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RESEARCH ARTICLE

Innovation and Inheritance Path of Nantong Blue Calico Driven by the Digital Technology

Chen Liu[1], Puvasa Ruangchewin[2*]

[1, 2] Faculty of Fine and Applied Arts, Burapha University, Thailand

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***Corresponding Author:**

puvasa@gmail.com

ABSTRACT

Nantong blue calico is an important traditional craft in Nantong, Jiangsu Province, which has profound cultural connotation and artistic value. With the increasing demand for personalization, environmental protection and fashion in modern society, traditional crafts are facing more and more limitations. This study discusses the application of the digital technology, especially laser engraving and digital design tools, in the process improvement and innovation of blue calico. It aims to improve production efficiency, reduce production costs, and expand its application prospects in the modern market. By analyzing the integration path of traditional crafts and modern digital technologies, the study points out that laser engraving technology significantly improves the accuracy and production efficiency of platemaking, while digital design tools deliver designers with greater creative flexibility. Therefore, traditional patterns and modern elements are combined, in line with the aesthetic and customized needs of contemporary consumers. This study provides a new idea for the modernization transformation and sustainable development of Nantong blue calico, and provides a reference for the digital transformation of other traditional handicrafts.

INTRODUCTION

Nantong blue calico is a representative traditional craft in Nantong, Jiangsu Province. It is famous for its unique blue and white color and the dye-resistant technology. However, with the acceleration of industrialization and modernization, blue calico has been gradually losing its market advantages. The low efficiency of handicraft and the lack of design innovation have greatly reduced its competitiveness in the modern market (Liang and Xi (2008)). At present, consumers' demand for personalization, environmental protection and fashion of products continues to increase, and traditional design modes and production modes can no longer meet these needs, resulting in the gradual reduction of the market share of blue calico.

Therefore, how to promote the inheritance and innovation of blue calico through the combination of modern design tools and digital technologies has become a key issue to be solved urgently. Innovatively, this study aims to explore how digital technology, especially laser engraving and digital design, can be applied to the process improvement and marketing of blue calico. Laser engraving technology has brought a revolutionary improvement to the traditional craft of blue calico by improving the accuracy and production efficiency of platemaking. The application of digital design software gives designers greater creative flexibility, so that traditional patterns can be recreated with modern elements to meet the aesthetic needs and personalized customization needs of consumers. In addition, the introduction of the digital technology further optimizes the production process and reduces costs, which provides new possibilities for the modernization and market expansion of blue calico.

Therefore, this study aims to analyze the integration path of traditional crafts and modern technologies, clearly put forward the specific application scenarios of digital technologies in solving the low efficiency and insufficient design of traditional process, explore its application prospects in the cultural and creative industry, and provide new ideas for the sustainable development of blue calico.

2. BACKGROUND AND LITERATURE REVIEW

2.1 Historical and cultural background of Nantong Blue Calico

Nantong blue calico is a typical representative of traditional handicrafts in Nantong, Jiangsu Province, and has a history of hundreds of years. It is famous for its unique blue and white color and dye-resistant technologies, and is one of the unique cultural heritages of Jiangsu Province. In 2006, Nantong blue calico was included in the National Intangible Cultural Heritage List (Wu et al (2016)), marking its importance as a cultural symbol in the Chinese folk art.

In its development process, blue calico has been a kind of practical daily necessities and decorations, and a cultural carrier bearing the function of expressing emotions and passing blessings. Its pattern design integrates cultural metaphors such as homophony and symbols, which forms a profound cultural connotation (Wu and Wu (2012)). For example, grapes, pomegranates, lotus flowers and other patterns symbolize "many children and happiness" and express the wish for the prosperity of the family. Similarly, auspicious motifs such as "fish leaping over the dragon gate" and "five sub-ka" reflect people's yearning for promotion, wealth, education and official status in the traditional society (Liang and Wang (2009)). These patterns are the embodiment of decorative art, and the materialized expression of the Chinese cultural philosophy. They show the local people's yearning for happiness and a better life.

