Received: 31 May 2024 | Revised: 17 Jun. 2024 | Accepted: 3 Jul. 2024 | Published online: 25 Jul. 2024
RESEARCH ARTICLE

Journal of Global Humanities and Social Sciences
2024,Vol. 5(7)234-239
DOI: 10.61360/BoniGHSS242016560701

Visualization Study of Traditional Artistic Crafts of "Kao Gong Ji" Based on Digital Simulation and Reconstruction

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Abstract: "Kao Gong Ji" is a major work of handicraft technology in early ancient China, which recorded in detail the handicraft methods and craft information of the pre-Qin era in China, summarized the industrial production technology and construction system at that time, and embodied the advanced social ideological concepts at that time. It plays an important role in studying the history of science and technology, crafts, and culture in China. The technical concept of "Heaven has time, earth has gas, material has beauty, and work has skill, and when these four are combined, then it can be made into a good one" still provides the basic method for modern craft production. Through digital visualization technology, we can digitally reproduce the craft technology and artistic expressions recorded in the Book of Examination and Records of Work, and understand the principles and characteristics of ancient craft technology more deeply. This can not only provide inspiration and reference for modern craft innovation but also help modern craftsmen better master traditional craft skills and promote the integration and development of traditional crafts with modern technology. The use of this technology is not only the inheritance and promotion of traditional culture but also a powerful impetus to the development of modern crafts.

Keywords: traditional crafts; visualization technology; digital reproduction

"Kao Gong Ji" is an important technical literature on handicrafts in ancient China, written during the Spring and Autumn and the Warring States periods. It contains detailed records of the design specifications and manufacturing processes of various types of handicrafts in the production of handicrafts at that time and demonstrates the outstanding achievements and unique charms of handicraft technology in the pre-Qin and Qin dynasties. It covers a wide range of trades such as carpentry, goldsmithing, leather, dyeing, scraping and grinding, ceramics, etc., and each of these trades is subdivided into several types of work. The book not only records the production methods of various tools but also describes in detail the production processes and standards of various handicrafts, such as the manufacturing methods of wheels, bows and arrows, musical instruments, jades, etc., all of which are described. In addition, "Kao Gong Ji" also summarizes the production management and camping system, reflecting the society's attention to industrial production and the idea of standardized management at that time. Through digital visualization technology, we can digitally reproduce the craft techniques and artistic expressions recorded in the Book of Examination and Works, and gain a deeper understanding of the principles and characteristics of ancient craft techniques. This can not only provide inspiration and reference for modern craft innovation but also help modern craftsmen better master traditional craft skills and promote the integration and development of traditional crafts and modern technology. The use of such technology is not only the inheritance and promotion of traditional culture but also a powerful impetus to the development of modern crafts.

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1. History of Goldsmithing: The Development of the Goldsmithing Process

Existing archaeological data show that China had already mastered the cold forging and casting technology of red copper as early as the Xia Dynasty (i.e., from the twenty-first century to the sixteenth century B.C.). With the evolution of time, the smelting and casting technology of bronze began to emerge at the end of the Xia and the beginning of the Shang Dynasty (i.e., from the sixteenth century B.C. to the eleventh century B.C.). After the middle of the Shang Dynasty, China developed a highly prosperous bronze culture. From the point of view of today's unearthed bronzes, there is a wide variety, not only a large number of ceremonial weapons, weapons, and daily necessities but also includes some of the tools of production, such as handicrafts tools and agricultural tools, and so on. The best of these bronzes, such as the heavy and solemn Simuwu Dading and the highly skillful Four Sheep Zun, fully demonstrated the deep attainments of our ancient people in alloy technology. All these show that our ancestors already possessed rich knowledge of alloy at a very early period. The pre-Qin period was a time of change and strife in Chinese history. During this period, various vassal states waged frequent wars to compete for territories and resources, so well-made weapons became an important part of national security. It is in this context, that the focus of the work of the craftsmen turned to the manufacture of weapons, and the ancient scientific and technological literature of the book “Kao Gong Ji”, which provides us with a detailed record of the weapons manufacturing techniques of this period. The descriptions of commonly used weapons such as arrows, gorges, halberds, etc. in the book not only include their shapes and styles but also explain in detail the size structure, and production process. In the manufacturing process of weapons, technologies such as metal smelting and mechanical analysis played an important role. Metal smelting technology provides high-quality raw materials for the production of weapons, while mechanical analysis ensures the structural stability and excellent performance of weapons. These simple scientific principles, although they had not yet formed a complete theoretical system at that time, had already achieved remarkable results in practical application (Wan, 2016).

