Application of Surface Modeling in Appearance Design of Creative Products

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Abstract. The article expounds application of curved surface modeling in appearance design of creative products. This paper introduces the connotation and relationship of creative products, appearance design and curved surface modeling. The application of curved surface modeling in product appearance design is analyzed in detail with the example of hollow flower basket. This article puts forward the advantages and basic principles of curved surface modelling. It provides an effective modeling method for the appearance design of creative products.

Keywords: curved surface modelling · innovative products · appearance design

1 Introduction

Creative design is to extend simple things or ideas and give them another way of expression. In short, it is composed of creativity and design. It is the process or result of extending, presenting and interpreting creative thoughts and ideas in the way of design. Creative design includes industrial design, architectural design, packaging design, graphic design, fashion design, personal creative zone and so on. In addition to the factors of "primary design" and "secondary design", the design also needs to integrate "distinctive design concept – creativity" [1].

Appearance design means appearance design for industrial products. It is simply understood as the artistic or decorative design outside the product. The design content includes shape, style, color, etc. [2].

A product is anything that is manufactured by man. Appearance design refers to the combination of product shape, pattern or color with shape and pattern. It is a new design that is aesthetic and suitable for industrial applications [3].

With the increasing requirement of computer graphics display for authenticity, real-time and interactivity, the trend of geometric design objects approaching diversity, particularity and complexity of topological structure is increasingly obvious. The pace of graphic industry and manufacturing industry towards integration, collectivization and networking is accelerating day by day. In recent years, the technology of surface modeling has been greatly developed, which is mainly manifested in the rapid expansion of the research field [4].

The surface modeling is widely used, which is more suitable for creating smooth surfaces. The biggest advantage is less control points, easy to adjust, and the flexibility of polygon modeling [5].

The surface modeling can meet the requirements of complex modeling design and high-quality surface. It has advantages over solids in creating complex shapes. It helps designers create smooth and extended curves. However, the surface model does not have the physical information and manufacturing information of the solid.

Surface modeling is widely used in innovative design of product appearance. It can meet the customer's demand for complex surface control of product shape. Surface modeling is especially suitable for creating smooth appearance shapes, Such as digital products, automobiles, etc. It has good visual effect.

2   Surface Modeling

Surface modeling is a method for creating and representing complex shapes using high curvature control. In general, surfaces can be used as an alternative when it is difficult to create specific features using solid models [6].

Surface modeling is also called NURBS modeling. NURBS is a special modeling method for curved objects. NURBS shapes are defined by curves and curved surfaces. Therefore, it is very difficult to generate an edge with edges and corners in NURBS surface. Because of this feature, we can use it to make various complex surface modeling and express special effects. Such as human skin and appearance or streamlined sports car, etc. [7].

The surface modeling, firstly, the surface is formed by the curve, and then the three-dimensional model is formed by the surface. The curve has control points, which can control the curvature, direction and length of the curve.

The outer surface of the solid model is composed of curved surface. The surface defines the shape of the solid. The surface can be flat or curved. The difference between surface model and solid model is as follows: 1) The solid model is always closed without any gaps and overlapping edges; The surface model is not closed. Several surfaces do not intersect, and there can be gaps and overlaps. 2) The information contained in the entity model is complete, the system knows which spaces are "inside" and which are "outside" of the entity. The surface model lacks information completeness [8].

The surface can be regarded as a very thin "thin-walled feature". The surface has only shape and no thickness. When multiple surfaces are combined together, and the boundaries coincide and there is no gap, the combined surfaces are "filled", The surfaces are converted to solid.

3   Application of Surface Modeling in Product Appearance Design

Generally, surfaces are created from curves. Curves are created by points, surfaces are created by curves [9], the general creation process is as follows:

(1) create the curve. The measured cloud points can be used to create curves. You can also sketch the required curve from the raster image.

(2) According to the created curve, the main surface of the product is created by using the commands such as through curve, ruled surface, through curve mesh and sweeping.

(3) Use the functions of bridging surface, quadratic section, soft rounding and so on to connect the surfaces created previously. Edit and adjust the surface with trimming, segmentation and other commands; Use smoothing commands to improve model quality; Finally, a complete primary product model is obtained.

(4) Use the rendering function to add materials and environmental backlight, and finally get the Rendering.

The following takes the hollow flower basket (Fig. 1) as an example to illustrate the application of surface modeling in appearance design of creative products. All dimensions of modeling are in mm.

First, create a part, select the upper datum plane to create a sketch, draw a circle with a diameter of 20 centered on the origin, and then exit the sketch. As shown in Fig. 2.

