Research on the Application of 3D Modeling Surface Parameters in Industrial Product Modeling Design

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ABSTRACT-Through the application of surface in industrial product modeling, it is found that the treatment of the relationship between surfaces has become the decisive factor for the beauty of product modeling. This paper analyzes and studies the surface modeling parameters in 3D modeling from three aspects: the internal continuity of curves, the continuity between curves and the continuity of surfaces, and summarizes the relationship between the order and continuity of curves and the relationship between the three continuity modes of curves G0, G1 and G2 and the control points; Finally, the related commands of surface modeling commonly used in 3D modeling of industrial products are summarized through surface splicing and surface fading, and the shaver 3D modeling is taken as a case to demonstrate the specific operation, showing the convenience and rapidity of 3D modeling for industrial product modeling and the ability to accurately express the modeling.

Key words: 3D modeling, product design, surface splicing, continuity

1 APPLICATION OF CURVED SURFACE MODELING IN INDUSTRIAL PRODUCT DESIGN

Surface modeling is an important part of computer aided geometric design and computer graphics. It is a modeling method for the appearance of surface products in product design. With the increasing requirements of computer-aided modeling for authenticity, real-time and interactivity, as well as people's requirements for the beauty and comfort of industrial products, product design is increasingly moving towards the trend of diversity, particularity and topology complexity[1]. In the current industrial product design, the application of curved surface is more and more extensive, from the past large-scale products such as aircraft, automobiles and ships to daily necessities such as mobile phones and lamps. Complex product modeling is generally difficult to describe the product shape through a curve or a curve. It is necessary to use multiple curves or surfaces for splicing. Therefore, surface smoothness has gradually become an important factor in modeling evaluation in industrial product design and an important field in industrial product development.

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2 RESEARCH ON SURFACE MODELING PARAMETERS IN 3D MODELING

2.1 Curve internal continuity

The quality of a curve can be judged by its continuity, which can be divided into the internal continuity of a single curve and the continuity between multiple curves. The better the continuity, the higher the quality[2].

All curves have degrees. The higher the degree, the better the internal continuity of the curve. As shown in Figure 1, for the three curves, the number of curve control points is 5, and the degree of the curve from left to right is 2, 3 and 4 respectively. It can be seen that the curve curvature graph with degree 4 is smoother. However, it should be noted that the higher the order, the more control points, as shown in Figure 2. In Figure 2, a is a third-order curve, which is upgraded to B. the curvature graph has not been improved, but control points have been added. After certain analysis and verification, the relationship between curve control points and order is: order ≤ control points -1.

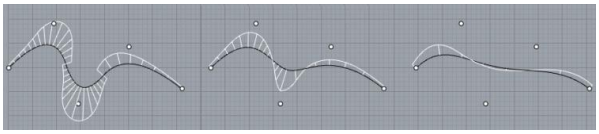

Figure1. Relationship between curve order and continuity

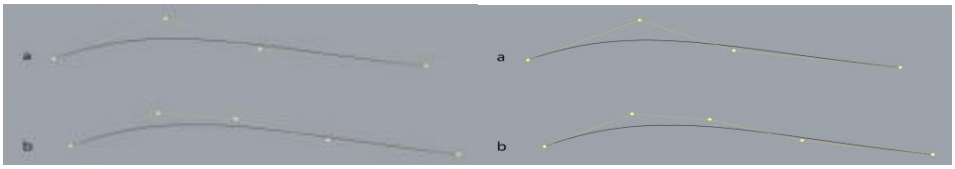

Figure2. Relationship between number and order of curve control points

2.2 Continuity between curves

In the actual modeling process, the commonly used curve order is 3~5. Because the increase of curve order will increase the number of control points and increase the difficulty of calculation, it is often used to copy by segments and then draw complex curves through mutual connection. At this time, it is necessary to pay attention to the continuity between curves[3]. It mainly analyzes the three continuous modes of G0, G1 and G2 between curves. Figure 3 shows the relationship between the position of curve control points and continuity, and Figure 4 shows the curvature analysis graph of two curves connected by the three methods.

(1) G0 continuous: also known as position continuous. For two curves, the ends of the lines coincide to form a continuous. G0 continuous between surfaces means that two surfaces directly intersect the lines, and there is no curvature relationship between the two surfaces; Positional continuity is the lowest condition for two curves to get rid of discontinuity. In G0 continuous mode, we can visually see that there are corners between curves or obvious edges between surfaces. Turn on control point observation.

(2) G1 continuous - tangent continuous. On the basis of continuous curve or surface points, the tangent direction at the ends of the two curves is the same or the tangent direction at the edges of the surfaces is the same. It is a common fillet in practical applications. Open the control point observation, and you will find that the two control points at the curve connecting end and the two control points at the adjacent curve connecting end will be on the same straight line.