In addition to the manufacture of weaponry, ritual artifacts were also one of the focuses of the introduction of the Kao Gong Ji. During the pre-Qin period, sacrificial activities were an indispensable part of the political life of the state, and sacrificial vessels were important symbols reflecting the divine right of the ruler. Artifacts such as the jade gui used for sacrificing to the heavens and the arrow targets used for sacrificing ancestors were indispensable props for ritual activities. In the process of making ritual objects, craftsmen not only pay attention to the beauty and majesty of the objects but also take into account their symbolic meaning and cultural connotations. Therefore, the production of these artifacts often needs to go through multiple processes and fine processing to ensure that they can perfectly reflect the majesty and mystery of the divine right of kings (Wu, 2018).

2. Techniques of Goldsmithing: “Gold Has Six Qi” Alloy Technology Process

As an important document on the technology of ancient Chinese handicrafts, Kao Gong Ji recorded in detail the ratio and application of bronze alloys at that time, among which the most well-known one is “gold has six qi”, which is the earliest understanding in the world of the relationship between alloy composition and performance. “Kao Gong Ji” mentioned “gold has six Qi: six points of its gold and tin in one, called the kind of tripod of Qi; five points of its gold and tin in one, called the axe catty of Qi; four points of its gold and tin in one, called the halberd of Qi Sen points of its gold and tin in one, called the big edge of Qi; five points of its gold and tin in two, called the cut to kill the vector of Qi gold tin and a half, called the flint of Qi”. This “six Qi” actually refers to six different ratios of copper-tin alloy, each alloy is widely used in different fields because of its unique properties.

2.1. Zhong Ding Zhiqi

The ratio of Zhong Ding Zhiqi is copper six tin one, i.e., the ratio of copper to tin is 6:1. The hardness of this alloy is moderate while maintaining good toughness, so it is very suitable for casting bells, tripods, and other ceremonial instruments. These instruments have an important position in ancient society, not only representing power and status but also a symbol of culture and art.

2.2. Axe catty of Qi

Axe catty of Qi ratio of copper five in one, that is, the copper-tin ratio of 5:1, the hardness of this alloy than the bells and tripods of Qi increased, and therefore more suitable for the manufacture of axes, patties, and other felling tools. These tools were important production tools in ancient societies, used for felling trees, building houses, etc., so they needed to have a high degree of hardness and durability.

2.3. Go halberd of Qi

The ratio of the halberd of Qi for copper four in one, that is, the copper-tin ratio of 4:1. this alloy in the hardness of further increase, while maintaining a certain degree of toughness, is very suitable for the manufacture of go, halberd, and other weapons. These weapons in ancient society were important equipment for war and defense and needed to have high hardness and toughness to ensure their stability and durability in the process of use.

2.4. The big blade of Qi

The ratio of the large blade of Qi for the copper three-tin one, that is, the ratio of copper to tin 3:1. This alloy is very hard, so it is particularly suitable for the manufacture of large swords and other weapons. These weapons have great lethality on the battlefield and are important equipment for warriors. The high hardness of the Great Blade of Qi ensures that the weapon will remain sharp and stable in battle.

