

Advantages and Methods of Product Innovation Design in the Context of 3D Printing Technology

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ABSTRACT

On the basis of analyzing the characteristics, principles and advantages of 3D printing technology, this paper expounds the three major roles of 3D printing technology in product innovation design, proposes that 3D printing technology has four advantages in product innovation design, including speeding up product design process, accelerating product design cycle, reducing creative design cost, and realizing product personalized design, and summarizes into two design methods of product structure innovation and product modeling innovation based on 3D printing, in order to achieve the purpose of reducing costs and shortening the product launching cycle.

Keywords: 3D printing technology, Product innovation design, Advantages and methods.

1. INTRODUCTION

For product innovation design, structure and modeling are important component elements and the external manifestation of the product. Through structure and modeling, consumers often have a certain emotional experience, which can meet the psychological and emotional needs of consumers, playing an important role and value [1]. When designing innovative products, designers can design various complex structures and modelings with the help of 3D printing technology and the production cycle is short and the operation is convenient. At the same time, 3D printing technology is an advanced manufacturing technology, which belongs to additive manufacturing and is a manufacturing method that can maximize the use of raw materials, which can meet people's diverse and customized product needs, providing new tools and methods for product innovation design and giving designers inspiration and creativity.

2. 3D PRINTING TECHNOLOGY OVERVIEW

2.1 Concept and Characteristics of 3D Printing Technology

3D printing technology refers to the technology of applying special forms of raw materials (such as powdered metal or filamentary plastics) on the basis of CAD software design to form physical products by accumulating raw materials layer by layer, so it is also called additive manufacturing technology [2]. Compared with the traditional product manufacturing technology (cutting excess material), 3D printing technology is a "bottom-up" method of manufacturing products, which doesn't require the application of traditional cutters, planers and multi-processing procedures and has obvious advantages. The differences between the two are shown in "Figure 1". Meanwhile, compared with other manufacturing technologies, 3D printing has the characteristics of digital manufacturing, layered manufacturing, stacking manufacturing, direct manufacturing and rapid manufacturing, and is suitable for rapid printing of products with complex structures and personalized customization of products [3].

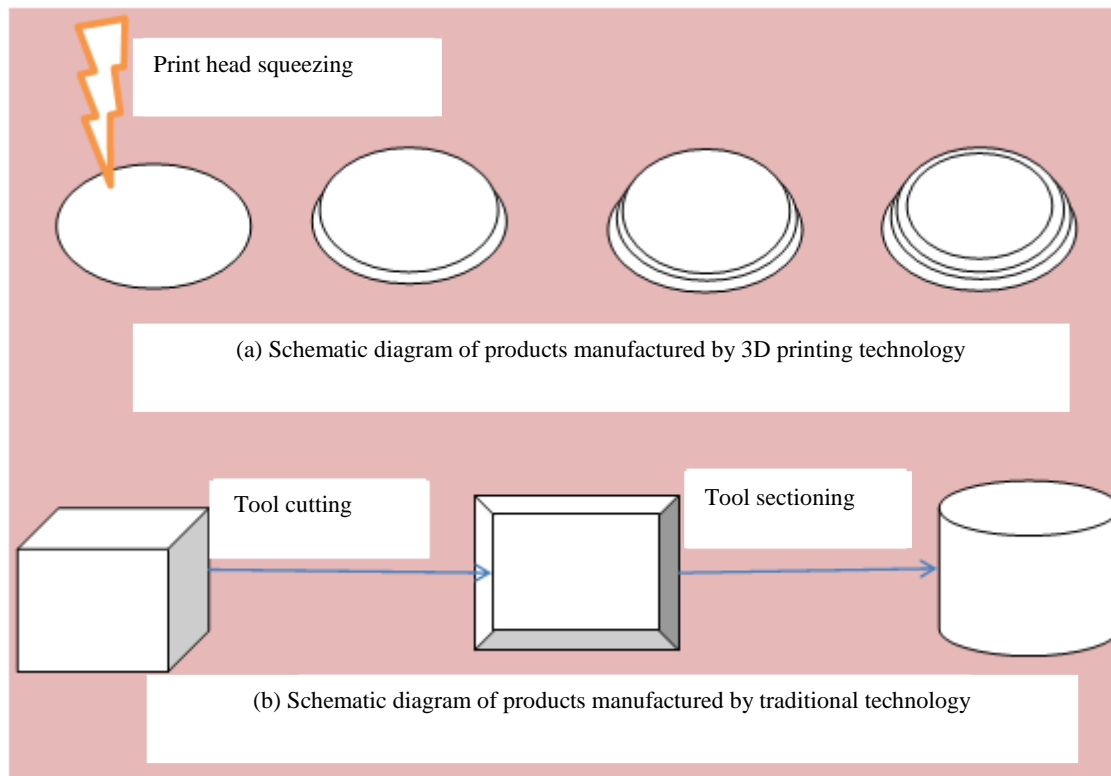


Figure 1 Comparison of 3D printing technology and traditional manufacturing technology.

