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The Research about the Two Meshing in the Generative Approach

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Abstract: The two meshing theory has important application in the field of manufacturing technology. It can make a reasonable explanation to the existing process problems, and it is possible to find some new transmission scheme. Two enveloping worm gear and worm driving, that is the application of the theory of the two meshing.

Keywords：two meshing; generative method; two kinds of boundary points; conjugate region

I.INTRODUCTION

The two meshing is that a point on the conjugate surface can meet the conjugate condition for two times, and has the two contact phenomenon occurs. A direct method is a method for processing dual, which is one of the transmission pairs as tools to other parts processing.

II.THE CHARACTERISTIC POINTS OF THE TWO MESHING AND TWO CONTACT LINE

When $\vec{R}_1$ was used to process $\vec{R}_2$, the instantaneous contact line was shown on the $\vec{R}_1$. As shown in figure 1:

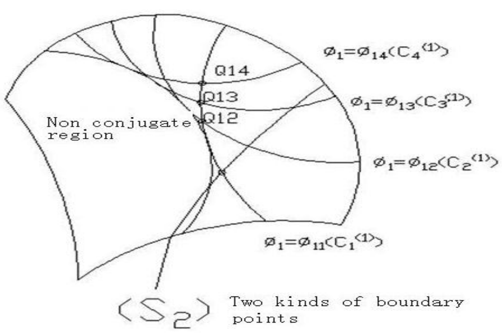

Fig 1 : Two types of boundary curves and two meshing feature points in $\vec{R}_1$

When the φ_1 was a series of constants: $\varphi_1=\varphi_{11}$、$\varphi_1=\varphi_{12}$、$\varphi_1=\varphi_{13}$、$\varphi_1=\varphi_{14}$……We got a series of contact lines on the R_1 : $(C_1^{(1)})$、$(C_2^{(1)})$、$(C_3^{(1)})$、$(C_4^{(1)})$…, their envelope was (s_2), that was the two kind of boundary curve. There woule be the intersection of the contact lines, such as Q_{12}、Q_{13}、Q_{14}..... They were the characteristic points of the two meshing. For example, when $\varphi_1=\varphi_{11}$, these points were coming into contact, because they were in the $(C_1^{(1)})$. When $\varphi_1=\varphi_{12}$, Q_{12} would once again come into contact, which produced two mesh point. And so on, Q_{13} point produced two meshing, when $\varphi_1=\varphi_{13}$, Q_{14} point produced two meshing when $\varphi_1=\varphi_{14}$ etc.

Processed into the surface of $\vec{R}_2$ was shown in figure two:

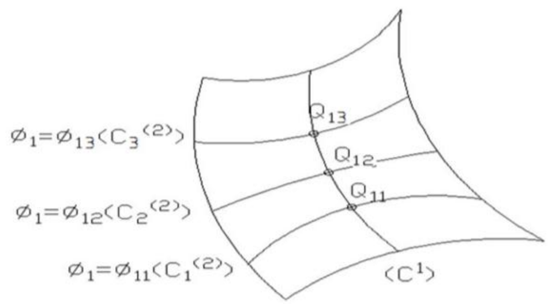

Fig 2: The two contact line

Among them $(C_1^{(2)})$、$(C_2^{(2)})$、$(C_3^{(2)})$…were instantaneous contact line. Their shape and the corresponding curve $(C_1^{(1)})$、$(C_2^{(1)})$、$(C_3^{(1)})$… exactly were the same. Because they were the instantaneous contact line of $\vec{R}_1$ and $\vec{R}_2$, these were the characteristic line. If the relative position between $(C_1^{(2)})$、$(C_2^{(2)})$、$(C_3^{(2)})$… and $(C_1^{(1)})$、$(C_2^{(1)})$、$(C_3^{(1)})$… were different $(C_1^{(2)})$ was the contact line when $\varphi_1=\varphi_{11}$. According to the above discussion, Q_{12}、Q_{13}、Q_{14}…… also meet the conditions of contact. They constituted a contact line (C’), that was the two contact line. For $\vec{R}_2$, there were two contact lines at every moment. Applying the theory of meshing surface was more easy to explain. Which was shown in figure three:

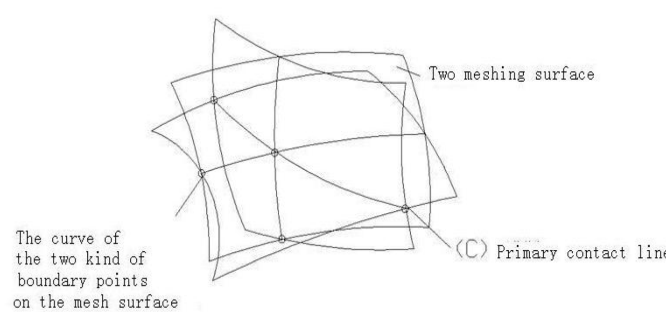

Fig 3:First contact line and two contact line

III. THE ANALYTIC EXPRESSION OF THE TWO CONTACT

The mesh surface was the locus of the contact line in the stationary coordinate system. The intersection of the conjugate surface and meshing surface was the instantaneous contact line. There were two meshing surface: the first meshing surface $\vec{r}_1$ and the two meshing surface $\vec{r}_1'$,the conjugate surfaces $\vec{R}_2$ intersected with them. We could get two contact lines (C) and (C') . At the same time, the intersection of $\vec{r}_1$ and $\vec{r}_1{'}'$ was the trajectory of the two kinds of boundary points on the mesh surface. So the intersection Q of (C) and (C') would be the two type of junction.

Two meshing surface:

$$\vec{r}_1' = B_1 \cdot (\varphi_1') \cdot \vec{R}_1 \quad (1)$$

Conjugate surfaces:

$$\vec{R}_2 = B_2^{-1} \cdot (\varphi_2) \cdot \left[B_1 \cdot (\varphi_1) \cdot \vec{R}_1 - A \cdot \vec{a} \right] \quad (2)$$

Where $\varphi_1' = \varphi_1 + \tau_1$。

At this point O_1 was the origin of $\vec{r}_1'$,point O_2 was the origin of $\vec{R}_2$. By the origin of the conversion:

$$\vec{r}_2' = \vec{r}_1' - A \cdot \vec{a} = B_1 \cdot (\varphi_1') \cdot \vec{R}_1 - A \cdot \vec{a} \quad (3)$$

Simultaneous (2) and (3), the two contact lines could be solved.when $\vec{r}_2' = \vec{R}_2$:

$$B_1 \cdot (\varphi_1') \cdot \vec{R}_1 - A \cdot \vec{a} = B_2^{-1} \cdot (\varphi_2) \cdot \left[B_1 \cdot (\varphi_1) \cdot \vec{R}_1 - A \cdot \vec{a} \right]$$

We put on both ends of the square, getting:

$$\vec{a} \cdot B_1 \cdot (\varphi_1') \cdot \vec{R}_1 = \vec{a} \cdot B_1 \cdot (\varphi_1) \cdot \vec{R}_1 \quad (4)$$

We put vector rotation expression on the formula:

$$\left(\vec{\Omega}_0^{(1)} \cdot \vec{R}_1\right) \cdot \vec{a} \cdot \left(\sin\varphi_1' - \sin\varphi_1\right) - \left(\vec{R}_1 \cdot \vec{a}\right) \cdot \left(\cos\varphi_1' - \cos\varphi_1\right) = 0 \quad (5)$$

Where $\vec{\Omega}_0$ and Ω were rotation angular velocity unit vectors and their modes.

We dealed with (5)

$$\sin\frac{\varphi_1' - \varphi_1}{2} \cdot \left[\left(\vec{\Omega}_0^{(1)} \cdot \vec{R}_1\right) \cdot \vec{a} \cdot \cos\frac{\varphi_1' + \varphi_1}{2} + \left(\vec{R}_1 \cdot \vec{a}\right) \cdot \sin\frac{\varphi_1' + \varphi_1}{2} \right] = 0$$

There are two solutions to the problem, and the solution to this problem is:

$$\sin\frac{\varphi_1' - \varphi_1}{2} = 0.$$

$$\varphi_1' - \varphi_1 = 4(n-1)\pi, \quad (n = 1、2......)$$

The basic solution is

$$\varphi_1' = \varphi_1 \quad (6)$$

This was the condition of the two contact line.

Control of a contact line, the geometric meaning of the above is as follows: If $\varphi_1 = \varphi_{10}$ was constant, then there was

$$\varphi_1 = \varphi_1(u_1、v_1) = \varphi_{10} \quad (7)$$

They were constant. The above type was a contact line. At the same time we could get:

$$\varphi_1' = \varphi_1(u_1、v_1) + \tau_1(u_1、v_1) = \varphi_{10} \quad (8)$$

They were constant. This is the two contact line.