2.5. Sharpening Yazaki

The ratio of copper to tin is 5:2. This alloy has a good balance of hardness and toughness, making it ideal for sharpening knives and arrows. Sharpening knives need to have a certain degree of hardness to ensure their sharpness, while arrows need to have a certain degree of toughness to ensure that they remain stable when fired. The ratio of Sharpening, Killing, and Arrowing Qi meets these needs.

2.6. Flint knives

The ratio of Jianshunzhiqi is half copper and half tin, i.e., the ratio of copper to tin is 1:1. The hardness and toughness of this alloy are relatively low, but it has good reflective properties and malleability. It is therefore well suited for the manufacture of mirrors and flint for firemaking. Mirrors need to be reflective to reflect the human face clearly, while flint needs to be malleable to ensure that enough heat can be generated to ignite a fire when rubbed together.

3. The Legend of Goldsmithing: Modernization of the "JinYuLiuQi" Alloy Technique and Digital Technology

3.1. Analysis of the feasibility of digitization of the alloy technology of "JinYuLiuQi"

There are many kinds of digital technologies, which are divided into six categories according to the types of technologies: digital preservation and archiving of cultural heritage; digital virtual museums; virtual cultural relics restoration, restoration and evolution simulation technology; digital patterns, handicrafts auxiliary design system; digital storytelling and narration technology; and digital dance choreography and sound-driven technology (Peng et al., 2006). Among them, the first three categories of digital technologies have wide applicability and occupy a pivotal position in the protection, inheritance, and display of non-heritage items. The application of these technologies not only significantly enhances the public recognition and visibility of NRM projects, but also injects new momentum into the modernization, transformation, and innovative development of traditional culture. For the alloying technique of "six golds" described in the "Book of Examination and Works", we can realize its digital reproduction and inheritance with the help of these technologies (Jia & Zhang, 2018).

The digitization of the alloy-making technology of "Jin You Liu qi" is mainly based on data

acquisition and storage technology, which ensures that the key information of the alloy-making process is properly preserved; new media communication strategy, which is used to widely disseminate the knowledge and charm of this traditional technology; parametric programming simulation, which simulates the process of alloy making and provides precise guidance for the artisan's computer-aided design techniques to optimize the design of alloy products. These technologies have been widely applied in the cultural industry and are therefore highly feasible (Pan, 2011).

The following three aspects are analyzed from the alloy proportion, production process, and artistic effect:

First, the data collection and storage technology is utilized to accurately record the metal composition and proportion involved in the alloy production technique of "Jin You Liu Qi". Through digital means, a database of alloy ratios can be established to facilitate subsequent research and application. The digital virtual museum technology can provide a virtual display platform for presenting the historical background, production process, and artistic effects of the "Jin You Liu Qi" alloy production technique. This can not only enhance the public's knowledge and understanding of the technique but also provide researchers with rich research materials.

Parametric programming technology is used to simulate the production process of the "Jinyouliuqi" alloy production technique. By setting the alloy ratio, temperature, pressure, and other parameters, the melting, pouring, and cooling processes of the alloy are simulated to predict the properties and appearance of the alloy. This simulation technology can provide important reference information for craftsmen to help them optimize the production process and improve product quality. Computer-aided design (CAD) technology can be used to design the artistic effects of "Jin You Liu Qi" alloy products. Through vector drawing software, the patterns and shapes of alloy products are drawn, innovated, and optimized. At the same time, image digitization technology is used to digitize the reference drawings for better integration into the design of the alloy products. After analysis, it can be concluded that it is feasible to digitize the alloy production techniques of Jin You Liuqi (Zhang & Zhang, 2006).

3.2. Digitalization of the "Jin Yu Ruoqi" Alloying Technique

(1) Digital Dissemination and Popularization of the Production Technique of JinyouLiuqi

As an ancient metal alloy craft recorded in the book "The Records of the Examiner", the production technology of "Jinyu Liuqi" has a thousand-year historical inheritance, and its unique cultural heritage and technical essence are treasures in the treasure house of Chinese culture. However, because the related cultural system has not yet been systematized and disseminated, the production technique of Jin You Liu Qi is not well known in modern society, which limits its further development. Modern digital display methods, such as web pages and virtual museums, can be utilized to convey the cultural charm of the Jin You Liu Qi production techniques to a wider audience. These display methods will differentiate the production techniques of Jin You Liu Qi from other metal craft non-heritage cultures, and allow people to understand its unique charm more conveniently, thus promoting its further development (Wang, 2009).

