

Innovative Application of Digital Printing Technology in “China Chic” Clothing

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-----ABSTRACT-----

As the resurgence of Chinese traditional culture gains global attention, "China Chic" clothing design has become a prominent trend in modern fashion. Digital printing technology is an advanced textile printing process. It has become a core technology in "China Chic" clothing because of its high precision, full-color gamut, versatile design capabilities, and environmental benefits. This study explored the application effect of digital printing technology on fabrics of different materials through printing accuracy tests and printing color reducibility comparison tests of different fabric structures with case analysis, and verified its superior performance in traditional pattern reproduction and customization. The results indicated that digital printing technology can not only meet the complex design requirements of "China Chic" clothing but also significantly enhance the environmental sustainability of the production process. In the future, the development of digital printing technology should focus on improving production efficiency, reducing costs, and developing more environmentally friendly inks to expand its potential in the textile industry further. Finally, the study shows the outstanding performance of digital printing technology in application efficiency, vision and color, which can provide strong technical support for the innovative design of "China Chic" clothing.

Keywords: China Chic; Digital Printing Technology; Clothing Design; Traditional Patterns; Environmental Sustainability

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I. Introduction

In recent years, with the global re-examination and revival of traditional culture, the "China Chic" phenomenon has attracted widespread attention at home and abroad. "China Chic" not only represents the reproduction and innovation of Chinese cultural elements in fashion but has also become an important trend in modern clothing design. In this context, how to combine traditional culture with modern technology so that "China Chic" clothing has both rich cultural connotations and meets the aesthetic and functional needs of contemporary consumers has become an important topic in the design field.

As an advanced textile printing and dyeing technology, digital printing technology has gradually become one of the core technologies in "China Chic" clothing design due to its high precision, full-color range, diversified design capabilities, and significant environmental advantages in the production process (Wang, 2017). Compared with traditional printing, digital printing technology can not only accurately restore complex traditional patterns, such as dragon and phoenix patterns, blue and white porcelain patterns, etc., but also can be controlled by computer to achieve personalized customization and rapid response to meet the diverse needs of modern consumers.

Although the technology of digital printing has been applied to a certain extent in the textile industry, its potential in "China Chic" garment design has not been fully explored. Nowadays some researchers focus on improving the performance of the technology themselves. For example, Dong, Lin, and Ding (2024) analyzed the scale of the printing industry, the progress of digital inkjet printing equipment, the research and development of nozzles, the progress of ink application technology, and market consumption, proposed that the future development direction is to further improve the printing speed. Sheng (2024) explained from the two aspects of technology and management that textile printing factories can achieve rapid updates and applications of technology and improve the intelligence and efficiency of management models by introducing cloud computing and big data technologies. Other studies include the research and development of resolution, printing speed, and Eco-friendly inks. However there is a lack of systematic research on how to combine digital printing technology with the "China National Tide" design concept.

Hua (2023) studied the use of digital printing to express auspicious patterns in Taohuawu New Year paintings, Jin (2023) used digital printing technology to express the pattern elements of Melting-water Miao

brocade, Shi, Zhao, and Li (2024) discussed the reproduction methods and practical cases of Chinese traditional clothing patterns using screen printing technique. In addition, in the actual application of digital printing technology, there are still some problems, such as how to improve production efficiency and reduce costs while ensuring printing accuracy, and how to further promote the market competitiveness of printed products base on meeting environmental protection requirements (Dehghani et al., 2004).

Based on this, this study aims to explore the application status of digital printing technology in the design of "China Chic" clothing and its future development trend. Experiments and case studies were conducted to verify the effectiveness of digital printing on different fabrics. The results highlight its advantages in reproducing traditional cultural elements and enabling personalized customization. In combination with market demand and technological development trends, the optimization direction and potential application areas of digital printing technology in the design of "China Chic" clothing in the future are proposed.

The research results will provide a scientific basis for the design innovation and production optimization of "China Chic" clothing, and help promote the wider application of digital printing technology in the textile field.

