

Research Article

Research on Innovative Thinking of Ceramic Art Design Based on Artificial Intelligence

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Ceramic product design is a method for creating the most functional, practical, and aesthetically pleasing product system out of ceramic materials. It is a conceptual, behavioral, and realization creative process. Design is a creative process, and designers' use of creative thinking is what gives them their power. Ceramic design, as a sort of design, cannot survive without creative thinking in the face of a continually changing market environment and market demands. The unique design of ceramic products is not only a critical component in its qualitative leap but also a requirement for ceramic products to achieve a competitive edge in sales. Artificial intelligence (AI) technology is now extensively employed in many industries, and designing ceramic products using AI technology as support is a new development route for the ceramic industry. This study explores the application of AI in the development of creative thinking in ceramic design, to provide theoretical support for related process optimization. Using AI, designers who play a key role in the development of ceramic product design can properly comprehend material characteristics, fully exploit technological boundaries, and recognize that technology can considerably encourage ceramic product design innovation.

1. Introduction

The rapid changes in design, limited time for the development of a product, costly raw materials, and nonavailability of an optimal model for designing new products are the basic issues in the ceramic industry. With the continuous development of society, new things are bound to replace the old things, and people must carry out self-mediation to awaken themselves to be liberated from the old enslavement [1]. The creative design of ceramic products will bring vitality to ceramic products, which is also an essential cause for ceramic products to get an edge in the harsh market competition [2]. With the improvement of people's living standards, ceramics are not only an instrument to meet people's life needs, but also an artistic product endowed with the spirit of the times and reflecting culture, personality, and emotion [3]. Therefore, innovative thinking has become the theme of ceramic product design. The ceramic design brings vitality to products. Once the innovative design of ceramic products is accepted by society, it is not only the decisive

factor for the leap of the value and quality of ceramic products but also an important condition for ceramic products to gain competitive advantages in sales [4]. Innovative design thinking can expand people's design thinking, inspire design inspiration, and make a ceramic product achieve the perfect combination of artistry and practicality in decoration, to promote the development of ceramic product design [5].

Today's ceramic product design has entered a new era of innovative design. The competition between products mainly lies in the design competition. Decoration design plays an increasingly important role. Innovation is the nourishment of product development [6]. In the theoretical sense, the study of innovative design thinking of ceramic product decoration is conducive to enhancing people's understanding of ceramic product design theory [7]. One of the most important tasks in ceramic design is how to improve the level of ceramic design [8]. The designer's knowledge structure and design level, design attitude, and existing technology level affect the innovation of ceramic

product decoration. With the maturity of technology, the integration of creative thinking and AI technology will bring great vitality to the development of the ceramic industry [9]. Digital products promote the combination of ceramic art and current development trends and have a profound impact on the industry [10]. Every kind of ceramic material product and spiritual product created by human society is the crystallization of creative thinking. It is precise because of people's full and continuous creation in practice that they can create the civilization of human society [11].

The birth of a new ceramic product begins with creative thinking. Creative thinking is the process through which people gather all types of relevant information, mix it, and process it using association, imagination, and inspiration in accordance with scientific thinking to come up with a fresh and original solution to a problem. Today's market rivalry is growing increasingly fierce, and only innovation can keep development [12]. The promotion of the social value of ceramic products is the prerequisite for the development of enterprises. The innovative thinking of ceramic product design should be implemented in the aspects of materials, modeling, decoration, function, etc., and the spirit of the times should be expressed with new design concepts so that the products have a distinctive style [13].

At present, AI technology is widely used in many fields. Using AI technology as support to design ceramic products is a new direction of the development of the ceramic industry [11]. AI will drive the reform of product design and development form and management. Nitin et al. [12] improved the quality and timeline of ceramic products using AI techniques such as artificial neural networks. To show the use of ceramic products, intelligence software module was developed. Sarah et al. [13] described a hybrid solution for the ceramic sector that combines fuzzy logic, neural networks, and algorithmic optimization. A prediction module was created combining two neural networks to estimate two quality parameters of slip cast components simultaneously. Using the neural network prediction module in the objective function, a process improvement method optimized controllable process settings. Sergio et al. [14] employed a predictive neural model to predict the quality of cast ceramic products using several inputs. Guo and Wu [15] investigated the use of the green design idea in contemporary ceramic design in the context of postindustrial social formation and ecological civilization, as well as providing important exploration for its development.