2.2 Inheritance and market challenges of blue calico

Blue calico has played an important role in the cultural heritage. However, with the acceleration of industrialization and modernization, its inheritance and development has been facing great challenges. Firstly, it is the inefficiency of handicraft. The traditional production process of blue calico is complex, mainly including design pattern, platemaking, dye-resistant treatment, dyeing and other steps. And the production cycle is long and the labor intensity is high. As a result, the production efficiency of hand-made blue calico is far lower than that of modern industrial production (Yin 2020). The low efficiency limits the adaptability of blue calico in the contemporary market, especially to meet the needs of modern fast-paced and efficient production. In terms of the platemaking technology, the engraving process of traditional blue calico is particularly complicated, and craftsmen need to complete the production of stencils by hand engraving. This process requires a lot of time and efforts, and highly relies on the individual skill level of the craftsmen. It results in the difficulties in accuracy and efficiency during production. The limitations of this process make the production of blue calico inefficient and unable to meet the modern market's demand for high quality and rapid production.

Second, it is the lack of design innovation. The traditional patterns of Nantong blue calico are mostly auspicious symbols. Although these symbols have cultural value, they are relatively simple and lack modern design elements, and there is a big gap between them and the aesthetic needs of modern consumers, especially the young generation. At present, consumers pay more attention to the personalization, environmental protection and fashion of products, and the traditional blue calico design is relatively insufficient in this respect.

In addition, the complexity of the process is also an important issue which for the inheritance of blue calico. Due to the long production cycle and high cost, blue calico is difficult to compete with mechanized textile products in the modern production system. Therefore, how to improve production efficiency, reduce production costs, and increase the diversity and modernity of products through innovative design and modern technological means has become the key to promote blue calico to win back the market.

2.3 Application of digital technologies in traditional crafts

In the context of the above inheritance and market challenges, digital technologies are widely recognized as one of the important ways to promote the revival of traditional crafts. The introduction of digital technologies can improve production efficiency, reduce labor costs, and give traditional processes more innovative possibilities, so as to better meet the needs of the modern market (Chen 2018).

Laser engraving is a modern processing technology that uses high-precision laser beams to cut and carve materials, which can greatly improve the fineness and production efficiency of patterns (Du 2014). In the production of blue calico, laser engraving can replace the traditional manual engraving to accurately and quickly complete the production of complex patterns. It can help shorten the process time, and reduce the high dependence of the process on the skill level of the craftsmen. The application of the modern means helps to realize the diversification of blue calico patterns in forms and styles and promote product innovation.

In addition, digital design technologies have also played an important role in the innovation of traditional crafts. Through digital design tools, the traditional patterns of blue calico can be digitally reconstructed, thus bringing more flexibility and creativity to product design. Digital design allows designers to repeatedly modify and combine patterns in the virtual space to meet different product needs. For example, traditional patterns of blue calico can be combined with modern geometric figures to explore new forms of artistic expression, which can attract the interest of young consumer groups.

In addition to laser engraving and digital design, the digital printing technology can print the traditional design of blue calico more accurately on a variety of modern textile materials. It makes it more widely used in home decoration, fashion accessories and other fields (Zhang et al. 2012). The introduction of digital technologies helps to improve the production efficiency and design innovation of blue calico, and enhances its uniqueness in cultural inheritance and further meets the diversified needs of the modern market.

3. Traditional production process and technical limitations of Nantong Blue Calico

3.1 Traditional production process

The production process of Nantong blue calico usually includes the preparation, dyeing and drying of resist paste. The preparation of resist paste is the first step in the process of blue calico. Craftsmen mix raw materials such as soy flour, lime and water to make a thick paste, and evenly apply the paste to the designated area of the cloth through the carved stencil to form the required pattern. The next step is to immerse the cloth in indigo dye extracted from bluegrass, which will stain the parts not covered by the resist paste dark blue. After dyeing, the fabric is taken out and dried in the sun to ensure the durability of the color and the texture of the fabric. As shown in Figure 1, while this series of processes is manual in complexity and time cost, and the process requires high-precision control.

