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Development of Hull Plate Surface Using Gaussian Curvature Method

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***Abstract* — Line-heating process as the main method to form the double curvature hull plate, can be considered as the inverse process of the hull plate surface development, moreover, the processing parameter can be determined by calculating deformation degrees generated by the plate surface development. In this paper, we present a new method for development of hull plate surface based on its Gaussian Curvature. According to the property of the offset surface and BP neural network model, the angular distortion of the plate surface development is analyzed. The plate surface is adaptively segmented based on Gaussian curvature, and the transverse shrinkage of the plate be calculated. A new method for surface development has been established to calculate the angular distortion and the transverse shrinkage simultaneously in plate surface development, which can provide guidance to determine the reheating information for unformed plates.**

Index Terms— Surface Development; Gaussian Curvature; Line-heating; Angular Distortion; Transverse Shrinkage.

I. Introduction

The process of line-heating is the main method to form the double curvature hull plate. To obtain the desired double-curved shape, the plate is shrunk on the partial areas. Line-heating process considers the inverse process of hull plate surface development. While the shrinkage of the plate surface development considers the deformation of line-heating process. The parameters of the line-heating process are determined merely by the deformation produced by the plate surface development. The focus is how to calculate the deformation produced by the plate surface development [JiZhuoshang 2001].

It is well known in mathematics that the undeveloped surface can be developed into its corresponding plane region by approximation. Many numerical methods have been used to develop these surfaces, such as stretching and without deformation. Chen [Chen- Dongren 2003] has presented a novel optimal method to flatten complex surfaces based on mesh edges and spring-mass model. Liu has given the calculation method of shrink distortion for plate surface [LiuYujun 1995]. But above mentioned researchers have not considered the thickness of plate, and the angular distortion has been ignored for the unit thick plate. At present, the angular distortion of the plate surface development has not been understood clearly [Zhu- Xiuli 2009]. The transverse shrinkage of the plate did not show entirely the curvature of the thick plate. The angular distortion and the transverse shrinkage of the plate are both the decisive factors for the parameters of the line-heating process.

The plate surface can be adaptively divided into regions based on gauss curvature and then the transverse shrinkage of the plate can be calculated. According to the property of the offset surface, a new method for surface development has been established to calculate the angular distortion and the transverse shrinkage simulate development, which can provide guidance to determine the reheating information for unformed plates. This study is the key technology of comprehensive automatic processing for line-heating, which can improve our shipyard's competitiveness in international markets and has important application value and academic significance.

II. Theories About Surface Development

A. *Definition of Offset Surface*

Support P be a point on the surface S, and P^* be the new point on the surface S_λ. S_λ is called the offset surface of S, when the point P^* can be obtained by removing λ distance along the normal direction of P.

The function of S is $S = S(u,v)$. Then the function of S_λ is

$$S_\lambda = S(u,v) + e\lambda n(u,v) \qquad (1)$$

Where denotes the unit normal vector on S. Let λ be plus constant, and $\lambda \neq 0$ $e=\pm 1$. Assume $S\lambda$ be the outer offset surface of S when e=1 , whereas $S\lambda$ be the inner offset surface of S when $e=-1$.

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Let n be the unit normal vector of any point on the surface S . Then

$$n = \frac{S_u(u,v) \times S_v(u,v)}{\left|S_u(u,v) \times S_v(u,v)\right|} \qquad (2)$$

B. Definition of Gauss Curvature

Suppose P is a point on the surface S, k1, K2 are the max and min values of normal curvature on the direction of tangent, calling the main curvature on the point of P in the surfaces S. The direction t1, t2 is called the main direction.

K is the product of two main curvatures on the point of P in the regular surface, which is defined as the gauss curvature or the sum curvature. H is the value of arithmetic mean on the point of P in the regular surface, which is called the mean curvature on the point of P.

