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9. Digital Printing of Textiles

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Abstract:

In this fast-moving fashion and consumerism era, the trend of novelty in everything and every day takes us to faster production technologies. Digital printing is one area where the application fields range from textiles, paper and ceramics. Digital printing on textiles is a profitable and cost-effective method along with advantages like high quality, more color possibilities, high resolution and faster production rate. With all these advantages, it can be helpful in many areas like interior design and fashion.

The use of digital printing on other substrates like paper and graphic printing has been in practice for a long time, but textiles and carpets are newly added objects to the list. This chapter deals with the most recent advancements in inkjet printing and the use of various technologies. It also covers the pretreatment and post-treatment of fabrics for digital printing.

Keywords: *Digital printing, Ink jet Technology, Pretreatment, Post treatment.*

9.1 Introduction:

The textile printing market is facing many challenges due to rapid changing fashion trends. The purchasing power of people has increased and population growths as well as fast moving fashion have acted as key drivers for growth in the market. Digital printing is a method of transferring colored ink onto the fabric using bitmap images or computer-generated patterns with special advantages of infinite pattern length and infinite color combinations.

Electrical signals are used for this transfer on to the fabric. Rapid and economic production of smaller lots of fabrics can be achieved. Since there is no screen making procedure like in traditional printing, one of the numerous advantages is the time savings. Another benefit of this method is its high resolution.[1]

Due to the expensive cost of the digital printing machine and the inadequate quality of the print “in the early days of the digital printing machine's introduction into the market

[1] Kwon, K.-S., Rahman, Md. K., Phung, T. H., Hoath, S., Jeong, S., & Kim, J. S. (2020). Review of digital printing technologies for electronic materials. Flexible and Printed Electronics. https://doi.org/10.1088/2058-8585/abc8ca

economical fabric production was an issue". Lots of development has been made recently, and this technology has been the center of attention.[2]

Digital printing also known as Ink jet printing is a proven technology with paper, but using it on textiles has many challenges. The main challenge in replicating ink jet printing on textiles is the durability of printing. A fabric undergoes a washing process, and print has to be long-lasting. Another task is the width of the machine required for fabric printing. Heavy width machines in the range of 1 m to 1.5 m are costly and the selection of ink to make dyes, which will repeat exactly, is another problem encountered. Ink jet printing cartridges have only four colors, CMYK: Cyan, Magenta, Yellow and Black. Hence with all these barriers, the process became expensive, and people used it for sampling purposes, and the scenario changed later. The textile printing industry is evolving quickly. Globalization, quick responses from customers and ecological considerations aimed at reducing waste and environmental contamination place heavy demands on the various printing system parts.[3]

9.2 Definition of Digital Printing:

The "process of printing textiles and clothing with colorants using inkjet technology is known as digital textile printing. As an alternative to screen printed materials, this technology enables the manufacture of single items, mid- to small-run cycles, and even long runs."[4]

9.3 Difference Between Analog and Digital Printing:

The traditional printing process might be considered as analog. Block making, roller making, screen making, color preparation, and hand tracing all need time, whether these are performed manually or automatically. Unless the consumer's order is huge, customization is complex.

In the case of digital printing, it enables speedy delivery, low-cost small runs, unique and distinctive designs, and customized textiles. It helps in the textile industry's "green" image.

The dyes are provided by the dye maker in color cartridges and are immediately used after being connected to the printer. Comparatively speaking, ink jet printing uses less energy and less water than traditional printing.

The lengthy and expensive process of producing screens can be avoided by the user. It is also easier and takes less time to go from one color scheme to another and from one design to another.While digital printing only takes around 2.5 weeks to deliver the finished printed products, conventional printing takes 6-7 weeks. Digital printing is utilized for mass-

[2] Digital printing of textiles. (n.d.). Moam.Info. Retrieved June 29, 2022, from https://moam.info/digital-printing-of-textiles_5a26864e1723ddc56ff74d4e.html
[3] Introduction to Digital Textile Printing Retrieved June 29, 2022, from https://archive.nptel.ac.in/courses/116/102/116102052/
[4] Digital Textile Printing Definition, Noga Chen Retrieved June 29, 2022, from https://www.kornit.com/blog/glossary-item/digital-textile-printing/

customization, short-run, and personalized garment samples. Design is developed as a computer-based digital file. Computer and Ink jet printer are connected. The digital design data to analogue image conversion happens using dots or pixels. Thus, the technique is clear and concise. Spot colors, which are generated by combining two or three different colors ahead of printing, are the colors used in traditional printing. Process colors are the inks used in inkjet printing. During printing, the desired shade is created on the fabric. It is accomplished by superimposing dots that are primarily Cyan, Magenta, Yellow, and Black (CMYK).[5],[6]