(2) Visualization of alloy production techniques

The production techniques of Jinyu Liuqi alloy are unique and complex, and it is difficult to fully capture their essence in traditional text descriptions. With the help of digital technology, these techniques can be visualized, simulating key steps such as alloy proportioning, melting, and casting, so that the audience can intuitively understand the detailed process of alloy production. This not only helps the inheritors to convey their skills more efficiently when teaching apprentices, conducting research activities, or online display but also enhances the public's interest in the alloy culture of Jinyu Liuqi and promotes its sustainable development (Tu, 2013).

(3) Digital unification of alloy product design

In the design process of Jinyu Liuqi alloy

products, digital technology is used to realize the digital unification of the design. By digitally organizing and analyzing the design elements of alloy products of past generations, a set of standardized design specifications and reference templates are formed. This will make the design of alloy products more standardized and efficient, and reduce errors and uncertainties in the design process. The digitized and unified design method will ensure that the alloy products not only meet the requirements of modern aesthetics and practicality but also maintain their unique craftsmanship characteristics, thus promoting their modernization transformation and development.

(4) Digital-aided design of alloy product patterns

Computer-aided design plays an important role in the digitization of cultural industries. In the pattern design of JinYouLiuQi alloy products, we can make use of computer-aided design software and related plug-ins to carry out digitally assisted design. Through big data analysis and market research, we can grasp modern trends and consumer preferences, extract the trend elements that meet the market demand, and integrate them into the pattern design of alloy products (Luo, 2021).

Conclusion

As a treasure of ancient Chinese handicraft technology, "The Records of the Examiner" not only recorded the craft technology and artistic expression of the pre-Qin period, but also embodied the concept of craftsmanship of "the sky has a time, the earth has a qi, the material has a beauty, and the work has a cleverness", which still has far-reaching influence on the modern craft production. Through digital visualization technology, we reproduce the production technology of "Six Qi of Gold" in the "Records of the Examining Engineer", and explore the principles and characteristics of the ancient alloy production, which will provide valuable inspirations and references for modern craft innovation.

As a representative of ancient metal crafts, combining the production technique of "gold with six qi" with digital technology not only enables more people to understand and appreciate the charm of this traditional craft but also promotes the integration and development of traditional crafts and modern technology. Although in the process of digitization, the handling of certain details still needs to be further improved, this is the driving force to promote the continuous progress of technology.

With the deep involvement of digital technology in the research and application of traditional culture, the "Jin You Liuqi" production technology will show a richer potential for application in the field of non-heritage culture. The use of this technology is not only the inheritance and development of our long history and culture but also a powerful innovation and promotion of modern technology. However, at the same time, we should also think deeply: in the fast-changing modern environment, how to ensure the survival of these precious traditional skills, and continue to revitalize new vitality? This requires us to actively explore new development models to get rid of the dilemmas faced in the process of inheritance and to inject new impetus into the prosperity and development of traditional culture.

Conflict of Interest

The author declares that she has no conflicts of interest to this work.

Acknowledgement

This research was funded by:

This article is an outcome of the project "Research on the Visualization Design of Traditional Technological Crafts of "Kao Gong Ji" Based on Meta-Cosmos Technology" supported by "the Research Foundation of Shenzhen Polytechnic University under Grant 6023312006S".

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How to Cite: Gao, F. (2024). Visualization Study of Traditional Artistic Crafts of "Kao Gong Ji" Based on Digital Simulation and Reconstruction. *Journal of Global Humanities and Social Sciences*, *05*(07), 234-239.
https://doi.org/ 10.61360/BoniGHSS242016560701