(3) G2 continuity - curvature continuity, which means that on the basis of G1 continuity, the curvature radii of two curves at the connecting ends are the same. Visible in the visual effect is smoother than the above two continuous methods.

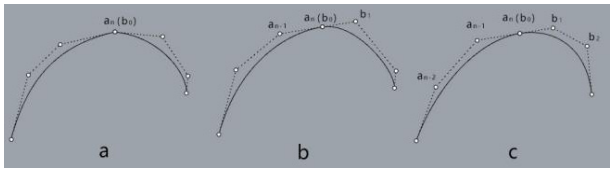

Figure3. Position and continuity analysis of curve control points

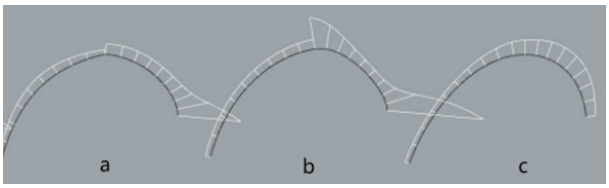

Figure4. Position and continuity analysis of curve control points

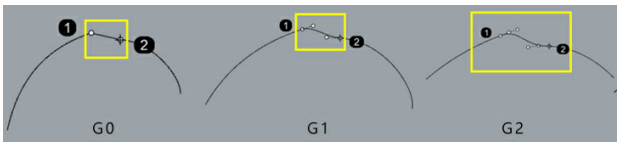

Figure5.Number of control points and curve continuity mode

As a in Figure 3 is G0 continuous, it will be found that the two control points at the curve connecting end coincide. Through curvature analysis, we can also find that the direction of the curvature line is also different.

In Figure 3, a, B and C are the results of the two same curves in G0, G1 and G2 continuous mode respectively. The position of the control point will change accordingly in different continuous modes. At the junction of two continuous curves G0, an and B0 coincide; When G1 is continuous, an-1, an, B0 and B1 are on the same straight line; Through the curvature analysis as shown in Figure 4, it can also be found that if the direction of G0 continuous curvature line is inconsistent, G1 continuous curvature line is disconnected but the direction is consistent, and G2 continuous curvature line is continuous.As analyzed in Figure5, the relationship between the number of control points and the curve can be found, and the curve follows the change of the number of control points. In table1, it can be seen that G0, G1, G2, G3, these four different continuous modes, the number of relevant control points will increase.

Table 1. Relationship between curve continutty mode and number of relevant control points

Continuous mode	Number of relevant control points
G0	2
G1	4
G2	6

2.3 Surface continuity

Surface continuity was first applied in the automotive industry. Surface continuity provides a strong guarantee for the development of high smoothness body. The smoother the body moves, the smaller the air resistance will be, and the less energy will be consumed. In recent years, with the development of manufacturing technology and the continuous improvement of computer modeling and design system, surfaces have been widely used in ordinary consumer products. The continuity of curves and surfaces has always been the key problem in surface splicing. When the surface is mixed, the continuous mode of connection is set to achieve the smooth effect of different levels. In rhino 3D software modeling, the quality of surface stitching can be checked through "zebra crossing". Zebra crossing simulates the result of an environmental reflection. With the help of this operation, the observation results are more intuitive. As shown in Figure 6, b shows the results of zebra crossing detection after the two surfaces are spliced in G0, G1 and G2 continuous mode. We can find that the zebra crossing in G0 continuous mode is discontinuous in staggered state, the zebra crossing in G1 continuous mode is continuous with sharp corners, and the zebra crossing in G3 continuous mode is continuous and smooth.

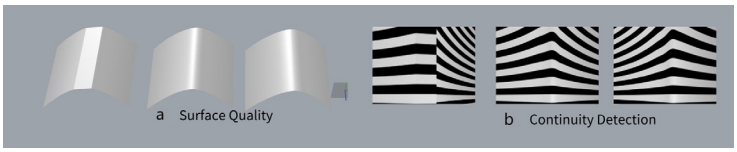

Figure 6. Surface splicing

3 RESEARCH ON THE APPLICATION OF SURFACE STITCHING IN 3D MODELING OF INDUSTRIAL PRODUCT MODELING DESIGN

In the 3D modeling of industrial products, points move to form lines and lines move to form surfaces, so control points are very important to the continuity of curves and surfaces. The more compact the formed surface is, the less control points are required. On the contrary, the more control points are, the more complex they are. The position and attraction of each control point control the shape of curves and surfaces[4]. In the process of model construction, it is necessary to divide and splice reasonably according to the modeling feature line and trend mutation line, so as to meet the modeling requirements[5].