9.4 Important Steps of Digital Printing:

Digital Printing Involves Four Crucial Steps:

a. Selection of design
b. Scanning design onto the computer
c. printer setting using software to transfer design data to an inkjet printer
d. Fabric preparation
e. Surface printing (Non-contact printing)
f. Dye fixing or Curing
g. Final washing.[7]

The principle of digital printing is non-impact printing (NIP). Plate less printing is the other name for non-impact printing technology. Other advantages include the machine's quiet operation and little maintenance.

Ink jet printing is a method of printing that does not utilize a printing master and relies solely on ink drops to reach the substrate. As a result, it's referred to as a "non-impact" printing method.[8]

9.4.1 Essential Equipment for Printing[9]:

- A computer,
- Software
- Digital printer and
- Textile substrate

9.5 Inkjet Technologies: Principle and Process

[5] Holme, I. (2006). Digital ink jet printing of textiles. Colourage. 53. 103-109.
[6] John Scrimshaw, International Dyer, July 2006, 13.
[7] Digital Textile Printing Process Retrieved June 29, 2022, from https://www.onlineclothingstudy.com/2011/06/digital-textile-printing.html
[8] Yilmaz, S., & Cavus, G. (2018). Digital Printing Applications in Textile and Printing Industry of Turkiye. International Journal of Engineering and Applied Sciences (IJEAS), 5(12).
[9] Leano, Maria. (2006). Specialised equipment for digital printing. 14. 32-35.

"In digital inkjet printing, print heads with banks of tiny nozzles fire fine droplets of distinct colored inks—typically between 50 and 60 microns in diameter—on to a pre-treated fabric that serves as the substrate. Digitally produced ink droplets are combined on the fabric surface to create the final color, or process color, for the print design." The print head responds to "high frequency digital electronic impulses" to regulate the placement of tiny droplets of ink onto the printing substrate from a nozzle. The underlying mechanism involves continuous feeding, breaking the jet into droplets and this information are passed through transducers. The droplets can have different colors to create photo quality images. To create droplets of ink, a specific amount of pressure must be applied to the liquid ink in its reservoir as it flows into the printing nozzles.[10],[11]

9.5.1 Parts of Inkjet:

A. Computer System with Software:

A colorful design with numerous colors must be separated based on the color i.e. CYMK. This operation can be compared to the number of rollers used in rotary printing. The separation of colors is done by software, which understands the cooler, divides it into areas, and calculates the percentage of each color. The software also decides the position of each color to be dropped. There is no mixing of colors in this process; every color is a separate entity and directed to a certain point where we see the final image.

B. Print Head:

A print head has nozzles where the required amount of color would be present and with the help of signals, the drop size is controlled. The print head is the heart of the machine, which responds to every signal that comes and it decides the speed of printing. In the fabric printing, since the width of fabric is too high (approximately 1 m to 1.5 m) the printing head has to move quite a lot from one side to another side.

If the surface of fabric is not smooth due to protruding hairs present on the surface, the life of print head will get affected. The drop size falls into such a small area that the human eye will not be able to resolve and the large number of drops fall into a smaller area which produces a fine print with better resolution. Controlling this pixel density would lead to the production of millions of shades.[12]

C. Selection of Ink:

[10] Digital Printing: Creating New Trends in Textile Printing Retrieved June 29, 2022, from https://www.fibre2fashion.com/industry-article/1908/digital-printing-creating-new-trends-in-textile-printing,

[11] Tyler,D.J., (2011). Digital printing technology for textiles and apparel. In Tyler,D.J. Computer Technology for Textiles and Apparel (pp. 259-282). Cambridge: Woodhead Publishing Series in Textiles.

[12] Ibid 3

The ink or the dye has to meet all the requirements of being standard in their spectral characteristics. Any slight change in the auxochrome of the dye will give a different color. There are many textile dye manufacturers for conventional printing but not many ink manufacturers for digital printing.

New requirements are placed on the colorants and formulas employed by digital printing methods. High viscosity pastes are used to apply color in screen printing. Ink compositions for inkjet printing must be extremely thin, and any colors or dyes used must have minuscule particle sizes because larger ones will obstruct the jets.

