

## Mechanical Properties of Candidate Materials for Hot Gas Duct of VHTR

Dae Whan Kim, Yong Wan Kim  
Nuclear Materials Research Division., Korea Atomic Energy Research Institute,  
1045 Daedeok-daero, Yuseong, Daejeon, 305-353  
[dwkim1@kaeri.re.kr](mailto:dwkim1@kaeri.re.kr)

### 1. Introduction

Hot gas duct of VHTR is operated at 950°C. Ni based superalloys, such as Hastelloy XR, Alloy 617, Haynes 230, for hot gas duct have been candidate material because of good strength and corrosion properties at high temperature. Mechanical properties of these alloys are tested at high temperature to apply to hot gas duct of VHTR.

### 2. Experimental procedure

Superalloys for test are commercial Hastelloy-X, Alloy 617, Haynes 230. Chemical compositions of alloys are in ASME range. Tensile tests were conducted at RT-1000°C and strain rate was  $2 \times 10^{-3}$ /s. Tensile test specimen was 2mm thick, 6.25 mm width, 25 mm gauge length.

LCF tests were conducted at 900-950°C and strain rate was  $2 \times 10^{-3}$ /s under strain control. Fatigue specimens was 7 mm diameter and 8mm gauge length. Waveform was triangular and fully reversed. Fatigue life was defined as 25% reduction of tensile peak stress.

All tests was conducted at air environment. Test temperature was maintained constant within  $\pm 2^\circ\text{C}$  during the period of the test.

### 3. Results

#### 3.1. Tensile properties

Tensile strength and elongation are show in Fig. 1. Yield stresses of Hastelloy X and Alloy 617 are not greatly different but that of Haynes 230 is higher than other alloys. Elongation of Alloy 617 is slightly higher than other alloys but almost same as Hastelloy X above 900°C.

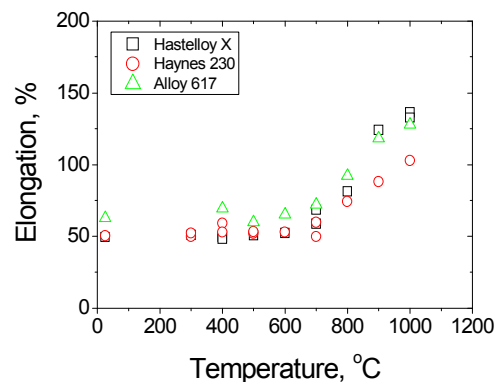
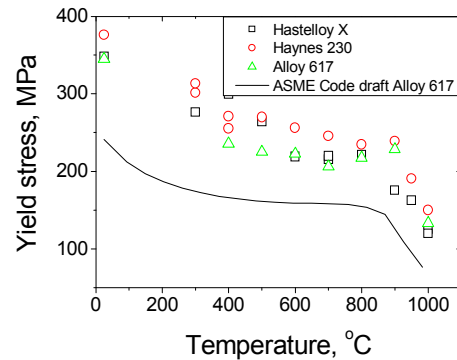


Fig. 1. Tensile properties of alloys with temperature.

#### 3.2. LCF properties

LCF life was shown in Fig. 2. LCF life of Hastelloy X was higher than other alloys. LCF lives of Alloy 617 and Haynes 230 were almost same. All alloys are safer than ASME draft Code Alloy 617 design curve.

Tensile peak stress of Haynes stress is the highest. And Alloy 617 is higher than Hastelloy X, Hastelloy X is the lowest. Fatigue properties of Alloy 617 tested at 950°C was shown in Fig. 3.

Precipitation after fatigue test at 950°C for Alloy 617 was shown in Fig. 4. Precipitation was  $\text{M}_{23}\text{C}_6$  and  $\text{M}_6\text{C}$ .

#### 4. Conclusion

Yield stress of Haynes 230 is the highest and those of Hastelloy-X and Alloy 617 are almost same. Elongation of Haynes 230 was the worst above 900 °C. LCF life of Hastelloy X is the best. Carbide was precipitated at grain boundary.

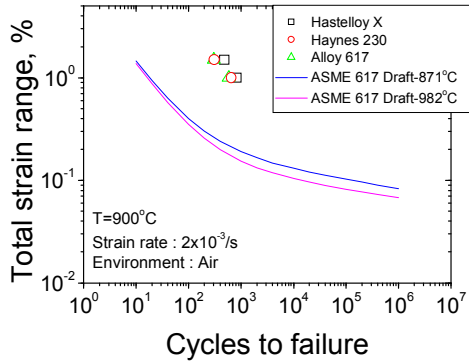


Fig. 2. LCF life of alloys at 900 °C

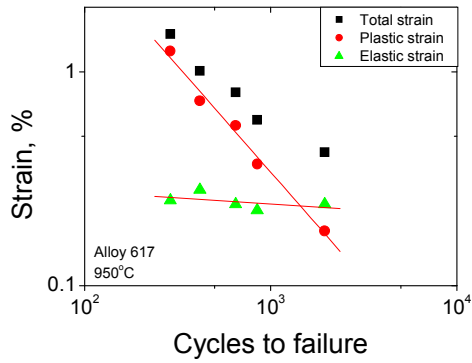


Fig. 3. Fatigue life tested at 950 °C for Alloy 617

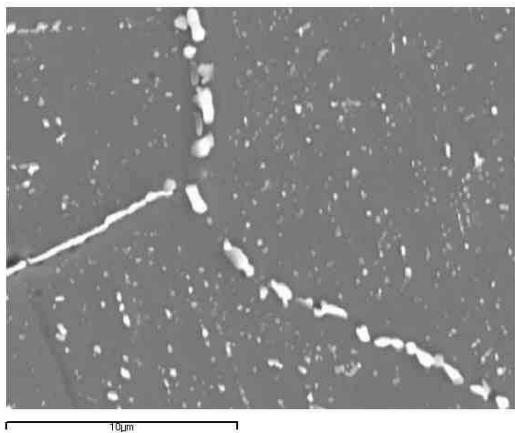


Fig. 4. Precipitation after fatigue test at 950 °C and 1% for Alloy 617