Computer-Aided Three-Dimensional Ceramic Product Design

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Abstract. This paper analyzes the design of ceramic products using computational aids and uses a three-dimensional approach to handle the design. Based on this, the current situation of using 3D printing technology in the field of ceramics is explored. Secondly, through personal design and experiments, the principles of using machines in the ceramic 3D printing process and the characteristics of 3D printed ceramic modeling are summarized. Finally, according to the characteristics of the ceramic 3D printing process and combined with the principles of aesthetics and modeling design, we applied ceramic 3D printing technology to design and produce several groups of ceramic shapes. It is hoped that it will provide a reference for expanding the space of ceramic modeling design and provide more possibilities for the future development of ceramic modeling design. We use digital means to extract the characteristics of Changsha kiln ancient artifact toys, summarize the rules of its modeling language, and extract the basic prototype that can be redesigned; and through the cooperation of digital form design and production practice, combined with the advantages of low cost and high plasticity brought by 3D printing technology, using digital 3D modeling means to convert into data expression, transfer to 3D printing to realize the design prototype materialization, and finally design a series of ceramic toys with the characteristics. The final design of a series of ceramic toys with the characteristics of Changsha kiln, for the product design of Changsha kiln ceramic toys to broaden new ideas.

Keywords: Computer-aided; three-dimensional; pottery product design
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1 INTRODUCTION

The emergence and development of ceramic melding technology have been going on for thousands of years, and different molding methods have resulted in different ceramic shapes. But because the ceramic material itself has certain limitations, prone to cracking and deformation problems, so for the molding skills are more demanding, and not all shapes can be achieved using ceramic materials, the completion of a shape during the need for repeated experiments and attempts. In the rapid development of science and technology today, more high-tech products for people's production life to provide convenience [1]. In the rapid development of modern science and technology, "excessive" demand for natural logging, the continuous destruction of the environment, not only destroy the harmonious relationship between man and nature but also on the ecosystem and human physical and mental health have caused a huge destructive impact. Currently, it is particularly important to adhere to the balanced relationship between man, nature, and science. The bionic design can reflect the contemporary people's aspiration for nature and their spiritual and emotional attachment. Therefore, this research will be based on the concept of bionic design of ceramic furnishings, which is not only a reflection on the heritage of traditional Chinese culture but also a new exploration of modern technology, ecological concepts, and sustainable development into the design. This research will also focus closely on ecological and environmental protection, green development, and the harmonious coexistence of man and nature.

As a comprehensive scientific theory, systems theory emphasizes rational concepts while considering creative thinking [2]. Therefore, if system theory is combined with emotional thinking in design, it can give full play to the way of thinking of emotional design, improve and enrich the value of system theory while promoting the progress of modern design, and form a scientific system design method to achieve a solution where everyone benefits. When solving modern design problems, it can integrate qualitative and quantitative methods to help designers accurately analyze the design problems and precisely grasp the major and minor contradictions; at the same time, it can avoid the situation that the design process only uses rational thinking to deal with problems and ignores the consideration of human emotions, which causes the process and results of the problems to deviate from expectations [3]. This system methodology coincides with the "human-centered" emotional design concept emphasized in modern design and can be an advanced concept to guide designers in solving design problems, which can be said to be a forward-looking system methodology.

Secondly, this systematic methodology is applied to the design content of home ceramic lamps and lanterns, and the design content of materials, techniques, shapes, structures, functions, and optical systems involved in the design of home ceramic lamps and lanterns are analyzed comprehensively to provide a more convincing theoretical basis for the selection of ceramic elements in the design of home ceramic lamps and lanterns; at the same time, user research and market research are conducted, and the research data and home ceramic lamps and lanterns related data. At the same time, we will conduct user research and market research, and analyze the research data and the data related to home ceramic lamps and lanterns to provide more accurate parameters for considering the "human factor" in the design of home ceramic lamps and lanterns. Third, to explore how to use design methods to make the design process of ceramic home lighting more scientific and reasonable. Fourth, based on the ergonomic theory of emotional design, we analyze how to use the emotional design method to achieve the effect of externalized expression of user's emotion. Fifthly, under the guidance of the WSR system methodology, the three dimensions of "matter", "physical" and "human" are fully considered, and human emotion is used as a link to establish the design process model of home ceramic luminaires. The design process model of home ceramic luminaires will guide the design practice and design innovative home ceramic luminaires with emotion.

