

IMPACT OF DIGITAL TECHNOLOGY ON PRINTED TEXTILE DESIGN PROCESS

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Abstract: The use of digital tools - software and hardware, has changed both the approach to traditional printing processes and the way of thinking about the production, application and storage of printed textiles. From design studios, through factories, to the market, changes are taking place in the design, production and use of printed textiles. The radical upheaval in the technological sphere and its influence on the design methodology was analyzed through examples from the literature and through direct experience in working with students at the Academy of Technical and Artistic Vocational Studies in Belgrade, during classes on the courses Design of Printed Textiles and Digital Design of Textiles and Clothing. This paper explores the impact of digital tools on traditional processes, design approaches, production methods, market trends, aesthetics and artistry shift in printed textile design. Furthermore, potential challenges and limitations associated with using digital technology in this field will be discussed.

Key words: Textile design, Digital technologies, Digital printing on textiles

1. INTRODUCTION

The share of digital printing in the global market of printed textiles is less than 10%, while rotary screen printing still prevails. The global market for digitally printed textiles in 2022 is 2669.9 million dollars, but is expected to grow by 14.4% in the period from 2023 to 2030. Digitally printed textiles are used in clothing, special purpose clothing (sportswear), protective and advertising textiles on buildings and vehicles (advertising industry), ambient textiles. The rapid growth of this industry can be attributed to the rapid changes in the field of fashion trends and the need for manufacturers to quickly adapt to them in order to remain relevant in the market. Textile materials show versatility in the field of application in the exterior and interior, so they have an increasing share in the field of advertising and interior design.

The reason for the rapid and stable growth of digital printing technology on textiles is also in greater flexibility compared to screen printing in terms of preparation, artistic elements and technical requirements that are placed before designers. Designers opt for digital printing in the case of smaller series and unique, exclusive collections and sportswear.

Digital textile printing is superior in terms of sustainability as it uses significantly less water and energy. During rotary screen printing, 50 to 60 liters of water are consumed per long meter. while digital printing consumes 14 to 20 liters, almost 70% less. [1]

2. TECHNOLOGICAL INNOVATIONS AS CATALYSTS OF CHANGE IN METHODOLOGY OF DESIGN PROCESS

With a cursory glance at the history of the technological development of printing on textiles, it is possible to see changes in patterns and areas of application of printed textiles. Block printing is responsible for the designs that were created by repeating blocks - stamps that fit both the length and width of the fabric. Rotary printing enabled continuous printing along the length of the fabric, which contributed to the organization of artistic elements into a repeat - a unit of printing that is endlessly repeated and fits in such a way as to ensure a continuous repetitive composition. Bulk printing became an integral part of the fashion system and clothing collections were conceived according to repetitive designs that were aligned with fashion trends, usually twice a year. Starting the production of a single pattern with rotary screen printing is an expensive and time-consuming process that is profitable in proportion to the amount of printed material. Apart from the construction of the composition of

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elements in a continuous pattern, which is a consequence of rotary printing (initially with wooden and copper rollers and later with rotary screens), the artistic design itself is closely related to the technical possibilities of printing technology. Printing with copper plates and later with rollers, gives the possibility to print thin lines, much thinner than printing with wooden stamps. Screen printing with reproduction photography gives the possibility of printing rasterized surfaces and thus fine tonal transitions with the use of one-color tone. Each color requires a special template for all printing techniques - stamps, copper rollers, screen printing. Digital printing provides the possibility of continuous printing without repeating units with the reproduction of artistic elements - lines, points, surfaces, a multitude of colors and their value values. In addition, digital printing does not require complex technical preparation or the process of separating colors and making templates for each color that participates in the design.

Technological innovations in printed textiles significantly changed the work methodology of designers - starting from competencies, technical-technological requirements, and organization of work to artistic and aesthetic characteristics of clothing fabric patterns and fashion collections. The work and competences of designers have changed with the development of technology - from a craftsman who was in direct contact with the material during production, through a highly trained professional who projects new designs in collaboration with engineers, to a closer contact with the finished product again through digital printing.

