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

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1. Introduction

A very high temperature reactor (VHTR) is one of the most promising Gen-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 a control rod system (CRS), a HGD, a core barrel, core supports, and a shutdown cooling system (SCS) in VHTR system [1]. Alloy 800H, which is a modification of alloy 800, was developed for applications in which additional creep resistance is required. Alloy 800H is approved for use up to 760°C under ASME Code Section III Subsection NH for nuclear applications [2]. Many studies for Alloy 800H base metal (BM) were done and the data for mechanical properties are available in reported documents [3-6]. However, the data of mechanical properties for its weld metal (WM) are rare and not available in the ASME code as well. Thus, the experimental data for mechanical properties should be provided to establish “the Gen-IV Materials Handbook DB” for design use of Alloy 800H weld components.

In this study, the tensile and creep properties for Alloy 800H WM, which was fabricated by a gas tungsten arc welding (GTAW) procedure, were evaluated through the tensile tests at R.T-900°C and creep tests at 850°C. A comparison for mechanical properties between the BM and WM was done.

2. Methods and Results

2.1 Experimental procedures

Commercial grade “Alloy 800H” (Brand name: ATI 800H) stainless steel, which was a hot-rolled plate with a 25 mm thickness made by Allegheny Ludlum Company, was used. In the chemical composition, the amount of each element was identified to be included well within the ASME specifications. 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. Alloy 800H WM was fabricated by a GTAW procedure.

Tension and creep test specimens of the WM were taken in fully weld metal for a 50 mm root gap. The specimens of the weld metal were machined into the transverse longitudinal direction (TD) against the welding direction. The tension and creep test specimens were a cylindrical form of 30 mm in gauge length and 6 mm in diameter. The tensile tests were conducted under a slow strain rate of 5.55E-4 (1/s) at R.T to 850°C. Also, the creep tests were performed under different stress levels at the identical temperature of 850°C. The pull rod and jig used in the creep tests were manufactured with Ni-base superalloy materials to endure oxidation and thermal degradation sufficiently during the creep tests at the high temperature. Creep strain data with elapsed times were taken automatically by a PC through a high precision LVDT.

2.2 Tensile and creep properties

Fig. 1 shows a comparison of tensile strengths for the BM and WM of Alloy 800H. The WM is slightly higher in tensile strength than the BM. However, in tensile elongation, the WM is lower than the BM as shown in Fig. 2. It means that the WM is reduced in ductility due to higher strength than the BM.

Fig. 3 shows a comparison of log stress vs. log rupture time for the BM and WM of Alloy 800H. The WM is higher in creep strength for up to about 2,000 h than the BM, but in the rupture time beyond ≅2,000h, its creep strength is reversely lower than the BM. It can be assumed that creep strength is reduced in the long-term creep time owing to inevitably some defects formed in the welded materials. We also identified that the creep strain rate of the WM was lower than the BM. It can be assumed due to the lower ductility and higher strength in the WM.

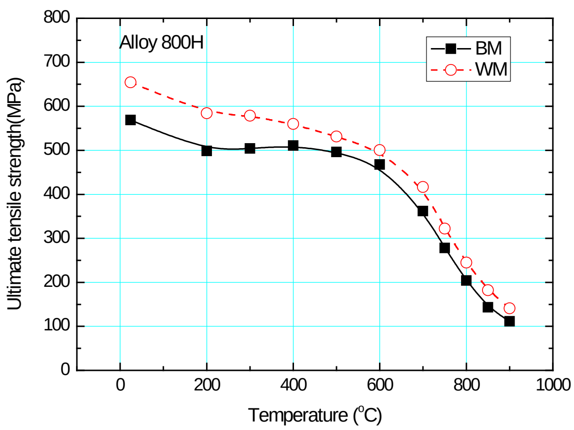

Fig. 1. A comparison of tensile strengths for the BM and WM of Alloy 800H.

