also known as digital denim. Due to its built-in skills and features, quick layout changes are possible, including positioning numerous images, rotating, and scaling, controlling ink control features like saturation, establishing color catalogues, specifying unique color profiles for textiles and inks, color grading, and more. manipulate photos using tools like Adobe Photoshop, Illustrator, Corel Graphics Suite, and Kaledo to control color and finishing effects.

The vast majority of textile printers are capable of printing digital images using the TIF, BMP, and JPG graphic file extensions.

With this new technological advancement, digital printing, processing effects like aging, damage, overpainting, wrinkled or worn, fading, and other effects modeling various stages of denim wear can be done more rapidly, effectively, and affordably in addition to simulating different stages of denim wear.

Besides the usual processing effects, digital denim can also replicate additional aesthetic aspects, such as embossed designs and stitching, in the form of:

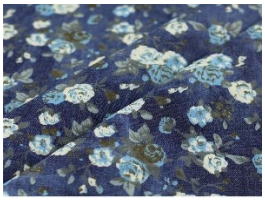

Fig. 6. Digital Printed Denim Fabric

Digital Printing Machines

According to the technology found in their print heads, commercial and textile inkjet printers may generally be divided into two groups: projection on demand (DOD), also known as bubble printing, and continuous inkjet printing, as depicted in Figure10:

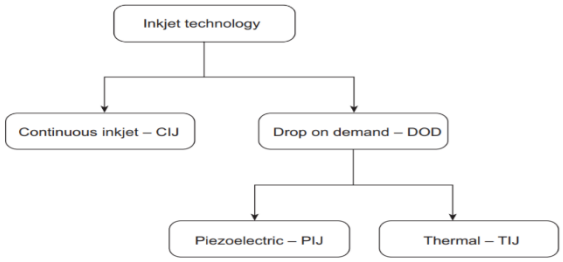

Fig. 7

The ink is mechanically expelled from the print head in a drop-on-demand system (controlled number O) when required and upon request. When necessary and upon request, the ink is mechanically expelled from the print head in a drop-on-demand system (controlled number O), which is how these systems are commonly identified. A thermoelectric mechanism (TIJ) or a piezoelectric mechanism (PIJ), the latter of which is definitely the most frequently used technology in textile printers (all models), is typically used to identify these systems.

In the earlier system, an impulse produced by a computer signal activates the electric heater inside each nozzle.

In 5 microseconds, the temperature increases to 300 °C, resulting in localized evaporation and the development of a water bubble. The ink droplet is discharged from the nozzle onto the substrate at a rapid rate of speed because of the high-pressure expansion. Bubble printing is another name for this procedure.

Other elements have a complicated and interconnected role in the success of digital printing and publication, as seen in the figure. [40, 41]

Ozone (O3)

A sustainable method that uses less energy and water is ozonation because this procedure doesn't require chemicals, waste isn't created, and water is reused. The earliest application of ozone in the textile clothing production industry was in the denim industry. Ozone has a strong oxidizing capacity. By attacking the glycosidic bond of cotton fibers and dissolving the olefin clusters of indigo pigment for its oxidizing capability, which aids in decolorization, it is utilized to produce color-fading effects in denim. In place of enzymes, pumice stones, and bleach.

Ozone can be created by exposing oxygen (2O) to ultraviolet light (ultraviolet Ul) or using the halo discharge method. Ozone is a gas and uses a lot less water than other decolorizing agents because materials must first be soaked. [42]

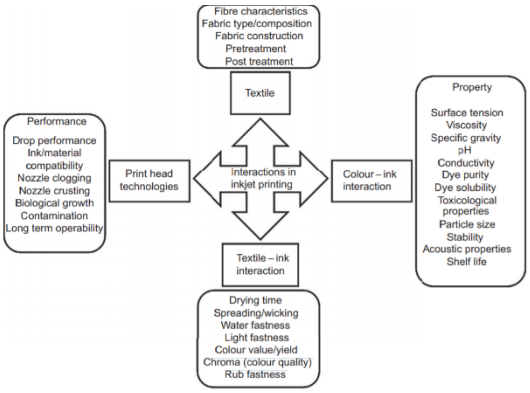

Fig. 8

Advantages of using ozone (O3)

