A. Inertia Welding for High-Pressure Hydrogen Storage Vessels

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Introduction

Inertia friction welding is being considered as an alternative to gas tungsten arc welding for girth welds of 21-6-9 stainless steel pressure vessels for the containment of high-pressure hydrogen isotopes. This is being done in an effort to improve joint strength, provide weld microstructures closer to forged microstructures, decrease sensitivity to detailed chemistry or surface preparation, and increase process simplicity. Typically, industrial inertia welds have been made using large upsets, with subsequent machining operations to finish to net-shape dimensions. However, this application requires low upset for precise volume control, and because subsequent machining of interior surfaces is not possible.

Technical Approach

The processing parameters that can be varied in inertia welding include rotational velocity, applied axial force and flywheel inertia. By varying these parameters, different upsets and bond qualities are achieved. Joint design also plays an important role in determining final weld quality. Thus, experiments were performed which varied the processing parameters and the joint designs, in an effort to further understanding and development of the process. Microstructural analysis and mechanical property tests were performed for evaluation of the welded specimens.

Results/Discussion

Microstructural analysis in 21-6-9 stainless steel inertia welds typically shows a fine-grained austenite region along the weld interface, mixed with some intergranular ferrite. Our research results describe varying the processing parameters in an effort to minimize the ferrite. Ferrite is less compatible with the storage of hydrogen isotopes, due to increased diffusion of the hydrogen and the resultant loss of ductility. Also, weld joint quality can vary considerably as parameters are varied. Consideration of joint design is also critical. Defects include tears along the weld interface, lack of bonding, and impurity inclusions. Our results describe how controlling processing parameters and understanding how joint design affects the welds can minimize these defects.

Conclusions

The capability to use inertia welding for the fabrication of the described pressure vessels is an important tool for design engineers. This will facilitate improved pressure vessel designs, which will incorporate higher quality joints, possibly new geometries, and simpler processing conditions.