2 RELATED STUDIES

Zhang et al. [4] make a systematic discussion and bring an evaluation system to ceramic design from an overview of ceramic modeling, ceramic design and its scope, the emergence of ceramic design, several stages of ceramic design development, systematic approach to ceramic design, steps, and procedures of systematic design, etc. This book talks about the systematic approach to ceramic design. Yang et al. [5] give an overview of modern ceramic product design, a brief history of the development of modern ceramic design, principles of product design for ceramic types, the use of computers in ceramic product design, the process science to be considered in ceramic product design, and the systematic approach to ceramic design. And through the concept of computer-aided design, the advantages of computer-aided ceramic product design, computer-aided ceramic product design software in the graphics technology to explain the computer-aided ceramic product design. The foundation of modern ceramic design creation is our traditional culture, through the derivation and development of traditional ceramic art to form our modern ceramic art [6]. Jing et al. [7] use a variety of expressions to vent their inner emotional world and understanding of the development of today's social life, its purpose is to excavate the complex deep emotional world of people living in modern society and redefine Modern ceramic art has deeper realistic properties than traditional ceramic art, as it strives to explore the deeper meaning of art and emotion in modern real life.

The digital sculpture has several distinguishing features, starting with the use of computer technology to create it. This is fundamentally different from the tools and materials used in traditional sculpture. The tools and materials used in traditional sculpture are tangible, and the work created is a physical model that can be touched; whereas the computer software used in digital sculpture is invisible, and the work created is a virtual model that can be seen intuitively. Secondly, digital sculpture belongs to the category of sculpture, and the sculptures still conform to the aesthetic rules and modeling characteristics of traditional sculpture and have the artistic expression of traditional sculpture. Once again, the purpose of the digital sculpture is still creation, expressing the creative intent, thoughts, and emotions of the creator. Finally, the digital sculpture has practical application value. Digital sculpture has advantages over the traditional sculpture in many aspects of design, and increased sculpture artists are inclined to use digital sculpture to design their works. Moreover, digital sculpture combined with advanced machines and equipment can quickly transform virtual sculpture models into physical models. Kang et al. [8] introduced the possibility of wearing a stereo helmet or stereo glasses and using data glove sensors to virtually shape the sculpture object in three dimensions. Shouman et al. [9] provide a theoretical introduction to the basic knowledge and theory of 3D printing technology and its related 3DCAD design and rapid mound technology and then introduce specific software, specific equipment, and specific methods in a logical sequence with relevant case studies. They also describe and investigate the emergence, development, and future of 3D printing technology.

Specifically, innovation is reflected in two aspects. Throughout the research literature on digital sculpture, the research contents are all theoretical studies on the virtual design of the digital sculpture, and there is no literature related to the study of the materialization of digital sculpture. This thesis presents and explains the physicalizing as a research topic to demonstrate its feasibility, conduct a theoretical summary, and form a thesis report. The paper analyzes the modeling effects produced by both 3D printing and CNC sculpting methods, illustrating them from several perspectives of morphological structure, sense of volume, texture effect, color effect, and integrity. The modeling problems that are difficult to achieve by both methods are summarized and the reasons are analyzed, and corresponding solutions are provided. During the research of the materialization topic, a lot of practice of 3D printers and CNC engraving was conducted. The working principle, specific operation methods, and characteristics of the materials used were mastered. Printed and sculpted various abstract types and realistic types of sculptures. Summarized what kind of sculptures are suitable for printing by the two methods, and referred to the selection for future sculpture projects. We have made a practical study with a specific project,

and encountered various problems and unexpected phenomena during the completion of the project, and researched the solutions to these problems.

