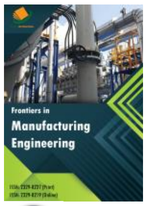
Frontiers in Manufacturing Engineering (FME)

DOI : http://doi.org/10.26480/fme.02.2017.04.06

ZIBELINE INTERNATIONAL PUBLISHING

ISSN: 2329-8227 (Print)
ISSN: 2329-8219 (Online)
CODEN : FMERA8



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NUMERICAL SIMULATION OF TEMPERATURE AND RESIDUAL STRESS IN MULTI-PASS DISSIMILAR METAL WELDING

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ARTICLE DETAILS

Article History:

Received 12 July 2017
Accepted 12 August 2017
Available online 1 September 2017

ABSTRACT

Dissimilar metal welding is widely used in machinery and equipment and a member of the petrochemical, aerospace, power plant boiler, engineering machinery industry. To study the residual stress in the multi-pass dissimilar metal welded joint, the welding process is simulated and analyzed by using ABAQUS software in this paper, which it is considered that the effect of the temperature, thermal convection, and radiation diffusion on the physical properties of the material. Meanwhile, the welding heat resource is simulated by an ellipsoidal heat source mode and the element birth-and-death technique and the sequential coupling approach is adopted in the simulation. The results indicate that the maximum residual stress appears in the weld metal region, which is beyond the yield stress of material, and the stress in the middle layer is less than the stress on the upper and lower surfaces in welded plate.

KEYWORDS

Dissimilar metal, multi-pass welding, finite element analysis, temperature field, residual stress field.

1. INTRODUCTION

Based on a study, it is well known that the residual stress in welded structure induced by welding thermal process is often up to or even over the yield strength of materials [1]. Study showed the residual stress is one of main factor to induce the fracture, deformation and capability degradation of the welded structure during service [2]. Eliminating or reducing the residual stress could greatly improve the service performance of the welded structure, however, it is quite complex to calculate and measure an accurate distribution of residual stress in the welded joint. Currently, the main method to obtain the residual stress is the laboratory measurement and numerical simulation [3]. According to a research, the difference of the material parameters is not considered in the current simulation and calculation of the temperature and the residual stress distribution in the dissimilar metal welded joint, which can not ensure to obtain an accurate residual stress field in the welded join [4-5]. To study the residual stress in the multi-pass dissimilar metal welded joint, the welding process is simulated and analyzed by using the element birth- and-death technique and the sequential coupling approach in ABAQUS, meanwhile, the difference of the material parameters in welded joint is also considered and the welding speed is determined by an actual welding process in this simulation [6].

2. FINITE ELEMENT MODEL

2.1 Geometric Model and Material Model

Figure 1 is a diagrammatic sketch of multi-pass dissimilar metal welded plate. Because defects such as incomplete fusion or crack might occur in welding process between F316 base metal and 304 welding metal, Alloy 132 is firstly welded on the edge of base metal as a butter metal. The research of the welding process is an extremely complex thermo-elastoplastic mechanical process, which it should be considered that the effect of the temperature change on the thermo-physical property in the numerical simulation of welding process [7-10]. The relations of the thermal physical and thermodynamic properties related to welding temperature are showed in Figure 2.

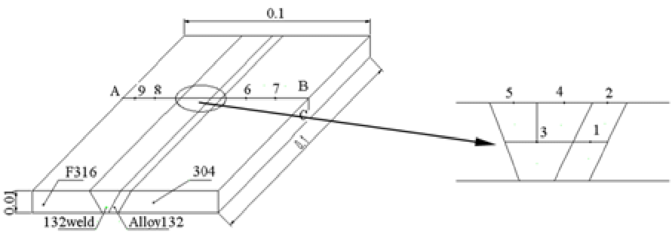

Figure 1: Diagrammatic sketch of multi-pass dissimilar metal welded plate.

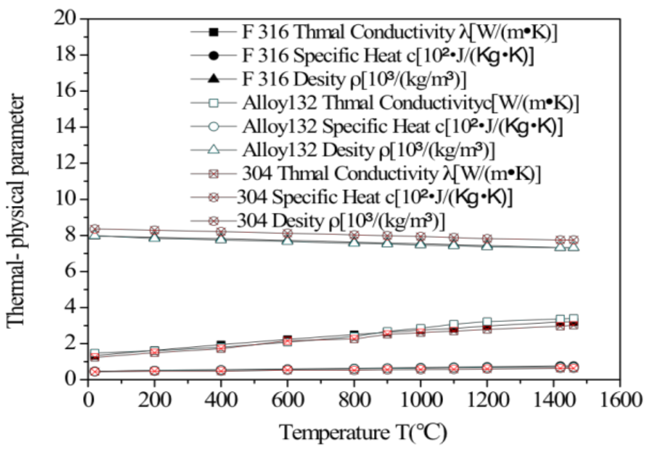

Figure 2: Thermal-physical property of material.