Therefore, only smooth ink flow can be ensured if the average ink particle size is much smaller than the nozzle orifices. In addition, the stability of ink formulations depends on the choice of an auxiliary system. Various types of fibres are available, and each type of fibre can be dyed with a particular class of dyes. Various agents, including washing, rubbing, chlorinated water (swimming), light, perspiration, etc. are applied to textile material while it is in use. Compared to paper, the fastness requirements for textiles are stricter. Adhesive forces are insufficient to provide printed textiles with the requisite fastness qualities. The interactive forces between the dye and the fibre are necessary to hold the ink (dye, pigment).

Depending on the fibre and dye class type, there will be different interaction forces.

Type of dye	Type of fibre	Type of bond
Reactive dye	Cellulose	Covalent bond
Acid dye	Silk	Electrostatic force
Disperse dye	Polyester	H bonding, entrapment in compact fibre structure

Textile materials are often highly porous and textured surfaces. They are stretchable and flexible also. Because of the porosity of textile materials, it is absorbent and requires a greater volume of ink than textiles. The loose fibres on the fabric will lead to clogging of nozzles. Hence a good pre-treatment of material is necessary.[13],[14]

9.6 Types of Inks:

[13] Essential Elements for Inkjet printing Retrieved June 29, 2022, from https://www.slideshare.net/nega2002/4-essential-elements-for-inkjet-printing-8603289
[14] The future of textile printing will be digital Retrieved June 29, 2022, from https://www.imaging.org/site/PDFS/Papers/2001/DPP-0-252/4749.pdf

"A higher clarity image is produced when water-based inks are utilized in an inkjet printer. A drop of solvent-based ink is made up of 65 percent a polar solvents and 35 percent pigment. On the other hand, a drop of water-based ink is made up of 33 percent pigment, 33 percent water, and 33 percent non-toxic, water-soluble polar solvents. The benefit is attained while printing."

9.6.1 Oil-Based /Solvent-Based Ink:

"The drop is resting on the substrate's surface and a polar solvent is only partially absorbed by the substrate's porosity. The residual solvent, which is insoluble in water, is left on top. The drop expands and spreads its pigment over a broader area than its nominal size as a result of the solvent's low surface tension, overlapping with neighboring areas."

9.6.2 Water Based Inks:

"When the drop rests on the substrate's surface, the water is instantly absorbed due to the surface's capillary structure. Due to the substrate's remaining humidity (4.5%), the water-soluble polar solvents are swiftly absorbed by the capillary structure of the surface. The pigment does not bleed into adjacent regions and remains where the print head left it."

9.6.3 Advantages of Water Based Inks:

"Water-based inks produce images with more excellent resolution, chromatic contrast, and color purity. A greater synchronization between the design phase and the production phase is guaranteed by water-based inks. With high ink density products and covering surfaces, water-based inks perform better."[15]

9.7 Continuous Ink Jet (CIJ):

A. [16]Binary System:

In the case of continuous inkjet which is basically designed for textiles, the jet is continuously being generated and it falls wherever it is supposed to fall and doesn't fall wherever it is not supposed to. Piezo electric crystals can be used as a displacement tool by providing suitable voltages. In this method the uncharged droplets will be unaffected by the deflection plates which carry a charge opposite that of the charging plates. The deflected drops then strike the substrate to form the image.

[15] Why water based inks provide higher definition printing than solvent based inks? (n.d.). Z&S - Ceramco. Retrieved June 29, 2022, from https://www.zschimmer-schwarz-ceramco.it/en/zs-lab/how-to/why-water-based-inks-provide-higher-definition-printing-than-solvent-based-inks

[16] David J Tyler (2005): Textile Digital Printing Technology, Textile Progress, 37:4,1-65

Drops carrying a charge are deflected to a gutter by the deflection plates for recycle. the jet velocity and the frequency of the excitation determine the droplet size, which can be controlled to very high accuracy.

B. CIJ Multi-Deflection:

In addition to binary textile printing has also been done with the multi-deflection continuous inkjet. The dye drops are given a variable charge in this system, as opposed to the binary system, which results in various deflections as the drops move through the deflection plates.

This enables up to 30 different spots on the substrate to be printed with a single jet. This technique was used in industrial marketing printers and formed the basis of t-shirt printers.

