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An Overview of Printing Textile Techniques

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Abstract

Textile printing is the process of applying ink to textile surfaces using specialized printing processes and machines. The most direct printing techniques used are discussed. Block printing is one of the ancient art forms in India that has been passed down through generations. Flat and rotary screen printing which are capable of extremely high rates of production due to their adaptability. Burn out printing which gives us distinguished designs and Digital printing which is one of the most exciting advances in the manufacturing and textile sectors. Indirect printing such as resist printing and discharge printing which attracts attention as its pattern appear with diverse colours on a dark background. The variety of designs that can be created using the discharge printing technique polluted the environment due to the toxic reducing and oxidizing agent used so they have been substituted with eco-friendly enzymes.

Keywords: Textile, printing, techniques

Introduction

1.1. Textile printing

Textile printing is very certainly as old as civilization itself. [1] The textile sector has a significant impact on the economies of countries. [2] The use of colour through dyeing and printing procedures has also played a significant part in all civilizations.[3, 4] The Colouration of fabric becomes a major process in the production of textile material. [5] Textile printing is an old art form that dates back thousands of years. [6, 7] It is one of the most diverse and significant methods of introducing colours and patterns to textile materials. [8-12] It is also the process of mixing a design concept, one or more colours, and a substrate (usually textiles) with a natural or synthetic thickener, while applying a technique to correctly apply the colours. [4, 13-26] The main objective of printing is to create colourful patterns with sharp borders on textile fabrics without any dye spilling beyond the design motif's borders.[27]

Textile printing is defined as a regulated technique of colouring cloth in specific patterns or motifs by employing specialized printing techniques and machinery. [28, 29] it is also the process of creating a colour pattern or drawing on textile materials. [26, 30] The colour is linked to the fibre in properly printed fibres to protect against washing and crocking. Localized dyeing is a term used to describe textile printing. Unlike dyeing, the dye penetrates into specific regions of the substrate during printing. [31, 32]

The application of colour to cloth is the primary distinction between textile dyeing and printing procedures. During the dyeing process, the cloth is immersed in a diluted dye-bath solution, and excess dye solution is squeezed out of the dye-bath. On the other hand, Printing is often accomplished by applying thicker pastes containing dyes or pigments together with other auxiliary substances to a cloth surface in

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accordance with a colour pattern. [30, 33] The viscosity of a printing paste, in particular, is important. It controls the amount of paste transmitted to the fabric as well as the amount to which it spreads on and into the surface yarns. [6, 33] Paste must colour all visible fibres on the printed surface, so it must penetrate considerably into the yarn structure.[33]

1.2. Classification of printing techniques

Generally, a difference is observed between printing processes and printing styles. Traditional textile printing processes can be classified into two categories: direct printing and indirect printing.[28]

1.2.1. Direct printing

Direct printing is the most popular method of adding a colour pattern. It can be done on white cloth or over previously coloured fabric, in which case it is referred to as over printing.[10] It is often known as 'print-on', and it is the most common and easy printing technique on fabrics in the modern industry. Originally, the term "direct" denoted that no previous mordanting or dyeing procedure was involved.[34] In which printing pastes come into direct contact with the fabric surface with no additional processing changes,[12, 33] and the dyes used in dyeing a fibre can theoretically be utilized in printing on the same fibre. [28] But Pigment is the most commonly used colourant in textile direct printing and cover approximately 75-80 % of the total of all printing processes as it is a simple and low-cost approach that does not require a lot of equipment, do not require washing, and produce just a minor quantity of waste. [7, 29, 31]

And to create fibres with appropriate colourfastness characteristics, the dye stuffs employed in the printing paste are chosen based on a number of factors, including the chemical structure of the fibre. [30] The final result is obtained in one operation using the direct printing technique, with knowing that fixing and washing may be required. [34, 35]

1.2.1.1. Block printing

Block printing is one such ancient art form in India that has been passed down through generations.[28] Block printing, as a manual method, is still performed in many Asian nations, mostly in the fine arts as it may be done at home by people in their spare time. [1, 28, 36] This technique is used to make a variety of products, particularly in the garment sector. It offers each piece of cloth a design that distinguishes it from the others in appearance. This type of productivity can never be expected from automated machines. [37]

