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Comparison of Mechanical Properties for Alloy 800H Base and Weld Metals

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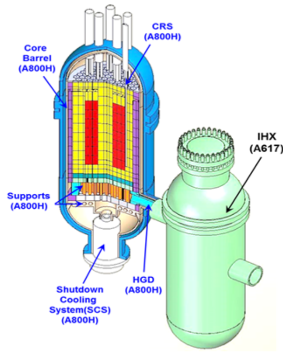
INTRODUCTION

Background

- A very high temperature reactor (VHTR) is one of the most promising Generation-IV reactors for the economic production of electricity and hydrogen. Its major components are the reactor internals, reactor pressure vessel (RPV), hot gas ducts (HGD), and intermediate heat exchangers (IHX). Alloy 800H is the primary candidate for use as the reactor internals: a control rod system (CRS), a core barrel, core supports, and a shutdown cooling system (SCS) in the VHTR system. However, the mechanical property data for the weld metal (WM) are not available under the ASME code or elsewhere. Thus, the mechanical properties such as the tension, creep, and creep crack growth (CCG) for the WM should be investigated for design use in reactor internals of Alloy 800H.



Objective of this paper

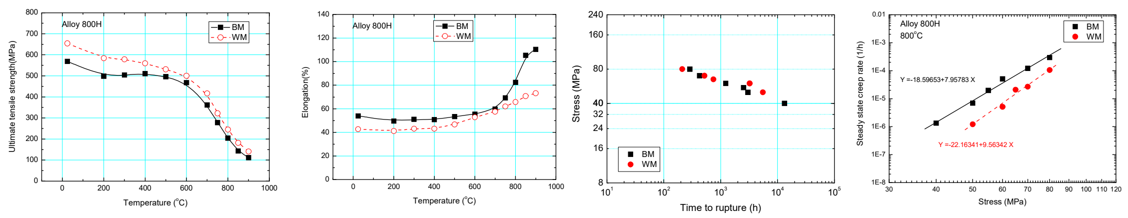
- This study is to comparatively investigate with the base metal (BM) on the tension and creep behaviors for the Alloy 800H WM which was fabricated by a gas tungsten arc welding (GTAW) procedure. In addition, it is to investigate the CCG behavior of Alloy 800H BM in terms of the C^*-fracture parameter through a series of CCG tests at 800°C.

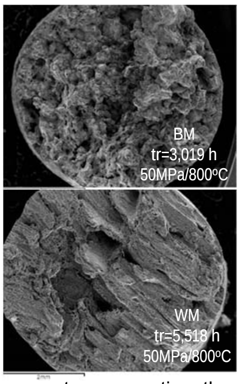
EXPERIMENTAL PROCEDURE

- Commercial grade "Alloy 800H " (Brand name: ATI 800H), which was a hot-rolled plate with a 25 mm thickness made by Allegheny Ludlum Company, was used. The WM was fabricated by GTAW method. The shape of the weld joint has a single V-groove with an angle of 80°. A filler metal was used for KW-T82 (brand name), manufactured by KISWEL Co. Alloy 82 (N06082) bare filler metal was prepared according to the American Welding Society (AWS) specifications, AWS SFA 5.14 ERNiCr-3 and its diameter was 2.4 mm.
- The tension and creep test specimens of Alloy 800H were a cylindrical form of 30 mm in gauge length and 6 mm in diameter. The creep tests were performed under different stress levels at 800°C. The CCG tests of Alloy 800H BM were carried out using compact tension (CT) specimens had a width (W) of 25.4mm, a thickness (B) of 12.7mm, and side grooves of a 10% depth. The initial crack ratio (a/W) was about 0.5, and the pre-cracking size was 2.0mm. Load-line displacement was measured using a linear gauge assembly attached to the specimen, and the crack length was determined using a direct current potential drop (DCPD) technique.

RESULTS & DISCUSSIONS

Comparison of tension and creep properties for the BM and WM

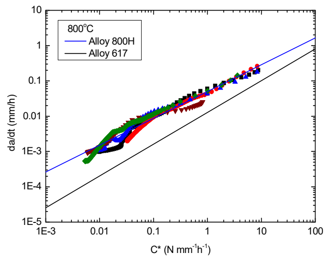


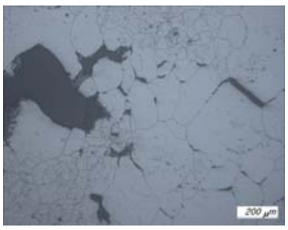


- In the tensile properties, the WM is higher in tensile strength than the BM, but it is lower in tensile elongation than the BM. In the creep rupture properties, the WM is similar or slightly higher in creep strength (or creep life) than the BM. However, in the creep strain rate and the creep rupture elongation, the WM is significantly lower than the BM. The reason for this is due to the lower rupture ductility than the BM.
- In the creep fracture microstructures, the BM shows ductile fracture, but the WM shows cleavage fracture.

CCG behaviour

- The CCG rate of Alloy 800H BM was estimated for a specific C^* fracture parameter
- A CCGR equation for evaluating CCGR for a given C* value was determined as da/dt $=0.05x(C^*)^{0.75}$.
- Alloy 800H is identified to be faster in CCG rate than Alloy 617. The reason for this is that Alloy 617 had higher creep strength than Alloy 800H .
- The CCG fracture surface shows similar creep fracture as intergranular fracture. The cracks are developed with a 45° zigzag pattern along grain boundaries (GBS). Minor voids (or cavity) are formed at GBs, and the cracks are propagated by interconnecting of the cavities. It is evident for typical intergranular fracture mode.





CONCLUSIONS

- In the tensile behaviors, Alloy 800H WM showed higher tensile strengths than the BM, but a decrease in tensile elongation. In the creep rupture behaviors, the WM showed higher creep strength and lower creep rate than the BM, and particularly lower rupture elongation. The lower creep rate in the WM was due to the lower rupture elongation.
- From a series of CCG tests at 800°C, a CCGR equation for evaluating CCGR for a given C* value was obtained as da/dt $=0.05x(C^*)^{0.75}$. The CCG fracture mode of Alloy 800H showed typical intergranular fracture along the grain boundaries.