2.2 The Principle of 3D Printing Technology

3D printing technology is based on the principles of discreteness and accumulation, and its product molding process is as follows [4].

First, the designer uses CAD software to draw a 3D model of the product or part in the computer and then triangulates the surface of the model to form an STL file. Second, the 3D printer sections the 3D model according to a certain thickness according to the process requirements, obtains the 2D plane geometric information (section outline information, including movement and filling paths), and generates numerical control codes after certain data processing. Third, under the control of the 3D printer software system, the print head processes in order according to the numerical control codes, and the section outlines of the product are obtained, which are gradually superimposed, and finally a 3D product is formed. Finally, after obtaining 3D products, it is necessary to carry out subsequent processing on these prototype products, such as polishing, coloring, etc., to make the products more beautiful and elegant.

2.3 Advantages of 3D Printing Technology

In 2013, 3D printing technology was included as one of the 12 disruptive technologies that will determine the future economy, which plays a major role in the upgrading and development of China's manufacturing industry, can not only quickly realize product innovation and manufacturing and speed up product development, but also reduce product manufacturing costs, providing opportunities for small and medium-sized manufacturing industries [5]. 3D printing technology is a supplement and extension to the traditional manufacturing industry, can manufacture products with complex shapes and small batches, gets rid of the shackles of traditional manufacturing, and plays a role in adjusting the structure of the manufacturing industry. At the same time, 3D printing technology can meet the individual needs of consumers, maximize the functions of materials and structures and create diversified and personalized products, with a strong market potential. In addition, with the emergence of Internet technology and network platforms, personalized orders and maker designs continue to emerge with a huge demand for 3D printing manufactured products, and a new production organization model has gradually formed,

providing enterprises with infinite business opportunities.

3. THE ROLE OF 3D PRINTING IN PRODUCT INNOVATION

3.1 Breaking Through the Technical Difficulties of Product Innovation

3D printing technology applies the unique molding methods of layered manufacturing and additive manufacturing, making it possible to form integrated product modeling, breaking through the technical difficulties of product molding. To begin with, products with complex modelings or nested structures can skip the processes of mold opening, processing, and assembly, and can be directly printed and molded by 3D printers, which is free from the limitations of traditional manufacturing processes. In the meantime, for designers, their creative thinking will not be limited by external factors, and they can design innovative products with more beautiful and diverse modelings, providing them with a broad space for creation. Next, in terms of production equipment, traditional product design needs to use a lot of large-scale industrial equipment, and once these equipment parts are damaged, it is necessary to find relevant parts, which is more difficult to replace. And the 3D printing technology can accurately print the required large equipment parts according to the actual size, and quickly obtain replaceable and size-matched parts to ensure the smooth progress of product manufacturing.

3.2 Embodying the "User-centered" Design Idea

One of the characteristics of 3D printing technology is to customize products according to people's requirements and characteristics to achieve personalized design, which undoubtedly reflects the user-centered idea. In the pursuit of personalization today, consumers undoubtedly have their own strong styles and characteristics and they need different product characteristics and styles. However, in traditional product design, the biggest feature is batch production. Therefore, users' demand for personalized design and customized design has gradually increased, which has become the core of competition in the design industry. 3D printing technology can print customized products with complex structures, unique colors, and human-machine matching, highlighting personalized design, which can well meet the needs of

consumers and play an irreplaceable role in product innovation design.

3.3 Cultivating Product Innovation Design Talents

With the maturity and development of 3D printing technology, the Maker Movement has developed rapidly, and everyone can become a product innovation designer. Designers are the key and soul of product innovation, and it is precisely because of designers' ideas that new products can be created. 3D printing technology provides a fertile ground for product innovation design talents to grow and can better develop the imagination and thinking of design talents, which deeply affects product innovation in product design, production and other links, breaks through the traditional product design mode, breaks through various related technical difficulties and at the same time ensures an endless stream of "Maker" talents, effectively improving the ability of product innovation design.