There is no doubt that the earliest textile-printing process (creating imprints) used blocks with raised printing, the printing paste is applied to the design surface of the block before pressing it onto the cloth and presses it firmly and continuously on the fabric, making a strong print by striking it skillfully on the back with a wooden mallet.[10, 36] The picture would be produced as a mirror-image from the pattern.[28] The technique is repeated with various colours and designs until the pattern is finished.[1] Some of the first blocks were constructed of clay or terracotta, while others were carved from wood by using a xylography tool (knife or chisel) for wood engraving.[28, 34, 36] If the design includes many colours, the fabric is often printed with one colour first, then dried and printed with the second, with the same procedures continued until all of the colours are printed. The block printing worker must be very skilled in order to position the blocks accurately where they are needed. [36]

On the other side it is a time-consuming operation, and there have been a number of client complaints about poor look, inappropriate patterns, and colour loss in this industry and it is not appropriate for high-volume commercial use.[36] Despite its beauty, this delicate art form is losing customers as a result of the influx of machine-made uniform garments in a globalized market. [37] **Figure 1** explain the block printing technique. [36]

1.2.1.2. Screen printing

Screen printing is an outgrowth of the stenciling process in which a coloured picture is created by transferring colour (printing paste) via open spaces in the silk screen put on the cloth surface, [33, 36] which can achieve deep depths of shadows.[1, 34] A mesh is coated with a compound that closes all gaps in the screen opening and prevents the dye paste from flowing through the screen except in the places to be printed according to the design specifications.[12] The screen printing procedure involves pushing ink through the holes of a tiny screen mesh [36]

Because of the breadth of the fabrics now being printed, mechanized screen printing has become the accepted method for short production runs.[1] Screen printing can be done using flat or cylindrical (rotary)

screens composed of silk threads, nylon, or polyester.[36] The machine speed of a flat-screen is often slower than that of a rotary-screen. [38] The printing paste or dye is put over the screen and driven through the unblocked sections of the screen onto the fabric.[38] For textile printing, two primary screen printing technologies are used flat screen printing and rotary screen printing as follows. [1, 29]

Figure 1: Block Printing

1.2.1.2.1. Flat-screen printing

A flat printing method in which the screen printing mesh linked to the rectangular frame usually made of wood or metal and the printing substrate are both flat.[38] A squeegee is used to spread the printing paste across the screen. The screen is wiped in order to bring the paste into touch with the cloth. [1, 34] The printed image is restricted by the size of the frame in this printing technology.[28] The machines can be operated manually, semi-automatically, or fully automatically.[1]

In flat screen printing the fabric is placed on a long table on top of the printing blanket. This blanket is normally made of cotton/polyester fabric that has been water-proofed with a neoprene rubber covering. To prevent printing distortion if the fabric moves, it is either pinned to the printing blanket or glued to it using a water-based gum or thermoplastic adhesive. The screens are then lowered, and the paste is pressed onto the cloth via the screens.[29, 34] After each application, the printed material passes one frame, and by the time it reaches the last frame, it has dried and is ready for fixation. [1] The cloth and printing blanket separate after printing. The blanket is washed to remove any gum and colour paste that has been transmitted through the material or beyond its edges. [33, 34] **Figure 2** clarifies the flat screen printing mechanism. [1, 28]

1.2.1.2.2. Rotary screen printing

The rotary cylinder printing machine is one of the most popular fabric printing equipment.[38] Rotary-screen printing machines work on the same concept as flat-screen printing machines, but instead of flat screens, the colour is transmitted to the fabric using lightweight metal foil screens in the shape of cylinder rollers which is made of stainless steel or nickel.[36] The fabric moves in a continuous movement under a series of cylinders' screens, with the printing paste mechanically supplied into the interior of the screen from a tank and squeezed through onto the cloth at each place.[10, 12] Each colour in the pattern requires its own cylinder roller. Rotary-screen printing machines are supplied with adhesive and washing equipment similar to those mentioned before for flat-screen printing. The belt is washed to remove the paste and adhesive remnants. For each colour change, not only the belt, but also the screens and paste input devices, must be cleaned.[1, 34]

The rotary printing process, in which the printing plate and the pressure element are both cylinders that revolve synchronously. Ink is transported from the interior of the cylindrical printing plate to outside.[29] The invention of rotary screen printing equipment capable of extremely high rates of production because of its adaptability, this style of printing has grown greatly in popularity in recent years.[9, 28, 36] The biggest downside is that it is not cost effective, and if the orders are tiny and we need to modify the design frequently, it is quite hard to obtain orders for the same design. **Figure 3** shows rotary screen-printing machine. [9, 36]