C. Analysis of Surface Development

Developable surface is ruled surface, where all points of the same ruling line share a common tangent plane. The rulings are principal curvature lines with vanishing normal curvature and the Gaussian curvature gets vanished at all surface points. The developable surface can be unfolded into a plane by bending along the perpendicularity ruling direction. For the undeveloped surface, we need to consider gauss curvature on every point as follows [ChenXiao- peng 2009].

TAUBIN algorithm is adopted to compute the main curvature of every points, moreover, to solve the gauss curvature on the scatter points. The method is high effective on the times and the complexity degree.

III. Analysis of Development For the Hull Plate Surface

There are two parameters for the partial deformation of the line-heating process simulation. One is the transverse shrinkage along the heating line, and the other is the angular distortion along the thickness of the plate. The transverse shrinkage is produced between two consecutive processes which are the high temperature pressed and the refrigeration strained. The angular distortion is produced by the temperature grads along the thickness of plate, and the primary reason is the different deformation between the top-side surface and the back-side surface. The formed plate and the partial deformation have the specific corresponding relationship. Then, the whole shape of the plate ensures the partial deformation. In mathematics, most of the surface can be regarded as the stretchy surface, which is free pull and shrunk. But the plate is regarded as the rigid surface in engineering application. A lot of cracks are produced when the rigid plate surface is developed into a plane. These cracks are the deformation on the heating-line process which contains the transverse shrinkage and the angular distortion.

A. Transverse Shrinkage

The thickness of plate can be ignored for the analysis of transverse shrinkage. The crack must be presented when such plate surface is developed into the plane. The breadth of those cracks is the transverse shrinkage. There are many methods to calculate the transverse shrinkage for such surface, such as guide strip, ruled approach and area mapping etc [ChenXiao-peng 2009]. All above method of developing parametric surface are the region segmentation along the same directions, which has the same range of gauss curvature. Every regional segmentation can be approached by the ruled surface that can be segmented by triangle gridding.

According to the geometric characteristics of the complex surface of hull plate, the surface can be fitted firstly to obtain the parameter gridding. The value of gauss curvature is needed to be computed at every point, which is the inhesion property of these points for refreshing data. The computation of power value for every point on the scattered surface is the basic foundation for the regional segmentation [WeiYue-chun 2005]. The property of surface development lies on the gauss curvature entirely, and then the triangle surface with the same range of gauss curvature is classified in one region. The surface is finally divided into some regions of development. The whole plate surface is segmented based on the breadth first using search algorithm. Then every region is developed into plane based on the equidistant mapping method. At the end, the transverse shrinkage is calculated by this way.

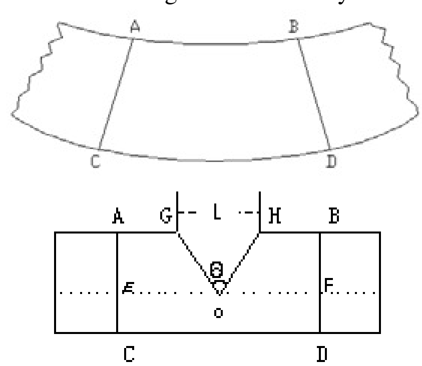

FIG. 1 THE DEFORMATION OF THE DEVELOPMENT FOR THE THICK PLATE SURFACE

B. Angular Distortion

The top-side of surface splits while the back-side of surface shrinks during the process of the developing plate surface. In the middle of the thickness of the steel plate layer that must be scalable invariant of a certain layer, here it is defined as neutral layer of [WeiYue-chun 2005]. The neutral layer plate can be regarded as the upper surface of the offset surface. As

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shown in fig. 1, the plate thickness is denoted as δ . The points of A and B on the top-side surface separately correspond to the points of E and F on the neutrosphere, and those corresponding points have the parallel normal vector according to the definition and the property of offset surface. Then the points of A and E have the superposition normal; so do B and F. GH denotes the crack produced by the split of AB. The dotted line of EF is called the neutrosphere. ε is the displacement coefficient of the neutrophere. Then the distant is ε-δ between the top-side surface and the neutrophere surface. The breadth of crack GH is the angular distortion denoted as l. The angle ∠GOH is the nip angle on the crack denoted as θ. The value of θ can be determined by the nip angle of the two points E and's F normal vectors. The formula θ=*tg*θ of exists when the value of θ is very small. Thus, the formula of the angular distortion for the thick plate surface development is as following:

$$l = \theta \cdot \varepsilon \cdot \delta$$

Where ε denotes the neutrosphere displacement coefficient. And δ denotes the plate thickness.