This study provides a theoretical and practical framework for the innovation and development of ceramic product design by researching creative thinking in ceramic product design under the background of AI. It is expected that it would lead to a breakthrough in the decorating of Chinese ceramic product design, as well as a more systematic and comprehensive design philosophy for Chinese ceramic products.

The rest of the paper is organized as follows: Section 2 provides an overview of the cognitive process of creating thinking in ceramic products designs. Section 3 highlights the importance of AI in creation of ceramic products. In Section 4, different results of the competitive neural network are presented and Section 5 is about the conclusion.

2. The Cognitive Process of Creative Thinking

The most basic feature of creative thinking is repeatability and creativity, which leads to new conclusions. Because logical and intuitive thinking types complement each other to make creative thinking, and intuitive thinking is the most essential aspect in producing the nonlogical portion of creativity, it is inferred that logical and intuitive thinking types complement each other. The cognitive and computational model of creative thinking is offered based on this viewpoint and the cognitive model of logic and intuition. In China, ceramics have a rich history and cultural significance. Ceramics are plastic products formed by mixing clay and stone silicate and then adding water. Not only is ceramic design the expression of material form but it also has aesthetic and functional characteristics [16].

Nowadays, although ceramic products can meet the needs of life, people are constantly developing new materials and making efforts to make ceramic products more diversified. The design elements of modern ceramic products include material technology and modeling, among which the dominant factor is the functional factor, which has decisive significance for materials and modeling. In the design of ceramic products, people's feelings about this decorative form are mainly through vision and touch [17]. Therefore, ceramic products' decorative interest is mainly discussed through decorative visual interest and touch interest. At present, China's building ceramics industry is at the forefront of ceramic material innovation. It has been proved that the ceramic tiles produced by combining ceramic materials with new optical materials are round and transparent in surface, clear in patterns, and changeable in a different light. In the process of ceramic product decoration innovation, the creator should not only have certain skills and artistic talents but also have certain cultural accomplishments. The artist's cultural accomplishment includes profound ideological accomplishment, artistic accomplishment, and extensive knowledge of natural science and social science. Moreover, it also requires the creator to study and practice diligently for a long time [18].

With the accumulation of people's experience in ceramic firing, ceramics have become the carrier of ideological expression and artistic creation, and because of the uncertainty in the production process, ceramics have a unique value in cultural heritage. People create a civilization to improve the living environment. Throughout the development history of international ceramic design, both modeling and decoration can reflect the characteristics of the times. Politics, culture, and economy in different periods have a significant impact on ceramic design, and the forms of expression in different periods are not the same. When people are engaged in some innovative work, they need the participation of creative thinking [19]. In many cases, the creative process can be refined into a logical process of reasoning or an intuitive process of production. The visual beauty of ceramic images lies in maintaining a harmonious relationship and showing aesthetic feeling to the public via the comprehensive use of various colors. Figure 1 shows the structure of image cognition.

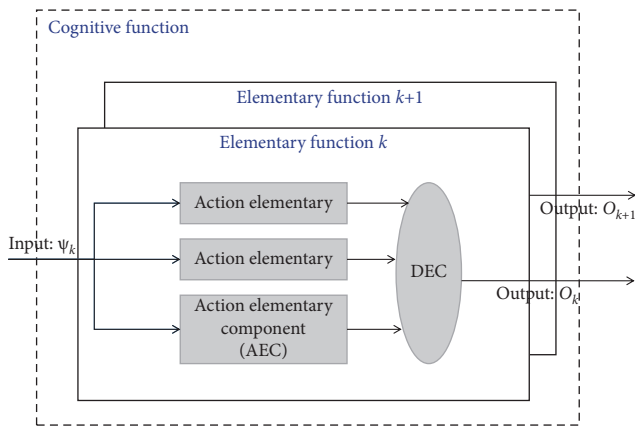


FIGURE 1: Image recognition structure system.