1- Environmental benefits: The generation and recycling of liquid waste are not issues in the ozone process, particularly dry ozone, which lessens environmental damage.
2- Economic benefits: The ozone technique reduces the use of chemicals, water, and energy, lowering production costs for denim makers. After the dry ozone procedure, there is no need to rinse. After the wet ozone process, just one rinse or two washings are required to eliminate any leftover ozone and bleach indigo from the denim, conserving water.
3- Social benefits: As a result of the ozone process, environmental pollution is decreased and there are no environmental pollution-related problems in society. It also lessens workload and worker burnout. However, the usage of ozone may have some detrimental effects on people's health, particularly Workers.
4- Other benefits: Because ozone removes colors so quickly, it speeds up the ozone process and reduces energy and operational expenses. The classic bleaching method has the drawback of leaving white filament stains on the back of denim and pocket bags, but the dry ozone method is devoid of this issue and wet ozone may have very little back staining.[36]

Three oxygen atoms make up the three-atom molecule known as ozone. Coronal discharge is a recognized method of ozone formation. Complex aromatic rings are easily decomposed from pigments,

resulting in decolorization, due to the high oxidation capacity of ozone (E = 2.07 eV).

Ozone (a potent oxidizing gas) is produced using simply air and electrical energy. Ozone does not leave by derivatives on processed goods because they are chemically unstable. [42]

Ozone gas is used in bleaching processes much more quickly than other oxidizing agents. While traditional whitewashing takes 30 to 50 minutes [43], bleaching just takes 15 minutes. While stone washing or chemical bleaching requires six to seven washing and rinsing operations, ozone finish only requires two to three. Ozone greatly lowers water use during the finishing of jeans, however, it cannot completely remove it.

It decreases energy use by lowering the needed temperature and the volume of water that must be heated for wet finishing. In addition to reducing chemical and water use by 85% to 95% and energy use by 70% to 80%, Janology G2 Dynamic technology is intended to ensure that the body is detoxified and that the fabric is sustainable. For instance, if 15 to 20 liters of water are needed per kilogramme of cloth, the G2 Dynami method only needs 0.5 to 3 litres of water.[43]

G2 creates the illusion of "sunwashed" clothing with the actual feel and look of outdoor use utilising ambient air. Additionally, employing ozone in place of some conventional finishes eliminates effluents and creates sludge out of pumice stones. Due to the possibility of ozonized water being removed by ultraviolet rays after washing, this method is straightforward and environmentally benign.[44]

In addition, various denim finishing procedures can be repeated using ozone after darkening, such as in stone washing. Because of its superior quality, comparatively better performance, long-lasting process effects, low maintenance costs, straightforward installation, low bleaching production costs, high production capacity, and efficiency, this method is sustainable. To prevent dangerous or fatal worker exposure to ozone gas, safety measures, and features should be fundamental. because it functions in arid environments.[45]

Plasma

Plasma Related to the Processing of Denim. Plasma technology has been used to treat textiles during the past few decades since the procedure is straightforward. The term "plasma" refers to a partially ionized gas made composed of electrons, neutrals, excited molecules, photons, and ultraviolet light as well as positive and negative ions.

