Numerical Model for Predicting Charpy Impact Toughness of Weld Heat-Affected Zone of Steels

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Abstract: Prediction of toughness of weld heat-affected zone (HAZ) of steels is a difficult task because it is controlled by many parameters including grain-size, brittle microphase, hardness, etc. No reliable model has been established, yet. In the present study, a numerical model for predicting Charpy impact toughness of weld HAZ of steels has been developed. The model comprises two parts: phase transformation and toughness prediction. In the former part, phase fraction, size distribution of martensite-austenite brittle microphase, hardness, size of grain boundary ferrite and bainitic ferrite plate, etc. are calculated and these parameters are used in the latter part, in which probability of cleavage fracture initiation at each deformation stage of Charpy impact specimen is calculated assuming local fracture criterion and weakest-link mechanism. Distribution of stress and strain near notch-tip is calculated by dynamic elastic-plastic finite-element analysis, taking ductile crack extension in Charpy impact test into account. The model was validated by Charpy impact test of simulated coarse-grained HAZ samples having different chemical compositions and cooling rates, successfully. Moreover, the model was applied to Charpy impact test for real welded joint HAZ, with fairly good accuracy. The model can also be applied to optimize chemical composition of steel for improving HAZ toughness.

DOI:10.32604/icces.2019.05781