The function and aesthetic function of ceramic design are perfectly combined, and the importance of aesthetic requirements is becoming more and more prominent. It is an important consideration standard together with the function. Decoration technology is an important link in ceramic products, and its technological level directly affects the quality of products and people's safety and hygiene [20, 21]. The cycle of logic and intuition itself is a process of self-improvement, and fitness is used to reflect the goal to be achieved. After testing and multiple cycles, the result that meets the fitness condition is regarded as the final creative result. Excellent ceramic products are not only an art form but also a part of our cultural heritage and civilization. The generation of AI technology brings new vitality to ceramic technology and brings innovation to the bottleneck of ceramic cultural inheritance.

3. The Requirement of AI Technology in the Innovative Design of Ceramic Products

AI technology provides an open platform for ceramic products including scene design, multimedia post-processing, creative design, image design, and human-computer interaction. AI completes the work of network multimedia production, mass media, and artistic creation. Modern ceramic design is a part of industrial design. With the progress of the times, ceramic design is no longer a simple physical form but covers functionality, economy, aesthetics, and other contents caused by it, which contains profound social significance. The most fundamental method of design thinking, "whimsical," can best reflect the active degree of innovation. This requires breaking the inherent creative mode of things, boldly guessing and questioning, and showing the necessary critical spirit for the feasibility and necessity of design. The design of ceramic products is not only conceptual art but also an overall artistic style. Its design is embodied as a whole, and the quality of works mainly depends on the internal elements of the whole [22]. Modern ceramic products are craft products produced in batches by using ceramic raw

materials, most of which are for use; some products pursue aesthetic functions, while most products need to have two functions at the same time, seeking a balance between use and aesthetic functions [23].

The color, line, and shape of ceramic product decoration are the laws that are formed by a regular combination of materials. It mainly includes contrast and unity, rhythm and rhythm, and symmetry and balance. It is an abstract summary and experience summary of the law of formal beauty in the practice of beauty creation. In the combination law, the beauty of balance is mainly based on people's visual center or force center of gravity, and the decorative elements are adjusted and configured so that the whole decoration can achieve balance, which can enrich the shape and increase the taste of products. AI technology is important not just as a tool, but also for its aestheticization, creativity, and new conceptualization [22, 24].

AI has provided surging strength to the creative production, making the expression forms of artistic works advance towards a diverse route, via the absorption of a range of new technologies and new ideas, the integration of a variety of technical media, and the growth of ceramic art [25]. Only by using innovative design concepts to free things from traditional thinking can the artistry of ceramic products be embodied. The soul of design is the perpetual exploration of innovation, and the most important thought of designers is to design continuously with the assistance of innovation [26]. Figure 2 shows the internal structure design of porcelain bowl packaging in the sense of "secondary structure," and Figure 3 is a more traditional porcelain bowl packaging design.

In terms of physical art, the image of ceramic pieces is usually more prominent. It is mostly the aesthetic sensation of modeling that is expressed in the form of expressiveness. Therefore, modeling is the most important feature of ceramic art, mainly in the external form and structure as well as the style, which should pay attention to the embodiment of modern ceramic art design. Any art innovation, including modern ceramic art design, is inextricably linked to real-life observation and thought, as well as the mapping and representation of the periods' culture. Ceramic items as a simple everyday necessity have been superseded by various lighter and new synthetic materials in the material-rich information age. Today's ceramic art designers should actively understand the needs of modern people, start from the modern lifestyle, and then carry out bold innovation according to the aesthetic of modern people [27]. The traditional style decoration has laid a solid foundation for the development of modern ceramic art. The creators should combine modern technology techniques to create works of different styles by using different colors and shaping different shapes. Traditional ceramic works are mainly created according to the needs of productivity and aesthetics of the times [28]. Under the background of different times, people's lifestyles are different. Designers avoid overcorrection and enrich the artistry of traditional ceramics based on retaining the use-value of traditional ceramics.

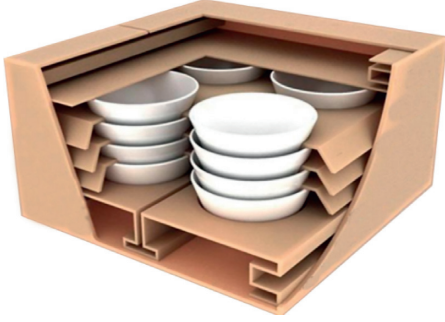


FIGURE 2: The internal structure design of porcelain bowl packaging in the sense of “secondary structure.”



