

# Research on parametric design of wine bottle modeling based on Grasshopper

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**Abstract.** This paper combs the function, shape, process and material of the existing wine bottles on the market, analyzes and summarizes the characteristics of the existing wine bottles. It explores the application scenarios and methods of parametric design in the design of wine bottles. By summarizing the concept and characteristics of parametric design, parametric modeling technology and the design process of wine bottles, it presents the modeling process of wine bottle design with Grasshopper, and verifies the effectiveness of the design process by using the Grasshopper parametric platform to build models for practical product cases.

**Keywords:** Grasshopper; Wine bottle modeling; Parametric design;

## 1 Introduction

Wine bottle is a kind of container for wine, which integrates wine history, wine art, pottery, archaeology, painting, calligraphy, sculpture, folklore, etiquette, etc., comprehensively reflecting the connotation of long-standing wine culture, and is an important manifestation of wine culture [1]. Different classifications can be made according to materials, types and uses. According to materials, they can be divided into ceramics, glass, metal and plastic, etc. With the progress of science and technology, the materials of wine bottles are also constantly developing. The recent emergence of light environmental protection materials, conforming materials and intelligent induction materials has enriched the diversity of wine bottle materials. Wine bottles can be divided into small bottles, medium bottles and large bottles according to capacity, and different bottles should be designed reasonably. According to the varieties of wine, they can be divided into white wine bottles, red wine bottles, beer bottles, foreign wine bottles, fruit wine bottles, rice wine bottles, etc. According to uses, they can be divided into wine for general occasions and theme wine [2]. According to different market orientations, the design trend of wine bottles should also be positioned accordingly. Shi Xiaoxia mentioned in the wine bottle design under the consumption upgrade that youth is a big trend of wine bottle design, and the innovation of wine bottle design should be guided by the target consumer groups, pay attention to what consumer groups like, what consumption modes and lifestyles they pursue, and impress them with appropriate designs [3]. As we are familiar with the liquor brand Jiang Xiaobai, it has always adhered to the concept of "I am Jiang Xiaobai, life is simple" and the design of youth simplicity, which has won the recognition of a large number of young consumers. It also continues to build the brand IP of "I am Jiang Xiaobai" to interact and communicate with young people. In order to adapt to the fast-paced life of the new era,

many brands have adopted small bottles with reduced capacity, leading the new trend of small wine consumption[4]. Generally, the capacity of wine is 500 ml, 600 ml, 750 ml, and it is difficult to drink it all at once after opening. Xiaolang wine is one of the series of wines launched by Sichuan Lang Wine Group. This "national hot-selling small bottle liquor" has been precisely positioned as "just two dollars a bottle", conveying the unique advantages of the product to consumers. In the continuation of the traditional wine culture, Chinese people pay attention to the "name", so the design should also have a theme, which has more rich significance. For example, annual meeting, wedding, birthday banquet, full moon, these are all wine-related themes [5]. In 2018, Wuliangye cooperated with the crystal brand Swarovski, with "love" as the theme, and launched the Yuanding crystal series of high-end wedding banquet wines. There are two versions, the Yuanding crystal ring version and the Yuanding crystal swan version, with the capacity of 500 ml and 520 ml respectively. Liquor enterprises generally have a large category system, and even there are sub-brands under a single category. From the perspective of brand strategic planning, the bottle design is a good way to achieve multiple benefits. According to the market trend and consumers' potential requirements, the serialized design can adopt the method of development and variation to accelerate the development of new designs at a lower cost. It can be seen that in order to occupy a better market, enterprises not only make efforts in marketing, packaging design and other aspects, deeply dig target customers, improve user experience, but also pay attention to the uniqueness and personalized customization of bottle design. The emergence of 3D printing and parametric design makes the design and customization of bottle modeling become simpler.