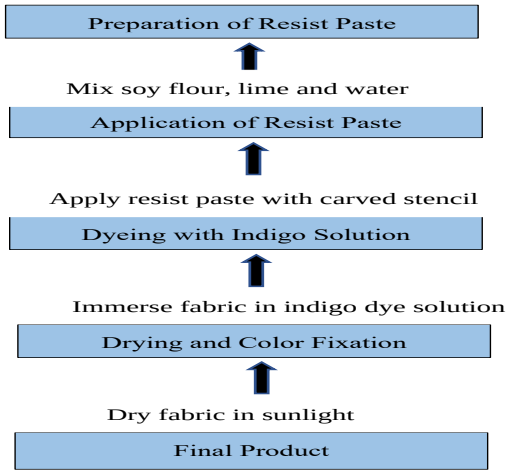

Figure 1: Traditional process flow of Nantong blue calico

3.2 Limitations in the production process of Nantong blue calico

The traditional pattern design of Nantong blue calico is severely restricted by the ancient technological conditions, especially the application of "cutting tool" techniques. When craftsmen carve stencils, they must ensure that the stencils are solid and durable, and they need to take into account the image characteristics of the pattern. This technological condition promotes the formation of unique language characteristics and structure of the blue calico. The point, line and surface are dense and harmonious, the virtual and the solid are combined, and the charm is vivid.

The "cutting method" directly affects the shape of the pattern by breaking the long straight line into short lines or spots (Ni et al. 2022). As shown in Figure 2, the pattern of the flat cutter is more static, while the diagonal cutter is more fluid. However, the process is limited in the precision and complexity of the pattern, especially for complex long lines, the craftsman can only build the overall pattern by breaking it down into multiple short lines. Therefore, patterns are often expressed in simplified forms, and it is difficult to express fine and complex designs.

Previously, the process was reasonable and effective under the technical conditions at the time, because it utilizes limited resources and tools. However, it limits the expression and diversity of the pattern. Although the strokes of the pattern are separated, its inner spirit remains coherent. It reflects the artistic charm of "Biduanqilian" (broken line but linked patterns) and the ingenious conception of traditional crafts. This technique shows the craftsmen's high degree of control over the expression of the pattern under limited technical conditions, and provides the possibility of breaking through the bottleneck of the traditional process for the subsequent application of modern technology, especially laser engraving technology.

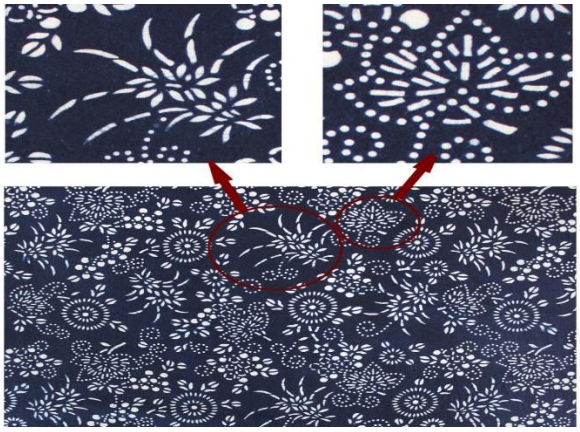

Figure 2: Performance of flat cutter and diagonal cutter in traditional blue calico

4 Application of the digital technology in process improvement

4.1 Application of the digital platemaking technology

In recent years, with the rapid development of the digital technology, great changes have taken place in the field of traditional handicraft. Especially in the production of Nantong blue calico, where the introduction of digital platemaking technology has greatly optimized the production process. Modern laser engraving technology, as the core digital tool, significantly improves the accuracy and efficiency of platemaking. For the traditional manual platemaking, it may take days or even weeks to complete complex pattern engraving. But when the laser engraving technology is used, the process can be completed in a few hours. It improves production efficiency, and ensures the stability of quality. The automated nature of laser engraving eliminates the possibility of human error in the manual production process, especially for blue calico products with complex pattern details, and digital technology ensures the precise presentation of every detail. At the same time, craftsmen no longer need to make tedious manual adjustments, and designers can

easily modify and iterate design schemes through computer software, and preview the effect in real time. Designers can perform multiple simulations on the computer to precisely control the depth of the engraving and the thickness of the lines to ensure the visual consistency of the final product. This technology significantly increases the flexibility of the design process to meet the demands of the contemporary market for customized and complex designs. The application of this technology has helped blue calico enterprises to greatly expand their product lines, from traditional cloth products to high-end home furnishing, art and other fields, and further enhance brand influence and market competitiveness.