FIGURE 3: Traditional packaging design.

4. Research on Innovative Methods in Ceramic Product Design

4.1. Multimode Comprehensive Application to Expand Creative Thinking Space. Ceramic product design is influenced by market needs. It is vital to thoroughly examine market demand and determine its substance. Some requirements can be addressed directly, while others must be met more indirectly. Generally, the formation of an ideal ceramic design scheme or the proposal of a solution to a problem is often the result of people’s creative thinking activities. Recently, with the improvement of life quality, a group of daily-use porcelain designers have emerged, whose products are innovative and have a strong sense of form. Creative thinking is to combine different related factors to produce new thinking methods and patterns and form horizontal and vertical patterns on the theme based on a large amount of knowledge in the designer’s mind. The connected design branch can also be called the highly unified theme, which makes the most representative design image appear constantly in the design and runs through the design as the core, which reflects the high degree of order beauty and all-around visual display.

Creating ceramic products entails the creation of new functionality. Ceramic design’s function and usefulness may suit not only the demands of usage but also the needs of people. The technological preparation process of pottery samples is shown in Figure 4. It is impossible to separate human beings from animals, with the positive and active creative thoughts of human beings; only animals and plants

in the biological world are adapting to the evolution of nature. Through virtual reality technology, the manufacturing process of ceramics can be reproduced, and a complete manual ceramic manufacturing process can be provided. Using 3D technology for virtual creation, we can contact the raw materials and complete the production according to the real process. In the virtual immersion environment, we can use the required materials and tools to perform various operations. In this environment, people can give full play to their subjective initiative and provide a good creative atmosphere on the scene, which can drive the creators to inspire and generate creative emotions [29]. Designers should experience it from the user’s point of view and then analyze it from the designer’s point of view to determine its feasibility. Ceramic design’s practical usefulness is coupled with its aesthetic function, and the aesthetic necessity is no more an afterthought in terms of ceramic design performance, but it rather has the same position as function. The essence of ceramic design cannot be simply considered as transforming technology into ceramic products, but ceramic products constitute humanized nature [30].

The user preference of each product category can be calculated according to the data and the evaluation information of users as given in

$$PC_{u,j} = \frac{\sum_{i \in I_u} PI_{u,i} \times \mu_j(x_i)}{\sum_{i \in I_u} \mu_j(x_i)}, \quad j = 1, 2, 3, \dots, \quad (1)$$

where $PC_{u,j}$ represents user u ’s preference value for category, $PI_{u,i}$ shows the user u ’s rating value of product i , I_u represents the product set that user u has evaluated, and $\mu_j(x_i)$ represents the degree of membership of product i to category j .

In this study, the composition, microstructure, and sintering process of ceramic materials are designed and determined according to the requirements of service properties or mechanical properties of ceramic materials. As shown in Table 1, there are 10 sets of experimental data between components and resistivity and flexural strength.

Under the condition that the test set is unchanged, the classification accuracy can be improved by appropriately increasing the data amount in the training set. Figure 5 is an accurate scale curve of three experimental datasets.

In the process of heat storage, the change curves of liquid phase volume fraction and point temperature were simulated and compared with the experimental results. The change of liquid phase volume fraction of heat storage material is shown in Figure 6.

Modern ceramic art should not only innovate in terms of modeling but also absorb and sublimate the essence of traditional ceramic art materials abundant in today’s world. Practicality and beauty should be thoroughly considered while creating ceramics to make visitors feel welcome. Modeling is one of the most important aesthetic features of ceramic art, which is the structural style of all external beauty and the essence of the modern ceramic art design. Successful ceramic works of art should have the power to move people’s

