PHYSICAL PROPERTIES OF SUPER ALLOY HAYNES-242 AT LOW TEMPERATURES

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Introduction

Haynes-242 is a Ni based commercial superalloy. High strength and high ductility at low temperatures makes Haynes-242 an attractive choice as the conduit material for the cable-in-conduit-conductor of superconducting magnets. In addition to its mechanical properties, for this application the knowledge of its physical properties such as thermal conductivity, specific heat, electrical conductivity and magnetization as function of magnetic field and temperature are important.

Experimental

As-received 1.6 mm thick Haynes 242 plates underwent aging process at 700 °C for 100 hours in atmosphere pressure Ar. We performed magnetization measurement as function of temperature using Quantum Design’s MPMS-7 system. Specific heat, thermal conductivity and electrical resistivity were measured by Quantum Design’s PPMS.

Results and Discussion

The magnetization (M) versus T is measured at 2-300K in a 100 Oe applied field. The magnetization at 2 K is 0.104 emu/cm³ smaller than ~0.18 and ~5.5 emu/cm³ for beryllium-copper and 304 stainless steel respectively. The M vs. H curve shows no hysteresis. The specific heat C_p vs T measured in 0 and 9 T fields is shown in Fig. 1.

For transport properties, as expected for alloys the dominating impurity scattering in the electrical transport process results in weak temperature dependence of electrical resistivity. The residual resistance ratio (R_{300K}/R_{4.2K}) is only ~1.1. The total thermal conductivity κ is a sum of electronic and lattice contributions. The electronic contribution approximately follows Wiedemann-Franz-Lorenz law where Lorenz number L_0 = κ_e/σ T (σ is the electrical conductivity) is constant.

The effective Lorenz number L = κ/σ T is a useful engineering parameter that can be used to calculate the thermal conductivity using electrical conductivity which is usually much easier to measure. Fig. 2 shows the effective Lorenz numbers of Haynes 242 in comparison with other alloys also important in superconducting magnet development.

Conclusions

Low temperature physical properties of Haynes-242 were measured. Haynes-242 shows weak paramagnetism in temperatures 2-300 K. No magnetic phase transitions or magnetic hysteresis were observed. As expected its electrical resistivity is only weakly temperature dependent. The thermal conductivity of Haynes 242 measured between 2 and 300 K indicates relatively strong lattice thermal conduction at temperatures <100 K. This results in effective Lorenz number eight times larger than L_0 at its maximum at ~ 20 K.

References