Estimation of Welding Distortion Using Neural Network

Yasuhisa Okumoto
Kinki University, School of Engineering
Higashihiroshima, Japan

ABSTRACT

Recently, the prediction of welding distortion of steel structure has been carried out widely. Though the thermal elastic-plastic FEM analysis is usually required to ensure the accuracy of the estimation, technical knowledge is required, and long computing time is necessary. In this study, simplification of the prediction was done using a neural network model, in which the calculation result of the FEM analysis was incorporated in teacher data, for the fillet welding of T- type build-up structure etc. This program would be able to estimate the welding distortion of the joint with different dimensions and welding conditions in a simple manner.

KEYWORDS: Welding distortion; fillet welding; FEM analysis; thermal analysis; numerical estimation; neural network; back propagation

INTRODUCTION

The residual deformation induced by welding processes is a cause of repair work at the subsequent process. Therefore it is necessary to manage the assembly of welded structures by estimating accurately the distortion considering welding conditions, welding length, and structural dimension, etc. Until now, theoretical, experimental, and practical studies have been carried out widely, and then the prediction of the welding distortion can be done accurately by using FEM analysis now. However, technical knowledge is required for the analysis, and long computing time is necessary to calculate the distortion, because thermal elastic-plastic FEM analysis is usually required to ensure the accuracy of the estimation (Nishikawa et al., 2004).

Though the elastic FEM analysis is applied generally in order to predict the welding distortion easily and practically, in this study simplification of the prediction was done using neural network model. At first, thermal elastic-plastic FEM analysis was carried out for the typical structure, and the relationship between welding conditions and welding distortions (mainly transverse shrinkage and angular distortion) was studied. Next the neural network model by back propagation method was programmed, and the FEM analysis results were given into the program as teacher's data. Then, the transverse shrinkage and angular distortion can be output by this program for the similar structure, if the welding conditions and structural dimensions are input. This program would be able to estimate the welding distortion of the joints with different dimensions and welding conditions in a simple manner. In this paper, a T- type build-up structure and stiffened panel are introduced as an example.

ANALYSIS OF WELDING DISTORTION BY FEM

At first, the welding distortion was analyzed for a T-type build-up structure which is one of typical fillet welding, using the software of thermal elastic-plastic analysis. Recently semi-automatic CO_2 arc welding is widely applied in shipbuilding. Then, the observation of welding operation in a shipyard was carried out, and the data of heat input (welding speed, voltage, current, etc.) of the CO_2 welding were collected, and these welding conditions were used in the analysis.

The computation model is shown in Fig.1. The model contains two types of 1,000mm and 2,000mm in length, and also two types of 12mm and 20mm in plate thickness. The fillet welding is carried out on both sides simultaneously, so-called twin welding. Thermal efficiency of the heat input is assumed to be 0.8 for the CO_2 welding. The data for the analysis is shown in Table 1.

The structural material used is the higher strength steel having 30kgf/mm^2 class yield point. The material properties are considered to have temperature dependency shown in Fig.2 and Fig.3, except the followings, which have constant value;

Density: 7.8×10^{-6}(kg/mm^3)
Specific heat: 0.13(J/g/℃)
Poisson's ratio: 0.3
Linear expansion coefficient: 1.5×10^{-5}(1/℃)

The analysis was carried out by two steps: the temperature distribution was gained by the unsteady heat conduction analysis for the assumed