3.1 Surface splicing

(1) *Mirroring*

The mirror function in 3D modeling is often used for symmetrical products, which greatly saves the workload of modeling. As for the model of the bubble machine in the figure below, it is necessary to draw the general outline first. In order to make the top structure G1 continuous when splicing left and right, the control points of the two curves must be collinear (the endpoints of the two lines coincide) as shown in Figure 7 below. After the basic shape is built, it is cut and divided according to some detail feature lines.

(2) *Blend surface*

Blending surface is a common way to connect two surfaces. As shown in Figure 8, it is a large-scale depilation equipment. First, the main body is built by trimming. Then, when the handle is connected with the main body, the blending command can be used. You can select tangent or curvature connection, and G2 continuity can be achieved here.

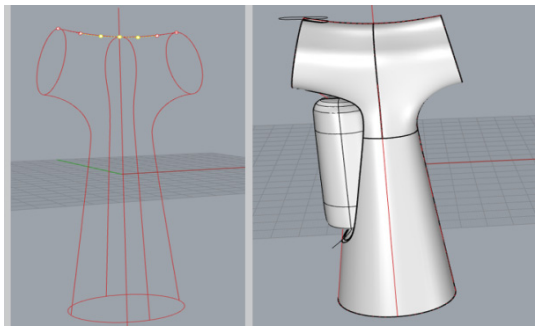

Figure 7. Modeling of bubble machine

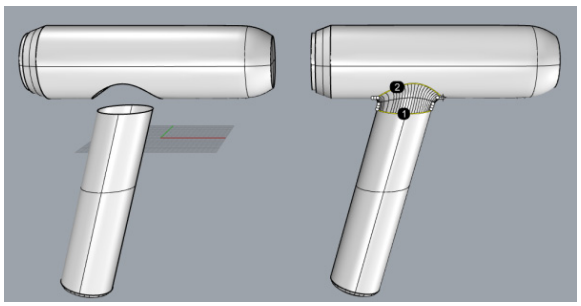

Figure 8. Surface blending

3.2 Vanishing surface

In the process of product design and modeling, in order to make the modeling design more rich and beautiful or make the grip of the product more comfortable, designers often adopt the design method of vanishing surface. It is the most widely used in automobile modeling design. Firstly, the high-low surface drop formed by the vanishing surface will bring people a strong

sense of stability and speed. At the same time, it also reflects the characteristics of a sense of technology and fashion simplicity[6]. In addition to this large product, the vanishing surface is becoming more and more common in small products such as mice and vases. In fact, the generation of vanishing surface is the change process of continuity between two surfaces from G0 to G2. In rhino 3D modeling, there are many tools to realize the establishment of this modeling, such as surface connection, feature shape cutting, UV cutting, point adjustment method, local flow method, etc.

4 APPLICATION PRACTICE OF 3D MODELING OF INDUSTRIAL PRODUCT MODELING -- TAKING RAZOR AS AN EXAMPLE

In the modeling of curved surface products, the modeling characteristics of the products should be analyzed first, and the product edges should be found and drawn in the three views[7]. For the model construction of shaver, the area grasped by people is the main form, so it is necessary to draw the outline of the handle first.

When drawing the right view, pay attention to the joint of the curve, as shown in a in Figure 9. The highlighted control points in the figure are on the same straight line, so as to ensure that the surface formed by the three curves can be G1 continuous. The shaver is a symmetrical product in shape. It is necessary to draw one side of the left and right boundaries and then make the other side through the mirror tool. Pay attention to that the control points near the end points and the control points at the end points are on the same straight line, As shown in b in Figure 9, only in this way can the surface formed after symmetry be smooth without edges and corners[8].