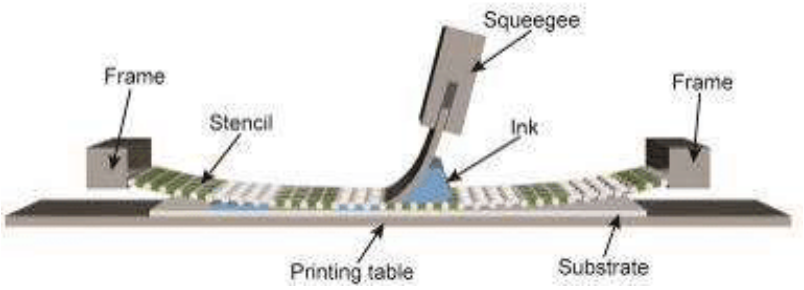

Figure 2: Flat screen-printing mechanism.

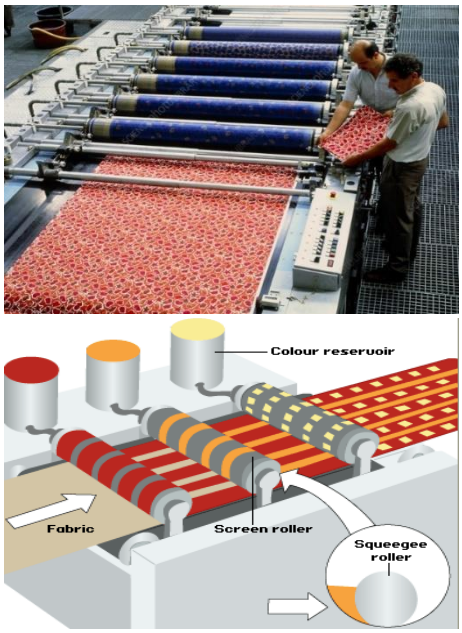

Figure 3: Rotary screen-printing machine

1.2.1.3. Burn-out printing

Burnout printing is a technique for producing a raised graphic on a sheer background.[36, 39] Burn-out printing involves the employment of a paste containing chemicals usually acids capable of dissolving or damaging one of the fibre components of a blended material and leaving behind only the synthetic fibres. [39]

Burn-out pastes are classified into two types: acid pastes and alkali pastes. Cellulosic fibres, nylon, cellulose acetate, and triacetate are destroyed by acid, whereas protein fibres are destroyed by alkali. In general, fibres must be blended in both the warp and weft of the fabric; or the fabric would dissolve.[40, 41]

Printing is achieved by combining a thickening agent, dye, mordant and the necessary ingredients. Furthermore, dyes with rapid transfer ability from paste to fibre are preferred; otherwise, the fixation period required to achieve adequate diffusion will be extended.[38] When the chemical runs across the cloth and comes into touch with the cotton section, the chemical reaction burns off the cotton. Cotton, in fact, is the victim in this case. When cotton burns, coloured polyester provides full shade and empty areas.[39]

It is obvious that sodium hydroxide is a powerful alkali that may burn out protein materials, the most damaged mix is one with a high percentage of protein, such as wool/polyester (50/50) followed by wool/polyester (30/70). Organic and inorganic acids, aluminum sulfate or sodium hydrogen sulfate have an effect on the cellulosic element in the blend. When oxidised, the cellulosic long chains convert to hydrocellulose with extremely small chains, which may be removed by washing after a dry heat fixation procedure leaving only polyester fibres. [41] . As a result, the most impacted mixes were cotton/polyester (50/50), followed by cotton/polyester (30/70).[40]

Burnout printing is commonly employed on velvet; a burnout print is the result of this procedure. [36, 40, 42] However, this technique is extremely destructive and necessitates the use of specific screens as well as extreme caution while handling.

Regardless of type of the burn-out substance utilised, raising the concentration of the chemical used resulted in an increase in the % weight loss. [40] **Figure 4** shows fabric printed with Burn out printing technique. [39]

Figure 4: Burn out printed fabric.