C. CIJ Pulsating System:

In this case, there is a pulsating system, which produces high frequency and large number of drops at very high speed, but droplets come in batches. It was called as Hertz Technology. Very small drops (of the order of 3 Pico liter) generated at speeds of about 40 m/s at excitation frequencies of over 1 Mhz.

D. CIJ Thermal Excitation Type:

The annular heater around the nozzle and heated in a pulse, so the viscosity falls down. Piezoelectric pump will give pulsed inputs for jetting It controls the viscosity of ink near the nozzle and is supported by drop deflection system. As the pulse is periodic and the jet velocity is constant, jet breaks into equal sized drops.

In the case of CIJ, the drop generation is simple and trajectory manipulation is complex. Because of the complexities associated with CIJ (charge and deflection, ink recirculation, pressurization) such print heads tend to be costly. The nozzles are actively replenished by positive pressure.

9.8 Drop on Demand:

Whenever a drop is needed, a drop is generated otherwise the drop is not generated. Piezoelectric transducers are used as displacement tool by impressing suitable voltages for generating the ink drop in Drop on Demand process. The transducer could be attached to a membrane that forms the ink chamber wall or this itself can act as a wall.

When an electric field is applied, chamber volume is proportionally reduced and ink drop is ejected. The impulse or drop on demand inkjet is a system of fundamental simplicity. This technology, as the name suggests produces an ink droplet when required and fires this on to the substrate.

Two things set it apart from continuous inkjet systems:

a. Since the ink droplets that produce the image are not charged, there is no need for a deflection mechanism.
b. Typically, electrical signals are employed to regulate when a specific droplet is required.

In Drop on Demand, the drop generation is complex and critical as there is no trajectory manipulation. The operating frequencies of these devices are at least an order of magnitude lesser than those used in CIJ systems.

Following are the types of DOD printers used:

- Bubble jet/ thermal jet
- Piezoelectric
- Valve-jet
- Electrostatic ink jet

A. Bubble Jet:

This kind makes up the majority of DOD printers currently in use. The printer with this technique relies on a thermal pulse to produce the ink drop. An ink drop is really ejected from the nozzle when a computer signal heats a resister to a high temperature and causes a vapour bubble to form in a volatile component of the printing ink. The ink chamber must then be refilled from a reservoir after the vapour bubble has had time to cool and collapse. The maximum cycle speed is 10,000 drops per second, and the volume of ink in each drop is between 150 and 200 picolitres. Ink output from a single thermal inkjet is therefore roughly 0.1ml per minute. The high rate of nozzle failure with thermal inkjet is its main flaw. The breakdown of ink components on the resister brought on by the high temperature (>3500C) needed for rapid drop ejection results in poor heat transmission and/or nozzle blockage. Another serious issue is the failure of the resistor as a result of rapid heat cycling. The low cost of nozzle manufacture is the primary benefit of thermal inkjet/bubble jet technology. As a result, thermal inkjets provide cheap cost print heads but struggle with speed and dependability.

B. Piezoelectric:

The piezo inkjet uses a piezoelectric transducer to eject the ink droplets. These transducers may take a variety of shapes, but they all operate on the same principle: they expand and contract under the applied voltage when a changing voltage is put across them. A computer uses an electrical potential across a piezoelectric material in a standard piezoelectric printer, which produces a contraction in the direction of the electric field and an expansion in the perpendicular direction.

When the potential is removed, the piezoelectric returns to its original dimensions, and capillary action fills the ink chamber with ink from an ink reservoir. The ink replenishment rate limits the cycle duration of piezo-based printers, which can be slightly faster (14,000

cycles per second) than thermal inkjet printers but produce smaller drop volumes (as low as a few picolitres). Piezo-based printers may generate prints with an extremely high resolution due to the small drop size (2880 Dpi is commercially available).

Additionally, these printers have a far longer print head life than a thermal-based system. The micro jet technology is an advancement of the piezoelectric inkjet in which ink droplets are ejected by the vibrating walls of the inkjet channels made of piezo ceramic.

High precision and the potential to construct large nozzle arrays economically are advantages. Additionally, piezo-type devices are appropriate for hot melt or phase change inks in many non-textile applications and aqueous and solvent-based inks.

C. Valve Jet:

This includes the usage of valves, as the name would imply. It employs solenoid valves to regulate the ink flow in the air stream that transfers the droplets to the substrate. Since the resolution is only 25Psi, fabric printing is not advised. However, these devices have been employed in some places.