3 ANALYSIS OF POTTERY PRODUCT DESIGN IN COMPUTER-AIDED 3D

3.1 Computer-Aided Three-Dimensional Ceramic Product Design System

The form is the entire external appearance of an object, a comprehensive conceptual body composed of countless shapes, the most basic pure form that can be cognized by human vision, the sum of material, structure, and form. Digital sculpture breaks away from the traditional form of sculpture in terms of modeling structure. In modern sculpture, the abstract sculpture obtained by using geometric forms as elements and the results of mathematical formulae fully embodies the parametric characteristics and digital laws, with symmetry, balance, and other rigorous and accurate modeling characteristics, the standard of this type of sculpture is difficult to achieve by manual methods, but digital equipment is very easy to achieve this type of modeling structure. For complex hollowing modeling, digital equipment reflects his advantages. Traditional manual methods in the realization of a hollow structure, to consider the toughness of the material and carving manual skills, the slightest inadvertence will damage the connection parts, resulting in carving failure [10]. The use of CNC equipment, especially 3D printers and new materials, even if the connection parts are only hair-level fineness, can also meet the requirements of the modeling. 3D printers for sculpture internal space modeling sculpture are unsurpassed by other methods, to achieve the internal sculpture in the state of the external structure of the sculpture model closed. This modeling mode breaks through the traditional sculpting method of sculpting a sculptural entity from the outside to the inside, and instead, a free, non-linear sculpting method is achieved from the inside to the outside.

Ceramic luminaire design is the use of different ceramic materials to shape a variety of luminaire forms. Depending on the installation method, ceramic luminaires can be divided into six forms: ceiling-mounted, recessed, suspended, wall-mounted, tabletop, and floor-mounted. Ceiling, hanging, desktop ceramic lamps, and lanterns in the modern home ceramic lamp design are the most common. Different forms of ceramic lamps and lanterns combined with different use of space and environment can produce different functional effects and aesthetic interests, as shown in Figure 1.

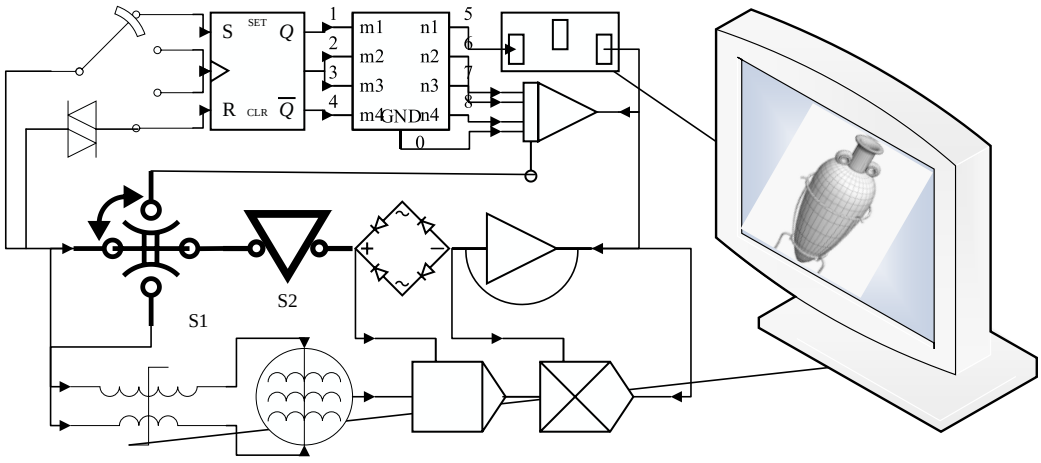

Figure 1: Framework of computer-aided 3D pottery product design system.

The advantages of the B/S architecture are high real-time performance, low development and maintenance costs, automatic upgradeability, and a user interface that can be implemented through a browser. Integrating the characteristics of enterprise production management, real-time requirements, and the advantages and disadvantages of the two structures, this topic selects the B/S technology structure to realize the information transfer of each system. In the whole architecture, computer-aided process planning is mainly to write process documents and form process BOM; product data management as the integration platform of CAPP and ERP systems is mainly to complete the conversion of BOM, product configuration management and workflow management; enterprise resource planning is mainly to carry out production control and form manufacturing BOM, etc. Enterprise resource planning is mainly for production control, forming manufacturing BOM, etc.; production planning and scheduling are carried out by using relevant data from the manufacturing execution system. In short, the functions of each system should be fully utilized to realize the management of process information of aerospace product production and manufacturing process.