4. THE ADVANTAGES OF 3D PRINTING TECHNOLOGY IN PRODUCT INNOVATION

The emergence of 3D printing technology has injected new vitality into product design, bringing new design patterns and design methods. Designers can save the steps of communicating with structural engineers and modeling makers, and directly print innovative products without worrying about the cost of product design, shortening the product design cycle with significant advantages, as shown in "Figure 2".

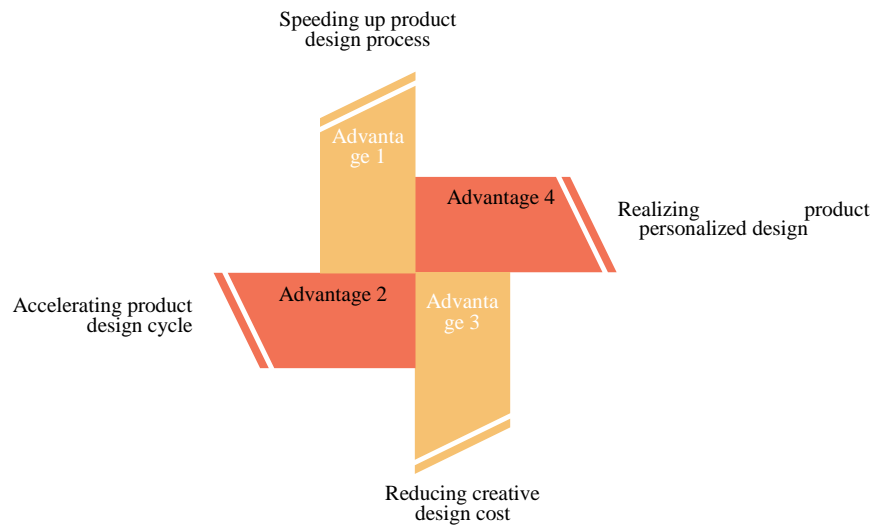


Figure 2 The advantages of 3D printing technology in product research and development.

4.1 Speeding Up Product Design Process

In the creative design process, designers can use 3D printing technology as an auxiliary tool and support technology for design, quickly convert flat graphics into 3D graphics, and feel the feasibility of the design scheme more intuitively. If it is feasible, 3D printing technology can be quickly applied to print and the produced product model can be analyzed; if not, the design scheme can be adjusted in time, so as to better improve and optimize the design scheme and avoid the risk of product development. In the model making process, designers can use 3D printing technology to quickly make product models. The error between the printed product model and the digital model is only a few millimeters, which can accurately achieve the designers' intentions. Therefore, the application of 3D printing technology to make product models can avoid various problems caused by poor communication, effectively reduce the risk factor, and avoid the limitations and disadvantages of traditional design models, speeding up the product design process.

4.2 Accelerating Product Design Cycle

The solid model printed by 3D printing technology has the characteristics of speed, accuracy and rapidity, and 3D printing technology can print any complex modelings. In the whole cycle of product design, it is only necessary to convert the digital 3D model of the product into an STL file, and then the formed product can be

printed without going through many processes of product design, which can effectively shorten the product design cycle and enter the long tail era of product management.

4.3 Reducing Creative Design Cost

3D printing technology can realize the designer's creative thinking in a short period of time, so that the designer's design intention can be accurately displayed, and the printed products can achieve any complex modelings, which broadens the designer's imagination space. At the same time, in product innovation design, the consumption of raw materials required by 3D printing products is relatively much less, only about one-tenth of traditional manufacturing, and no molds are required to complete production injection molding, which virtually reduces the cost of product research and development. Not only that, 3D printing technology can realize long-distance transmission, transmit 3D model files of products through the Internet, and realize remote transmission and printing, which invisibly reduces transportation costs and reduces the waste of social resources.

4.4 Realizing Product Personalized Design

Influenced by traditional manufacturing technologies, most products are produced in batch production, which is difficult to meet product differentiation and individual design requirements. In batch production, the products purchased by consumers are all of the same modeling, process, and material, so it is difficult to achieve

personalized product design. 3D printing can print the curved surface shape of complex structure, which can effectively enrich the modeling design of products, provide users with more choices, and meet the personalized requirements of users. In 3D printing technology, 3D printing technology software can be used to design more personalized products, namely, related products can be printed according to consumers' preferences and needs to meet the different needs of consumers.