9.9 Recent Developments in Ink Jet Printing:

Make → Features↓	Reggiani DReAM	Monna Lisa	Dupont Artistri 2020	Colorwings Texjet 254	Mimaki TX3-1600	Leggett and Platt Digital Technologies
Print heads	scitex Aprion	Epson print heads	piezo print head		Piezo DoD	Spectra S class
Ink	Cibacron RAC reactive dye	Reactive and acid dye inks developed by Epson	Acid, disperse, reactive, and pigment inks.	Acid, disperse, reactive, and pigment inks.	Acid, disperse, reactive, and pigment inks	UV curable ink for polyester
Width	1.6 m				1.6 m	2.5 m
Prodn capacity	150 m^2 /h	28 m^2/h To 78 m^2 /h	30-50 m^2 /h	50 m^2/h		125 m^2/h
Dots per inch (Dpi)	600	360-720Dpi			360-720Dpi	

9.9.1 Developments in Ink:

New inkjet inks are being created for the textile market to suit the growing demand. Bafixan disperse dye inks, Helizarin pigment inks, and a novel pretreatment method, Luprejet HD, have all been introduced by BASF. For cellulose fabrics, Ciba Specialty Chemicals has developed a line of reactive inks called Cibacron RAC, which react chemically with the fibres to provide vibrant colors and good application performance. Inks for different fibres are also being developed, such as dispersion inks for polyester, pigmented inks for home furnishings made of all fibres, and acid inks for high fashion and sportswear textiles made of silk and polyamide/Lycra blends. These advanced inks must have the proper consistency to move quickly through the heads and dry on the fabric.

Additionally, Ciba Specialty Chemicals has created a unique chemical mix for fabric preparation appropriate for Cibacron RAC inks. Customers can purchase a complete integrated ink jet textile printing solution from the system, which consists of the inks, the preparation recipe, and the printer with its specific printing heads.

9.9.2 Fabric Pre-Treatment for Ink-Jet Printing:

For inkjet printing, a very efficient pre-treatment is required. Fabric must be singed to get rid of surface hairs that can reduce the quality of fabric printing and to reduce the chance that surface fibres would touch the print head and clog the nozzles, leading to defects. Desizing, Scouring, and Bleaching are necessary to get rid of impurities and produce a cloth with consistent whiteness and absorbency. Fabric mercerization can be used to increase the perceived color depth of the print because the color depth that can be achieved with inkjet printing is a significant limiting factor.

The fabric pre-treatment method will change depending on the inks' dye content. The pad liquid used to print reactive dyes on cellulosic fabrics may contain alginates to limit penetration, urea to deepen color, and alkali, which is necessary to create a covalent link between the dye and the fibre.

9.9.3 Pretreatment of Fabric for Digital Printing[17]:

The pretreatment of fabric is an important step because it determines the sharpness of print and it helps in preventing the spilling of dye beyond the design outline. The ink application on the fabric should be in such a way that it should stay within the boundaries of the design limit; otherwise, the ink will spread out in an uneven fashion covering a larger area. As a result, a fuzzy image with low color intensity will be obtained.

Contrary to conventional printing, printing chemicals and auxiliary materials cannot be mixed with ink. Padding is used to apply this auxiliary to the fabric. Such pre-treatments aid in maximizing the textile substrate's capacity for ink absorption and reaction. Pre-

[17] Fabric pretreatment for digital printing Retrieved June 29, 2022, from https://patents.google.com/patent/WO2015094564A1/en

treatment chemicals can be as basic as soda ash, alginate, and urea, or they can be as complex as cationic agents, softeners, polymers, and inorganic particles like fumed silica. Many of them were directed towards clothing materials like cotton, silk, nylon, and wool.[18]

A pre-treatment auxiliary (thickening agent) is applied on all types of substrates to get sharp prints on fabric. This thickener can be applied on wool, cotton, silk, polyester, viscose and nylon. There are different types of thickeners available in the market. Some thickeners are specific to a particular fiber, but few thickeners can be applied to any fabric. Mainly padding process is employed for the thickener application onto the fabric.

Characteristics of The Thickening Agents Used on All Substrates:

- It should be a high molecular weight product that locally increases the viscosity.
- It should prevent the spreading of prints.
- It must deliver level prints with sharp outlines and improved color value. It should have a film-forming and adhesion property.
- It should possess consistent viscosity.
- No mildew attack should happen.
- Feel of the fabric should remain unaltered.