1.2.1.4. ***Digital printing***

Digital printing is one of the most interesting advances in the manufacturing and textile sectors. Digital textile printing can recreate an infinite number of colours and tints as well as excellent print fastness. [36, 43]

1.2.1.4.1. Inkjet printing

Ink-jet printing is a digital printing process that allows for printing on a variety of textile substrates without any touch between the substrate and the ink. [43] Inkjet printing technology is employed in a variety of sectors specially in textile field. Due to its easy process, quicker process time, and reduced material consumption with digital control and non-contact printing technique. [44]

In this kind of printing Micro-sized droplets of dye are applied to the cloth using an inkjet print head. [36, 44, 45] The data produced by digital image file is interpreted by the print system software which regulate the particular colour of the ink jet, the volume of ink, and the placement of the micro droplets [9, 12] The digital image file contains the data required to regulate the droplet output and achieve image quality and colour control. [28, 36] Fabrics used for inkjet printing include specially prepared cotton, bamboo, and silk fabric sheets. [36]

Colour ink is an important component of ink-jet printing technology that has a significant impact on printing quality. As a result, printing inks evolved along with the development of printers. [43] The jetting ink composed of Colourant (dyestuff or pigment), solvent (water), and various ingredients (such as surfactant, salt, and binder for pigment ink).[38] Digital printers use four primary colours (yellow, magenta, cyan, and black), which presents new issues in colour mixing for textiles.[12]

Recently, there has been a growing interest in the use of ink-jet printing for textile applications.[10, 43] Ink-jet printing provides advantages such as speed, flexibility, creativity, cleanliness, competitiveness, and environmental friendliness.[44] In traditional textile printing dyes are used along with the printing chemicals in the form of a printing paste. However, due to the requirements of ink purity and specific conductivity for digital ink-jet printing, none of the conventional printing chemicals such as alkali, urea, and sodium alginate can be entered directly into the ink formulation, and thus a printing medium for textile digital ink-jet printing must be prepared. Inks for fabric printing are often divided into two types: dye-based inks and pigment-based inks. Pigment-based ink printing improves the fabric's wash and light fastness over dye-based ink printing. It conserves water and energy, and most importantly, it is ecologically friendly. [43, 46] **Figure 5** shows inkjet printing machine. [36]

Figure 5: inkjet printing machine

1.2.1.4.2. Transfer printing

Transfer printing refers to the method of printing a pattern on a flexible, non-textile substrate and then transferring it to a textile material via a separate process.[47] In transfer printing the design is first printed on sublimation transfer paper with sublimation dyestuffs and the most successful is disperse dye [9], and then the dye sublimates and migrates to textile material by heat press with a hot press or hot calendar.[8, 9] The temperature of the hot press or hot calendrer should be properly managed, and for pure polyester, it should be roughly 180–200°C in around 20–30 seconds. [38, 47] Sublimation transfer, melt transfer, film release, and wet transfer are the four types of transfer printing processes.[8, 12] Sublimation transfer printing is the most common transfer printing method, which relies on the employment of a volatile dye in the printed pattern.[28, 34]

This printing method has more advantages, such as low manufacturing costs, transfer methods make it far easier to produce short-run repeat orders than direct printing, when patterns are stored on paper rather of printed fabrics stock volume and storage expenses are reduced and there is no need to create and store screens for a printing factory, most transfer-printing procedures allow textile printing to be done with basic and low-cost equipment in a small amount of area with no effluent generation or washing-off required.[8, 34] The limitation of transfer printing is the lack in flexibility when printed on different fabrics. **Figure 6**

shows transfer printing process. [8, 28]

Figure 6: Transfer printing

1.2.2. Indirect printing

Indirect printing is different from the direct printing. The resist and discharge printing are types of indirect printing. These techniques have been used in textile printing since the beginning. [34] Despite the fact that modern technology have made the use of direct printing possible for many more designs and decreased the requirement of utilizing these styles in recent years, they will always be important as the results achieved are more often different and visually superior. [11]

1.2.2.1. Resist printing

Resist Printing is a centuries-old method of imparting pattern to fabric. Resist printing technique is still as popular now as they were in the past. [27] Resist printing style gets its name from the fact that the cloth is printed with a compound that it is used to inhibit dye absorption on cloth by preventing dye penetration or fixing. [4, 7, 10]

Resist printing is a printing technique in which the pre-treated cloth is first printed with the resist agent and then coloured by dyeing. [12, 27] Only the areas that are not coated with resistant paste will be affected by a dye, resulting in a pattern on a colourful background. [4, 28, 48] A multicolour pattern can be made by placing a paste containing a material resistant to second dye on already coloured cloth. [28]

Resist printing, in which some portions of the fabric are initially coated with waxes or other compounds in order to prevent colouring by printing pastes or inks and prevent the fixation of cloth, however in the case of resist printing , the cloth is first printed with a resist agent and then coloured.[7, 34]