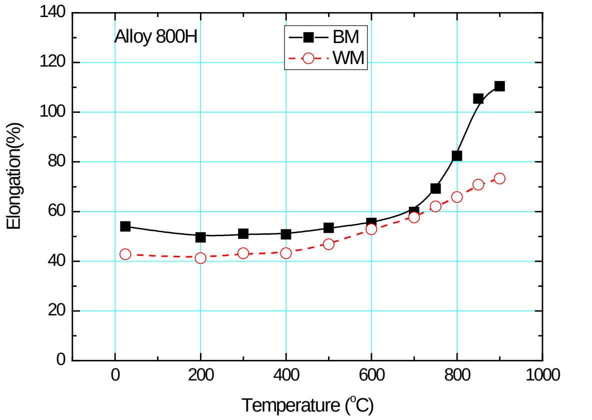

Fig. 2. A comparison of tensile elongation for the BM and WM of Alloy 800H.

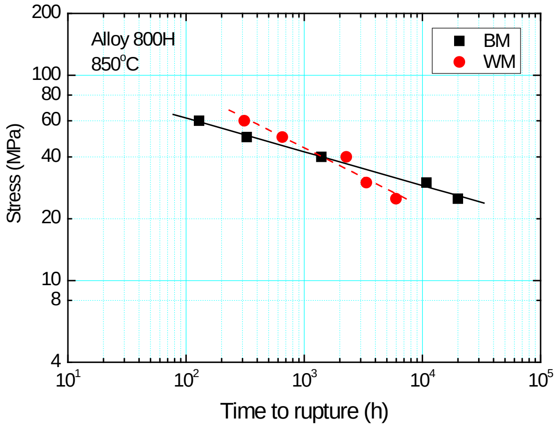

Fig. 3. A comparison of log stress vs. log rupture time for the BM and WM of Alloy 800H.

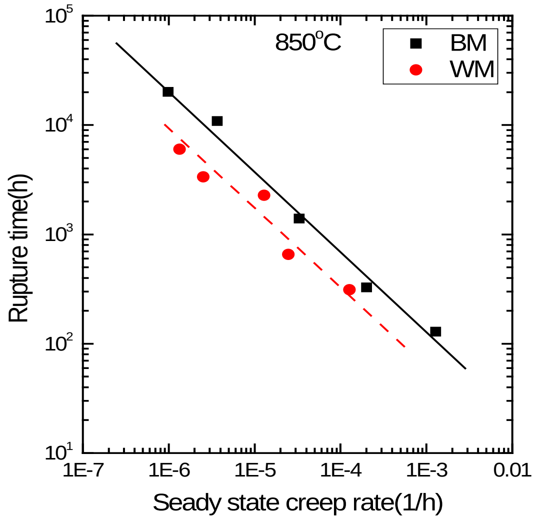

Fig. 4. A comparison of Monkman-Grant (M-G) plot for the BM and WM of Alloy 800H.

Fig. 4 shows the Monkman–Grant (M-G) plot of log-rupture time vs. log-creep strain rate for the BM and WM of Alloy 800H. The M-G relationships can be expressed by $\log t_r + m \log \dot{\varepsilon}_{ss} = C$, where t_r is the creep rupture time, and *m* and *C* are the material constants. It means that the creep rupture time is in inverse proportion to the creep strain rate. If the constants are known for the material, we can estimate one from the other. In the M-G plot, the WM is clarified to be lower position than the BM.

3. Conclusions

Mechanical properties for the tensile and creep behaviors between the BM and WM of Alloy 800H were comparatively investigated. The WM was higher in tensile strength than the BM, but in tensile elongation, the WM was lower than the BM. In addition, in the creep properties, the WM had higher creep strength and lower creep rate than the BM, and a particularly lower rupture elongation. The lower creep rate in the WM was due to the lower rupture elongation than the BM.

ACKNOWLEDGEMENTS

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