Unified Modeling Language (UML) is a standard modeling language that uses a collection of text, graphics, and symbols to describe the activities of various types of things in real life and the relationships between them. As a modeling language, it allows developers to focus on building the model and structure of the product rather than on what programming language and algorithm implementation is chosen, and when the model is built it can be transformed by UML tools into the specified programming language code. Using UML techniques, use case models, component models, deployment models, concurrency models, and logic models of the system can be constructed. Use case diagrams are simple and straightforward and allow participants to understand the mutual functions and relationships in a short time, but the details of the functions are not easy to describe too much in the use case diagrams, so the overall functionality of the system can be modeled in conjunction with the use case documentation. When writing the documentation, it should be described in simple and easy-to-understand language, and include some important contents such as each participant in the use case diagram and the effect after execution, as shown in Figure 2.

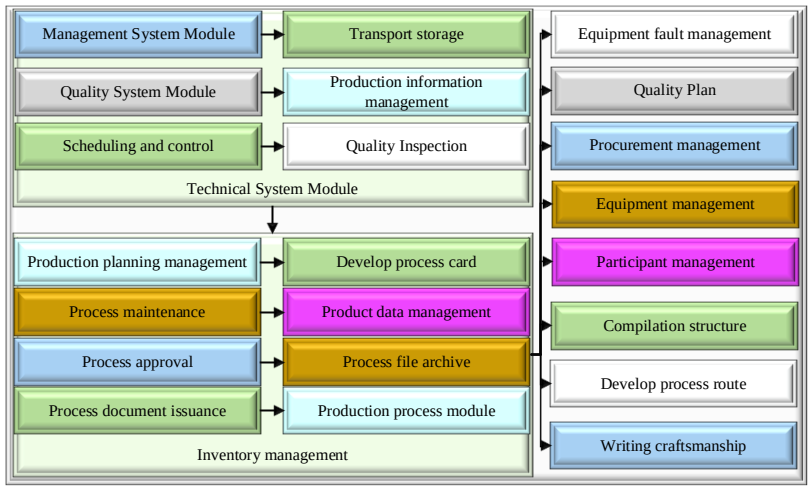

Figure 2: Overall system function design diagram.

According to the constructed system use case model, from the beginning of the product design to the completion of the manufacturing process, there are varying degrees of manual entry of information by each participant, and a large amount of this information is repeatedly entered. The root cause of this phenomenon is the lack of a standard information management system.

Therefore, Lean Process Production Information System is mainly to integrate product-process-manufacturing-workshop information in a unified system to complete the product production process. The integration of this information is also the integration of CAPP, MES, PDM, and ERP systems. The overall function of the integrated system is shown in Figure 2. This module is a general term for the application of computer systems by enterprises in the management field, usually with enterprise resource planning (ERP) as the core, with functions covering production planning, resource allocation, inventory, transportation, and procurement at all levels, and is a system in the form of operating production plans, material requirements plan, shop floor plans, and capacity requirements plans as the main body. The quality system module focuses on collecting, storing, processing, and evaluating quality-related information that exists in the design and production process so that quality can be detected and managed to ensure quality and further improve it.

3.2 Experimental Design of Pottery Products

Without relying on the influence and promotion of external factors, the idea of ceramic furnishings design is automatically or self-controlled to lead to the bionic concept design thinking, absorbing the innovation in the bionic concept for research and reflection. The bionic concept is an important way to promote scientific and technological innovation, and it is especially important to promote the original innovation of science and technology. Many of the breakthroughs and significant innovations at the frontier of various fields are innovative applications of the bionic concept and are closely related to it. The bionic concept is not a new science, but it is a field that human beings relentlessly pursue on the path of nature and science and technology innovation. Whether in the field of basic research or innovative technology, the driving and leading role of the bionic concept design thinking can be found. Paying high attention to and cultivating the bionic concept and cultivating the design thinking of ceramic furnishings based on the bionic concept can inspire designers to pay high attention to and actively explore the curiosity of the functions, characteristics, and laws of bionic models in nature, and then they can carry out more in-depth research and practical activities. Many of the bionic activities are initially guided by the design thinking of the bionic concept, in which people actively discover the functional characteristics of the model, then consciously think about the principles, and relate them to engineering problems, and finally design bionic products that can effectively solve engineering technology problems. This shows the influence of using the bionic concept on the design thinking of ceramic furnishings and the positive and efficient effect of enhancing original innovation and technological innovation, as shown in Figure 3.

