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Analysis and Prediction of the Multi-Heating Lines Effect on Plate Forming by Line Heating

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Summary

Line heating is an effective method to form curved shell plates with complex three-dimensional geometry. However, the line heating requires many man-hours and the empirical intuition of hard-to-find skilled shipwrights. Therefore, automation is highly required. At present, no automatic system that can accurately form a plate without significant human help has been developed.

In order to establish an automatic plate forming process by line heating, the heat-induced deformation needs to be accurately predicted. However, the heat-induced deformation has many complex and uncertain factors which are obstacles to the accuracy required by automatic systems. Experimental observations have shown that the inherent deformation produced by multiples heating lines is not a simple addition of the inherent deformation produced by single heating lines. Thus, to accurately predict inherent deformation, the method of superposing inherent deformation is not appropriate. To overcome this, based on the inherent deformation theory, the authors investigate the effect of multiples heating lines on line heating plate deformation.

At first, the deformation produced by a single heating line is estimated by integrating the inherent strain obtains through a three dimensional thermal elastic-plastic finite element analysis. Then, multi-heating line are applied and the inherent deformation obtained by FEM is compared with that obtained by superposing inherent deformation of single heating lines. From this, three combinations of multi-heating lines are identified and studied; overlapped, parallel and crossed heating lines. For each case, the influence of residual stress, initial curvature, sequence of heating, and side plate edge on inherent deformation is then studied as possible causes of the variation on inherent deformation.

It is demonstrated that the residual stresses produced by previous heating lines is the main factor affecting the total inherent deformation while the influence of plate curvature, for small curvature, such as that produced by single heating lines, the influence of sequence of heating and the influence of side plate edges on multi-heating lines are small and can be neglected. Finally, correction factors are proposed to improve the accuracy of the predictive method.

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