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NUMERICAL STUDY OF VIBRATION FATIGUE FAILURE FOR PIPELINE WELDED STRUCTURE IN LIQUID ROCKET ENGINES

Abstract

The fatigue fracture of welded joint under vibration conditions is the main failure mode in the liquid rocket engine pipeline, which limits the life of the engine. This paper establishes a numerical model to accurately predict the fatigue life of pipeline welded structure under random vibration loading. The model first conducts the three-dimensional thermal-structural coupling analysis for the welding process, and the welding residual stress and strain are obtained. Then, considering the influence of welding residual stress on the pipeline dynamic characteristics, this model completes the prediction of the random vibration fatigue life of the welded joint structure. The accuracy of the numerical model is verified by welding experiments and vibration fatigue experiments in terms of residual stress, structural vibration response, and pipeline life. Research results show that the radius and power of the heat source during the welding process have a significant impact on the residual stress. When the welding residual stress is considered, the natural frequency of the pipeline increases by more than 5%, and the maximum deviation of the displacement harmonic response is more than 0.5%. The established failure analysis model of pipeline welded joint realizes accurate life prediction, which provides technical support for the fatigue design of liquid rocket engine pipeline.