## **2 Analysis and Design Exploration of Wine Bottle's Shape**

### **2.1 Analysis of existing wine bottle shape**

Wine bottle design is important in capturing consumers' attention[6]. The common shapes of wine bottles on the market mainly include round bottles, square bottles, flat bottles, and shaped bottles, etc. Among them, round bottles, square bottles, and flat bottles are mostly symmetrical. These basic bottles can be extended to many similar bottles after appropriate deformation. For example, round bottles can be conical, round table, round sphere, and round drum after changes in diameter, height, and proportion. Compared with conventional wine bottles, the shape of shaped bottles is more special, which is manifested in bionic, imitation scenic spots and historic sites, imitation cultural celebrities and other modeling. Panda is a popular animal among consumers. In recent years, some well-known brands have successively launched bearCat-themed wines, such as Yibin Wuliangye's Panda Wine, Tuopai's Shede Panda and Jinliu Fu Panda, are bottled in the shape of pandas. In addition, some wine bottles are shaped like traditional Chinese porcelain, such as jade vase with spring, plum bottle, calabash bottle and gall bottle. These historically tested bottles are exquisite and elegant, and are very popular.

### **2.2 Exploration of Wine Bottle Design**

Bottle modeling design mainly involves appearance, color, texture and other elements, after processing these elements will get a lot of schemes. As a container, the design of bottle is bound to be practical and beautiful, gradually unfolding in shape, size, proportion, color and

texture. The expression of color is the most intuitive, and the color of bottle can attract the attention of consumers. Reasonable color collocation can effectively increase the market competitiveness of packaging containers. Bottle texture will give people different feelings, the external texture of bottle can be achieved by polishing, sandblasting, sculpture and other techniques, can also be achieved by adding accessories or parts on the bottle, can also be achieved by 3D printing.

The appearance and shape design of wine bottles can also adopt geometric structure method and bionic design method. Bionic design mainly studies the external form and symbol of living things (including animals, plants, microorganisms, etc.) and natural objects, and applies them to the design through corresponding techniques. During the design, concrete bionic, abstract bionic and image bionic can be carried out according to the degree of similarity between the design object and the bionic prototype. The appearance and shape design of wine bottles can also adopt geometric structure method and bionic design method. Bionic design mainly studies the external form and symbol of living things (including animals, plants, microorganisms, etc.) and natural objects, and applies them to the design through corresponding techniques. During the design, concrete bionic, abstract bionic and image bionic can be carried out according to the degree of similarity between the design object and the bionic prototype [7]. For example, the bottles of panda wine, bamboo wine and Taishan wine all belong to bionic design. The appearance of wine bottles generally has basic forms such as square, round, column and cone. With the basic form as the prototype, the whole or part of the form can be appropriately changed and combined to produce interesting appearance modeling. The wine bottles designed by geometric structure have simple, generous, rigorous and lively visual effects. Two or more basic forms can be combined into a new overall shape according to the laws of art. According to the design goal, the form can be changed richly through fusion, cutting, interpenetration and other techniques. The basic forms can be changed into new forms such as proportion, tilt, symmetry, rotation, bending and other changes in three dimensions of length, width and height [8]. In addition, the adjustment of the radius of the edge line and chamfer can also play the role of shape change. Wine bottles have accumulated a lot of effective design experience through long-term development. The design method in practical application is not fixed, but needs to be adjusted according to design practice.

### **3 Grasshopper parametric design platform**

The Rhino modeling workspace combined with Grasshopper supports graphics and morphology research during the design, providing convenience for design [9]. Grasshopper is a parametric plugin for the Rhino platform, which is a very powerful tool for parametric design [10]. In the development of parametric design, after continuous research by many scholars, Grasshopper has been used in a wide range of fields, including architectural design, product design (jewelry, lamp) and so on. [11], it can assist designers to complete complex surface structure and surface design, and the design process is visualized [12]. Compared with traditional modeling software, its modeling method has many obvious differences. Its most important feature is that a complete model generation logic can be built through a series of modular modeling instructions, and these instructions can be executed through logical operations to generate the final model [13]. In the whole modeling process, Grasshopper can easily and quickly change data to achieve complex shape adjustment and optimization [14],

and the generated model can be intuitively and instantly displayed to us through the Rhino platform. Parametric design has three significant characteristics [15].

