Title	Study on prediction of welding deformation for large-scale structure by T-E-P FEM using 3D shell element
Author(s)	Zhang, Xueyuan; Luo, Yu; Wang, Yang
Citation	Transactions of JWRI. 2010, 39(2), p. 73-75
Version Type	VoR
URL	https://doi.org/10.18910/6738
rights	
Note	

Study on prediction of welding deformation for large-scale structure by T-E-P FEM using 3D shell element†

ZHANG Xueyuan*, LUO Yu**, WANG Yang*

KEY WORDS: (T-E-P FEM) (Welding deformation) (Large-scale structure) (3D shell element) (Parallel calculation)

1. Introduction

Recently numerical simulations of industrial manufacturing processes have been widely studied, and various methods of numerical simulation for welding mechanical behavior have been developed. But the reports about simulation involving large-scale structures, especially by T-E-P FEM, were still rare. The reason maybe is a huge amount of computation time. It is possible to save computation time by replacing 3D solid elements using 3D shell elements.

In this paper, a bead-on-plate welding is the research model, and simulations by T-E-P FEM have been performed using software Abaqus. Through the comparison of the calculation results using 3D solid and shell element, the possibility of using 3D shell element to simulate deformation of large-scale structure is confirmed. Then, Mesh size effect has been discussed, and parallel calculation was employed in calculating.

As an example, a typical large-scale hull double bottom structure is modeling, and 3D shell element T-E-P FEM was used to simulate welding deformation. The feasibility of welding deformation prediction by 3D shell element T-E-P FEM is verified.

2. The Comparison of 3D solid and shell T-E-P FEM

2.1 Research Model

The size of model is 1000mm, 500mm and 10mm for length, width and thickness respectively. The smallest element is 10mmx2.5mmx2.5mm. Heat input parameter (Q/h^2) is 13.0 (J/mm^3), welding speed is 10mm/Sec.

The thermal properties and mechanical properties are dependent on temperature, which reference to paper [1].

2.2 Comparison of temperature

Figure 1 shows the distribution of temperature by 3D solid and shell element at center cross-section on the surface of the plate when welding time is 50 sec. As in Fig. 1, it is found that the distribution of temperature is in good agreement.

2.3 Residual Stress Analysis

The comparison of von-mises residual stresses is shown in **Fig. 2**, also it is shown that the von-mises residual stresses of 3d solid element model agree quite well with that of the 3d shell element model.

2.4 Comparison of plastic strain

Figure 3 displays the plastic strain in the Y-direction for the 3D solid model and 3D shell model at center cross-section in middle of plate. Both are almost the same

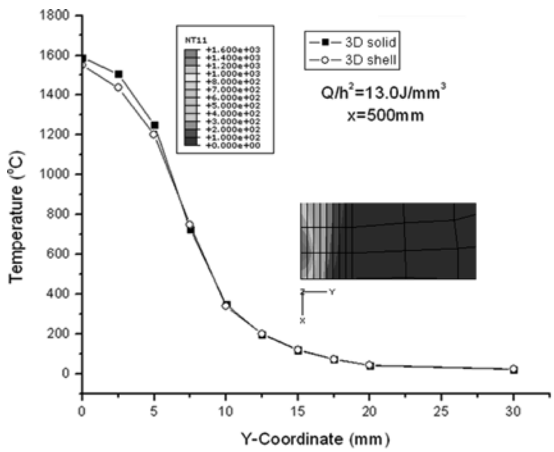

Fig.1 Comparison of temperature at center cross-section

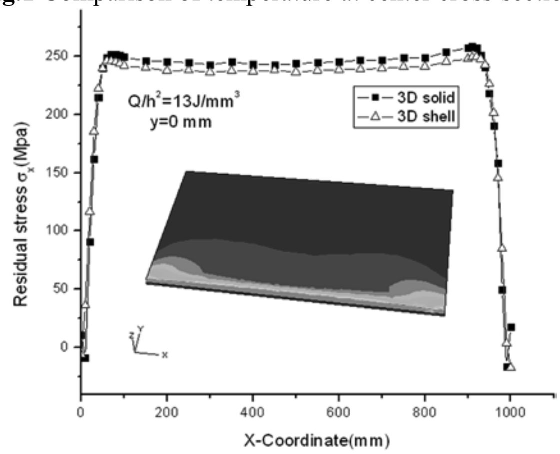

Fig. 2 Comparison of von-mises residual stress at welding line

† Received on 30 September 2010

* Graduate School, Shanghai Jiao Tong University, Shanghai, China
** Shanghai Jiao Tong University, Shanghai, China

Transactions of JWRI is published by Joining and Welding Research Institute, Osaka University, Ibaraki, Osaka 567-0047, Japan

