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Construction of Welding Deformation Prediction Simulation Model for Automotive Components

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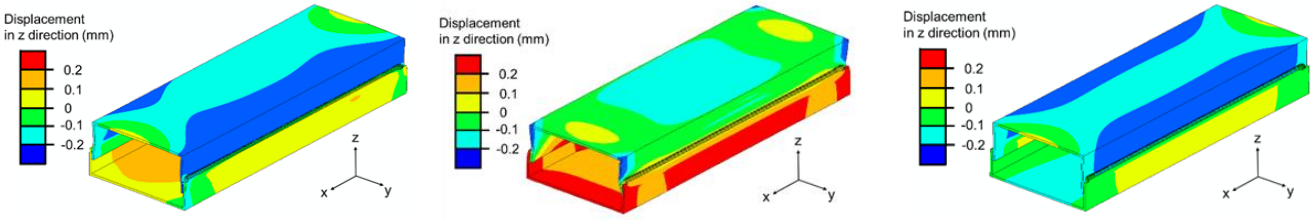
Welding is an essential process in the manufacture of automotive components. However, deformation caused by heating and cooling due to welding is generally unavoidable, and welding deformation is problematic because it reduces strength performance and production efficiency. Therefore, it will be useful if computer simulation can be used to predict welding deformation accurately and quickly. Numerical simulation techniques for welding deformation include detailed welding phenomenon analysis and simplified analysis using the thermal shrinkage technique. The former requires a large amount of calculation time and memory capacity to solve the stiffness equations for each time increment. The latter assumes thermal shrinkage that occurs during the cooling process in welding and uses the shrinkage strain as input data. And it can significantly reduce calculation cost because the stiffness equations do not need to be calculated sequentially.

In this paper, we constructed a detailed welding phenomenon analysis model and a simplified analysis model using the thermal shrinkage technique capable of predicting welding deformation for thin plate box-shaped lap-welded joints assuming automotive components. In the thermal shrinkage technique, a new method for setting the thermal shrinkage parameter was proposed to improve the accuracy of predicting welding deformation for thin plate structure. The accuracy of each model was confirmed by comparison with the experimental results, and the calculation cost of each model was compared and evaluated.

Fig. 1(a) shows the overall view of the welding deformation obtained by detailed welding phenomenon analysis. In the center section, both sides of the plate are depressed inward and the upper plate is slightly convex. The deformation tends to be larger at the edges of the upper plate and both sides. As described above, it can be confirmed that welding deformation appears complexly in a box-shaped cross-sectional structure as a result of shrinkage in welding part. Fig. 1(b) shows the overall view of the welding deformation obtained by a simplified analysis using the thermal shrinkage technique with conventional thermal shrinkage parameters. The results of the simplified analysis differ from those of the detailed analysis in both deformation shape and deformation amount. Therefore, it is not necessarily



(a) Detailed analysis (b) Simplified analysis (conventional method) (c) Simplified analysis (new method)

Fig. 1 Welding deformation invertical (z) direction

appropriate to apply conventional thermal shrinkage parameters to predict welding deformation of thin plate. This is because the inherent strain distribution, which is the cause of welding deformation, is different. Therefore, the thermal shrinkage parameters were redefined to consider the inherent strain distribution. Fig. 1(c) shows the overall view of the welding deformation obtained by a simplified analysis using the thermal shrinkage technique with the new thermal shrinkage parameters. The results of the simplified analysis using the new thermal shrinkage parameters show the same deformation trends as those of the detailed analysis. The simplified analysis using the conventional method has low prediction accuracy for welding deformation, but consideration of the inherent strain distribution improves the prediction accuracy, and it is confirmed that the prediction accuracy for welding deformation is equivalent to that of the detailed analysis.

Finally, Fig. 2 shows the calculation time required for each simulation model. The detailed analysis took 81.5 hours and the simplified analysis took 0.6 hours. It indicates that the simplified analysis can predict welding deformation in about 1/136 of the time of the detailed analysis.

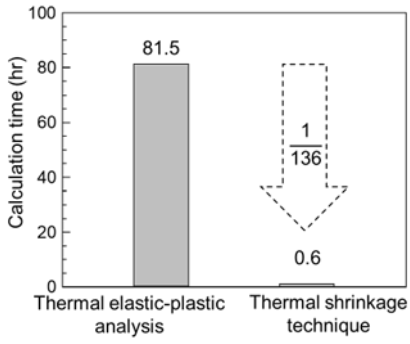


Fig. 2 Comparison of calculation time between detailed analysis and simplified analysis