IDENTIFICATION OF RESIDUAL STRESS DIRECTIONALITY USING ANISOTROPIC INDENTER IN INSTRUMENTED INDENTATION TESTING

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Instrumented indentation testing can be used to quantitatively evaluate the local residual stress on the surface. Many studies have confirmed that indentation load-displacement curves obtained from Vickers indentation and Berkovich indentation are shifted depending on the residual stress state. Based on this, many researchers have proposed models for evaluating the residual stress by comparing indentation curves obtained from stressed and stress-free specimens of the same composition and microstructure. Though Vickers and Berkovich indenters can quantitatively evaluate the residual stresses, it is difficult to evaluate their directionality such as principal direction and principal stresses because the indenters are axisymmetric. In order to overcome these limitations, we have evaluated the residual stress directionality by using less axisymmetric indenters, such as the Knoop indenter and a modified Berkovich indenter (a conventional Berkovich indenter extended along one axis). [1] With these two sorts of indenters, the degree of shifting of the indentation curve depends on the direction of the long axis of the indenter in the non-equibiaxial stress state. We introduced a conversion factor, a proportional constant between indentation load difference and stress, and proposed a method for quantitatively evaluating the directionality of surface residual stress using this conversion factor. We applied a non-equibiaxial stress state to cruciform specimens and verified the accuracy of the proposed model using the conversion factor in Knoop and modified Berkovich indentation testing. Also, the experiments and finite-element analysis of Knoop and modified Berkovich indentations showed that the ratio of the length of the major axis and minor axis of the indenter is correlated to the conversion factor ratio; a generalized formula is proposed.

REFERENCES

[1] Jong-hyoungKim and Huiwen Xu, “Determination of directionality of non-equibiaxial residual stress by nanoindentation testing using a modified Berkovich indenter”, JMR 33. 3849-3856, 2018.