Resist mechanism can be physical or chemical, with a combination of both types of resist agent ensuring optimum efficacy.[6, 27, 34] Coloured resists necessitate the addition of dyes or pigments to the print paste that are properly fixed in the presence of the resist agent, either before or during the process of fixation the ground colour. [27, 34] The styles of resist printing materials are identical to those of the discharge technique, but the resist printing method has an advantage in the range of dyes that may be chosen for ground colour, whereas dyes used in the discharge method only focus on those with instability that can be readily destroyed.[38] Figure 7 shows white resist printing pattern. [49]

1.2.2.1.1. Physical resist printing

Physical resist printing techniques are now only used on batik items. Which is described in Figure 8, in which cotton fabric is printed with a wax, fats, or resins to create pattern design.[12, 50] Following that, the cloth is immersed in a cold solution of substantial dyes (having groups capable of reacting with diazotized bases or Diazonium salts, rapid colour salts). The combination with the Diazonium salt occurs after drying with air. Rinsing and boiling-off in water finishes the process.[1] A physical resist (see Figure 8) prevents dye absorption (in order to make them water-repellent) .[4, 6, 34]

Figure 7: Resist printing pattern

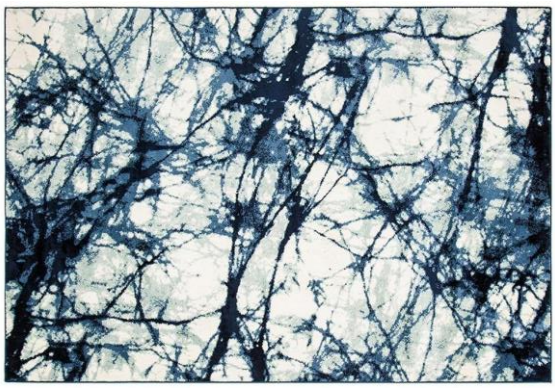

Figure 8: physical Resist printing

1.2.2.1.2. Chemical resist printing

Chemical resist which is shown in **Figure 9**: Chemical resistprevents fixing of the dye into the fabric.[27, 34] It is favourable for (1) dye dissolution (oxidative or reductive), (2) dye insolubility (through the addition of anti-solution agent), and (3) blocking the dye site on fibres.[4, 6]

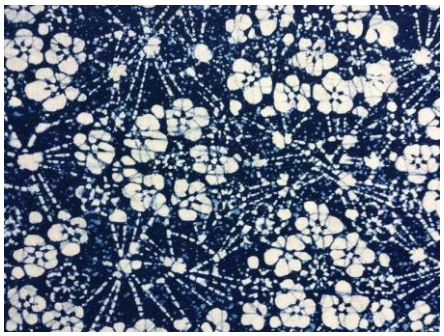

Figure 9: Chemical resist printing

1.2.2.2. Discharge printing

Discharge printing is a type of printing and sometimes known as "extract printing" that involves bleaching or destroying specific colours in a pattern after it has been printed. [28, 51, 52]

Discharge printing is now gaining popularity in both the local and international sectors because of the prevalence of patterns with varied colours on a dark background.[28, 35, 53] Discharge printing specially on cotton, wool and silk fabric has always been important, regardless of fashion trends.[1]

Discharge printing methods are classified into two categories. The first is white discharge (bleaching), while the second is colour discharge. In white discharge printing, the ground cloth is initially printed with discharge agent. The coloured textiles are printed using a paste comprising the discharge agents. During the fixation process, the discharge agent is chemically activated and bleaches away the ground colour, resulting in white pattern.[41, 52] Figure 11 shows white discharge printing design

Colour discharge printing is similar to white discharge printing in that the dyes can be chemically degraded by the discharge agents. But instead of printing with a paste that simply contains the discharge agent, additional colourants known as illuminating colours are used. The discharge agents do not chemically destroy these illuminating colour, but instead bring new colours into the fixation process. [41, 52] And **Figure 10** shows colour discharge printing designs.