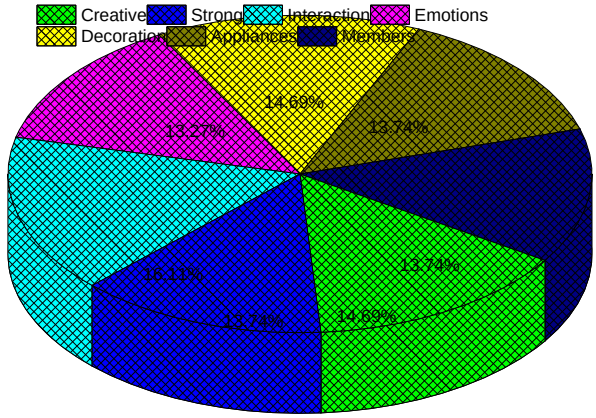

Figure 3: Propensity to demand ceramics.

The general principles include feasibility and functionality as well as artistry and technology. The principle of feasibility and functionality refers to the selection of feasible solutions for practice because not all furnishing designs can use bionic concepts or ceramic materials for practical activities; the principle of artistry and technology means that when conducting research on bionic ceramic furnishing design, the artistic properties of the product and whether the design solution can achieve the goal through existing science and technology need to be fully considered. The optimization principle refers to the optimization or optimization of all the parts that will effectively drive the whole design process, the optimization of the bionic model, the optimization of the bionic simulation, and finally the optimization of the bionic products. The ecological principle refers to the requirement to learn and imitate the operation mode and law of nature to create the design mode and method in the lowest consumption, the most economical, the most environmental protection, and the highest energy way, and apply the development mode of nature's sustainability to the development path of bionic ceramic furnishings design. The principle of naturalization elaborates on the choice of model, the aesthetics of order and the naturalization of texture effects, and the combination of the natural characteristics of the bionic concept and the naturalness of ceramic furnishings from each of these three aspects. The principle of digitization is the core principle of the bionic concept, and nowadays, with the increasing importance of high-tech 3d printing, ceramic furnishings can also be 3d printed, which is an important stage in the design of ceramic furnishings. These five principles are complementary and indispensable, and they are the basic principles that must be followed when researching bionic ceramic furnishing design, and they are also the basic principles that must be adhered to in the development of bionic ceramic furnishing design.

Whether it is the bionic concept, ceramics, or furnishings, which are in the field under the scope of aesthetics, all give people the enjoyment of beauty, to meet the needs of people's spiritual world and the product of the trust. Bionic ceramic furnishings as one of the language carriers in the design language, the design purpose is to add artistry to people's lives or to meet the aesthetic requirements of the people, different forms, colors, the texture will give consumers a different sense of experience. Different sizes, details, forms, etc. add to the design intention that the designer wants to express. Therefore, the design of the bionic ceramic furnishings studied in this topic rightfully possesses the principle of artistry, as shown in Figure 4.

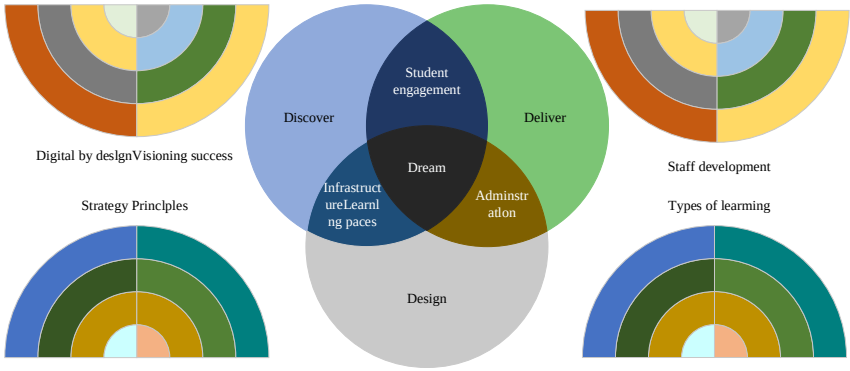

Figure 4: Artistic and technical principal requirements.

