International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 6 Issue 5 Ver. I ǁ 2018 ǁ PP. 17-21

Evaluation of Class-A Surface in Vehicle

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***Abstract**: The quality requirements of class a surface of automobile body are expounded. According to the geometric continuity condition of the curve, the methods of control vertex, curvature comb, zebra line and Gauss curvature are used to evaluate the internal quality of a surface and the continuity accuracy of the curved surface, and a comprehensive evaluation system is given. The evaluation system can well evaluate the overall quality of the surface and discover the problems of the surface.*

***Key Words**:vehicle,Class-A surface,evaluation*

Date of Submission: 21-05-2018 Date of acceptance: 05-06-2018

I INTRODUCTION

With the acceleration of the demand for new vehicles in the automobile market, the cycle of auto renewal and replacement is becoming shorter and shorter. The speed of its design will directly restrict the development of the automobile industry. Modern computer aided design technology has brought great changes to the development of automobile. Therefore, the application of reverse engineering in the field of automobile design greatly improved the status of automobile manufacturing industry.

Reverse engineering refers to the process of reconstructing the space model by using a three-dimensional geometric modeling method according to the surveying data, using a certain measure method to map the model or object of a car. In automobile body design, the most important reverse technology is reflected in the surface smoothness of Class A.The smoothness of the Class-A surfaces includes two meanings: smoothness and beauty. The so-called smoothness refers to the transition of the corner of the curved surface to satisfy the curvature or continuity, the boundary line is continuous, the distribution of the inverse ray is uniform and the thickness is uniform, and the control vertex distribution rule is uniform between the control points of each line, and the parameters after smooth splicing have no obvious distortion. In recent years, although there is a lot of literature on the surface stitching technology, it is limited to continuous curved surface splicing theory[1-5], the operability is not strong in practice, and the literature of surface quality evaluation is more rare. From the practical point of view, this paper gives the evaluation method of Class-A surface of vehicles.

II FAIRING REQUIREMENTS FOR CLASS-A SURFACE OF VEHICLES

Class-A surface is a high visible surface surface in the outer surface of the car, including the engine cover, front and back flank, front and rear bumper, door, A column, B column, C column, back door, top cover, side enclosure, and high visible area in interior parts.

In engineering practice, the Class-A surface of the body should conform to the requirements of the modeling features. The continuity of the surface splicing is in the ideal G^2 continuous (two order geometric continuity, continuous curvature) or more, except for the discontinuity of the modeling features.The number of patches on a single surface is 1 (Bézier surface) in the two parameter directions of u and v. The number of control points should be controlled within 6 rows (5 times), control vertex distribution rules, and the angle of the control vertices of each row is uniform. There is no reverse concave on a single surface.

When the surface is smooth, the accuracy requirement of surface and point cloud should be determined according to the actual situation. If it is a reverse vehicle, or the oil sludge model is more accurate, the precision of the mapping point cloud can express the characteristics of the car well within 0.3 to 0.5 mm. If the sludge model is poorly made, the accuracy requirements should be formulated according to the specific circumstances.

III GEOMETRIC CONTINUITY CONDITIONS OF BÉZIER CURVES

According to the requirement of Class-A surface, it must be a special case of B spline surface -- Bézier surface. In the evaluation of smoothness, it is often evaluated by the continuity of the section line of the surface, so the geometric condition of the continuity of the Bézier curve is given.

The expressions of Bernstein basis functions for two N times Bézier curves T_1 and T_2 are as follows:

$$p_1(t) = \sum_{i=0}^{n} a_i B_{i,n}(t), 0 \le t \le 1 \quad (1)$$

$$p_2(t) = \sum_{j=0}^{n} b_j B_{j,n}(t), 0 \le t \le 1 \quad (2)$$

In the formula, $p_1(t)$ and $p_2(t)$ are the point vectors on the two curve respectively. $a_i(i = 0,1,..., n)$ and $b_j(j = 0,1,...n)$ are two control points of the vector (the point at the end of the vector is the curve control point). $B_{i,n}$, $B_{j,n}$, respectively, are two curve Bernstein basis functions; t is the parameter of the curve.

