Abstract

The fatigue strength of common welded joints is well documented in standards and recommendations of well-established classification institutions as well as international scientific and engineering bodies. Nevertheless, welded thin-walled joints may have unexpected fatigue strength properties when the wall thickness is $t = 5$ mm or less.

This work presents the analyses of the fatigue strength of a welded tube-to-plate joint with a wall thickness of $t = 2.9$ mm. This joint is a geometrically-simplified scale model of one found on the offshore research platform FINO3, which is located 80 km west of Germany's North Sea coast. The representative test specimen geometry was developed with the help of systematic parameter variation studies using finite element methods. The test joints were welded using gas-shielded arc welding and dynamic tensile tests were performed on them under the application of constant force amplitudes. The fatigue strength was assessed using the nominal stress concept. Additionally, Xiao and Yamada's 1 mm structural stress approach was performed to the test specimens series. Weld shape geometry parameters were measured with a 3D laser scanner and used in the analysis of notch stress with reference radii of $r_{ref} = 0.05$ mm and $r_{ref} = 1.00$ mm. Results of the nominal, structural and notch stress analyses were compared with characteristic fatigue classes (FAT classes) of common standards and recommendations from the International Institute of Welding, Eurocode and DNV GL.

Fatigue tests show that weld root failure is the critical failure mode. Numerical analyses indicate that Xiao and Yamada's 1 mm approach describes the fatigue behaviour of the tested specimens in a conservative way. The modified notch stress approach with a reference radius of $r_{ref} = 0.05$ mm as well as the original notch stress approach with a reference radius of $r_{ref} = 1.00$ mm adequately represent the fatigue test results.