4.2 Application of digital design tools

In the aspect of pattern design, the wide application of digital design tools has brought new creative possibilities for Nantong blue calico. Modern design software such as Adobe Photoshop and Illustrator provide designers with rich design tools to help them create and optimize patterns in a more efficient and accurate way. For example, designers can quickly adjust the color, shape and proportion of a pattern in Photoshop, or generate vector graphics through Illustrator to make the design more delicate and flexible (Bao and Liu (2013)). Designers can carry out multiple color matching experiments on traditional patterns through Photoshop, and finally find a color combination that retains the traditional style and meets the preferences of modern consumers, shortening the design development cycle. In addition, the filters and effects capabilities of these tools help designers create innovative visual representations that bring traditional patterns to life.

The modern design method represented by cultural symbol reconstruction has gradually been applied to the design of blue calico. In this way, designers can re-interpret and redesign traditional cultural symbols on the basis of respecting them, so that they retain the original cultural connotation, and meet the aesthetic needs of contemporary consumers (Zhao 2016). Through the reconstruction of cultural symbols, designers re-shape the traditional elements of blue calico, such as lotus flower, fish leaping dragon gate and other symbols, and use digital design tools to carry out multiple iterations of these symbols to achieve modern visual effects. This design method greatly increases the flexibility of pattern design, and provides a new technical support for the creation of blue calico, and promotes the further development of this traditional process in the field of modern design.

5. Design and Digital Innovation of Cultural and Creative Products

5.1 Digital reconstruction design of traditional materials

In the innovative design process of traditional blue calico, the introduction of digital technology has injected new vitality into it. Taking the traditional blue calico pattern as the blueprint for re-creation and expanding the design through modern design techniques such as fragmented composition, gradual change and distributed, it is a new construction of the aesthetic appreciation of the traditional blue calico pattern (Jiang and Jiang (1995)). This reconstruction retains the classic features of traditional patterns, and enables them to meet the diversified needs of the modern market through digital means.

Specifically, the designer digitizes traditional blue calico patterns by using scanners, and then extracts and processes these patterns using design software such as Adobe Photoshop and Illustrator. For example, a pattern or specific element of an area, such as a flower or leaf, is extracted from a scanned pattern, and the design is digitally recombined to create a new pattern that fits the modern aesthetic. This process enriches the design content of blue calico, and greatly improves the efficiency and accuracy of the design process. It enables designers to quickly make multiple modifications and iterations, and finally achieve the dual goals of innovation and marketization.

The introduction of digital technology is a simple imitation of the traditional blue calico pattern, and a re-creation and redesign, which gives the traditional pattern new vitality and visual expression. Through digital design, traditional elements are redefined, and the artistic characteristics of traditional blue calico are preserved and developed, while injecting a sense of modernity and innovation. Figure 3 and Figure 4 show the design cases based on the traditional Nantong blue calico crafts and the culture of the Chinese

zodiac. The themes are "The rat makes you rich" and "The rabbit makes you suddenly rich" respectively. These works combine tradition and modernity through digital technologies, express the meaning of wealth and good luck through homophony, and combine modern buzzwords to make them closer to the aesthetic needs of young consumers.

The specific design steps are as follows: First, the traditional patterns are collected and digitized by computer scanning, as shown in Figure 5. Next, graphic design software is used to extract and filter the desired element patterns. The patterned details are then fine-tuned to ensure a balance between traditional and modern styles. In the design process, combining the traditional "cutting method" technique, through the modern composition of the pattern organization, change and division arrangement, to achieve the perfect integration of traditional technology and modern design. For example, Figures 6 and 7 show the extension of these new designs to modern daily necessities such as desk calendars, bags, and cups. Digital design improves the flexibility of pattern design, and effectively meets the needs of modern consumers for personalized and diversified products, and enhances the market competitiveness of blue calico.