C. *Algorithm of Development for the Hull Plate Surface*

On the research of the thick plate surface development, the transverse shrinkage of the plate surface development can be calculated by the neutrosphere surface. The thickness of plate is denoted as δ. The fitting top-side surface is *S*.

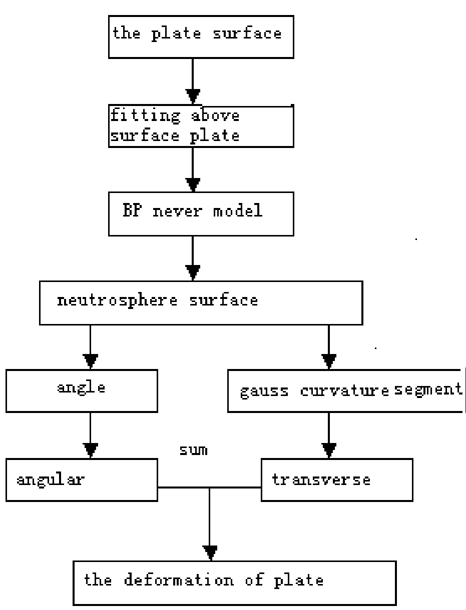

FIG. 2 THE FLOW CHART OF THE DEFORMATION FOR THE PLATE SURFACE DEVELOPMENT

IV. CASE STUDY OF DEVELOPMENT FOR THE HULL PLATE SURFACE

A. *Case Study of Angular Distortion*

Input parameters are the thickness of the plate, nip angle and angular distortion, while output parameters are the neutrosphere displacement, the model of BP nerve network designed. The number of unit intermediate hidden layer is 2. The model output layer is the sigmoid function nerve cell. The study velocity is 0.01, and the error target is 0.01.

Using the training samples, training of the BP network model, in Figure 3 for the network model in the sum of square error curve of corresponding different training times, in the network model trained by 17 times, the error model can be seen to achieve error index. After learning the training after the success of fixed weights and thresholds as shown in Tab 1.

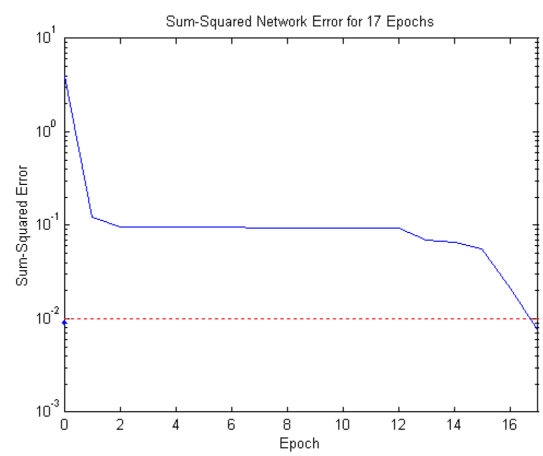

FIG. 3 THE ERROR SQUARE SUM CORRESPONDING THE DIFFERENT TRAINING OF THE NETWORK MODEL

TAB. 1 THE VALUE OF RIGHT AND THRESHOLD FOR THE SUCCEED TRAINING

Power value ω_1	Threshold b_1	Power value ω_2	Threshold b_2
0.9004 0.2137 0.7826	-0.0871	-0.2841	-0.6961
-0.0731 -1.8491 1.0767	0.4679	2.1689	

Using above settled power value or threshold value in table 1, the neutrosphere surface displacement ε of the thick plate is computed corresponding to these input parameters. Then the angular distortion *l* can be calculated through Eqn.(5). By contrast with the metrical vale, the computed value of angular distortion error is small within 0.001 mm. It seems that the BP net model is reliable.