Unlike direct printing, the fabric being printed in discharge printing is first dyed using dischargeable dyes. [28] The dyed cloth is then printed with a paste containing chemicals that have the capacity to damage the dyed colour. After steaming, the colour on the printed patterns will be discharged.[7, 12] After rinsing, white patterns appear on coloured cloth.[34] If the printed paste contains dye that has not been discharged or decreased by the reducing agents (These dyes, known as brilliant colours) , followed by steaming and washing. Then pattern will reflect the colour of the dyes and creating a colourful pattern on a dyed ground rather than a white design and it is known as colour discharge as mentioned previously.[1, 7, 10, 34, 51]

The first process is known as white discharge printing in which there is no colour added to the discharge printing paste, while the second is known as coloured discharge printing which is limited to a very limited palette of dyes.[28] In which a vat dye and also basic dyes are introduced to the discharge printing paste, the discharge agent decreases the dye while also allowing it to colour the cotton fibre and gives colour discharge printing [1, 34, 38, 54] The colour that surrounds a printed pattern is known as ground colour since it acts as the printed pattern's background. In this context, the pattern colour is known as the illuminating colour, as it seems like coloured light brightens the ground colour on the textile. This effect is enhanced when the ground colour is dark.[34]

For discharge printing, fabric should be 100% cotton and the fabric should be dyed with dischargeable reactive dye. [52] Usually, dischargeable dyes for ground are azo dyes having –N=N– group that can be reduced by breaking the double-bond. [4, 55] Despite the fact that they all contain the same azo group, dyes with various structures have distinct dischargeable properties. The choice of discharge dyes for lighting colour is directly connected to the specific conditions in printing, such as printed material, colour shades, and the discharging agent chosen.[10] So we can concluded that discharge printing theory is based on the degradation of the chromophore system of the dyestuff used in the textiles by a chemical reagent. [4, 11, 56]

Discharge printing is preferable for some reasons;(1) It is feasible to make printed materials with huge regions of ground colour, the depth, levelness, and penetration of which would be difficult, if not impossible, to achieve using a direct printing technique. [41] (2) Delicate colours and elaborate

patterns may be recreated on the ground of any depth with the clarity and sharpness that have become characteristics of this technique. (3) Complex white designs lose their sharpness when printed by direct method because the print paste spreads unevenly in different directions. (4) Furthermore, a coloured motif inserted within a direct print either leaves unprinted white borders or creates a third colour when fall-on occurs.[34]

Figure 11: White discharge printing

Figure 12: colour discharge printing.

Such effects are acceptable in some circumstances, but they can be removed by utilizing the discharge technique. The additional procedures required and the increased expenses of discharge pastes raise manufacturing costs, but the visually superior outcomes increase the product's value and allow profit margins to be maintained or even enhanced. When applied to long-lasting patterns such as scarves, ties, cravats, and dressing robes, the greater costs of discharge printing are frequently compensated .[34, 54]

1.2.2.2.1. Traditional discharge printing using chemicals

Discharge printing, as explained it is a fabric printing technique that destroys specific portions of coloured textiles to generate white or other coloured small-detailed patterns against a colourful background.[55, 57, 58] Nowadays, the most significant discharge techniques are based on reduction; by using reducing agent.[1, 11]

Discharging agents, such as reducing and oxidizing agents, acids, alkalis and various salts, are the most commonly and widely used in discharge printing [1, 4, 56] The most significant discharge agents in textile printing nowadays are reducing agents such as formaldehyde sulfoxylate (Rongalite c) ($NaHSO_2.CH_2O.2H_2O$), formaldehyde zinc sulfoxylate (Decroline) and processed stannous chloride ($SnCl_2$), sodium dithionite and thiourea dioxide [$(NH_2)(NH)CSO_2H$]. $SnCl_2$ is not suggested for hydrophobic materials because capillary migration of the liquid causes haloing defects around the pattern, lowering its sharpness. [38] Generally Sulphoxylate are often stronger and popular reducing agents than tin II chloride and may be used to discharge a wider spectrum of colours.[10]

Potassium permanganate ($KMnO_4$), hydrogen peroxide, sodium hypochlorite, sodium perborate, perchloric acid, chromic acid, benzoyl peroxide and sodium percarbonate are examples of common oxidative agents. [1, 54, 57, 59-61] The amount of reducing agent actually used is dependent on the dyes used, both the ground and the illuminating colour, as well as the cloth being printed. [38, 55]