5. PRODUCT INNOVATION DESIGN METHODS BASED ON 3D PRINTING

5.1 Application of 3D Printing in Product Structure Innovation

The application of 3D printing technology can innovate the structural design of products, print products with more complex structures, and at the same time broaden the structural types of products. The innovative application of its product structure is mainly manifested in the following two aspects.

5.1.1 Optimizing Product Structure

For a long time, the optimization of product structure has relied on the communication and cooperation between product designers and engineering designers, and the integration of product structure and design can't be realized. In traditional product manufacturing, product design and product manufacturing belong to different departments, with clear distinctions, and it is impossible to achieve free communication between the digital world and the physical world. But the application of 3D printing technology can scientifically and rationally optimize the product structure while satisfying the designer's design ideas. When designing the product structure, designers can apply 3D printing technology to optimize the product structure, and from the perspectives of saving materials, improving strength, and improving stability, apply relevant modeling software and computer-aided tools to achieve reasonable optimization of product structure. Taking the butterfly structure as an example, the application of 3D printing technology can adopt a material-saving structure, such as a hollow structure, to reasonably design the butterfly wings to make them more beautiful and save materials effectively at the same time.

5.1.2 Printing Different Product Structures

Taking the butterfly-shaped structure as an example, in the traditional product manufacturing technology, there are only simple geometric shapes, and only the simplest geometric structure can be formed by combining and splicing these geometric shapes. Once the product has a more complex curved surface structure, the traditional manufacturing technology is somewhat overwhelmed. Butterfly structure design needs to use a variety of different types of curved surface structures, but traditional manufacturing technology is powerless, can't produce on a large scale and in large quantities, and can only polish manually, which is very labor-intensive and time-consuming. In 3D printing software, there are a variety of curved surface structures, complex internal flow passages, etc., and designers can use these structures to assemble into a unique structure and then print it out through a 3D printer, which is very convenient. Besides, structures with internal hollows can be printed by 3D printing technology, which are special structures that can't be achieved by traditional manufacturing methods. Based on 3D printing technology, designers can design products with complex structures, therefore, 3D printing technology is an indispensable tool for product structure design.

5.2 Application of 3D Printing in Product Modeling Innovation

Before the emergence of 3D printing technology, product design followed the concept of batch design and production, which had its own unique advantages with high production efficiency, high degree of automation, and low production cost. However, this batch production method is somewhat deficient in materials, equipment, shapes, etc., and gains market competitiveness at the expense of product diversification. The products produced in this way tend to be homogenized, the shape of the product parts is relatively single, and the material utilization rate is relatively low, which has certain limitations.

5.2.1 Breaking the Bottleneck of Traditional Product Modeling

At present, 3D printing technology has been widely used in art design, aerospace, medical treatment and other fields, and has gradually become an important technical support for

innovation and practice [6]. At the same time, major colleges and universities are actively bringing 3D printing technology to the classroom, teaching students the relevant knowledge of 3D printing technology, and encouraging students to explore and develop 3D printing technology to meet social needs. The bottleneck of product design is gradually broken, and designers can give full play to their imagination in digital design, create and improve product modelings with unique characteristics, and print design models in various forms. For example, designers can apply 3D printing technology to print various innovative product shapes, such as octopus-shaped pen holders, butterfly-shaped ornaments, plant-shaped handicrafts, etc., and easily create product modelings that can't be produced by traditional technologies.

5.2.2 *Providing Technologies and Tools for Product Modeling Design*

With the continuous maturity and development of 3D printing technology, it has had a subversive impact on the traditional production industry, changing the simple and conventional geometric forms and one-stop production methods in the past, adding design methods similar to natural forms, providing technologies and means for product modeling innovation, and making product modeling more beautiful and harmonious, which is of epoch-making significance. In recent years, many designers have applied 3D printing technology to go beyond the original design ideas, boldly innovate, and take personalized design as the core to push product modeling innovation to a new climax. Whether it is 3D printing modeling software or 3D printing equipment, it provides new tools and technologies for the innovative design of product modeling. Designers use these tools to carry out innovative design of product modeling, which greatly enriches the modeling of product design and plays an important role in product innovation and development.

6. CONCLUSION

With the continuous maturity of 3D printing technology, especially in the context of its increasingly significant role and advantages in product innovation design, designers should make full use of the technical advantages of 3D printing in product modeling and structure, speed up product research and development, realize rapid innovative manufacturing of products, and satisfy

the individualized and customized emotional needs of consumers while better realizing design ideas.

AUTHORS' CONTRIBUTIONS

This paper is independently completed by Xinghe Wang.

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