1. Analysis of the application effect of digital printing technology

Digital printing technology has been shown to achieve high-precision full-color gamut pattern printing on textile fabrics through computer control, which is particularly suitable for complex traditional patterns and diverse design requirements. This research uses Mimaki printers to print multi-color images on textiles. In the experiment, the same pattern was applied to fabrics with different structural characteristics, including plain, twill and satin, and the performance of digital printing technology on these materials was tested (Tkalec M. et al., 2024). The following are the specific experimental results:

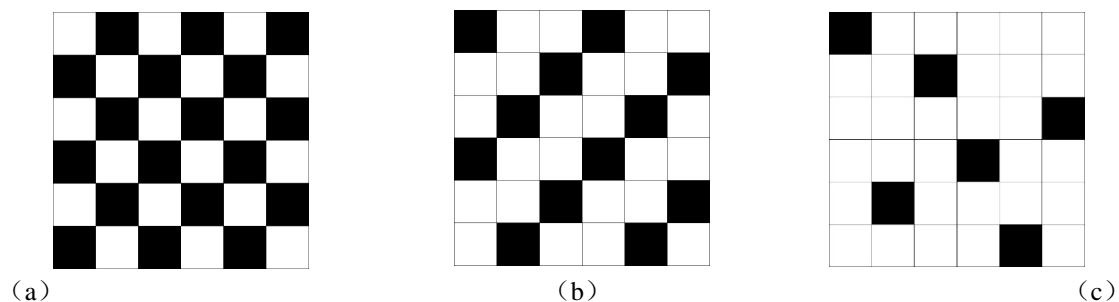


Fig. 1. Selected fabric structures. Samples (a) Plain weave 1/1; (b) Twill weave 1/2 Z; (c) Satin weave 1/5 (irregular satin)

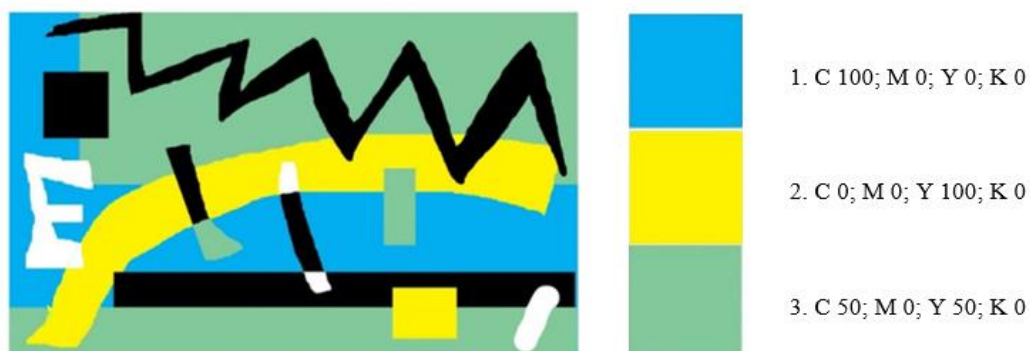


Fig. 2. Image created in Adobe Photoshop



(a)



(b)



(c)

Fig. 3. Digital inkjet printing. (a) Sample 1 (plain weave 1/1); (b) Sample 2 (twill weave 1/2 Z); (c) Sample 3 (satin weave 1/5)

The experiment compared the color performance of the original design and the print outcome. According to Tkalec et al (2024), the results showed that the color reproduction of digital printing technology was different on three fabrics with different structural characteristics, but all of them were able to achieve a high degree of color reproduction, especially in highly saturated colors (such as yellow and blue), as shown in Figure 3.

When printing patterns with high complexity, the digital printer achieved 98.5% pattern reproduction without obvious image distortion or color deviation. Hasanbeigi and Price (2015) analyzed that for patterns with rich details (line width <math><1\text{mm}</math>), the printing accuracy still reached more than 96%, showing excellent refinement ability. The finer the yarn and needle count of the knitted fabric, the more delicate the printed pattern can be. According to Kawai (2018), the yarn supplier UPW printed the same floral pattern on fabric samples with different yarn counts and compositions to study the differences in color performance and printing accuracy, as shown in Figure 4. Pure content samples, such as DP02, DP03, and DP04, have better saturation and layering

effects, while mixed content samples, such as DP05, DP08, and DP09, look slightly pale and blurred. These results can provide a preliminary concept and reference for the selection of digital printing materials.