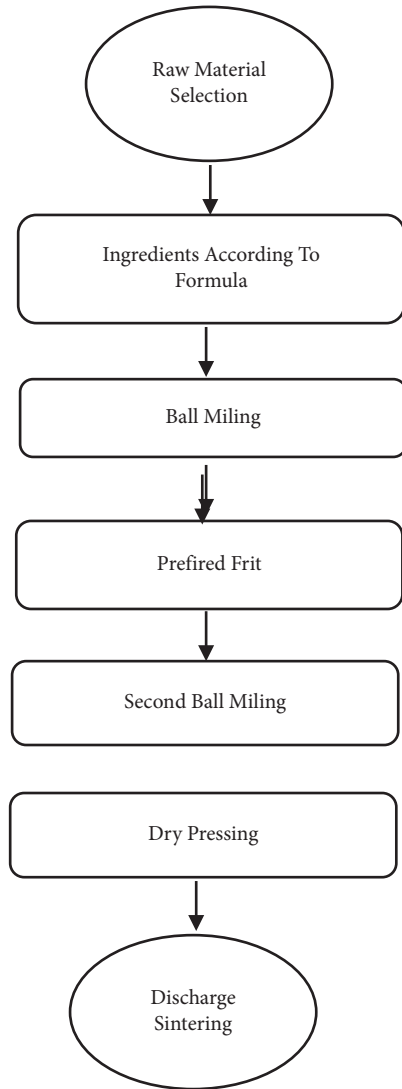


FIGURE 4: Process flow of dielectric material preparation.

hearts, to dig out the deep meaning contained in the works [31]. Ceramic art designers now work on the beauty of historic implications, perform a good task of invention and progress, and fulfill people's aesthetic demands based on modern aesthetic and spiritual needs. In the design of modern ceramics, the patterns are bolder, mainly showing modern thoughts and concepts, and paying attention to reflecting modern lifestyles. These contents should be fully expressed and displayed in the works, and diversified development should be pursued to make the works more emotional and individual.

4.2. Application of AI Technology in Ceramic Product Design.

Ceramic products are almost everywhere in our life. People have to touch, use, and feel them every day. The usage function is crucial for ceramic goods that combine appreciation and its application. For the functional utility of ceramic design, not only the simplest use requirements must be met, but also the field of ceramic functional design must be open to seeking the form that conforms to the

functional utility and then constantly put forward the improvement requirements in the use process, to gradually improve the functional utility of ceramic modeling [32]. With the continuous development of society, the change and renewal of ideas cannot suddenly appear. Without a starting point, it must depend on the foundation of national traditional culture. Therefore, designers can only innovate and change constantly according to the experience and foundation left by their ancestors, and at the same time, they should constantly introduce modern advanced concepts.

The classic ceramic-making method is rather straightforward. The process of finishing a job is usually difficult, and the design plan must be updated several times before it can be chosen. A variety of shapes can be designed by computer, and the texture and color used in design ideas and materials can be truly expressed by AI technology in the later stage, which can obtain higher visual quality and artistic appeal. Figure 7 is a schematic diagram of the plasma treatment of ceramic materials.

Any artistic progress is a stable process. The ability of Chinese modern ceramic art designers to deconstruct traditional ceramic art models using current design language and material technology is their biggest asset. As one of the important aesthetic features in ceramic art, modeling has become the focus of modern ceramic art design. When carrying out essential innovation, modern ceramic art can promote the development of innovation. Modern ceramic materials are also very important basic elements. Different materials can show different aesthetic feelings. Good ceramic materials can bring some inspiration to designers and arouse the enthusiasm of creators. Breaking through traditional thinking is a feasible innovative way, but blindly pursuing "antitradition" may also go to the other extreme without foundation. In the era of new technology and new technology, computers and networks are used to capture creative inspiration, analyze presentation effects, and inject three-dimensional technical support for innovative design. Modern ceramic art designers should actively understand modern people's spiritual needs and aesthetic consciousness, proceed from the modern lifestyle and then make bold creations and designs according to the above comprehensive information.

To model the modern ceramic art design we employed a competitive neural network. Choosing the correct learning rate is very important for the convergence of competitive neural networks. We employed a learning rate of 0.1. The output layer unit error is computed as

$$dF_r = \tau b dx. \quad (2)$$

Samples are sent to the hidden layer unit through connection weights, and a new activation value of the hidden layer unit is generated:

$$dF_r = 2b \int_0^L \tau dx. \quad (3)$$

The quantitative phase analysis using the crystal structure refinement method is performed as shown in

TABLE 1: Relationship between components and performance.