2.1. From screen printing to digital textile printing

Traditionally, textile designers relied heavily on manual processes such as screen printing or block printing to create intricate patterns on fabrics. These methods required a manual labor and are time-consuming, also often limited designers' ability to experiment with new ideas due to time constraints and technical limitations. However, with the introduction of digital technology, designers now have access to advanced software programs that allow them to create intricate designs more efficiently.

Digital tools have changed the approach to printing processes in textile design by offering new possibilities in terms of precision and complexity. Designers can now manipulate colors, shapes, and textures digitally before sending their designs for production. This shift towards digitalization has made designers more involved in the production process as they can visualize how their designs will appear on textiles before finalizing them. Among students at the course of printed textile design at ATUSS, there is large prevalence of those who incline towards usage of digital tools in each segment of design process. Conceptualisation at the beginning of the process is seldom digitalised (about 7% of students do first sketches in Procreate or Photoshop), at later stages of finalisation of pattern the percent is much larger (about 85%), in prepress for screen printing all students use digital tools (100%).

Screen printing still has the largest share in the market of printed textiles, however, as can be seen throughout the history of printing technology, the introduction of new technologies begins with the parallel existence of new and widely applied technologies.

Screen printing is still the most economical when dealing with large quantities of material, because the cost of preparing a new pattern is very expensive. The preparation of a new design involves the creation of printing forms for each color value, then setting up and adjusting the position of the rollers and preparing the colors. Each of these operations requires skilled personnel and factory space for both production and storage of both printed materials and printing forms. Each color change in the pattern requires washing the printing forms and re-adjusting the machines. These requirements also determine the minimum amount of printed textiles that is profitable for production. Designs produced in this way must also be versatile in order to have the widest possible application within the fashion industry, which is also a significant factor. The fashion industry is more and more oriented towards solutions that would ensure faster changes of fashion collections, which is why printed fabrics that can satisfy quick changes and smaller quantities and still be profitable from an economic aspect are sought after. Rotary screen printing is not flexible with regard to the rapid changes and smaller series that today's fashion industry introduces through the possibilities provided by digital printing. Digital printing does not become cost effective with higher production. The price of smaller and larger quantities remains the same because the preparation costs are significantly lower and less time-consuming.

Table 1. Comparison of printing techniques of screen printing and digital printing on textiles from the aspect of design

	Rotary screen printing	Digital printing on textiles (ink-jet)
Design composition	Limited repeat format (smallest repeating unit), repeating system. The necessary fitting of artistic elements in order to ensure the continuity of the composition.	The image is prepared using computer programs or obtained by scanning. There is no need to construct a repeat. The format is limited only by the memory of the computer and printer.
Image preparation	Color separation. Preparation of films for screen exposing (with painting tools, reproduction photography or using computer programs)	Adjust contrast, color intensity (no need for color separation)
Color range	Maximum 16 colors. Each color requires a separate template. It is possible to get more colors by planned overlapping. Requires skill in processing, especially when dealing with gradients (value and tone)	It is possible to achieve thousands of colors depending on the type of printer. The image is based on gradients.
Pattern variations	Through the created printing form, it is possible to print different color combinations	Image alterations are possible in each segment
Design methodology	The designer designs the pattern according to strict technical and technological parameters, participates in the process of preparation for printing, separating colors and creating color solutions. Technicians involved in the design process are also involved in the preparation for printing. The designer is not in direct contact with the production process and alterations during printing are minimal or non-existent.	The designer freely designs the pattern and creates using computer programs. The image that is visible on the screen in this process is very similar to the image that will be printed on the textile material. Printing samples allows for changes during the printing process itself. The designer is in direct contact with the production.
Textile materials on which it is possible to print	Almost all textile materials including yarn printing.	Limited and depend on the machine used.
Colors that can be used	Very wide application in terms of colors, which also includes special effects – texturizing ink, reflective ink, various textures, glitters, fluorescent colors, metallic colors, devores, flock...	The application of different inks depends on the printer and the print head. Special effects are very limited and currently it is not possible to print with glitter, flock or texturizing paste.
Print speed	Fast	Slow
The price	High but variable due to the high cost of preparation for printing and setting up a new pattern. With a larger amount of printed material, the cost of printing per square meter decreases.	Static because there are no special preparation costs for printing. The price therefore remains the same regardless of the amount of printed material.
Impact on the environment	Strong solvents are used when cleaning and preparing the equipment, high consumption of water and energy, the equipment takes up a lot of space.	Less water and energy consumption, chemicals are used to prepare textile materials before printing.