The two Bézier curve should be continuous in curvature, first of all, the position continuity is required, that is, the control vertex vector an of the T_1 end of the curve and the vector b_0 of the control vertex of the T_2 beginning end (Figure 1), that is, $a_n = b_0$

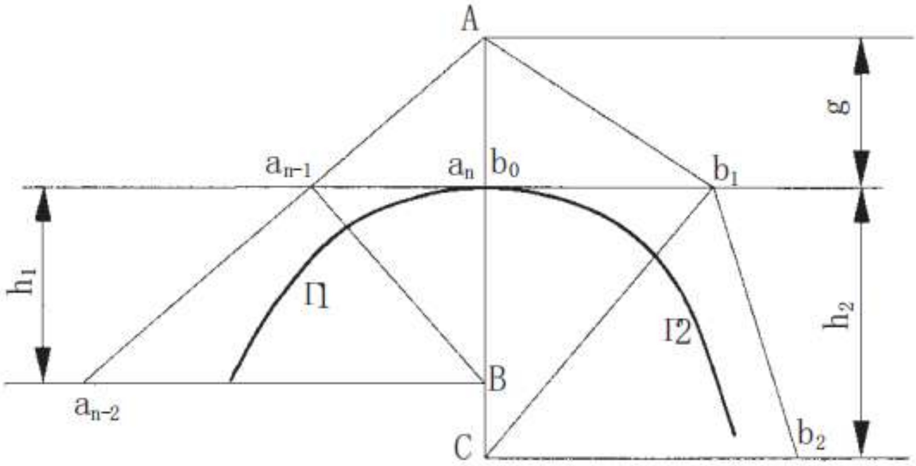

Fig 1 The condition of G^2 continuity of Bézier curve

It is also necessary to satisfy tangent continuity, that is, control vertex vector $a_{n-1}, a_n(b_0), a_n$ collinear:

$$\Delta a_{n-1} = \delta \Delta b_0 \quad (3)$$

In the formula, $\Delta a_{n-1}, b_0$ arethe first order forward difference vector, $\Delta a_{n-1} = a_n - a_{n-1}, \Delta b_0 = b_1 - b_0$ and δ is a coefficient.

To achieve the G^2 continuity of curves T_1 and T_2 ,figure 1 should satisfy the point A and the vector a_{n-1} end connection and the point B perpendicular to the vector a_{n-1} end line. And the curvature values of the two curves at common points should be equal.

To sum up, in order to keep the curvature vector of curve T_1 and T_2, we must have the same curvature value at common points, and at the same time, we should have a common tangent plane. Namely, $a_{n-2}, a_{n-1}, a_n(b_0), b_1, b_2$ 5 vector end points must be coplanar, and a_{n-2} and b_2 two vector end points are on the same side of the common point common tangent.

IV EVALUATION OF VEHICLE OF CLASS-A SURFACE

The evaluation of A-grade surfaces includes surface feature evaluation and surface quality evaluation. Feature evaluation is whether the surface made by the stylist according to the requirement of automobile modeling meets the design intention. This paper mainly describes the evaluation of surface quality. The methods of surface quality evaluation include control vertex method, curvature comb method, zebra line method, Gauss curvature method and continuity accuracy evaluation.

(1) Control vertex evaluation

According to the requirement of Class-A surface of automobile body, taking the part of the automobile engine hood as an example, the quality of Class-A surface is evaluated by the control point method. Fig. 2 is a rear hood hood and its control points. As can be seen from Figure 2, the engine hood consists of 3 surfaces, each of which is

1 in the two directions of u and v, and the number of control points is within 5 times (6 rows of control points). Moreover, according to the changes of engine hood characteristics, control points are arranged orderly. The curvature of the middle part of the engine hood changed little, so the control vertex of the area was arranged evenly and sparsely; and the control vertex of the surface became dense when the curvature of the two sides was more intense. In short, the arrangement of control points varies according to the characteristics of engine hood, and its changes also show certain regularity.