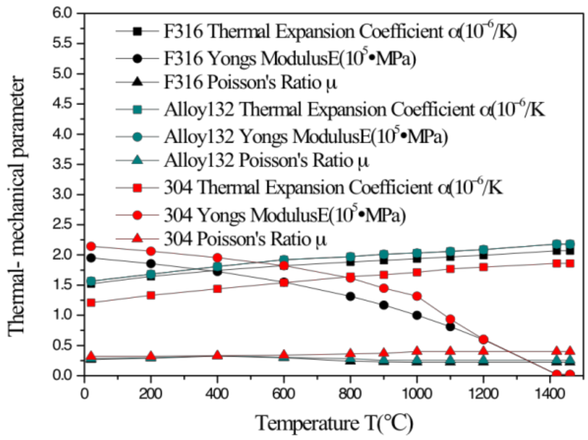

Figure 3: Thermal-mechanical property of material.

2.2 Simulation of Welding Process

Firstly, a heat source model is establish, and the welding process is simulated under certain welding specifications, then the temperature field is obtain by using a transient heat transfer analysis, finally the residual stress distribution in welded joint is obtain by the thermo-elastoplastic mechanical analysis [11-13]. The ellipsoid model was adopted as the heat source model in this paper. The main parameter in the welding process is shown in Table 1.

Table 1: Main parameters in the welding process.

Welding channel	Electrod e diameter (d/mm)	Voltag e (U/V)	Curren t (I/A)	Weldingvel ocit y (v/(mm/s))
Butterin g	2.5	22.5	85	3.25
First layer	3.2	23	121	2.63
Second layer	4.0	24	156	2.52

2.3 Boundary Condition and Mesh Model

Based on a research the boundary condition in the temperature and the stress analysis should be considered in the welding process. In the temperature analysis the flow coefficient is 10, and the blackness is 0.85 respectively [14]. The two faces of the welded joint perpendicular to welding zone are constrained and the degree of freedom of Y direction is applied as 0 in the stress analysis. Metal absorbs heat from solid to liquid state and conversely releases heat in the welding process, which considers the effect of the latent heat of pool phase transition on the temperature field when the dissolved latent heat of dissolution of the metal is assumed equal to that of solidification [15-16]. The mesh will be determined by the computing time and the result accuracy. The latent heat parameter of materials is shown in Table 2.

Table 2. Latent heat parameter of material.

Material	Latent Heat	solid-phase line	liquid phase line
F316	300	1420	1460
Alloy132	300	1420	1460
304	300	1399	1454

3. RESULTS AND DISCUSSIONS

The welding process is a coupling process between temperature and stress, and the stress field depends on the welding temperature field. Figure 4 shows the temperature field in different time.As can be seen from the graph, center of heat source temperature at 1600℃. Heat affected zone and heat source center temperature of 1600℃.

Figure 5 shows the thermal cycle process beneath the welding bead in various reference points, which the temperature increased to the melting point quickly and then drop down slowly in each reference point, where the temperature on other reference points are the environmental temperature before the heat source arrive at the reference point. The residence time of temperature above phase change point of in the weld zone is basically same, and the cooling time (the phase transition dropped to 500 °C) of reference points in the weld district is also basically equal. The highest temperature at the point that the weld heat source arrivals in the welded zone is higher than the melting point of the metal that is about 1450℃, but the temperatures of far away from the welded zone are less than 1420℃, which indicate the metal is not melted, and the simulated situation meets the actual welding process. The farther the reference point is from the welded zone, the smaller the high temperature is.

machined surface. Grinding heat in the process of MEG is produced by the interaction between both the outer and inner abrasives on wheel end face and the workpiece materials. Because of the different effect of abrasives in outer rings and inner rings, the grinding temperature field will have the different influence on workpiece surface