Fig. 4. Color performance and printing accuracy of printed samples with different fiber contents provided by UPW[6]

Compared with traditional printing, digital printing consumes only 0.5 liters of water per square meter of fabric during the production process, reduces wastewater discharge by more than 90%, and does not require the use of chemical fixers. Itoh (2016) indicated this technique greatly reduces environmental pollution. The comparison of water consumption and pollution between digital printing and traditional printing is shown in Table 1 (Kašiković, Vladić & Novaković, 2016).

These experimental results show that digital printing technology can not only meet the complex and exquisite design requirements of "China Chic" clothing in terms of visual expression but also significantly improve the environmental protection of the production process, providing strong support for the green production of "China Chic" clothing.

Table 1. Comparison of water consumption and pollution between digital printing and traditional printing

Features	Digital Printing	Traditional Printing
Water Consumption	- Low water consumption: Digital printing uses almost no water or very little water.	- High water consumption: Traditional printing processes require a lot of water, especially in the rinsing and dyeing stages.
Wastewater Discharge	- Little or no wastewater: Digital printing produces little wastewater, which is easy to treat.	- Lots of wastewater: Traditional printing produces a lot of wastewater, which requires a complex treatment process.
Chemical Application	- Little chemicals: The inks used are usually environmentally friendly, reducing the need for chemicals.	- Lots of chemicals: Traditional printing requires the use of a variety of chemicals, including dyes, auxiliaries, etc.
Energy Consumption	- Low energy consumption: Digital printing equipment is generally more energy-efficient.	- High energy consumption: Traditional printing processes require heating and long water treatment, which consumes a lot of energy.
Environmental Implication	- Small: Digital printing has a smaller impact on the environment because it reduces the amount of water and chemicals used.	- Large: The wastewater and chemicals generated in the traditional printing process have a greater impact on the environment.

Cost	- High initial investment, but low running costs: Digital printing equipment costs more, but long-term running costs are lower.	- Low initial investment, but high running costs: Traditional printing equipment costs less, but the use of water and chemicals leads to higher running costs.
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2. Application examples of digital printing technology in "China Chic" clothing design

To verify the actual application effect of digital printing technology in "China Chic" clothing, this study uses two specific examples to demonstrate the modern expression and personalized customization capabilities of traditional cultural elements.

Example 1: Digital reproduction of traditional cultural elements

In this example, we analyzed HUI 2024 spring and summer ready-to-wear "Miao Print" series, as shown in Figure 5. HUI inspiration for this season comes from the ancient and mysterious Miao culture. The characteristic of Miao clothing is the pursuit of gorgeous and heavy colors in simplicity. This season, the representative traditional floral patterns are applied to the "China Chic" clothing design of silk fabrics. The bold and dazzling prints convey the distinctive "China Chic" culture. Digital printing technology can restore the floral patterns with beautiful lines and bright colors. The lines of the finished pattern are clear and the color layering is significant. This series combines Western tailoring with iconic Chinese elements in terms of pattern and style, such as the cheongsam stand-up collar and buttons, as well as traditional prints with strong visual effects. This kind of design successfully integrates traditional culture and modern fashion and has a high market value.



Fig. 5. HUI 2024 Spring/Summer Ready-to-Wear "Miao Print" Series

La Maison Jade 2024 Spring and Summer Women's wear "Flower" Series, as shown in Figure 6, also uses digital printing technology to express plant flower patterns with traditional classical charm, integrating the national style temperament of oriental aesthetics with Western design concepts. The prints are bright and colorful, conveying a bright and vigorous national-style beauty. Printing on silk and satin fabrics with good gloss makes the clothing more textured. Applying the technology of digital printing to clothing can directly and vividly convey design concepts, and express the distinctive design style of clothing.