Group number	Resistivity ($\mu\Omega\cdot m$)	Refraction intensity (MPa)
1	40.3	28.5
2	39.6	23.1
3	41.9	24.6
4	40.7	26.9
5	43.6	29.7
6	38.2	34.4
7	45.9	42.3
8	43.6	36.6
9	39.9	33.7
10	47.4	26.0

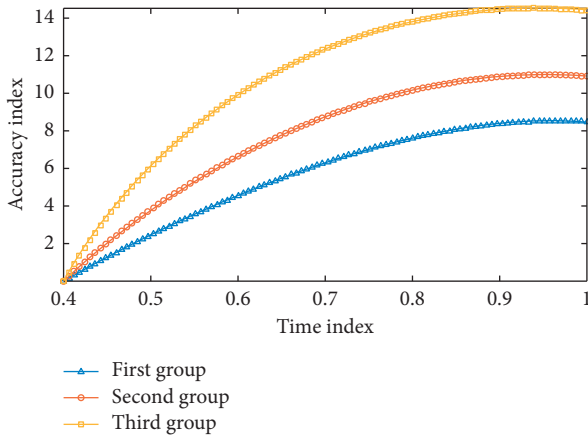


FIGURE 5: Changes in the accuracy of experimental data.

$$F_r = (A_c + W \tan \varphi) \left[1 - \frac{K}{iK} (1 - e^{(iL/k)}) \right]. \quad (4)$$

After optimization, the hidden layer structure of three neurons was selected. After 5246 training, the total error was 0.3%. After training the network is used to predict the experimental test data. The network is also evaluated with the data not included in the training set. The comparison results of the learning values of flexural strength and resistivity with the experimental values are shown in Tables 2 and 3, respectively.

The liquid phase volume fraction change curve and point temperature change curve in the heat storage process are simulated and compared with the experimental results. The comparison results are shown in Figure 8.

Figure 9 shows the relationship between the size of model characteristics and the discrimination results obtained from two sets of experiments of the same batch of samples.

Because of the complexity of the pattern and the change in glaze color, the technical requirements for workers in the production of traditional ceramic products are higher. The same pattern is produced by different artists, and its effect is also different. Imagination plays an important role in divergent thinking. Only under our excellent imagination can we try our best to break through the limitations of the existing thinking framework and find the connections between things in many aspects, to find more and better

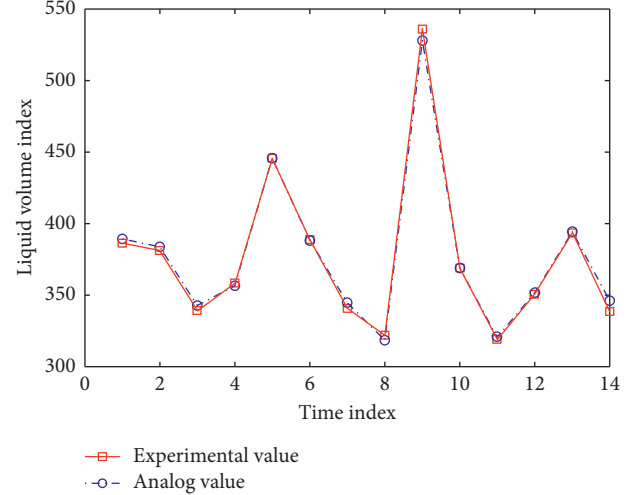


FIGURE 6: Changes in liquid phase volume fraction of heat storage materials.

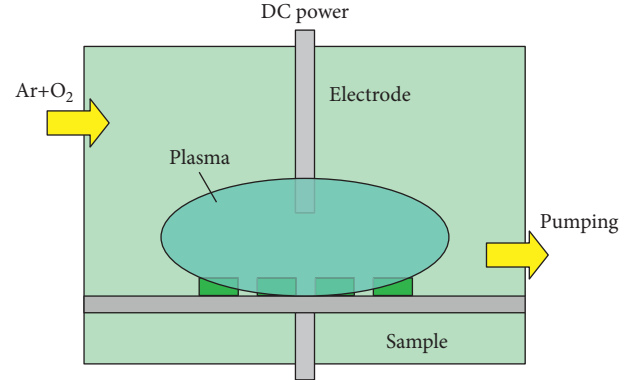


FIGURE 7: Principle of plasma treatment of ceramic materials.

