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C3Po1D-08: Stress Distribution and Sealing Performance Analysis of Metal Sealing Joints in Liquid Hydrogen Pipelines

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Metal sealing joints are widely used in cryogenic fluid storage and transportation systems, where their sealing performance is critical under extreme low-temperature conditions. In cryogenic environments, changes in material properties can lead to uneven stress distribution at the contact interface, thereby affecting the sealing effectiveness. This study first investigates the variations in the mechanical properties of metals under cryogenic environments, with a particular focus on the changes in the elastic modulus and yield strength of 304 stainless steel with temperature. A leakage model for the metal sealing joint is developed to establish the relationship between contact stress at the sealing surface and the leakage rate at cryogenic temperatures. Additionally, a macroscopic static analysis is used to map the relationship between the preload force and torque of joint. Finite element analysis is employed to simulate the stress distribution of the cryogenic metal sealing joint under varying preload forces, highlighting potential stress concentration regions in the joint structure and their impact on sealing performance. The findings of this study offer valuable insights for improving the sealing effectiveness and safety of metal sealing joints in cryogenic environments.

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