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Simulation of Door Welding Deformation based on Finite Element

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Abstract

In this paper, taking 7050 aluminum alloy as an example, the welding deformation finite element analysis software is used to simulate the welding process of the door, and the welding deformation data of the door under different welding voltage, welding current and welding speed are obtained.

Keywords

Finite Element Analysis; Welding Deformation; Deformation Control.

1. Introduction

Welding technology is widely used in vehicles, aerospace and other fields, especially in the special vehicle industry. No matter what kind of large and complex vehicle body, it is necessary to use welding technology to connect aluminum alloy materials such as doors and decks [1]. In the welding process, the welded metal undergoes heating, melting and other processes due to the input and transmission of energy, and inevitably deforms under the influence of high temperature and high pressure.

As the main numerical analysis method, finite element analysis uses mathematical approximation to simulate real physical systems. It not only has high calculation accuracy, but also can calculate various complex shapes. It has become an indispensable engineering analysis method. Cui et al. [2] simulated the welding of SS7E locomotive welding frame, and the predicted results were in good agreement with the measured deformation values, which not only proved the effectiveness of the method, but also provided an important numerical means for the welding quality control of the frame.

In this paper, the finite element analysis model of welding deformation of large car body door structure is established. Based on the finite element analysis method, the 7050 aluminum alloy door structure is simulated by the special welding simulation software Simufact Welding 2020, and 18 sets of welding deformation data under different process parameters are obtained.

2. Finite Element Analysis Model

2.1 Structural Modeling

The three-dimensional modeling of the door is carried out by Solidworks software, The size of weldment 1 is 1500mm * 1240mm * 30mm, the size of weldment 2 is 460mm * 860mm * 30mm, the size of weldment 3 is 200mm * 200mm * 25mm, and the size of door handle is 190mm * 20mm * 6mm. All the welded specimens are meshed by shell elements. The total number of elements is 96,000, of which the maximum mesh size is 40 mm and the minimum mesh size is 8 mm. The mesh between the weldment and the weldment is properly encrypted to ensure that the mesh size at the weld is 5 mm, and the mesh size in the area affected by heat is not too sparse. After the mesh is divided, it is imported into the special welding finite element analysis software Simufact Welding for numerical simulation calculation. The simulation environment diagram is shown in Figure 1.

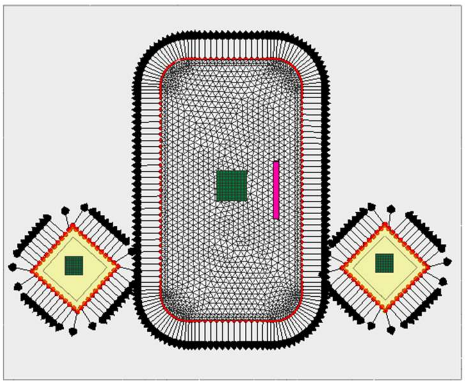

Figure 1. Schematic Diagram of Door Simulation Environmen

2.2 Finite Element Analysis Process

The finite element method is a numerical method used to solve mathematical physics problems [3], which uses mathematical approximation to simulate geometric and load conditions. The steps of finite element analysis include three stages : pre-processing, solution calculation and post-processing.

(1) Pre-processing work includes building a three-dimensional model, meshing, and checking the quality of meshing;

(2) Solution calculationThe finite element model is solved by running the Simufact Welding solver;

(3) Post-processing can visually view the results of numerical analysis of welding deformation, showing the temperature cloud, deformation cloud, equivalent stress cloud, which can help us quickly summarize the factors affecting welding deformation and improve welding quality.

2.3 Heat Source Model

During the welding process, the temperature of the weldment will rise rapidly with the concentrated input of the welding heat source. Due to the great difference in the surface temperature of the weldment [3], it is easy to cause welding deformation. Therefore, choosing a suitable heat source model will greatly improve the welding quality and reduce the welding deformation. At present, the commonly used heat source models include the double ellipsoid heat source model and the Gaussian heat source model [4]. The double ellipsoid heat source model fully considers the characteristics of uneven heat source distribution in the welding process, and can better reflect the actual welding process conditions. Considering comprehensively, this paper uses the double ellipsoid heat source model, and the energy density distribution function of the double ellipsoid heat source is shown in equations (1) and (2). Fig.2 shows the three-dimensional model of the energy density distribution of the double ellipsoid heat source.

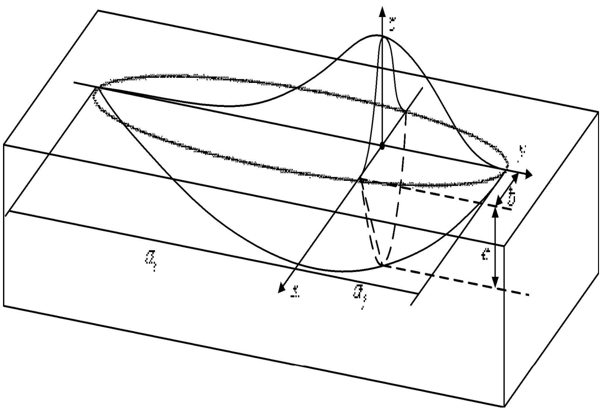

Figure 2. Energy density distribution model of double ellipsoidal heat source

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The energy density distribution function of the ellipsoid heat source in the first half is [5]:

$$q_1(x,y,z)=\frac{6\sqrt{3}f_f\eta UI}{a_f bc\pi\sqrt{\pi}}\exp\{-3[(\frac{x}{a_f})^2]+(\frac{y}{b})^2+(\frac{z}{c})^2\} \tag{1}$$

The energy density distribution function of the ellipsoid heat source in the latter half is [5]:

$$q_2(x,y,z)=\frac{6\sqrt{3}f_r\eta UI}{a_r bc\pi\sqrt{\pi}}\exp\{-3[(\frac{x}{a_r})^2]+(\frac{y}{b})^2+(\frac{z}{c})^2\} \tag{2}$$

In the formula : af, ar, b, c are heat source shape parameters ; η is the welding heat source efficiency ; u is the arc voltage ; i is the welding current ; v is the welding speed ; τ is the power supply lag time factor ; ff and fr are heat flux distribution coefficients.