TABLE 2: Comparison of experimental and predicted values of flexural strength.

Group number	Experimental value	Predictive value
1	30.7	31.9
2	42.7	45.3
3	44.9	46.2

solutions to problems. Unlike divergent thinking, convergent thinking develops thinking in all directions. It conducts ordered and systematic thought and finds the best and practical solution to the difficulties when the ideas of the problems to be solved have been clarified. In the life experience accumulated over a long period, people constantly use various methods to make ceramic products more convenient and more in line with the needs of life, and its changes and updates are reflected with the changes in people's lifestyles. Designers should not only use and experience as a consumer but also recognize it in theory as a designer and find out feasible modification schemes. The design of functional utility of ceramic products cannot be taken for granted, nor can it be based on traditional habits,

TABLE 3: Comparison of experimental and predicted resistivity values.

Group number	Experimental value	Predictive value
1	42.72	45.12
2	44.94	47.38
3	30.75	31.88

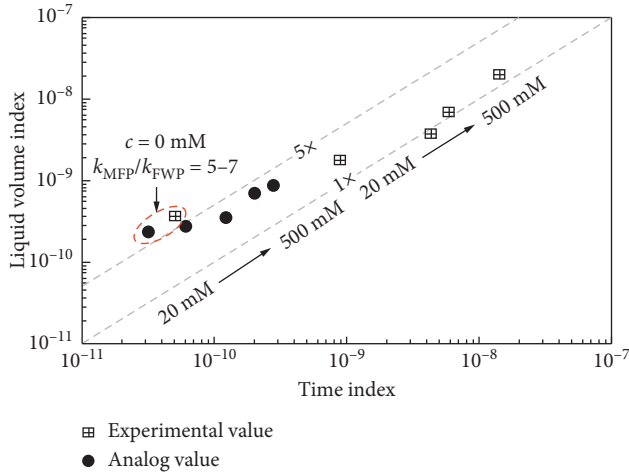


FIGURE 8: Changes in liquid phase volume fraction of heat storage materials.

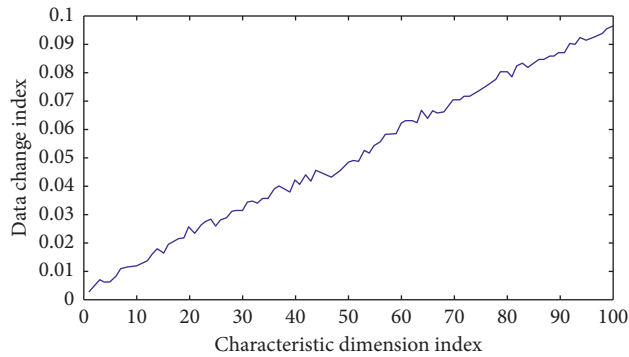


FIGURE 9: Data changes based on the construction of mechanical model information construction pattern.

but should be based on modern lifestyles and habits and study and solve this problem with scientific methods.

5. Conclusions

As an example of the intangible cultural heritage inherited from Chinese traditional culture, ceramics can not only meet people’s living needs but also have aesthetic value. Ceramics design that lacks inventive thought will lead to the industry’s stagnation. The innovative design of ceramic products requires designers to understand the innovative significance of design from a new perspective. The design of ceramic products should have advanced consciousness and dare to challenge traditional ideas. This study investigates the application of AI in the development of creative thinking in ceramic design, to provide theoretical support for related

process optimization. This study suggests that designers who play a key role in the development of ceramic product design should properly comprehend material characteristics, fully exploit technological boundaries, and recognize that technology can considerably encourage ceramic product design innovation. Moreover, designers should not only apply their knowledge and experience as consumers but also identify it in principle as a designer and devise practical alteration strategies. Ceramic product design should stay up with the changes and continually bring out new ideas since innovation is a topic that never fades away.

Data Availability

The data used to support the findings of this study are included in the article.

Conflicts of Interest

The authors declare no conflicts of interest.

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