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M3Or4M-05: [Invited] Strength and Fracture Toughness of Type 304 and 316 Austenitic Stainless Steels at 4.2 K

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The austenitic stainless steels, such as type 304L (18Cr-9Ni, mass%) and 316L (16Cr-10Ni-2Mo), are widely used in cryogenic applications. However, their strength is relatively low, and the martensitic transformation appears when they are strained at low temperature. For structural applications at 4.2 K, therefore, type 316LN (17Cr-11Ni-2Mo-0.2N) nitrogen-strengthened austenitic stainless steel is commonly used for its high strength and toughness, thermodynamic stability, and excellent weldability. To advance the understanding of metallic materials for structural components at cryogenic temperatures, the 0.2% proof stress and fracture toughness of type 304 and 316 austenitic steels at 4.2 K in the literatures are summarized with the NIST trend for 300 series. The data which are for rolled plates, not very thick plates exhibit a trade-off relationship. These references may serve as a useful decision-making tool during initial mechanical design as well as for further alloy development.

The plane strain fracture toughness of type 316LN steel depends on its stability at 4.2 K, which is characterized by the *Md*₃₀ index. Here, the *Md*₃₀ is the temperature (K) at which 50% volume of austenite matrix transforms to martensite under a true strain of 0.30 in tension for single-phase austenitic steels. The *Md*₃₀ of the plates correlated well with their respective fracture toughness values, where a higher *Md*₃₀ indicated lower fracture toughness. Low plastic strains were responsible for an increase of α'-martensite formation at the crack tip. An alloy design having a higher Ni, Mn and Mo, and lower N content in its chemical composition would be favorable for type 316LN steel to provide a higher fracture toughness owing to higher stacking fault energy.

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