(1) Instant visibility: Common programming modeling requires writing code by yourself, and the model will be generated after the code is completed. Therefore, after each compilation, the model needs to be tested and adjusted continuously, and finally the model can be generated. Grasshopper's operators are all completely encapsulated code in the form of battery sliders, which are visual, flexible and logically clear. This makes the design process instantly visible and suitable for auxiliary design process inference.

(2) Logic modeling: Grasshopper writes the model generation process, in which the most important

What is significant is the composition logic under the potential form, which will promote the design activities to pay more attention to the logic of form generation.

(3) Dynamic modeling: the characteristics of the Grasshopper logical operation generation model enable the dynamic change of a certain form trend to occur in the whole generation result when the parameters of the input end of an arithmetic unit are changed. Parameterized design can deconstruct and interpret the regularity and complexity of surface forms, and effectively produce diverse changes to adapt to the changing and multi-quality demands of contemporary society [16].

Grasshopper is mainly divided into three parts: parameter operator, logic operator and geometric operator, each of which is equivalent to an integrated operation code. (Figure 1) shows the classification of Grasshopper operators. The visual characteristics of logic are reflected in that it transforms the basic code of programming into the logical relationship between operators, which visualizes and simplifies the design process [17]. Designers can dynamically adjust the modeling form by changing the numerical value of parameter operator through the combination of operators according to the design intention.

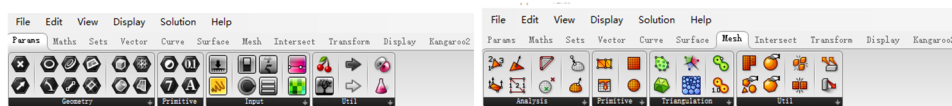


Fig.1. Grasshopper Calculator

## 4 Wine bottle design example

Design task analysis: determine the design goal - carry out creative research - plan design scheme - make design draft - produce and produce - follow up and evaluation. This design task is for Guizhou Miao rice wine bottle design, because rice wine is a traditional brewing technique, so each household brewing rice wine taste is different, its packaging can also be distinguished, such as a village of rice wine form can be a series. In this process, the introduction of parameterization, can make its product serialization easier. The bottle of rice wine shape and texture is beautiful, after drinking can also be used as a flower arrangement, thus achieving sustainable products.

#### 4.1 Concept generation

This design project is rice wine bottles. After collecting and comparing a large number of domestic and foreign materials, it is found that the current design method of wine bottles is mostly mold forming, which generates new shapes by changing the shape of the outer contour line. In terms of surface decoration, most of them are planar patterns or color glazes. Based on the above two points, this design will get rid of the traditional design method, and use the advantages of parametric design to increase the personality of the work.

#### 4.2 Logic construction process of parametric design

Form is the most significant visual feature of wine bottle modeling. In the process of parameterized logic construction, firstly, design objectives are determined, geometric features of design objectives are analyzed, and corresponding geometric operators in geometric operators are found, namely feature parameters. Then, according to the changing characteristics of form and grasshopper algorithm rules, the relationship between parameters and logic operators is established to generate the prototype of form. Finally, dynamic forms changing within the constraint range are obtained by adjusting the parameter operators. The designer obtains the optimal form through screening. The whole design process can be summarized as follows:

DetermineDesign-parameter-Algorithm-Parameter-Evaluation-Determine

#### 4.3 Model Morphological Construction

Through analysis, the design objectives are mainly composed of two parts: form and texture. The model is divided into internal model construction and external model construction. The internal bottle body is constructed by editing curves with Rhino software, and setting out according to several curves.

- (1) Create a rounded rectangle in the rhino interface with the origin as the center.
- (2) Introduce the arithmetic sequence and the moving operator to make the rounded rectangle move many times along the z-axis direction to form an array. The number of arithmetic sequence and the number of steps control the number of movements and the distance of moving of the rounded rectangle respectively, so as to control the height of the modeling.
- (3) Introduce the scaling and the graph mapper operator. Through the function mapping, control the scaling of each rounded rectangle, so as to achieve the purpose of controlling the modeling form (Fig.2).
- (4) Get the modeling form through the lofting.