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B. Case Study of Transverse Shrinkage

The thickness of the deformed plate is 20 *mm*, length of which is 3000 mm and the breadth is 1400 mm. By using the fairing algorithm to fit such plate surface [ZhuXiu-li 2005], the BP net model trains the settled power value or threshold value, given the neutrosphere $\varepsilon = 0.700$. The region segment threshold value is 0.300. By using the new method, the computational results of the development distortion for the plate surface are shown in Table 2.

TAB. 2 COMPUTATIONAL RESULTS OF THE DEVELOPMENT FOR PLATE SURFACE

neutrosphere displacem ent quotiety ε	α Threshold value	The sum of transverse shrinkage on the four edges			
0.7000	0.0300	45.310	45.330	19.500	19.590

The deforming of Heat-Ling is the sum of the transverse shrinkage and the angular distortion. The numerical results are obtained to show the efficiency of this method by contrast with the data in auctorial paper [ZhuXiu-li 2009]. It is discovered that the religion calculated value error is small within 0.03 mm.

V. CONCLUSION

The deformation of the development for hull plate surface can be used to forecast the deformation of Heat-Ling. In this paper, we have presented a new method to analyze the angular distortion of the plate development based on the BP neural network model, and the common region segmentation algorithm gets improved, by the adoption of the gauss curvature for the calculation of the transverse shrinkage of the developing plate. This method offers the reasonable line-heating parameter for the plane plate deforming directly to the surface plate.

REFERENCES

[1] Chen Dongren, Wang Guojin, "A complex surface adaptive segment and development algorithm based on Its Quasi- Rulings", Journal of Software, vol.14 no.3, pp. 660-665, 2003

[2] Chen Xiao-peng, "Research on Surface Compartment Technique Based on Gauss Curvature", Jiangsu Machine Building & Automation, pp, 14-17, 2009.

[3] JI Zhuoshang, Liu Yujun, "Development of study of ship hull plate bending by line heating", Journal of Dalian University of Technology, vol. 41no.5, pp.505-510, 2001

[4] Liu Yujun, Ji Zhuoshang, Dong Shoufu, "Approximate calculation of contraction of formed camber", Journal of Dalian University of Technology, vol. 35 no. 1, pp. 88-93., 1995

[5] LIU Yu-jun, ZHU Xiu-li, GI Zhuo-shang, "Ship hull processing surface fairing with constraints based on B-spline", Journal of Marine Science and Application, vol. 4 no. 3, pp. 13-17, 2005

[6] Qun Lin, Rokne J G., "disk Be2ler Curves", CAGD, vol.15 no.2, pp.: 721-737, 1998

[7] Wei Yuechun, "Analytic properties of offset surface", Mathematics in Practice and Theory, vol.35 no. 3, pp. 142-144, 2005

[8] Yu G, Masubuchi K, Maekawa T, Patrikalakis NM. A finite element model for metal forming by laser line heating. In: Chryssostomidis C, Johansson K, editors. Proceedings of the 10th International Conference on Computer Applica-tions in Shipbuilding, ICCAS'99, vol.2.Cambridge, MA: MIT: pp. 409-418,1999

[9] ZHU Xiu-li, LIU Yu-jun, "An analysis of the angle deformation rate of complex plate based on BP net", Journal of Marine Technology Bimonthly, vol. 20 no.4, pp. 315-322, 2010

[10] ZHU Xiu-li, LIU Yu-jun, JI Zhuo-shang, Jin Shi-liang, Yu Wen-xi, "A Method for Development of Hull Plate Suface Based on Its Quasi-Rulings", Journal of Ship Mechanics, vol..13 no. 6, pp. 934-941, 2009

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