The following are some additional key advantages of plasma processing over traditional wet chemical processing of textiles: liquid-free and environmentally friendly dry operation; single-step, faster operation; less chemical requirement; and cost-effectiveness in terms of processing time and temperature. Plasma processing is therefore thought of as a sustainable method of modifying the surface properties of polymers and textiles.[46, 47]

It is good knowledge that the kind of gas, processing time, pressure, and discharge power all play a role in the outcomes of plasma-related processes. Using Ar and O2 in the low-temperature plasma (LTP) process with varying exposure times[48], Ghoranneviss et al. studied the fading effects of denim fabric. It was found that Ar-treated samples had lower K/S values when tested at the same frequency and for the same period. Additionally, the indigo-dyed denim fabric is subjected to LTP and corona treatment, both of which are connected to the production of reactive molecules and radicals in oxygen-containing gas mixtures. This causes the indigo dyes to oxidize and produce the desired faded effect.[48, 49]

Enzymatic

Enzymes have become more and more popular as alternatives to the chemicals used in bleaching and shading, and they are undoubtedly more resource- and wastewater-efficient. [50, 51]

Laccases

Laccases are crucial enzymes in the environmentally responsible bleaching of blue denim. They belong to the oxidoreductase enzyme class. Laccases often require a chemical mediator to be put between the enzyme and the substrate for them to function. In the presence of an aqueous solution, the enzyme undergoes oxidation, attacking the mediator and transforming it into free radicals. In the end, the indigo is attacked by free radicals, turning it into oxidized products[43]. The use of this enzyme is beneficial for certain indigo colors, not for the fiber itself. Without impacting other colors like sulfur, direct, or reactive dyes, the enzyme degrades the indigo molecule.[45]

Cold DeniLite

The new cold bleaching solution from Novozymes is called DeniLite Cold. The current approach relies on peroxidases and doesn't require any additional oxygen from the water or the air to function. 90% of the reaction is completed in just 10 minutes because of the fast reaction rate of this novel peroxidase. The cold bleaching process extends the life of denim fabric due to the moderate bleaching conditions. The indigo dye on the fabric is subjected to extremely precise enzymatic conditions. This makes sure that the fabric's suppleness and strength are preserved, unlike with harsher bleaching agents.[45]

Concept of Combined Washing

A combination of pumice stones and enzymes or the use of chemicals is used to rub denim clothes. A revolutionary wash processing plan from Novozymes called Novozymes Denimax Core strengthens the handling of the scrabbled area that takes place before the combined desizing process[52]. The combination technique uses less water than the standard method, which uses two rinses and two baths instead of one rinse and one bath. Heat savings may be obtained by switching from any of the conventional methods procedures to the combined process due to the decreased procedures.[45]

Conflicts of interest

There are no conflicts to declare

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References

[1]. Al Sayad, G. and Idris, I. The effect of altering weave structures and martial type on the performance efficiency of double denim fabric, *Journal of Architecture, Arts and Humanities*, 3(10 (1)) 420-440 (2018).

[2]. Hassabo, A.G., Abd El-Aty, M. and Othman, H.A. A critique on synthetic thickeners in textile printing, *J. Text. Color. Polym. Sci.*, 19(1) 99-109 (2022).

[3]. Soliman, M.Y., Othman, H.A. and Hassabo, A.G. A recent study for printing polyester fabric with different techniques, *J. Text. Color. Polym. Sci.*, 18(2) 247-252 (2021).

[4]. Hamdy, D.M., Othman, H.A. and Hassabo, A.G. A recent uses of plasma in the textile printing *J. Text. Color. Polym. Sci.*, 19(1) 1-10 (2022).

[5]. El-Sayed, E., Othman, H. and Hassabo, A.G. A short observation on the printing cotton fabric using some technique, *J. Text. Color. Polym. Sci.*, 19(1) 17-24 (2022).

[6]. Saad, F., Hassabo, A., Othman, H., Mosaad, M.M. and Mohamed, A.L. A valuable observation on thickeners for valuable utilisation in the printing of different textile fabrics, *Egy. J. Chem.*, 65(4) 431 – 448 (2022).

[7]. Hassabo, A.G., Zayed, M., Bakr, M. and Othman, H. An overview of carpet manufacture: Design, dyeing, printing and finishing, *J. Text. Color. Polym. Sci.*, 19(2) 269-290 (2022).

[8]. Hashad, A., Moawaed, S., Abd El-AAty, M., Othman, H., Mohamed, M., Abdel-Aziz, E. and Hassabo, A.G. An overview of carpets printing using inkjet technique, *J. Text. Color. Polym. Sci.*, 19(2) 223-234 (2022).