Discharging auxiliaries such as anthraquinonoid are frequently employed to enhance the discharge effect of a reducing agent and are therefore utilized on textiles dyed with azo dyes. Some auxiliaries, such as

zinc oxide, titanium dioxide, or barium sulphate, can also be added to discharge print pastes to cover the residual un discharge ground colours and provide a plastic appearance in patterns. White discharge frequently necessitates the use of penetrating agents, particularly on knitted materials. Glycerol, ethylene glycol, and thiodiglycol are examples of this type of additive, they are mostly advantageous because of their humectant qualities. Wetting agents are also required when printing on low absorbency cloth that may be covered with a dried film of thickener from the prior pad-dye process. [1]

The major issue with utilizing an oxidizing agent in the oxidation process is the chemical's negative effect on the cotton substrate. If the right conditions are not satisfied, an oxidizing chemical may readily damage cotton. The most significant discharge methods are based on reduction. This general approach may be modified and changed to produce discharge with most dye classes and on most textiles.[55]

The thickener used in discharge printing should be impermeable to the reductant. As a result, non-ionic types are chosen. Furthermore, a thickener with a high-solid, low-viscosity feature is required to ensure that defined patterns are effectively obtained. [38]

White discharge printing was done on the coloured cotton cloth. In discharge printing, sodium hydrosulphite, stannous chloride, or zinc sulphoxylate formaldehyde can be employed as discharging agents. The following **Error! Reference source not f ound.**describes the recipe for traditional discharge printing on cotton fabric. [55]

Table 1: Discharge printing recipe for cotton fabric

Reagents	concentration in kg
Sodium hydrosulphite (Discharging agent)/ zinc sulphoxylate formaldehyde/ stannous chloride	140 gm
TiO2 (titanium dioxide)	80 – 150 gm
Potassium Carbonate	90 - 100 gm
Glycerin	20- 50 gm
British Gum (Thickener)	680 gm

Discharge printing can also be done on wool fabric. Little information on discharge printing of wool has been published, possibly due to the challenges inherent in this method. The original dye in the printed regions is chemically destroyed during discharge printing of wool fabric using Sodium/zinc/calcium formaldehyde sulphoxylate as reducing agents. Steaming is done for 10–20 minutes at 100–120°C, with air-free steam which being important. The following The discharge paste, which is an oxidizing and **reducing chemical**, destroys the colour by oxidation and reduction in order to eliminate or reduce the chromophore colour through printing, resulting in a white discharge on the printed fabric after processing. [1] After reduction the dye is benzylated into a water-soluble, and the dye bond to the fibre is broken here, and the by-products of discharge are eliminated during washing. [1, 54]

Aside from being wasteful, inefficient, and overused, using too much of the reducing agent will result in haloing or flushing of white discharge, blurred edges, and a loss of fine detail. While using an inadequate reducing agent will result in an incomplete discharge. [54]

However, these discharge agents have many defects throughout the discharge printing process. For example, Rongalite c and Decroline may produce the human carcinogen. Formaldehyde and stannous chloride frequently include heavy metal ions and decompose readily to produce HCl gas. Moreover, processed stannous chloride always leaves a significant quantity of residual zinc on the textiles, resulting in heavy metal contamination. As a result, it is critical to produce a safe and environmentally acceptable discharge agent.[57, 62]

Table 2: Discharge printing recipe for wool fabricdescribes the recipe for traditional discharge printing on wool fabric. [58]

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Table 2: Discharge printing recipe for wool fabric

Reagents	concentration in kg
Dye	x
Urea	300–500 gm
Thio diethylene glycol	300–500 gm
Sodium/zinc/calcium formaldehyde sulphoxylate	180–300 gm
thickener	500 gm
Ammonium chloride	20–50 gm
Zinc oxide 1: 1	20–50 gm

1.2.2.2.2. Bio-discharge printing using eco-friendly agents

Textile industries generate hazardous wastes during the creation and use of dyestuff, pigment, and auxiliaries, resulting in pollution of the environment. [61] Significant quantities of complicated effluents, varying in both amount and character, commonly arise in the textile wet processing sector. The textile industry's effluent is recognized to be brilliantly coloured, having a high concentration of suspended particles, a broad range of pH changes, high temperatures, and a high need for chemical oxygen (COD). So, several attempts have been made to reduce pollution by utilizing natural dyes and auxiliaries. [4, 63]

Nowadays, global demand for greener textile technology is expanding. So the use of eco-friendly natural dyes, auxiliaries, as well as low-impact biotechnology, is gaining popularity. [61] Biotechnology has been used in textile production for over 2000 years as a sustainable technologies. [10] Enzymatic pre-treatments are the most well-established use of biotechnology in textiles. [64]