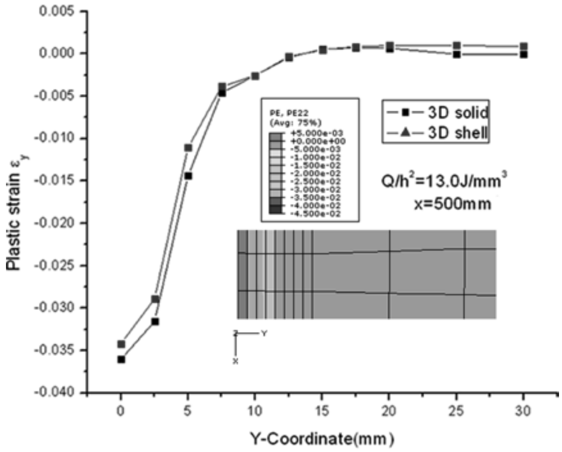

Fig. 3 Comparison of plastic strain at center cross-section

2.5 Effect of Mesh Sizes

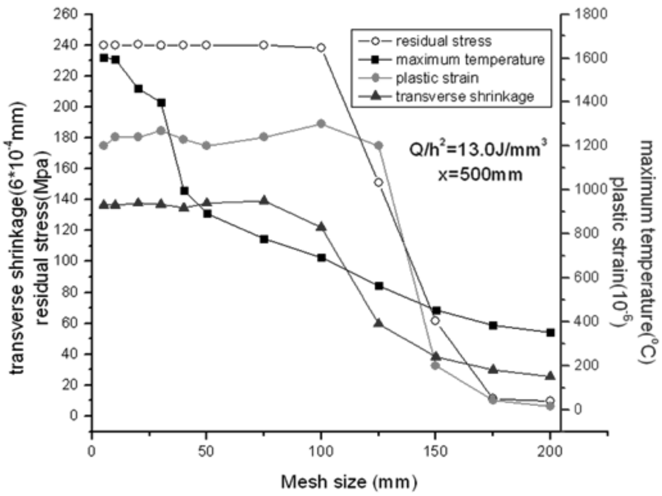

Fig. 4 Effect of Mesh Sizes on Welding Deformation

As Fig. 4 shows, as the size of the mesh increases, the peak temperature at welding line will be gradually reduced, when the size is 100mm, the temperature dropped to 693℃. If the size is greater than 100mm, residual stresses on welding bead began to decline. Also, transverse plastic strain decreases with the mesh size increasing. From these curves it can be suggested if mesh size is less than 100mm, calculation results will not be greatly affected.

As a summary, the results of comparison between 3D solid and shell models are listed in **Table 1**.

Table 1 The results of comparison between 3D solid and shell models

	Mesh size(mm)	Residual stress(MPa)	Shrink age	plastic strain	Cost time(min)
Solid	10x2.5x2.5	240.2	0.096	0.00120	140
Shell	2.5x2.5	240.7	0.094	0.00124	30

As seen from Table 1, it is clear that the results obtained from using 3D solid and shell elements are consistent, and cost time is three times less.

3. Calculation example

As an example, a typical of the hull structure, called large-scale hull double bottom structure, is modeling, and 3D shell element T-E-P FEM was used to simulate welding deformation.

3.1 Model and welding conditions

As **Fig. 5**, the length, the width and the height of the Double Bottom Structure are 16125mm, 11860mm and 1750mm respectively. The element size is 100mm × 100mm, and the total number of elements is 123512, which amounts to 426078 degrees of freedom. DS4 was used for temperature field calculation, and the S4 shell element was chosen appropriately for simulation of stress field. Material properties are the same as above bead-on-plate model.

In order to improve calculation speed, parallel calculation was performed by establishing a computer cluster system composed of two server computers.

It takes about 15 hours for completing the computation of temperature field and stress field with two Dual-Core Xeon processors with 3.0 GHz clock speed.

3.2 The calculated results

Figure 5 shows the distribution of temperature by 3D shell element. The six weldments on floor plate and stiffener are proceeding.

Figure 6 displays welding deformation enlarged 200 times. Transverse and longitudinal shrinkage which most are concerned is approximately 3.96mm and 2.56 occurring at the middle of the double bottom.

So, the 3D shell element T-E-P FEM should be a useful tool for prediction of welding deformation of large-scale structure.

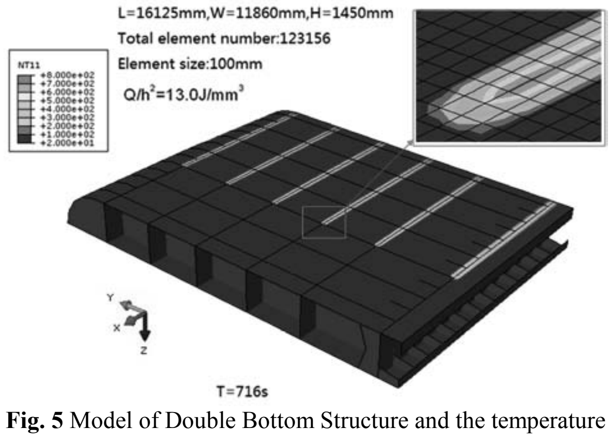

Fig. 5 Model of Double Bottom Structure and the temperature field

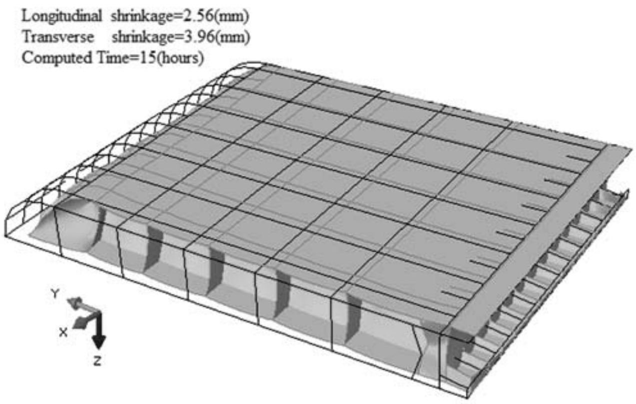

Fig. 6 Welding Deformation

4. Conclusions

The conclusions of this study are summarized as follows:

(1) Regarding bead-on-plate welding, the calculation results obtained by 3D solid and shell element T-E-P FEM are in good agreement.

(2) If mesh size is less than 100mm, calculation results will not be affected greatly by mesh size

(3) By simulation of a typical of large-scale hull double bottom structure, the feasibility of 3D shell element T-E-P FEM was verified.

References

[1] Yu LUO, Hidekazu MURAKAWA and Yukio UEDA: Trans. Of JWRI, Vol. 26 (1997), No.2.467-475.