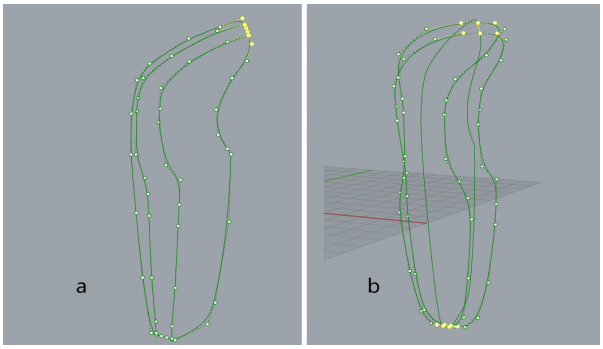

Figure 9. Position relationship of control points

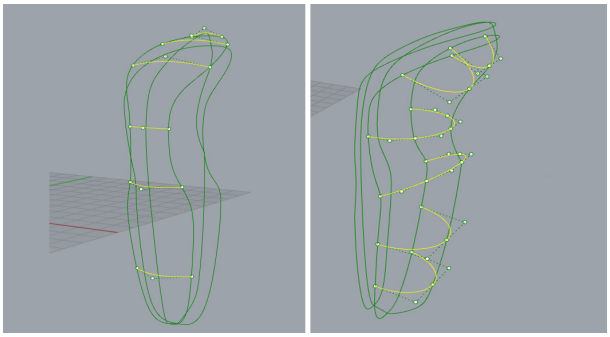

Figure 10. Control section line

After the edge line is drawn, it is necessary to form a surface through a curve. Here, the tool for creating a surface from a network line can be used to realize this command. The curve in one direction must cross the curve in the other direction, and the curves in the same direction cannot cross each other. Since the currently drawn curve is only the line in the vertical plane, the control section line should be added in the horizontal direction, as shown in Figure 10; Then execute the command to create a surface from a network line. The effect is shown in a in Figure 11. The surface in the middle part can be realized by using the double gauge sweep or blend surface command, and the effect is shown in b in Figure11[9].

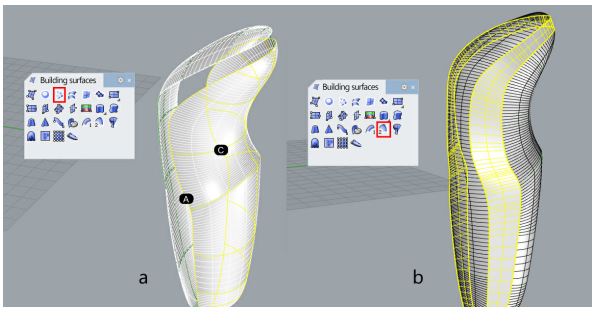

Figure 11. Surface splicing method

When it is necessary to connect the shaver head with the handle, the joint between the two is often not a plane. At this time, we need to use the command of projection curve, so that the drawn circle can be projected onto the surface at the top of the handle. Then use the split and trim command for the built shape, and finally use the mixed surface to connect the large shape with the head, as shown in a in Figure 12, to achieve G2 continuity with both sides respectively.

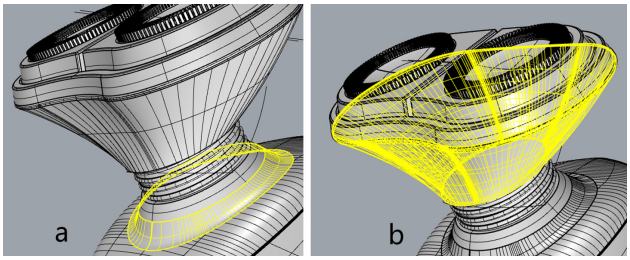

Figure 12. Formation and connection of irregular surfaces

When drawing an irregular surface such as b in Figure 12, we can draw the edge of the desired shape, and then use the two rail sweep command to realize it[10]. After the overall modeling is completed, a surface fillet command is usually copied. The final modeling effect is shown in Figure 13.

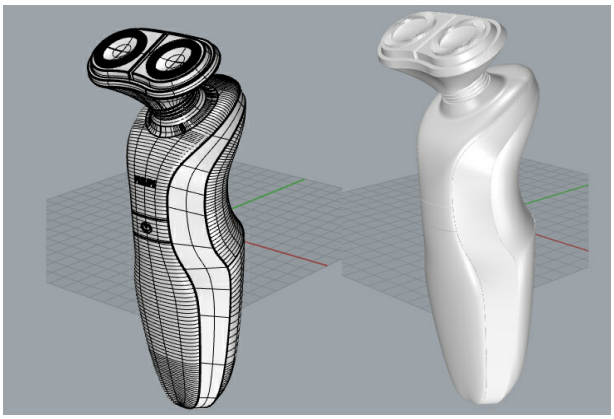

Figure 13. Effect drawing

5 CONCLUSION

There are many factors that determine the modeling of industrial products. For users, they need to meet the psychological needs while meeting the practical functions. For manufacturers, they should pay attention to the process requirements of production and processing and the cost control. Computer 3D modeling has become a bridge between various factors[11]. Rhino modeling technology, as the current mainstream surface modeling technology, with its powerful surface modeling ability and excellent local continuous control ability, can well control the continuity of the object surface, so as to help product designers create more complex, more vivid and smooth surface modeling in the product creative design stage and detailed design stage[12]. Through research and practical application, the relevant laws of curve and surface splicing and their continuity can be summarized:

(1) High order curve can improve the continuity of curve, but with the increase of order, the number of control points increases. Generally, 3-5 order curve is used, and the order ≤ control points -1;

(2) G0, G1 and G2 continuity of curve and surface is mainly realized by adjusting the number and position of control points at the connection;

(3) In order to make the surface splicing more smooth, multiple section lines are usually added during surface blending;

The above surface splicing methods and their related laws provide a certain theoretical significance and application value for improving the smoothness and quality of surfaces.

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