[9]. Ragab, M.M., Othman, H.A. and Hassabo, A.G. An overview of printing textile techniques, *Egy. J. Chem.*, 65(8) 749 – 761 (2022).

[10]. El-Sayed, G.A., Othman, H. and Hassabo, A.G. An overview on the eco-friendly printing of jute fabrics using natural dyes, *J. Text. Color. Polym. Sci.*, 18(2) 239-245 (2021).

[11]. Hassabo, A.G., Mohamed, N.A., Abd El-Salam, N.A., Gouda, N.Z. and Othman, H. Application of modified xanthan as thickener in the printing of natural and synthetic fabrics, *J. Text. Color. Polym. Sci.*, 20(1) 41-56 (2023).

[12]. Ebrahim, S.A., Othman, H.A., Mosaad, M.M. and Hassabo, A.G. Eco-friendly natural thickener (pectin) extracted from fruit peels for valuable utilization in textile printing as a thickening agent, *Textiles*, 3(1) 26-49 (2023).

[13]. Hassabo, A.G., Reda, E., Ghazal, H. and Othman, H. Enhancing printability of natural fabrics via pre-treatment with polycationic polymers, *Egy. J. Chem.*, 66(2) 167-181 (2023).

[14]. Saad, F., Mohamed, A.L., Mosaad, M., Othman, H.A. and Hassabo, A.G. Enhancing the rheological properties of aloe vera polysaccharide gel for use as an eco-friendly thickening agent in textile printing paste, *Carbo. Polym. Technol. App.*, 2 100132 (2021).

[15]. Hassabo, A.G., Elmorsy, H.M., Gamal, N., Sediek, A., Saad, F., Hegazy, B.M. and Othman, H. Evaluation of various printing techniques for cotton fabrics, *J. Text. Color. Polym. Sci.*, 20(2) 243-253 (2023).

[16]. Saad, F., Hassabo, A.G., Othman, H.A., Mosaad, M.M. and Mohamed, A.L. Improving the performance of flax seed gum using metal oxides for using as a thickening agent in printing paste of different textile fabrics, *Egy. J. Chem.*, 64(9) 4937 - 4954 (2021).

[17]. Abd El-AAty, M., Mohamed, M., Hashad, A., Moawaed, S., Hassabo, A.G., Othman, H. and Abdel-Aziz, E. Investigation of the discharge printing of cotton and silk fabrics dyed with reactive and natural dyes, *J. Text. Color. Polym. Sci.*, 19(2) 203-210 (2022).

[18]. Ebrahim, S.A., Hassabo, A.G. and Othman, H. Natural thickener in textile printing (a mini review), *J. Text. Color. Polym. Sci.*, 18(1) 55-64 (2021).

[19]. Moawaed, S., Hashad, A., Mohamed, M., Abd El-AAty, M., Hassabo, A.G., Abdel-Aziz, E. and Othman, H. Overview of discharge printing techniques on denim fabric, *J. Text. Color. Polym. Sci.*, 19(2) 211-221 (2022).

[20]. Hassabo, A.G., Abd El-Salam, N.A., Mohamed, N.A., Gouda, N.Z. and Othman, H. Potential application of natural gums suitable as thickeners in

textile printing, *J. Text. Color. Polym. Sci.*, 20(1) 57-65 (2023).

[21]. Diaa, M., Othman, H. and Hassabo, A.G. Printing wool fabrics with natural dyes curcuma and alkanet (a critique), *J. Text. Color. Polym. Sci.*, 19(1) 11-16 (2022).

[22]. Abd El-Aziz, E., abdelraouff, A., El-Desoky, S.S., El-Bahrawy, G.A., Ezat, H.A., Abd El-Rahman, R. and Hassabo, A.G. Psychological color and texture in marketing and textile printing design, *J. Text. Color. Polym. Sci.*, 20(2) 265-275 (2023).