Select the front datum plane to create a sketch, and draw the sketch as shown in Fig. 3. Add corresponding geometric constraints, that is, the left and right lines are symmetrical about the centerline and the endpoint of the line penetrates the arc. Add dimensional constraints to make the sketch fully constrained, and then exit the sketch.

Select the right datum plane to create a sketch, and draw the sketch as shown in Fig. 4. Add corresponding geometric constraints: the left figure and the right figure are symmetrical about the centerline, the endpoint of the straight line penetrates the arc (diameter 20), as shown in Fig. 5. Draw a horizontal centerline through the upper endpoint of the arc. The other endpoint of the centerline passes through the center of the inclined centerline in the front datum plane sketch, as shown in Fig. 6. Then add
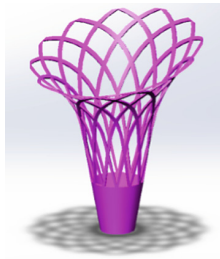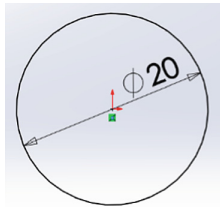

Fig. 1. The hollow flower basket

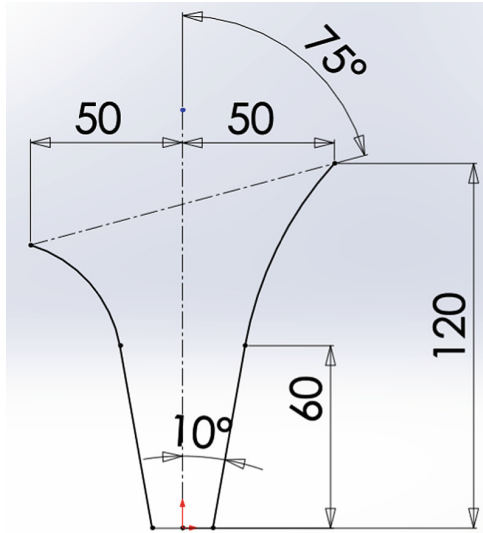**Fig. 2.** The sketch of the upper datum plane

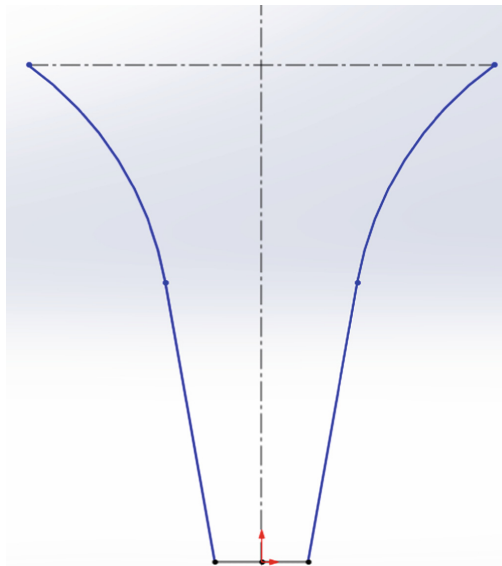**Fig. 3.** The sketch of the front datum plane

Fig. 4. Create a sketch from the right datum

dimensional constraints to make the sketch fully constrained, as shown in Fig. 7. Exit the sketch after completion.

Create the datum plane through the straight line AB and CD, as shown in Fig. 8, The created datum is shown in Fig. 9.
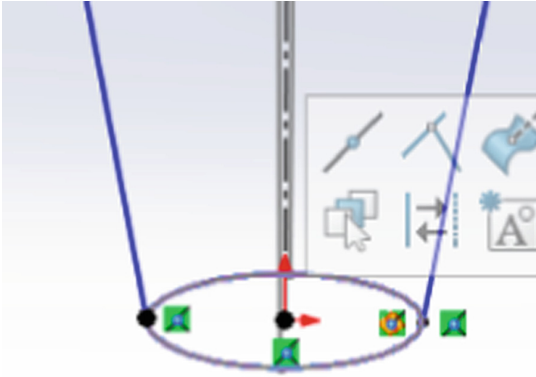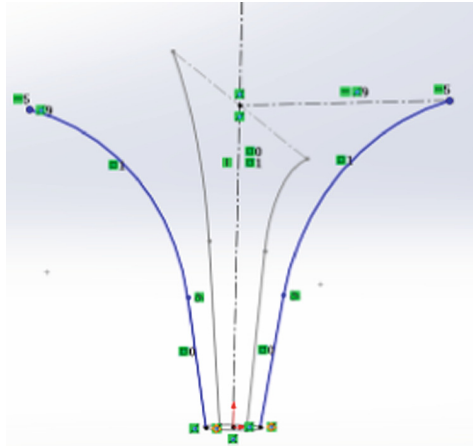
Fig. 5. Penetration constraint

Fig. 6. Centerline constraint

Create a sketch on the datum plane and draw an ellipse, as shown in Fig. 10. Add geometric constraints to make the vertices E and F of the ellipse penetrate the arcs L1 and L2 respectively, as shown in Fig. 10, Make the ellipse fully constrained, as shown in Fig. 11.