Fig. 6. La Maison JadeLa Maison Jade Spring/Summer 2024 "Floral" Collection

Example 2: Rapid response to personalized customization

Another major advantage of digital printing technology is its flexibility and rapid response. In this experiment, we designed unique patterns for a batch of customized "China Chic" sportswear, including a fusion design of personal icons and traditional patterns provided by customers. The entire customization process took only 72 hours from design to final product. Using paint printing, no sizing treatment is required before printing and no steaming or baking is required after printing. It can achieve clean, efficient and short-process printing, and enables each finished product to accurately meet the customer's personalized needs (customized sportswear display, Figure 7). One of the most important steps in the production process is the positioning of the printed pieces. The printing range of sportswear covers a large area, and the performance of printing is also a highlight of this sportswear design. After using CAD to make a pattern, the prepared pattern is positioned and printed according to the design requirements to ensure the accurate position of the pattern. The customer expressed high satisfaction with the finished product and believed that the technology of digital printing provides a high-quality solution that meets personalized needs. Digital inkjet printing technology has a short process flow, flexible pattern design and good process reproducibility. With the development of technology, it can be applied to a wider range of fabrics. The finished fabric printing products have good color fastness and feel, and can also save a lot of water, chemicals and energy. Therefore, digital printing technology has obvious advantages in "China Chic" clothing design.



Fig. 7. Customized sportswear display picture

3. Future development direction of digital printing technology

Although digital printing technology has shown significant advantages in the design of "China Chic" clothing, it still requires further technical improvement and market exploration in the future development. The following are possible development directions:

Improve production efficiency and reduce costs: As Clark(2003) said, although the current digital printing technology has significantly improved production efficiency, further technical optimization, such as increasing printing speed, reducing ink costs, etc., fully analyzing production costs and efficiency, as shown in Table 2 (this table provides a basic framework to illustrate the production cost and efficiency of digital printing. The actual situation may vary depending on the specific production scale, technical level, and market demand), which will help expand its application in large-scale production. In recent years, China has made some progress in the research and development of digital inkjet printing nozzles. The thermal foaming nozzle developed by Shanghai Ruierfa Digital Technology Co., Ltd. has a resolution of up to 1200 dpi and a maximum jet frequency of 20 kHz; the piezoelectric nozzle has 1440 nozzle holes, a resolution of up to 800 dpi, and a maximum jet frequency of 40 kHz. The nozzle manufactured by ASKA Co., Ltd. using piezoelectric technology has 512 nozzle holes, a resolution of 200 dpi, a maximum jet frequency is 40 kHz, and an ink drop volume between 40~70 pL. A reflux channel is set in the nozzle, and the maximum reflux flow rate can reach 100 ml. In terms of printing speed, the single pass digital inkjet printing machine is currently the fastest type of digital inkjet printing equipment, with a printing rate of 80~90 m²/min; the direct-injection equipment is affected by the pattern and fabric, and the actual stable operating rate is 60~70 m²/min. Honghua Digital Technology has launched the VEGA 9180DI digital printing machine. The product has a daily output of up to 15,000 meters and is equipped with a variety of intelligent systems, such as a quadruple intelligent nozzle protection system, nozzle constant temperature, enhanced intelligent water-saving guide belt cleaning system, and automatic cloth feeding centering system.

With increasingly stringent environmental protection requirements, the development of more environmentally friendly digital printing inks will become a research focus in the future. For example, natural dye inks based on bio-materials can not only further reduce environmental impact, but also increase the cultural value and market competitiveness of "China Chic" clothing. EFI Reggiani launched the EFI Reggiani eco TERRA digital printing solution, which combines fabric pretreatment, printing and post-treatment on a single paint digital printing device. It uses matching paint inks with printing pretreatment additives such as pigments and adhesive agents. The finished fabric printing products have good color fastness and feel, and can also save a lot of water, chemicals and energy. Mimaki launched the waterless printing system Trapis and the latest industrial-grade high-speed sublimation transfer inkjet printer Tiger600-1800TS, which produces almost no wastewater in the textile printing process. In the future, digital printing technology will gradually be combined with intelligent production systems, optimize printing processes through big data analysis, improve production accuracy and efficiency, and further promote the innovative design of "China Chic" clothing.