[23]. Hassabo, A.G., Saad, F., Hegazy, B.M., Elmorsy, H.M., Gamal, N., Sediek, A. and Othman, H. Recent studies for printing cotton/polyester blended fabrics with different techniques, *J. Text. Color. Polym. Sci.*, 20(2) 255-263 (2023).

[24]. Hamdy, D.M., Hassabo, A.G. and Othman, H. Recent use of natural thickeners in the printing process, *J. Text. Color. Polym. Sci.*, 18(2) 75-81 (2021).

[25]. Ragab, M.M., Othman, H.A. and Hassabo, A.G. Resist and discharge printing techniques on different textile based materials, *J. Text. Color. Polym. Sci.*, 18(2) 229-237 (2021).

[26]. Hassabo, A.G., Bakr, M., Zayed, M. and Othman, H.A. Review on some fabric pretreatment via plasma to improve their printability using various types of colorants and dyes, *Materials International*, (Accept 2022).

[27]. Hassabo, A.G., Reda, E.M., Ghazal, H. and Othman, H.A. Synthesis of agnps and znonps using tea leaves extract and their utilization to improve dyeability, printability and functionality of cotton and wool fabrics, *Inorg. Chem. Commun.*, 150 110525 (2023).

[28]. Ragab, M.M., Hassabo, A.G. and Othman, H. Synthetic thickeners in textile printing, *J. Text. Color. Polym. Sci.*, 18(1) 65-74 (2021).

[29]. Hassabo, A.G., Sharaawy, S. and Mohamed, A.L. Unsaturated fatty acids based materials as auxiliaries for printing and finishing of cellulosic fabrics, *Biointerf. Res. Appl. Chem.*, 9(5) 4284 - 4291 (2019).

[30]. Abo-Shosha, M.H., Nassar, F.A., Haggag, K., El-Sayed, Z. and Hassabo, A.G. Utilization of some fatty acid/peg condensates as emulsifiers in kerosene paste pigment printing, *RJTA*, 13(1) 65-77 (2009).

[31]. Nassar, F.A., Abo-Shosha, M.H., Haggag, K.M., El-Sayed, Z. and Hassabo, A.G. Utilization of some fatty acid/peg condensates as emulsifiers in kerosene paste pigment printing, 3rd International Conference of Textile Research Division, NRC; Textile Processing: State of the Art & Future Developments, Cairo, Egypt, pp. 359 - 368 (2006).

[32]. Hassabo, A.G., Hegazy, B.M., Elmorsy, H., Gamal, N., Sediek, A., Saad, F. and Othman, H. Denim manufacturing and washing as a fashioned garments, *J. Text. Color. Polym. Sci.*, 20(2) 203-216 (2023).

[33]. Muthu, S.S. Sustainability in denim, Woodhead Publishing, (2017).

[34]. Moawaed, S., Hashad, A., Mohamed, M., El-AAty, A., Hassabo, A.G., Abdel-Aziz, E. and Othman, H. Overview of discharge printing techniques on denim fabric, *Journal of Textiles, Coloration Polymer Science*, 19(2) 211-221 (2022).

[35]. Siddique, A., Hussain, T., Ibrahim, W., Raza, Z.A. and Abid, S. Optimization of discharge printing of indigo denim using potassium permanganate via response surface regression, *Pigment Resin Technology*, 47(3) 228-235 (2018).

[36]. Nayak, R., George, M., Jajpura, L., Khandual, A. and Panwar, T. Laser and ozone applications for circularity journey in denim manufacturing-a developing country perspective, *Current Opinion in Green Sustainable Chemistry*, 100680 (2022).

[37]. Unal, F., Yavas, A. and Avinc, O. Sustainability in textile design with laser technology, *Sustainability in the Textile Apparel Industries: Sustainable Textiles, Clothing Design Repurposing*, 263-287 (2020).