Generate boundary surface: select circle and ellipse in direction 1, select four vertical curves one by one in direction 2, select Open Loop in the immediate menu and confirm, as shown in Fig. 12, the boundary surface can be produced, as shown in Fig. 13.

Create a sketch on the front datum plane and draw a horizontal line with a distance of 30 from the origin, as shown in Fig. 14. Use the split line command and use a straight line to divide the surface into upper and lower parts, as shown in Fig. 15.

Select the upper datum plane to create a sketch, draw two arcs with a radius of 32, and other dimensions are as shown in Fig. 16. Mirror copy them with the vertical centerline as the axis to obtain four circular arcs.
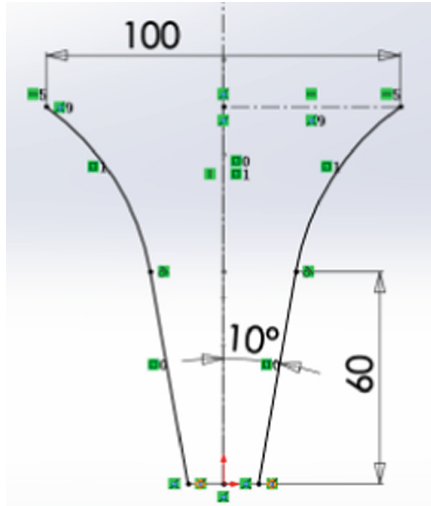
Fig. 7. Sketch full constrain
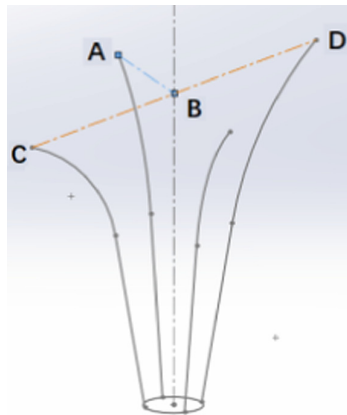
Fig. 8. Straight line AB and CD

Using the split line command, use four arcs of R32 to split the upper part of the surface, as shown in Fig. 17.

The dividing lines are arranged in a circular array with equal intervals, and the number of arrays is 12. The completed array is shown in Fig. 18.

Using the delete surface function, delete the blue part in Fig. 19 to get the flower basket shape. At this time, the flower basket is a surface without thickness, so it is necessary to apply the surface thickening command to thicken the whole flower basket by 1mm. In this way, the design modeling of hollowed flower basket is completed, as shown in Fig. 20.
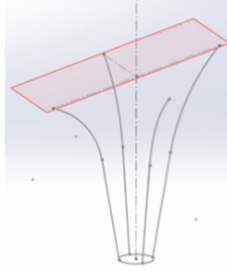
Fig. 9. Create datum
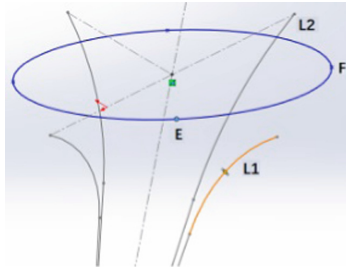
Fig. 10. Draw ellipse
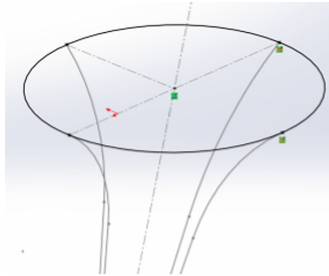
Fig. 11. Make ellipse fully constrained
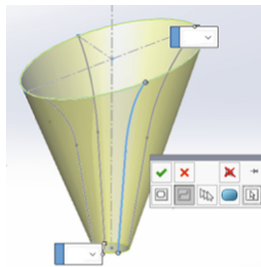
Fig. 12. Direction selection
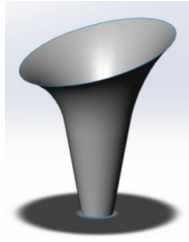
Fig. 13. Generate boundary surface
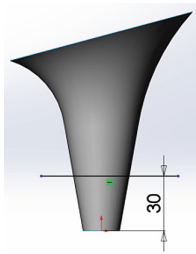