Different spaces require different types of bionic ceramic furnishings. In the public space means the need to meet the needs of different places, different types of people. Most public spaces have a larger space area, and the volume of bionic ceramic furnishings needs to be increased, such as large ceramic murals, large pot decorations, ceramic sculptures, etc. Private space is a space for people's daily life and rest, so the selection of bionic ceramic furnishings is needed to meet the personalized requirements of the owner of the private space and to meet its need to create the

space environment. Such as ceramic flowers, small vases, sculptures, ceramic prints, ceramic lamps, and so on. Office space is a space where people work for a long time every day, different industries and company atmosphere requires different application methods to bring comfort and natural feeling to employees as well as to customers to bring a reliable and secure impression as the main purpose, then the rich expression of bionic ceramic furnishings can meet this demand. Commercial space in the bionic ceramic furnishings need to highlight the product, with the product and the space environment, and the product to form an echo, cause consumers to enter the commercial space and the desire to buy goods.

4 ANALYSIS OF RESULTS

4.1 System Performance Results

XML documents are plain text files that can be created with an editor. Editors that can be used for XML document generation are plain text editors, visual editors, and structured editors. The parsing of documents is done by XML syntax parser, which first reads the XML document and then checks the completeness of the XML document contained therein, and if the document passes the test of the syntax parser, the program converts it into a tree-structured document composed of document elements. There are two standards for implementing XML document parsing: SAX, which is mainly used in cases where some elements need to be extracted from a document and memory is limited or there is not much information in the document, and DOM, which is mainly used in cases where the structure of the document needs to be understood in detail and the components of the document need to be moved more often and the information in the document is used several times. The latter is chosen here, as shown in Figure 5.

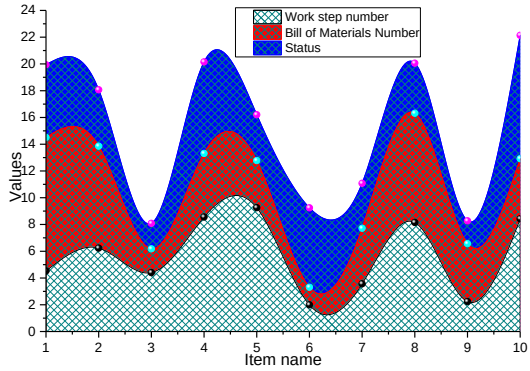

Figure 5: Work step material data.

Start the overhaul process in a simulated noisy environment, each entry overhaul results in 3 identification opportunities, if a successful identification will proceed to the next entry identification, if the identification fails, continue the identification of the entry until the 3 opportunities are used up. After each entry overhaul is completed, 3 times recognition results are recorded. After all the entries are tested, statistical data are counted and the recognition accuracy of the 3 times is averaged as the recognition accuracy of a single process, and the test results of a single process are shown in Figure 6.

The maximum standard deviation of ASR recognition accuracy in the noise-free environment is 0.87%, and the maximum standard deviation of ASR recognition accuracy in the simulated noise environment is 2.23%, indicating that the test data error is small and the model stability is good in the single process test.

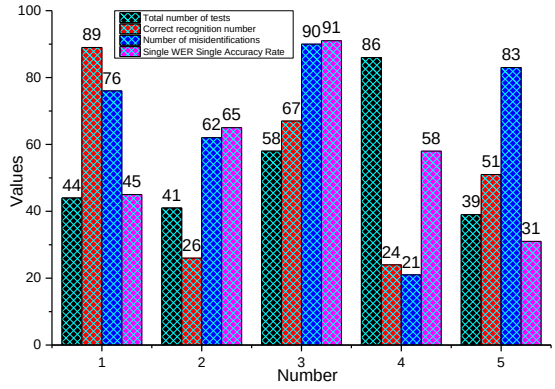

Figure 6: Single process test results.

Most of the results to be recognized by the inspection process are short phrases, which are slightly easier to recognize compared with long sentences. From the test results, the ASR recognition accuracy reaches 90.35% in the noise-free environment; it fully meets the system design requirements. In the simulated noise environment, although the system performance is reduced due to the strong noise interference and the high-frequency noise component superimposed on the speech signal spectrum, the extraction of speech feature parameters is affected, but the ASR recognition accuracy is still 81.56%, which can already meet the accuracy requirement under the noise.