[38]. Venkatraman, P.D. and Liauw, C.M. Use of a carbon dioxide laser for environmentally beneficial generation of distressed/faded effects on indigo dyed denim fabric: Evaluation of colour change, fibre morphology, degradation and textile properties, *Optics Laser Technology*, 111 701-713 (2019).

[39]. Kan, C.-w. Co2 laser treatment as a clean process for treating denim fabric, *J. Clean. Produc.*, 66 624-631 (2014).

[40]. Lucas, J., Belino, N., Miguel, R., Pereira, M. and Ribeiro, L. Digital printing techniques for denim jeans, Denim, Elsevierpp. 287-312, (2015).

[41]. Wang, M. Development and evaluation of digital denim technology, North Carolina State University, (2020).

[42]. Ben Hmida, S. and Ladhari, N.J. Study of parameters affecting dry and wet ozone bleaching of denim fabric, *Ozone: Science Engineering*, 38(3) 175-180 (2016).

[43]. Periyasamy, A.P., Ramamoorthy, S.K. and Lavate, S.S. Eco-friendly denim processing, (2019).

[44]. Sangita, S., Kumar, P. and Chandran, M. Types of stone wash & their effects on the denim fabric, *The Indian Textile Journal*, (2010).

[45]. Khan, K.R. and Jintun, S. Sustainability issues of various denim washing methods, *Textile Leather Review*, 4(2) 96-110 (2021).

[46]. Yip, J., Chan, K., Sin, K.M. and Lau, K.S. Low temperature plasma-treated nylon fabrics, *Journal of Materials processing technology*, 123(1) 5-12 (2002).

[47]. Pu, F.R., Williams, R.L., Markkula, T.K. and Hunt, J.A. Effects of plasma treated pet and ptfe on expression of adhesion molecules by human endothelial cells in vitro, *Biomaterials*, 23(11) 2411-28 (2002).

[48]. Ghoranneviss, M., Shahidi, S., Moazzenchi, B., Anvari, A., Rashidi, A. and Hosseini, H. Comparison between decolorization of denim fabrics with oxygen

and argon glow discharge, *Surface Coatings Technology*, 201(9-11) 4926-4930 (2007).

[49]. Periyasamy, A.P. and Periyasami, S. Critical review on sustainability in denim: A step toward sustainable production and consumption of denim, *ACS omega*, 8(5) 4472-4490 (2023).

[50]. Ragab, M.M., Othman, H.A. and Hassabo, A.G. Various extraction methods of different enzymes and their potential applications in various industrial sector (a review), *Egy. J. Chem.*, 65(10) 495 - 508 (2022).

[51]. Hassabo, A.G., Gouda, N.Z., Khaleed, N., Shaker, S., Abd El-Salam, N.A., Mohamed, N.A. and Othman, H. Enzymes in digital printing of polyamide fabric, *J. Text. Color. Polym. Sci.*, - (Accept 2023).

[52]. Khan, M.A. A new concept in denim washing, *Pakistan Text. J.*, 61(6) (2012).

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الملخص

تعرف المادة المستخدمة في إنتاج الجينز باسم الدنيم. إنه نسيج مريح للغاية مصنوع من نسيج قطني 100٪. في جميع أنحاء العالم ، يستخدم هذا القماش لإنشاء مجموعة متنوعة من الملابس للرجال والنساء من جميع الأعمار ، بما في ذلك الجينز والمعاطف والقمصان وحقائب اليد وحقائب اليد. يتم لف اللحمة عبثا تحت لفتين أو أكثر لإنشاء الدنيم ، والذي يتميز عن القطن العادي بالتضليع. ينتج عن عملية نسج الدنيم الجينز البسيط المألوف عن طريق تلوين السداة مع ترك اللحم أبيض. تم استخدام الدنيم في الأصل لملابس العمال ، ولكن بمرور الوقت ، خضع للعديد من التعديلات والإضافات المبتكرة ليصبح رمز التصميم الذي هو عليه اليوم.

الكلمات الدالة: قماش الدنيم ، تكنولوجيا الطباعة ، تقنيات الطباعة.