2.2. Pattern structure without the repeat

Digital technology has had a profound impact on the aesthetics and artistry of printed textiles. With access to an extensive library of digital patterns, designers can explore various styles and motifs without the limitations imposed by manual techniques. Furthermore, digital tools allow for precise color matching and manipulation, resulting in vibrant prints that accurately translate designers' visions onto fabrics [2]. The ability to visualize designs digitally before production enables designers to make informed decisions about color combinations and scale.

Digital technology challenges traditional notions of repetitive patterns by providing alternative approaches to pattern creation. Rather than relying solely on manually repeating elements across a fabric surface, designers can now employ algorithms or generative design techniques to generate complex non-repetitive patterns [3].

This shift towards exploring non-repetitive patterns adds an element of uniqueness to printed textiles while still maintaining visual coherence throughout the design. Among students of ATUSS who undertake graduate work in the field of printed textile design, in the last 10 years, there is a large prevalence of those who use digital printing in production of the final product. The conceptualisation of the pattern is being done in correlation with the garment cutting pattern without repeat, often presented in digital mock ups used also in the design process.

Technical and technological conditions have always dictated the design parameters of printed textiles. The organization of patterns through the repeat is present through all printing techniques that include rotating, cylindrical printing forms. And the fabric structure itself follows the logic of repetition. Such a long tradition of repetitive patterns is woven into the clothing and fashion industry as well. The size of the motif and the ratio is harmonized with the dimensions of the human body, i.e. furniture, if it is an ambient textile. However, through the development of textile printing technology, during the 20th century, patterns became more complex and constructed with the idea of masking the repetition. In this way, the printed fabric can be rotated in any direction during cutting and sewing, thus reducing waste. Also, for the same purpose, motifs of the maximum size of the repeat (dimensions corresponding to the circumference of the rotary template) are used. The motifs are uniform across the entire surface in terms of art, so their parts fit together properly when sewing clothes. In this way, one garment can consist of only one pattern report. Nevertheless, textile designers still find it difficult to leave the limits of the ratio imposed by the technology of rotary stencil printing. Technical limitations have become a hallmark of the printed textile industry and with the shift to digital printing there is a strong tendency for patterns to retain a repetitive structure. However, the new approach combines the well-known and well-founded structure of repetition, but with the introduction of the newly obtained "freedom" from the dimensions of the repeat through the alteration of the elements, so that at first glance it seems as if the elements are repeated in the usual way, while they are progressively transformed into others shapes or change dimensions and orientation on the surface of the fabric. The repeat slowly, while retaining its artistic aspect, loses its functional inevitability.

2.3. Line colour and texture

The basic characteristic of color treatment in screen printing on textiles is that for each color it is necessary to create a special printing form. Considering that the printing forms are made by a photographic process, it is necessary to make appropriate films that leave certain parts of the surface of the template unexposed - protected from light so that those parts become permeable to paint. The separation of colors and the production of films are also decisive in terms of designing patterns for screen printing. The designer comes up with a pattern by thinking about the number of colors, the thickness of the line and the dot that can be printed with this technique.

The use of computer programs has significantly increased the palette of art elements that can be prepared for screen printing, eliminating the profession of reproduction photographer who was in charge of making such films in the printing industry. Reproduction photography, before the use of computer programs for image rasterization, was the only way to obtain different shades and transitions of the same color using a raster dot or to produce optical color mixing by overlapping raster dots. Digital technology has enabled the wider application of patterns containing photographic elements and tonal transitions in screen printing through software that supports image rasterization as well as color detection and separation.