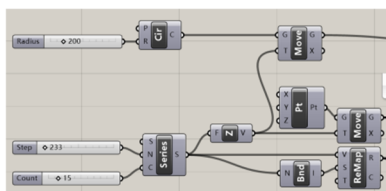


Fig.2. Wine bottle base model

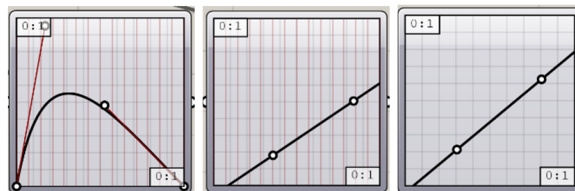


Fig.3. Model texture builder

#### 4.4 Model texture construction

In the selection of epidermal texture, this design will use curved torsion to achieve flow. The specific process is as follows: (1) According to the surface, the network point distribution is carried out, and then the data structure is classified to obtain the surface texture line. (2) Then it is transformed into a grid with Mesh Surface, and the number of U direction and V direction is set. (3) The contour line of each mesh surface is extracted through Face Boundaries, and the center point of each mesh surface is found. (4) Call Graph mapper operator and change its function type to Sine function. (5) The equal fraction value is assigned to Graph mapper operator for function mapping. The output data of the function is mapped to the range of 0.2 to 0.8 through Remap Numbers and Construct Domain two operators (Fig. 3). (6) Finally, the point is assigned to the V input end of Construct Mesh operator, and the grid can be created according to the ordering of vertices (Fig. 4). (7) The final grid texture is obtained (Fig.5).

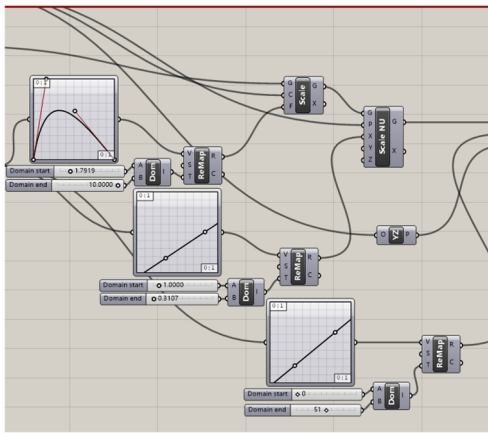


Fig.4. Model texture builder

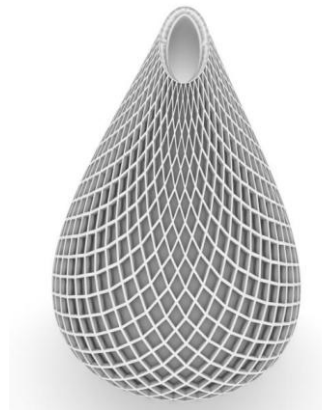


Fig. 5. Product shape and texture

#### 5 Conclusions

With the development of the information age, the consumption pattern of the future new generation has changed a lot, consumers are more in pursuit of novelty and personality, pay attention to emotion and experience. The demand of consumers for wine products has also changed, so the bottle design should also have a certain forward-looking, actively adapt to the new demand, create the design that users really need, and the parametric design method has important practical significance in the field of bottle design. On the one hand, it provides a new design thinking method for designers, according to the design purpose, the introduction of constraints and variable parameters; on the other hand, the unique "dynamic shape finding" design method can be more intuitive and quickly adjust the shape, which is helpful for the communication between designers and customers, and enriches the form of products, and promotes the generation of serialized products. This paper gives full play to the advantages of parametric in the bottle modeling design modeling process through the actual case - rice wine bottle parametric modeling design. Its biggest advantage is that the output results of the modeling program can be easily changed by modifying the data numerical value, and the link

relationship between the parameters and the geometric modeling can be used to constantly refine and optimize the program, which also provides more possibilities for the bottle design of customized wine.

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