9.10 Fixation of Prints[19]:

The digitally printed fabric's fixation and development are crucial. The requirements of the retailers and consumers point of view of wash fastness, rubbing fastness, and light fastness cannot be met unless the prints are appropriately fixed on to the fabric. Depending on the dyes used in ink formulations, it makes sense to apply the same fixing technique that has been successfully used in conventional printing techniques like curing and chemical padding.

Process→ Fabric ↓	Padding	Printing	Washing
Polyester	Padding with thickener and drying	Ink-jet with disperse ink Steaming:170-180 ^{0}C for 6-8 min. or Thermofix: 180-190 ^{0}C, 1-2 min. or Calendaring: 200-210 ^{0}C, 30 sec.	Cold wash: 5 mins. Reduction clearing: at pH 4.5-5.0 at 60-70^{0}C for 10 mins.

[18] Ibid. 13
[19] Ibid. 10

Process→ Fabric ↓	Padding	Printing	Washing
Cotton/viscose	Padding with thickener along with urea and soda ash and drying	Ink-Jet with Reactive ink Steaming: 102-105 ^{0}C, 7-10 min. or Thermofix: 140-150 ^{0}C, 3-5 min.	Cold wash: 5 mins. Soaping at 98 ^{0}C, for 5 mins. Hot wash: 3 mins at boil. Cold wash: 5 mins.
Silk/wool/ Polyamide	Padding with thickener along with urea and ammonium sulphate and drying	Printing: Ink-Jet with Acid ink Steaming: 102-105 ^{0}C for 30-40 mins.	Cold wash: 5 mins. Polyamide / Wool needs an extra fixation step with fixing chemical at pH 4.5-5.5 at 70-80^{0}C for 15-20 min.

9.11 Conclusion:

The ability to satisfy mass customization market trends today is made possible by digital printing. It has become a recognised technology for producing samples and long runs. Comparatively lesser printing speed with respect to conventional rotary printing, is one of the biggest barriers which is also overcoming currently with the introduction of new machines.

9.12 References:

1. Kwon, K.-S., Rahman, Md. K., Phung, T. H., Hoath, S., Jeong, S., & Kim, J. S. (2020). Review of digital printing technologies for electronic materials. Flexible and Printed Electronics. https://doi.org/10.1088/2058-8585/abc8ca
2. Digital printing of textiles. (n.d.). Moam.Info. Retrieved June 29, 2022, from https://moam.info/digital-printing-of-textiles_5a26864e1723ddc56ff74d4e.html
3. Introduction to Digital Textile Printing Retrieved June 29, 2022, from https://archive.nptel.ac.in/courses/116/102/116102052/
4. Digital Textile Printing Process Retrieved June 29, 2022, from https://www.onlineclothingstudy.com/2011/06/digital-textile-printing.html
5. Yilmaz, S., & Cavus, G. (2018). Digital Printing Applications in Textile and Printing Industry of Turkiye. International Journal of Engineering and Applied Sciences (IJEAS), 5(12).
6. Leano, Maria. (2006). Specialized equipment for digital printing. 14. 32-35.
7. Digital Printing: Creating New Trends in Textile Printing Retrieved June 29, 2022, from https://www.fibre2fashion.com/industry-article/1908/digital-printing-creating-new-trends-in-textile-printing,

8. Tyler, D.J., (2011). Digital printing technology for textiles and apparel. In Tyler, D.J. Computer Technology for Textiles and Apparel (pp. 259-282). Cambridge: Wood head Publishing Series in Textiles.
9. Essential Elements for Inkjet printing Retrieved June 29, 2022, from https://www.slideshare.net/nega2002/4-essential-elements-for-inkjet-printing-8603289
10. The future of textile printing will be digital Retrieved June 29, 2022, from https://www.imaging.org/site/PDFS/Papers/2001/DPP-0-252/4749.pdf
11. Why water based inks provide higher definition printing than solvent based inks? (n.d.). Z&S - Ceramco. Retrieved June 29, 2022, from https://www.zschimmer-schwarz-ceramco.it/en/zs-lab/how-to/why-water-based-inks-provide-higher-definition-printing-than-solvent-based-inks
12. David J Tyler (2005): Textile Digital Printing Technology, Textile Progress, 37:4,1-65
13. Fabric pretreatment for digital printing Retrieved June 29, 2022, from https://patents.google.com/patent/WO2015094564A1/en