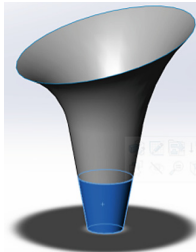**Fig. 14.** Draw a straight line

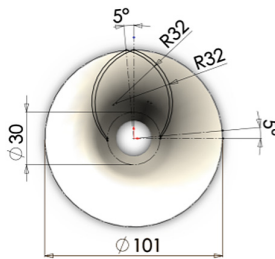**Fig. 15.** Dividing line

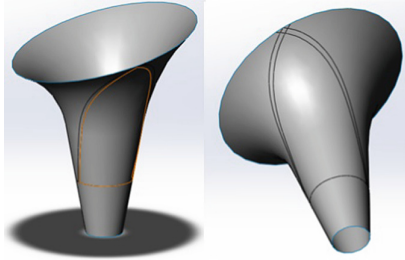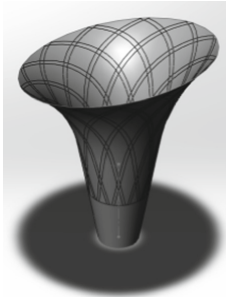**Fig. 16.** Draw the arc of R32

Fig. 17. The segmented surface
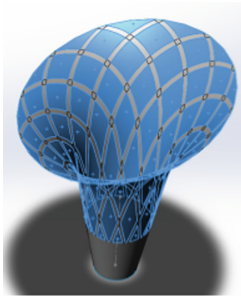

Fig. 18. Array split line
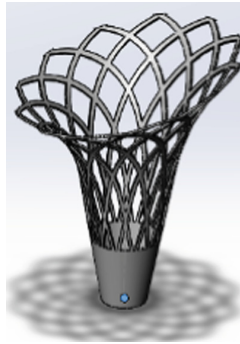

Fig. 19. Delete surface

Fig. 20. The hollow flower basket

4   Conclusion

Surface modeling has a very large degree of freedom, and you can draw what you think of. The appearance of any part, especially the more complex appearance parts, can be drawn as long as it can be imagined. These are what solid modeling cannot do [10].

However, surface modeling is different from solid modeling, which is not a fully parametric feature. In surface modeling, the following basic principles should be paid attention to:

(1) Create the boundary curve of the surface as simple as possible. In general, the order of the curve is not greater than three. When we need curvature continuity, we can consider using a fifth order curve.
(2) The boundary curves used to create surfaces should be smooth and continuous. Curves avoid sharp corners, intersections and overlaps. In addition, when creating a surface, it is necessary to analyze the curvature of the curve, and the radius of curvature should be as large as possible, otherwise it will be difficult to process.
(3) Avoid creating nonparametric surface features. Parametric feature is a design method that basically conforms to the thinking of designers. It embodies the process from design intention to detailed design. Parametric modeling can create and analyze new models by changing the parameter values in the model.
(4) The surface should be as simple as possible and the area should be as large as possible. The unnecessary parts should be trimmed. The number of surfaces should be as few as possible.
(5) According to the shape characteristics of different parts, the various surface features are used reasonably. When creating thin shell parts, try to use solid trimming before shelling.

References

1. HU Shuang xi. (2019) Personalized Product Innovation Design and Model Making Based on Reverse Engineering. Mechanical Engineering & Automation,(05):197–199.
2. Wang Shuang, He Zhong xiu. (2005) Product expression in industry design by Solidworks. Pachaging Engineering, 26(6):166–169.
3. WU Yu bin. (2020) Research on the fast modeling of 3D hull surface with Creo software. Ship Science and Technology, 42 (6A):19–21.
4. Wang Chao. (2019) The influence of computer aided design on Industrial Design. West Leather, 3:83.
5. Chen Xi, Chen Guo gui.(2020) Application Research of Anchor Surface Modeling Method Based on UG NX. Mechanical Engineering & Automation, (04): 203–205.
6. Zhu You Lin.(2021) Research on the Influence of Industrial Product Appearance Design on Structural Design. Modern Manufacturing Technology and Equipment,12:27–29.
7. Kong Ling de, Kang Feng' e. (2020) Research and Implementation of NURBS Surface Subdivision Modeling Technology. Journal of Luoyang Normal University, 39 (05): 26–31.
8. Gan Zhao Yang. (2020) Discussion on product appearance design. Industrial Design, 5:61–62.
9. Huang Gui yun, Li Yong, Cui Jian.(2021)Research on Modeling of Cutting Parts Based on Solidworks. In: ICMSE2021.wuhan. 110–114.
10. Huang Gui Yun, Cui Jian, Zhang Sai Kun. (2020) Research on modeling of Superimposed Parts based on Solidworks.IFEEA2020,9: 920–923.