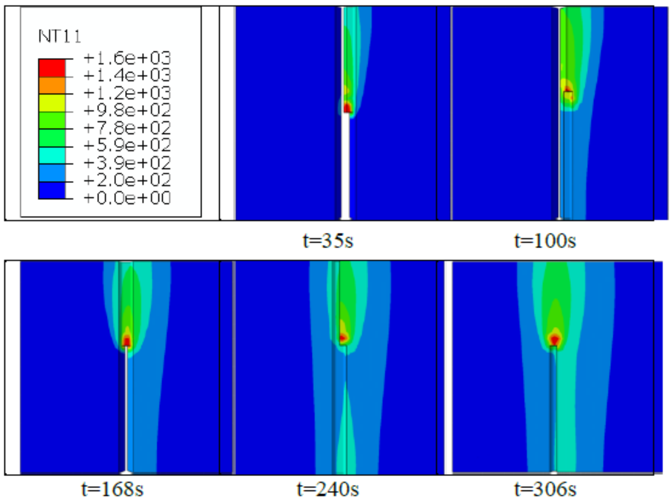

Figure 4: Distribution of temperature field in welding process.

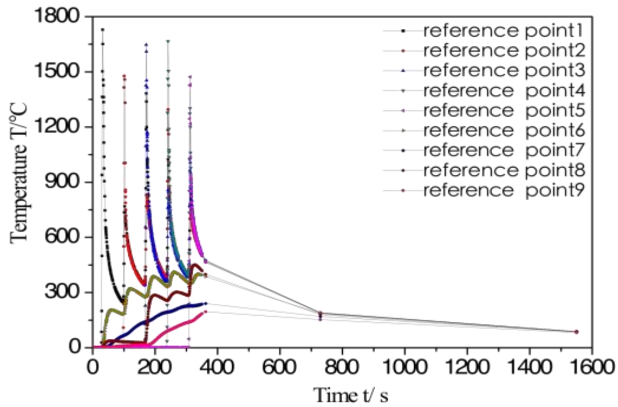

Figure 5: Temperature change in welding process.

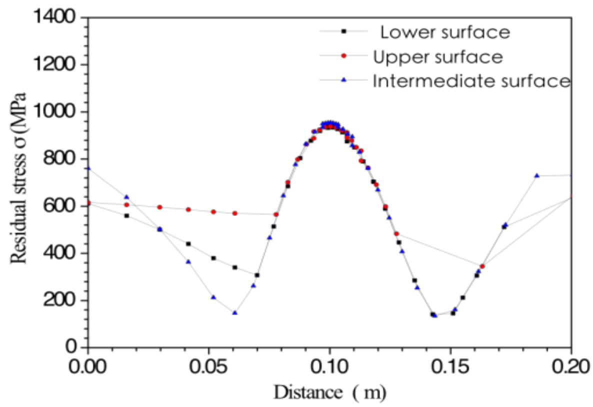

Figure 6: Residual stress distribution on different surfaces.

Cite The Article: He Xue, Yingru Wang, Weibing Wang, Xiaobo Li, Yuankui Gui, Xiaoqing Tao, Rui Guo (2017). Numerical Simulation Of Temperature And Residual Stress In Multi-Pass Dissimilar Metal Welding. *Frontiers in Manufacturing Engineering*, 1(2) : 04-06.

Figure 6 shows that the distribution of the residual stress, which indicate that the residual stress is similar on the upper surface, intermediate layer, and lower surface and the maximum stress is about 900 MPa, which exceed the yield stress of the material. The distribution of the residual stress in the thickness direction of the welded plate is different, with the difference of the welding heat input condition, welding speed, thermal conduction velocity and work hardening of the metals.

4. CONCLUSIONS

The thermal cycle curves and the residual stress distributions are simulated and analyzed in the multi- pass welding process of the dissimilar metal plate in this paper, and the conclusions is obtained as following,

(1) The maximum residual stress exists in the welded region, which is much bigger than the yield stress of welded metal.

(2) The stress in the intermediate layer of the plate are less than those in the upper and lower surface, which is because the temperature change in the intermediate layer only depend on the heat conduction and the change is slow in the cooling process of the welding.

(3) In the process of welding, welding heat affected zone of each point on the experience of the welding thermal cycle and post weld cooling rate are not the same "result and the performance of the whole heat treatment of weld zone tissues do not exhibit uniformity, the uneven joint performance was particularly prominent in the welding of dissimilar metal.

(4) Due to the weld area organization bulky "its strength and hardness is higher than the base" and toughness is lower than the parent metal "aging treatment can improve the toughness of the weld .

Two kinds of material thermal expansion coefficient of different lead to produce very big thermal stress at the interface between welding.

ACKNOWLEDGMENT

This work is financial supported by the National Science Foundation of China through Grant 51475362 and the Specialized Research Fund for the Doctoral Program of Higher Education of China (20136121110001).

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