Digital printing gives the possibility of reproducing thousands of colors with different tonal and shade values without any prior calculation or preparation for printing. This characteristic, in contrast to the compositional conditioning of the repeat, was readily accepted by designers and the market. The first is due to greater freedom in work and the second is due to the speed with which production can respond to the demands of smaller clothing manufacturers and the need for smaller batches. The possibilities of reproducing thinner lines and fine tonal transitions depend only on the material on which it is printed. On the other hand, screen printing is still a technique that allows the use of special media for printing, such as texturizing inks that give a relief surface, reflective inks, discharge emulsions, and the like. Digital printing can still be applied only to certain types of textile materials that need to be pre-prepared by chemicals. Printing on dark fabrics, which is possible in screen printing with opaque colors and color discharge systems, is not yet possible with digital printing.

Digital printing significantly changes the art of contemporary clothing and ambient textiles. Digital images, reproduction of Impressionist and 20th century artworks, photographs, multitude of colors, complex patterns are part of this new art of printed textiles.

3. CHANGES IN DESIGN METHODOLOGY

The integration of digital technology into the printed textile design process has led to significant changes within design studios, factories, and markets alike. In design studios, there is now a seamless transfer of information from designer to manufacturer through digital files rather than physical prototypes or samples. Designers have adapted their approach to printed textile design due to digital technology's integration into the field. With access to a wide range of software tools and virtual platforms for collaboration, designers can now explore their creativity more freely while experimenting with different combinations of patterns, colors, textures, and overall visual appeal. These tools have expanded opportunities for innovation by allowing designers to manipulate elements digitally in ways that were not possible before.

In factories, advancements in digital tools have increased production efficiency by reducing errors during pattern reproduction. Computer-controlled machines can accurately replicate complex patterns at a faster pace compared to traditional hand-printing methods.

Moreover, digitization has also impacted consumer behavior by offering customizable options for printed textiles. With web-based platforms allowing consumers to personalize their fabric prints or choose from a wide range of designs, the market has become more inclusive and responsive to individual preferences.

Lev Manovich recognizes the connection in the work (interoperability) of digital systems as their main characteristic that significantly influences the change of methodology in the work of designers [4]. Due to the interoperability of digital systems, the designer is now in direct contact with the final solution. Not only are trades such as reproduction photographers gone, but any technical staff other than digital printer and laser plotter operators are redundant. The designer creates the pattern using the software, transfers it to a drawing of the garment in vector form, which is ready for laser cutting and printing on the CAD system.

The linearity of the production of fashion products changes considerably with the networking of digital production systems, thus favoring the active consumer who becomes a participant in the process of design and production of clothing items. Digital printing gives the possibility for "print on demand" production so that more and more designers are using websites and applications to advertise "potential" designs for printing among which customers like "curators" choose what will be printed, sewn and delivered to their address. This way of selling designs changes the designer's work methodology. For now, digital printing on textiles is being incorporated into the fashion system in several ways: sampling before larger production through rotary screen printing (prototyping), personalization and customization, and print on demand services and applications.

4. CONCLUSION

New mechanical and chemical technologies, new fibers, printing media, printing techniques, dyes and chemistry for textile finishing, have always been drivers of changes in textile design, both from a visual aspect and a methodological sense. With the emergence of industrial production, there is a need

for a professional - a designer, who should know the technique and technology of the production of textile materials and printing, but also be educated in the field of visual arts. Since then, the methodology of the designer's work has changed several times, but always under the influence of technological innovations.

Digital printing technology is evolving faster than the market and design methodology is adapting to it. Still in the realm of repeat pattern which is strongly associated with the concept that has dominated printed textile design since the industrial revolution, the textile and fashion industry has yet to completely redefine the visual language it uses. Designers now have greater control over pattern creation processes and can experiment with new forms through advanced tools such as 3D printing. The integration of digital tools has also transformed consumer behavior by offering customizable options for fabric prints while improving production efficiency in factories. Additionally, advancements in software programs have enhanced pattern creation processes. This level of control over pattern design not only increases efficiency but also opens up new possibilities for creativity and experimentation

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