In the future, with the continuous growth of personalized customization market demand, digital design will further promote the innovation and development of blue calico. Consumers' pursuit of unique design and cultural elements makes traditional patterns show broad market potential in modern design. Through high-precision laser engraving technology and digital design software, designers can efficiently carry out repeated experiments and iterations, improve the accuracy and consistency of the design, greatly shorten the development cycle, and thus promote the sustainable development of blue calico in modern innovation.

Figure 3: "Rabbit makes you suddenly rich" scheme based on the digital reconstruction design of traditional materials

Figure 4: "Rat makes you rich" scheme based on the digital reconstruction design of traditional materials

Figure 5: Elements extraction and processing of traditional patterns by using digital design software

Figure 6: Digitally-designed desk calendars

Figure 7: Digitally-designed cups

5.2 Digital innovation design of new themes of blue calico

In terms of innovative design of new themes, Nantong blue calico has broken through the limitations of traditional handicrafts through digital technologies. It shows its strong market potentials in cross-border applications of fashion, home and cultural and creative products. Taking the design project themed "Colorful World" as an example, we first selected the traditional plant patterns such as large leaf blue flower rattan, large leaf purple bead and curly grass pattern. Through modern digital design tools, these patterns are geometrized, simplified into exquisite visual symbols, and the natural rhythm and rhythm are expressed in the form of two continuous forms. With the support of digital design tools, these traditional patterns have been further optimized, making the classic color scheme of white flowers on blue background more in line with the aesthetic needs of modern consumers. Through operations such as symmetry, flipping and copying, high-quality patterns are quickly generated, so that these patterns retain the technical characteristics of blue calico, and have the fashion sense of modern design and meet mass production characteristics, as shown in Figure 8.

Next, the stencil is made by using the laser engraving technology, which ensures the accuracy and consistency of pattern engraving through computer-controlled laser equipment, as shown in Figures 9 and 10. This process greatly reduces the errors in manual engraving and improves production efficiency and product quality. In the production stage, the traditional blue calico process is used to complete the production of the final product, as shown in Figure 11. The introduction of digital technology runs through every link from pattern design to platemaking to production, which simplifies the traditional complex process, and greatly improves the precision and efficiency of production, ensuring the quality and visual beauty of blue calico fabric.

These innovative designs are widely used in product types such as home decoration, fashion accessories and household utensils. They have created new market opportunities for blue calico. By combining modern digital technology and traditional handicrafts, Nantong blue calico retains its cultural characteristics, and has modern aesthetic value, which meets the needs of contemporary consumers for personalized and diversified products, thus enhancing its market competitiveness and achieving a win-win situation between culture and market. In the future, with the continuous progress of digitalization and personalized customization technology, blue calico will radiate new vitality in more application fields, and promote its sustainable development and modern innovation.

Figure 8: Pattern designed by using digital design tools

Figure 9: Stencil made by laser engraving

Figure 10: Stencil completed by digital engraving

Figure 11: Use digital engraving to complete the stencil and then produce blue calico fabric products

6. CONCLUSIONS

The innovative path of Nantong blue calico in modern design fully reflects the deep integration of traditional crafts and modern technologies. Through the introduction of advanced technologies such as laser engraving and digital design tools, the design process and production process of blue calico has been significantly optimized. This technology-driven innovation greatly improves production efficiency and design flexibility, and opens up a broad market space for the modernization of blue calico. This study reveals how digital technology has breathed new life into blue calico. Laser engraving technology has improved accuracy and efficiency of platemaking, and digital design tools have made the design process more flexible to meet the needs of the modern market. This innovative path maintains the cultural identity of blue calico, and enhances its market competitiveness and provides a reference for the modernization of other traditional crafts.

In the future, with the continuous progress of digital technologies, the modernization of Nantong blue calico and other traditional crafts will usher in more opportunities and challenges. Digital means will continue to promote the protection and innovation of cultural heritage, so that traditional crafts in the context of globalization with new vitality, meet the market demand, t and achieve sustainable development of cultural inheritance.

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