Table 2. Production cost and efficiency analysis

Analysis Dimension	Description	Production cost and efficiency considerations
Printing Speed	Refers to the ability of a digital printing machine to complete printing in a unit of time.	<ul style="list-style-type: none"> - High-speed printing: high production efficiency, suitable for large-volume orders. - Medium and low-speed printing: suitable for small-volume or personalized customization, with relatively low production efficiency.
Ink Cost	Includes unit price, consumption, and maintenance cost of ink.	<ul style="list-style-type: none"> - High-end ink: higher cost, but better color reproduction and durability. - Standard ink: moderate cost, suitable for general needs.
Equipment Investment	The initial cost of purchasing a digital printing machine.	<ul style="list-style-type: none"> - High cost: high-end equipment, suitable for professional production. - Low cost: entry-level equipment, suitable for small-scale or start-up companies.
Maintenance and operation	Daily maintenance, operator training, and replacement of consumables and other costs.	<ul style="list-style-type: none"> - Low maintenance cost: stable equipment and easy operation. - High maintenance cost: complex equipment and requires professional maintenance.
Flexibility in design	The convenience of changing patterns and the frequency of design updates.	<ul style="list-style-type: none"> - High flexibility: suitable for diversified and personalized production, and increased product added value. - Low flexibility: suitable for long-term mass production of the same pattern.
Material Waste	Costs of scrap and misprints during production.	<ul style="list-style-type: none"> - Low waste: Digital printing can be printed on demand, reducing waste. - High waste: Improper equipment commissioning or operation may lead to increased waste.
Total cost	Overall production cost after taking all the above factors into consideration.	<ul style="list-style-type: none"> - Small batches: Digital printing has a lower total cost and is suitable for personalized and small batch production. - Large batches: Traditional printing may have a lower total cost, but digital printing has an advantage in complex patterns.

As an important innovation in the field of modern textile printing and dyeing, digital printing technology is gradually becoming one of the core technologies in the design of "China Chic" clothing. Through the continuous advancement of technology and the development of the market, digital printing technology will be more widely used in "China Chic" clothing, promoting the modern expression and fashionable development of traditional culture.

IV. Conclusion

This study systematically analyzed and experimentally verified the application of digital printing technology in the design of "China Chic" clothing, and drew the following main conclusions:

First, the experimental results show that digital printing technology has shown excellent performance in high-accuracy and panchromatic pattern printing. Through the digital printing machine produced by Mimaki, high-precision restoration of complex patterns was successfully achieved on plain, twill, and satin fabrics with different structures, and the finer the yarn and needle count of the fabric, the more exquisite the printed pattern that can be achieved. This result shows that the technology of digital printing can meet the needs of "China Chic" clothing for the modern reproduction of traditional cultural elements, and is particularly good at high-saturation color performance.

Second, compared with traditional printing technology, the environmental protection property of digital printing technology in the production process has been significantly improved. Tyler (2005) demonstrates that the water consumption of digital printing technology is only 0.5 liters per square meter of fabric, the wastewater discharge is reduced by more than 90%, and no chemical fixer is required. This shows that digital printing technology not only improves the design accuracy and visual expression of "China National Tide" clothing but also provides an effective solution for green production, which meets the high requirements of the modern textile industry for environmental protection.

However, some problems and challenges were also found during the experiment. First, although digital printing technology can achieve high-accuracy pattern printing, there are still problems with production efficiency and cost control in large-scale production. Improving printing speed and reducing ink costs are key issues that need to be solved in the future (Wang and Zhang, 2019). In addition, although eco-friendly inks have reduced environmental pollution to a certain extent, how to further develop natural dye inks based on bio-materials to further reduce environmental impact is still an area that needs to be explored. Based on these experimental results, the application of the technology of digital printing in the design of "China Chic" clothing has important practical significance and guiding value. It can not only enhance the cultural expression and market competitiveness of clothing but also promote the textile industry to develop in a more environmental and sustainable direction. Future research should focus on the following aspects: first, further, optimize the production efficiency and cost of digital printing technology to meet the needs of large-scale production; second, develop more eco-friendly digital printing inks to enhance its application potential in green textiles (Md. Mahbubur, 2021); finally, combine digital printing technology with intelligent production systems to improve production accuracy and efficiency through big data analysis and optimization of printing processes.

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