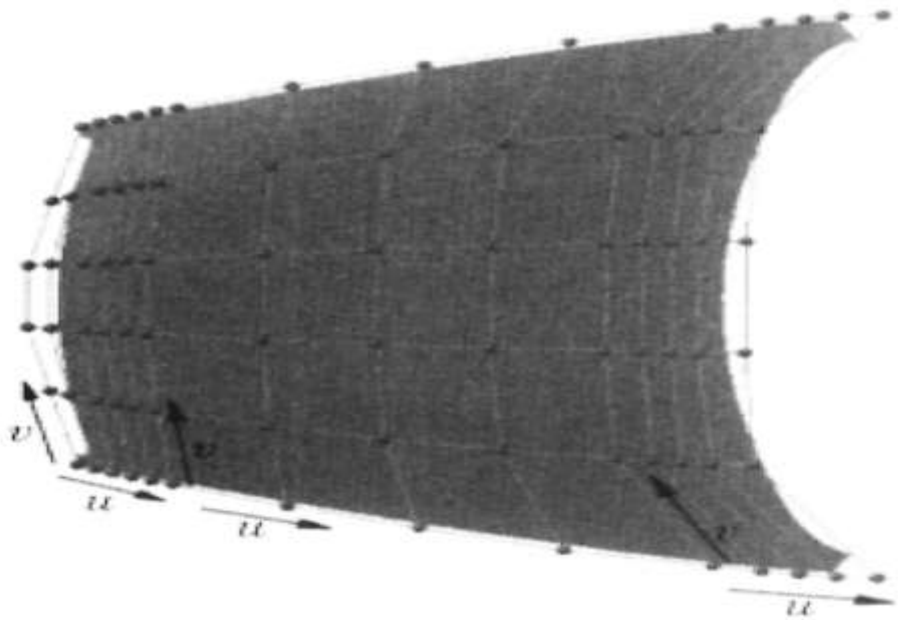

Fig 2 Rear hood surface and its control vertex

(2) Curvature comb evaluation

When the curvature comb is used to evaluate vehicle Class-A surface, a series of section curves are taken on the surface, and then the curvature comb is analyzed to evaluate the quality of the continuity between the surface and the surface. According to the continuous condition of the curve, the following cases are analyzed in Figure 3.

Figure 3a is the result of continuous curvature comb detection for curve position (G0). It can be seen that when the curve satisfies only G^0 continuity, the curvature comb has an included angle at the junction, and its outer edge height is also different. In smoothing practice, this is not allowed unless the surface feature is required.

Figure 3b is evaluated by curvilinear tangent (G^1) continuous curvature comb. At this point, the curvature comb of the curve has no angle at the common point, but there is a difference in the height of the outer edge, which is not allowed for the surface with high visibility.

Figure 3c is an evaluation of curvilinear G^2 continuous curvature combs. In this case, the curve curvature comb has no angle at the common point, and the outer edge of the curvature comb is also of equal height, which is acceptable for the A-class surface of the body.

Figure 3d is an ideal G^2 continuous curvature comb evaluation. At this time, the curvature comb of the curve has no angle and gap at the common point, and the outer edge of the curvature comb is smooth transition. It is an ideal condition for building a body a surface of a body.

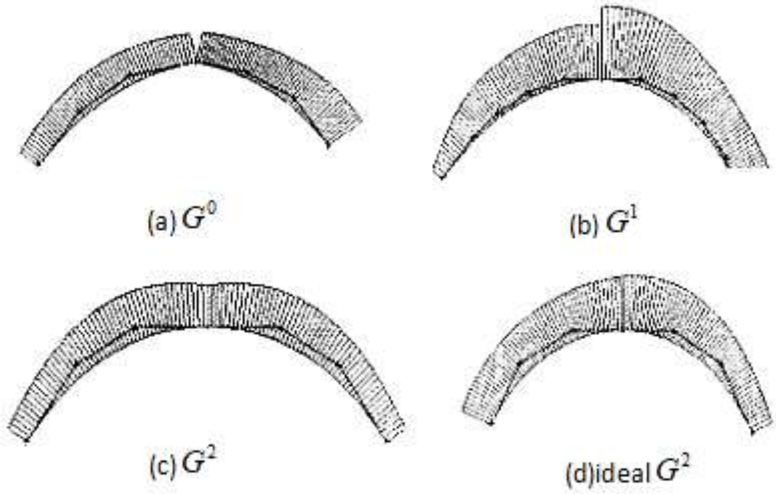

Figure 3 Continuous curve evaluation

If the curvature comb does not meet the requirements of Class-A surface, the control point search problem of the related surface should be opened and modified until the requirement is met.

(3) Zebra line evaluation

In engineering practice, the zebra crossing is often used to evaluate the quality of class a surface. Generally, the zebra crossing of the surface is uniform and the spacing between horses is uniform.