From (7)、(8) we could get $\vec{q} \cdot \vec{e}_3 = 0$、$\tau_1 = 0$ at two kinds of boundary points. This shown that the two contact lines were in the two kind of boundary points.

We had the second contact conditions $\varphi_1' = \varphi_1$ in (2) and got two contact line expression.

$$\vec{R}_2'' = B_2^{-1} \cdot (\varphi_2) \cdot \left[B_1 \cdot (\varphi_1') \cdot \vec{R}_1 - A \cdot \vec{a} \right] \quad (9)$$

The two contact line can be combined into a new conjugate surface $\vec{R}_1'$ in the course of motion. Because $\vec{r}_1 - \vec{r}_2 = A \cdot \vec{a}$，$\vec{r}_1 = B_1 \cdot (\varphi_1) \cdot \vec{R}_1$，$\vec{r}_2 = B_2 \cdot (\varphi_2) \cdot \vec{R}_2$ .We could get the conjugate surface expression from (9)

$$\vec{R}_1' = B_1^{-1} \cdot (\varphi_1) \cdot B_1 \cdot (\varphi_1') \cdot \vec{R}_1 = B_1^{-1} \cdot (\varphi_1) \cdot B_1 \cdot (\varphi_1 + \tau_1) \cdot \vec{R}_1 \quad (10)$$

$\vec{R}_1'$ was the conjugate surfaces which was made by the two contact lines on the $\vec{R}_2$. $\vec{R}_1'$ and $\vec{R}_1$ were not exactly the same. They were shown in Figure four.

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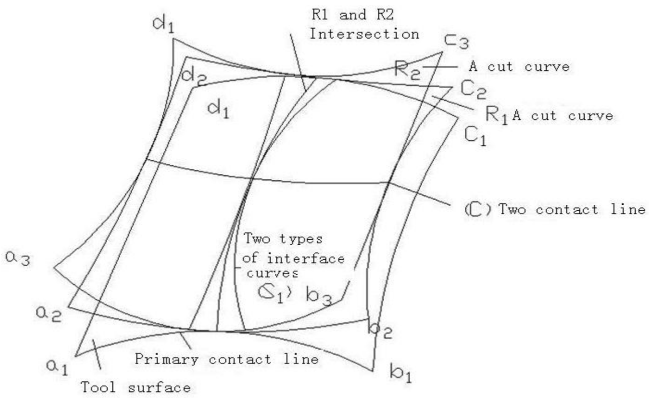

Fig 4: A generative surface and a two time generative surface

IV.CONCLUSION

The tool surface $\vec{R}_1$ first created the curved surface $\vec{R}_2$, and the first contact line between them was (C). The line (C') in $\vec{R}_2$ also meet the Meshing Conditions of the two contact, when $\vec{R}_2$ in turn to create $\vec{R}_1$, the situation was more complex. (C) family constituted the original tool surface $\vec{R}_1$, (C') family constituted a new two tool surface $\vec{R}_1'^{\prime}$. There was a relationship between the three surfaces:

(1) Three surface($\vec{R}_1'$、 $\vec{R}_2$、 $\vec{R}_1^{\prime}$) tangented to the two kinds of boundary points Q.

(2) $\vec{R}_1$ and $\vec{R}_1'$ was connected and tangented at the two types of boundary curve (S_2).

(3) $\vec{R}_2$ and $\vec{R}_1'^{\prime}$ tangented to the two contact line (C') , and intersected at the x curve. And x was over two types of boundary points.

The conjugate surface would be composed of two parts when using the direct generative method processing tooth surface, The two part tangented connection in the two kind of boundary point curve.

A case study of direct generative machining of worm gear and worm gear. The worm wheel was used as a tool to create a worm, and the worm wheel was made to produce a worm wheel cutter. At this time, the worm wheel profile would be composed of two parts, one part was a conjugate surface, the other was the two conjugate surface.

The direct creation of the two envelope method had the following advantages:

The non conjugate region which was restricted to the two kinds of boundary points could be changed into the conjugate area, the contact area was increased, and the contact stiffness was improved.

the induced curvature of the two conjugate surfaces was zero at the two kinds of boundary points. It was very good to improve the transmission properties.

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