The parameters of the double ellipsoid heat source model used in this paper are shown in Table 1:

Table 1. Parameters of double ellipsoid heat source model

parameter	numerical value
Front axle lengthaf a_f(mm)	6
Rear axle lengthar a_r(mm)	10
Width b(mm)	8
Depth d(mm)	8
gaussian parameter(mm)	3
Heat source front end scale factor	0.75

3. Simulation Results

The base metal of the door welding is 7050 aluminum alloy, and the chemical composition is shown in Table 2.The simulation platform is configured with a 6342ES processor, 160G running memory, and 5T hard disk storage space. The simulation temperature is set to 20 °C, and the simulation time is 0-1500 s. The welding voltage is controlled at 20-24V, the welding current is 180-220A, and the welding speed is 8mm / s-13mm / s. By randomly changing the welding voltage, welding current and welding speed within the above parameter range, 18 sets of welding simulation data as shown in table 3 are obtained. The welding voltage is 24V, the welding current is 180A, and the welding speed is 8mm / s. The deformation simulation cloud diagram is shown in Figure 3.According to the table, when the welding voltage is 20V, the welding current is 180A, and the welding speed is 13mm / s, the minimum deformation is 0.58mm.Recording the time of each welding simulation, fill in table 3, and the average time required for Simufact Welding simulation is 316.81 minutes.

Table 2. Chemical Composition (Mass Fraction) of 7050 Aluminum Alloy

Al	Zn	Ti	Mg	Zr	Cu	Fe	Mn	Si	Cr
87.69	6.6	0.06	2.5	0.14	2.6	0.15	0.1	0.12	0.04

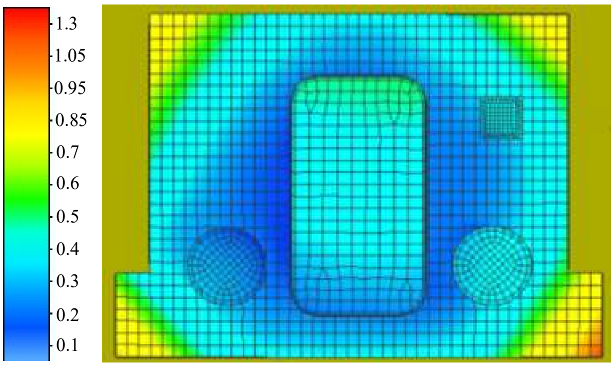

Figure 3. Simulation cloud diagram of welding deformation

Table 3. Welding simulation results under different parameters

number of classes	welding voltage U/V	welding current I/A	welding speed mm/s	Deflection /mm	simulation time /min
1	20	180	8	1.06	312
2	20.5	177	8.5	1.03	323
3	21	180	9	0.99	325
4	20	179	11	0.72	334
5	20	178	12	0.64	326
6	20	182	10	0.84	319
7	20	180	13	0.58	318
8	22.5	195	8.3	1.19	327
9	22.5	205	12.4	0.89	331
10	22.0	200	12	0.86	309
11	23.5	210	11.3	1.06	311
12	24	210	13	0.95	309
13	22.5	220	11	1.07	316
14	24	180	10	1.02	321
15	21.4	220	13	0.95	326
16	23.2	191	11.6	0.92	317
17	21.8	203	12.5	0.84	306
18	20.7	211	12.8	0.80	309

4. Conclusion

Simufact Welding can simulate and predict the deformation under different parameters by adjusting the welding voltage, welding current and welding speed, which can control the welding deformation and improve the welding efficiency.

Acknowledgments

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References

[1] CUI X F,MA J,XIA Y M,et al.The Numerical Simulation of Welding Deformation and its Application in SS7E Locomotive BogieFrame[J].Machine Tool&Hydraulics,2004,(08):60-62.

[2] EILEEN W C W, DO K K. A simplified method to predict fatigue damage of TTR subjected to short-term VIV using artificial neural network[J]. Advances in Engineering Software, 2018, 126:100-109.

[3] WANG J X,CHU G N,YU C L,et al.General Study on Prediction of Welding Distortion of Construction in Naval Architecture[J].Ship Engineering, 2011, 33(S2):1-5.

[4] WU Chunbiao, WANG Chao, KIM Jae-Woong. Bending deformation prediction in a welded square thin-walled aluminum alloy tube structure using an artificial neural network[J]. The International Journal of Advanced Manufacturing Technology, 2021, 117:2791-2805.

[5] DING J,GU Y C,HUANG X,et al.Research on Prediction Accuracy of Flow Stress of 304 Stainless Steel Based on Artificial Neural Network Optimized by Improved Genetic Algorithm[J].Journal of Mechanical Engineering, 2022, 58(10):78-86.