Fig 4 is the evaluation of the zebra crossing after the splicing of two surfaces. The two surface of Fig 4A is G^0 continuous, so the zebra crossing is stagger at the public boundary. This is not allowed except feature requirements. The two surface of figure 4b is G^1 continuous, and the zebra line of the two surface is aligned, but there is a sharp angle at the splicing common boundary, and it is not allowed to stitching the large surface of the body a surface.Fig 4C is a continuous case of the two surface G^2, the zebra line of the two surface is smooth in the stitching, and the body a surface must meet such requirements; figure 4D is an ideal G^2 continuous case.

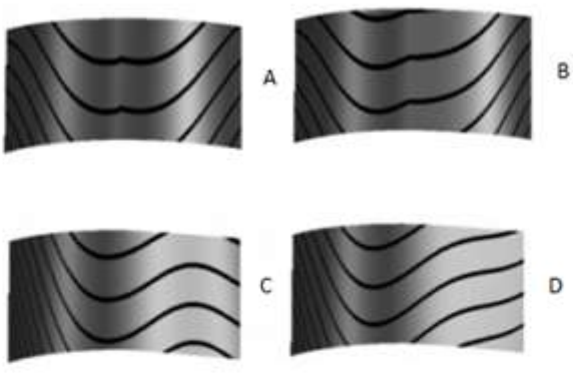

Figure 4 Zebra line evaluation after two surfaces splicing

(4) Gauss curvature evaluation

A cross section of a curved surface has numerous surfaces, and the curvature of these sections is usually not equal. In the curvature of these cross-sections, there is a maximum value $k_{\max}$ and a minimum value of $k_{\min}$, and Gauss curvature $k = k_{\max} k_{\min}$.

The Gauss curvature analysis method is to connect the curvature of the surface with the set color of the Gauss. If the Gauss curvature of the surface is consistent, then the color of the surface is the same when doing the Gauss analysis. If the curvature changes, then the color changes.

(5) Continuity accuracy of surface stitching evaluation

In engineering practice, in addition to the above evaluation, the accuracy of continuity of surface stitching should be evaluated. For the surfaces with high visibility, the maximum deviation of G^0 continuity is < 0.005 mm.The maximum deviation of G^1 is $< 0.05^\circ$, while the maximum deviation of G^2 is $< 0.5mm^{-1}$.

(6) Standard and weight of comprehensive evaluation of Class-A surface quality

When evaluating the A-level surface of car body, we must first pay attention to its basic surface. The internal quality and continuity of the basic surface can be evaluated from the number and order of the patch, the order of the control vertex and the curvature comb,zebra crossing and Gauss curvature map color change and so on. of the cross section line from the two parameters of the surface u and v. Because the basic surface affects the construction and continuity of the subsequent transition surface, 50% weight is given.

The internal quality and continuity of the transition surface can also begin with the number of patches, orders, the arrangement of the control vertex, the curvature comb of the cross section, the color change of the zebra line and the Gauss curvature map in the two parameters direction of the surface u and V, but compared with the basic surface, the requirements are relatively low, so the weight of 35% is given. It's heavy.

If the basic surface and the transition surface are constructed accurately, then the continuity evaluation of the basic surface and the transition surface can be evaluated only by the curvature comb, the zebra line and the Gauss curvature graph, so the proportion of the basic surface and the transition surface is the lowest, and only 15% weights are given.

V CONCLUSION

This paper evaluates the class a surface of vehicle body by means of control points, curvature comb, zebra crossing and Gauss curvature. 3 methods of curvature comb, zebra line and Gauss curvature can evaluate the internal quality of a single surface and evaluate the continuity between surfaces. This method can be used to find the problem of the surface, then find the root cause and modify the control vertex from the control vertex of the related surface, that the vertex is ordered to meet the requirement of Class-A surface.

In the 4 evaluation methods, curvature comb, zebra line and Gauss curvature method reflect the surface of the surface problem, and the control vertex arrangement is the fundamental reason for the existence of the surface problem, so the arrangement of control points should be paid attention to in the evaluation of a curved surface.

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Jiang Mingyang." Evaluation of Class-A Surface in Vehicle.” International Journal of Research in Engineering and Science (IJRES), vol. 06, no. 05, 2018, pp. 17–21.