Environmental and industrial safety conditions have enhanced the possibility of using enzymes in textile processing to achieve eco-friendly production. [11] There is an increasing realization for the use of enzymes in textile industry. They are well recognized and well established in several technologies and utilized in numerous remediation procedures to target particular reasons and have gained widespread acceptance. [56, 65]

Recent biotechnology improvements in this direction have enabled the creation of cheaper and more easily available enzymes through improved isolation and purification techniques.[62] Enzymes are naturally contain of complex protein made up of 200 to 250 amino acids, and they are found in all living cells and play an important role in regulating metabolic processes.[10] And capable of catalyzing particular chemical processes and act as catalysts, which facilitate the reaction. [10, 11, 65] As a result of catalyzing the chemical process, the enzyme is freed and can catalyze another reaction and so on. They can operate in a moderate environment, they are also safe, biodegradable, simple to manage and can replace harsh chemicals.[10]

Biotechnology has greatly expanded the range of enzyme system applications in all areas of textile manufacturing.[56, 62] Enzymes are now widely utilized in medical, food analysis, genetically modified foods, transgenic animals and plants, and home detergents and also in textile field.[65] Commercial enzymes are derived from three basic sources: animal tissue, plants, and microbes. [66] Plants, fruits and vegetables are the primary nutritional supplies of all living species and have been for a long time. Furthermore, plant compounds are employed as enzymes in the food industry and in other life-sustaining supplies.[67] For example the extraction and characteristics of polyphenol oxidase enzyme from apricot, apple, eggplant, banana peel and potato.[68] And also Moringa Oleifera which is well-known medicinal plant that is extensively spread in tropical areas, it includes a combination of various hydrolytic enzymes, the most important of which are proteases, which have been shown to have pharmacological effect.[69] Currently horseradish, turnip roots, soybean seeds, sweet potato, Garlic, waste cabbage leaves are the primary source of commercially available peroxidase.[70] Plant lipases, which have high activity above room temperature, cheap, simple to produce, are extracted from Sunflower seeds. [71] Laccase enzyme is also found in potato peels.[72]

Enzymes may be created to perform particular reactions such as hydrolysis, oxidation, reduction and to reduce the environmental effect of textile wet processing, resulting in energy savings, reduced water usage, and the replacement of harsh chemicals in the

manufacturing of textile materials.[73]

In textile discharge printing, a toxic chemical has been substituted with eco-friendly enzymes. Enzymatic discharge printing involves contacting a dyed fabric substrate with a phenol oxidizing enzyme system including an enhancing ingredient under conditions, which caused the dye to be selectively discharged and removed from the cloth in certain regions, resulting in a printed surface.[62]

Coloured cotton textiles were printed with a sodium alginate-based printing paste in the presence of an oxidative enzyme, then dried at different temperatures. Enzymes have been shown to improve the discharge impact on coloured cotton fibres. [73] This highlights shows the effectiveness of using enzymes to make textile surface patterning.[73]

Enzyme working are based on lock and key theory, in which the enzyme creates a complex with the substrate. After the reaction, the enzyme is freed from the complex and operates on a different substrate surface. In the case of textiles and other insoluble substrates, the enzyme is absorbed by the substance before the complex is formed. [10]

Summary

Textile printing is an ancient art form that has been practiced for thousands of years. It is one of the most varied and important techniques of adding colours and patterns to textile fabrics using different styles such as (1) Block printing, this technology is used to create a wide range of items, notably in the clothing industry. (2) Direct screen printing, (which is classified as flat and rotary screen printing) Screen printing is an evolution of the stenciling method, in which a colour image is generated by transferring colour to a textile surface. (3) Burn-out printing, uses a paste containing chemicals capable of destroying one of the fibre components of blended material. (4) Digital printing, printing is capable of reproducing an endless number of colours and hues. In direct printing (which is classified to resist and discharge printing) A harmful chemical such as (reducing and oxidizing formaldehyde compounds) has been replaced with eco-friendly enzymes in textile discharge printing. Plant chemicals are also used as enzymes in textile printing techniques. For example, the extraction and properties of polyphenol oxidase enzyme from apricot, apple, eggplant, banana peel, and potato. The process of connecting a coloured cloth substrate with oxidizing enzyme system is known as enzymatic discharge printing. The procedure allows the dye to be released from the fabric selectively in specified areas, resulting in a printed surface. This highlight demonstrates the effectiveness of employing enzymes to create textile surface patterning.

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