Selected Ni Alloy Considerations for Superconducting Magnets

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Introduction

High field superconducting magnets require strong non-superconducting components as reinforcement. Much characterization has been performed on modified 316 LN stainless steel which is used for Cable-In-Conduit-Conductor (CICC) in superconducting magnets. Work has also taken place on two other high modulus materials with high nickel content. Haynes 242 is a Ni-Mo alloy and a good candidate for conduit materials in CICC magnet design. MP35N (35 wt% Co – 35 wt% Ni – 20 wt% Cr – 10 wt% Mo) is a multiphase alloy which is currently used as a reinforcement material in pulsed magnets operating at 77 K [1]. MP35N is also a candidate material as a substrate for high Tc YBCO conductors.

Experimental

All mechanical testing was performed on a 100 kN capacity servo-hydraulic Materials Test System (MTS) equipped with a cryostat for 4 K testing.

Results and Discussion

The stress-strain curve of modified 316 LN SS in **Figure 1** indicates strength levels that meet most of the design requirements of current generation CICC magnets. **Figure 2** demonstrates that the Haynes 242 alloy can achieve higher 4 K strength than the modified 316 LN after heat treatment temperatures between 923 and 973 K.

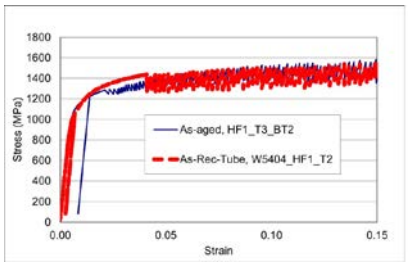

Figure 1. Stress-strain curves of modified 316 LN at 4.2 K.

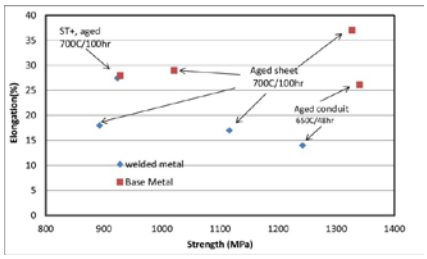

Figure 2. Yield strength and elongation to failure at 4.2 K of Haynes 242 base metal and welds.

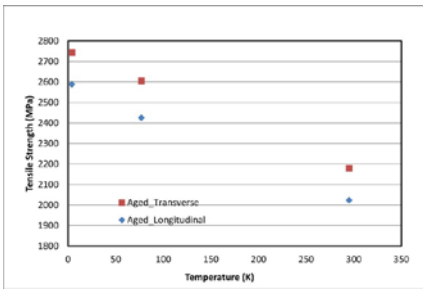

Figure 3. Comparison of tensile strength of aged MP35N

Figure 3 summarizes the ultimate tensile strength of aged MP35N. The 4 K strength ranges between 2550-2750 MPa which is higher than most substrates used for high temperature conductors to the best knowledge of the authors.

Conclusions

Modified stainless steel 316LN shows good mechanical properties for use in superconducting magnets. Alloys with Ni and other alloy element contents higher than 316LN provide higher strength at cryogenic temperatures. Therefore, they can be considered as candidates for reinforcement materials for future superconducting magnets.

Acknowledgements

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References

[1] Han, K., *et al.*, IEEE Transactions on Applied Superconductivity 12 (2002)1244-1247.