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Mechanical Properties of Candidate Structural Materials for Molten Salt Reactor

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1. Introduction

After the Fukushima nuclear accident, public concern about the safety of large-scale nuclear power plants around the world is growing and the standards are rising day by day. On the other hand, at a time when there is also a consensus that nuclear power is an inevitable choice to realize carbon neutrality to tackle global warming, advanced countries are spurring the development of smaller and safer nuclear reactors. The Molten Salt Reactor (MSR), a small modular reactor that uses molten salt as a coolant, is expected to remarkably improve safety and economy among nuclear reactors currently under development [1]. However, since MSR uses salts at a high temperature of up to 700ºC, the structural materials of the reactor cooling system must maintain excellent mechanical properties even in the operating environment [2]. Some candidate materials are not listed in the American Society of Mechanical Engineers (ASME) high-temperature reactor code, Boiler & Pressure Vessel Code Section III-Division 5, which is essential for high-temperature reactor design, so it is necessary to obtain and select property data for various candidate alloys [3]. Various mechanical property data were obtained from the test results, and they were compared and evaluated. The mechanical properties in the atmosphere will be used as basic data for the evaluation of mechanical properties in a molten salt environment.

2. Experimental

Four types of candidate materials, Type 316H stainless steels, Alloy 800H, Inconel 617 and Hastelloy N (Alloy N), for MSR components were tested for mechanical characterization. The chemistries of candidate alloys are listed in Table 1. In this study, tensile tests were performed on which are candidate materials for MSR structures, using small specimens at room temperature and operating temperature (650ºC). Tensile tests were performed according to the ASTM E8/E8M-21 standard test method. The specimens were subsidized with a reduced section of 15 mm, a thickness of 1mm and a width of 3 mm as shown in Figure 1.

Table 1. Chemistries of candidate alloys for MSR.

Element / Alloy	C	Si	Mn	Cr	Ni	Mo	Co	Fe
Type 316H	0.049	0.57	0.59	16.82	10.29	2.12		bal.
Alloy 800H	0.07	0.42	0.98	20.43	30.18			bal.
Alloy 617	0.090	0.14	0.08	22.20	52.61	9.52	12.3	1.26
Aloy N	0.072	0.273	0.414	7.66	69.33	16.0	0.253	3.66

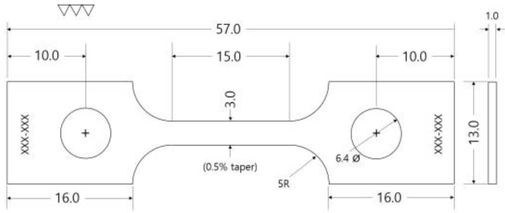

Fig. 1. Drawing of subsize tensile specimen.

The test was conducted using MTS Landmark hydraulic material test system with a strain rate of 4.2 x 10^{-4}/s.

3. Results and Discussion

The mechanical properties of the four alloys at room temperature are compared and shown in Figure 2 and Figure 3.

The strength was high in the order of Hastelloy N, Alloy 617, Type 316H, Alloy 800H but all alloys showed values above the adequate level as shown in Figure 2.

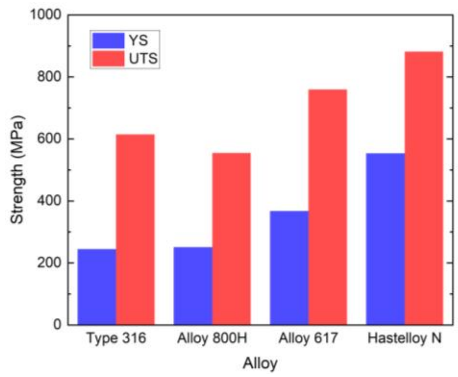

Fig. 2. Drawing of subsize tensile specimen.

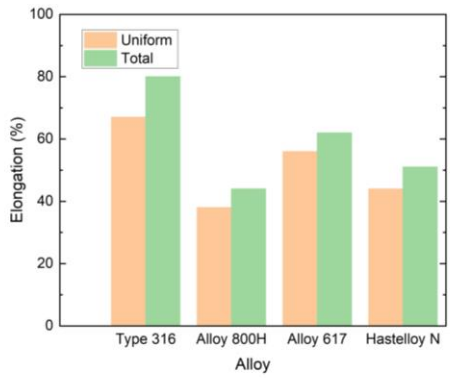

Fig. 3. Drawing of subsize tensile specimen.

In the case of elongation, it was high in the order of Type 316H, Alloy 617, Hastelloy N, Alloy 800H, and all alloys showed more than an adequate level as shown in Figure 3.

Tensile testing at 650°C on candidate alloys is ongoing, and the results of the room temperature tests will be used as base line data.

REFERENCES

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