(328) Stress Analysis of Plate during Accelerated Cooling

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1.Introduction

One of the important considerations in applying Accelerated Cooling (ACC) process is the flatness control of a plate. Nonflatness of the plate is attributed to the excessive thermal stress, caused by the nonuniform temperature distribution during ACC process. In this study, thermal stress analysis model was developed and the wave-type plate distortion was analyzed.

2.Modeling

The thermal stress analysis model was formulated under the following assumptions;
i) The wave-type plate distortion depends on the longitudinal stress only.
ii) Temperature distribution in the through-thickness direction is not considered, but the mean temperature is used.
iii) Compatibility condition is that a plane, orthogonal to the rolling direction, remains a plane orthogonal to that direction.

In the model, the stress state was analyzed using the temperature-dependent mechanical properties of materials and the volume-change during phase transformation was expressed as the effective thermal expansion coefficient.

3.Results

The actual temperature history of 10mm(t)*3000mm(w) size plate was measured by K-type thermocouples. For convenience, simplified temperature history shown in Fig.1 was used in thermal stress calculation. Thermal stress calculation results are shown in Fig.2. In certain temperature range, thermal stress was equal to the yield strength($\sigma/\sigma_Y = \pm 1$). This means plastic deformation or plate distortion occurred.

The residual stress was measured through the Hole-drilling method and compared with the calculated value. There was a good correlation between these two values.

This thermal stress analysis model was found to successfully predict the deformation behavior during ACC process.
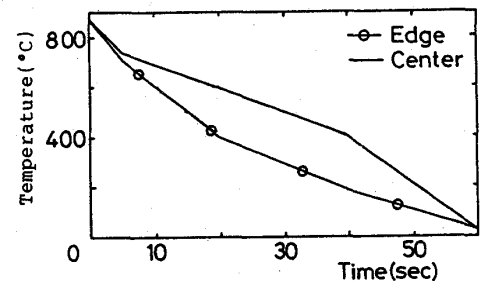

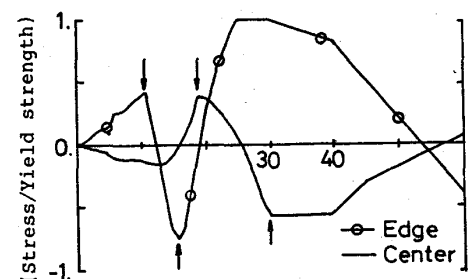Fig.1 Typical temperature history at edge and center in plate.

Fig.2 Results of thermal stress analysis.

↓ : Transformation start.

↑ : Transformation end.

4.Reference

1) A.Mendelson, PLASTICITY; theory and application, The Macmillan Co.,1968
2) Calculation of Internal Stresses in Heat Treatment of Metallic Materials, Sympo. Univ. of Linköing, May 1984