4.2 Analysis of Experimental Results

To improve the firing stability of the 3D printed ceramic pieces different concentrations of silicate slurry can be used in different parts of the ceramic piece. A higher concentration of silicate slurry is used in the lower and middle parts of the ceramic piece to increase the density of the blank. This increases the strength and weight of the bottom part of the piece. The use of a thinner silicate slurry in the upper and middle parts of the ceramic piece reduces the weight of the upper part and thus improves the stability of the ceramic and the success of the firing, which also helps to reduce the overall weight of the ceramic piece. Based on the theoretical support of the above practical techniques, the ceramic digital model slices were imported into the ceramic 3D printer, and the data and parameters were adjusted and set according to the findings of the time exploration. Eventually, you can get a reasonable density distribution, the work of accurate modeling, clear surface texture of the ceramic three-dimensional printing works in the ceramic three-dimensional printer before starting to print to calibrate the printing platform to the horizontal state. If the printing platform is not in a horizontal state ceramic works in the printing to a certain height will be tilted or even collapse. Also, adjust the spacing between the clay print head and the printing platform within 3 mm-6 mm. If the error is large will directly affect the quality of ceramic artwork. After completing a series of adjustments, the ceramic artwork can be printed. The clay print head will automatically run to the starting point of the digital model in the print platform and start to extrude the clay to print the ceramic artwork, as shown in Figure 7.

At present, a ceramic three-dimensional printer in the production of ceramic modeling works requires a very demanding working environment, the temperature, humidity has strict requirements. In the printing of ceramic modeling works on the size of the work height、diameter also has a strict limit. Ceramic modeling works printed after the completion of its ceramic physical density is loose, texture and hardness are not high. These problems at this stage need ceramic printing silicate supplies, ceramic three-dimensional printer control systems for comprehensive improvement and innovation.

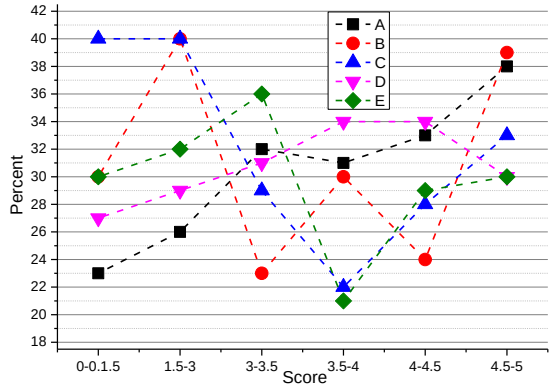

Figure 7: Experimental results.

At the national level has also introduced some support policies aimed at vigorously supporting the development of the field of incremental printing. Ceramic three-dimensional printer into the traditional ceramic modeling production and did not form a perfect, mature industrialization of the great development. The key is to solve how to make the ceramic 3D printer and ceramic 3D production software for more optimal, more efficient cooperation work. This makes the ceramic modeling products achieve the goal of high yield and high yield rate.

5 CONCLUSION

Through the study of the application of 3D printing technology in ceramic modeling design, it is argued that to the extent that science and technology have developed to today, 3D printing is represented as the most innovative emerging science and technology today. How the use of electronic computer programming software operation, how the different working principles and the operation of different types of printers to produce differently from the traditional style of digital processing of ceramic modeling design works. How to integrate the advanced ceramic 3D printer with the traditional ceramic modeling design to promote the innovation and development of the traditional production process. Today, science and technology, productivity, and rapid development of the public aesthetic level of artwork are undergoing huge changes. The introduction of a three-dimensional ceramic printer to the traditional ceramic modeling design to inject fresh blood, making it more contemporary. Ceramic three-dimensional printing is a new tool for ceramic designers is a powerful complement to traditional ceramic design, vigorously promote China's ceramic design to globalization. The perfect fusion of science and technology and traditional artisanship has brought a variety of artistic styles to the market, greatly expanding design ideas, and further narrowing the gap between the imagination and reality of ceramic modeling works.

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