A NEW HIGH MODULUS HIGH STRENGTH Ni-Mo-Cr-Re SUPERALLOY

P.L. Mao (NHMFL), Y. Xin (NHMFL), K. Han (NHMFL)

Introduction

Pulsed and superconducting high-field magnets require high-strength materials with high elastic modulus to support the Lorenz forces. This report describes a potential candidate for structural material with high modulus and high strength. This new Ni-Mo-Cr-Re superalloy is developed in the NHMFL. The modulus is higher than most of the alloys currently used in the NHMFL's magnets.

Experimental

We measured the dynamic modulus by a dynamic mechanical analyzer (DMA) and the tensile properties were measured by TMS tensile test machine. In addition, TEM and microhardness were used to investigate the new alloys

Results and Discussion

Fig.1 shows that the dynamic storage modulus for the new alloy is higher than Haynes 242 at the same temperature, where Haynes 242 is the high modulus alloys proposed to be used for conduit material for series connected hybrid. Both cold work and aging increase the mechanical properties of the new alloy significantly. The ultimate tensile and yield strength reach 1795 Mpa and 1781 MPa, respectively for the alloy cold worked for 62% and then aged at 600°C for 4 hours. The hardness response to the aging time at 600°C is shown in Fig.2. The hardness values increase from about 200HV for annealed samples to around 300 HV after aging for just 4 minutes, then leveled off up to 529h, indicating that the ordering precipitates are very stable during the long time aging. Retention of properties during reaction is particularly important if the materials are employed in wind-and-react Nb_3Sn superconducting magnets. Our alloy shows very stable properties after 1000 hrs aging at temperatures close to Nb_3Sn heat treatment temperature. For the new alloy, we found from the TEM diffraction patterns and imaging that after 4 min. aging at 600°C, the Ni_2(Mo, Re) nano-sized precipitates were already formed.

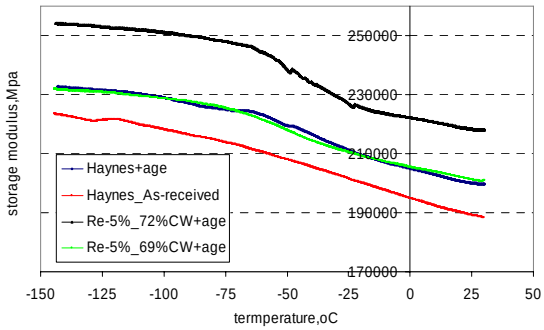

Fig.1 Dynamic modulus testing result of Haynes 242 and the new alloy

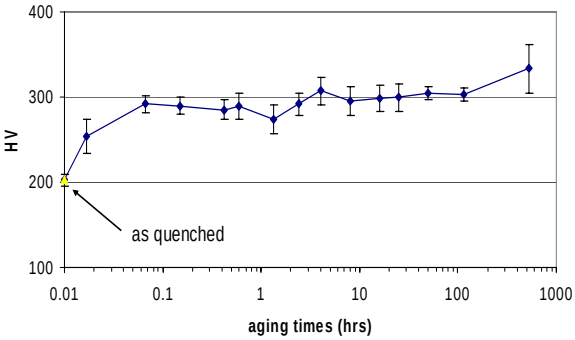

Fig.2 Hardness response to the aging time at 600°C
.

Conclusions

Comparing the mechanical properties and ordering behavior of the new alloy with Haynes 242 we think that the addition of element Re plays a key role in increasing the new alloy's modulus and strength and changing the new alloy's ordering kinetics.

Acknowledgements

This work was supported by In House Research Program under the NSF Core Grant of NHMFL.