Development of High-Strength Austenitic Steel by Incorporating Yttrium Oxides

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Austenitic stainless steels are promising materials for next generation nuclear reactors due to their excellent mechanical properties and reasonable corrosion resistance compared to ferritic and ferritic-martensitic steels.[1] However, they suffer from lower strength and void swelling resistance. Oxide dispersion strengthening (ODS) addresses these issues by incorporating nano-sized oxides, which pin dislocation motion and prevent grain coarsening, thus enhancing mechanical strength and creep resistance at high temperatures.[2] Additionally, the matrix-oxide interfaces act as sinks for radiation-induced defects, improving swelling resistance.[3]

In this study the preparation of oxide dispersion-strengthened austenitic steel 316L involved mechanical alloying of the steel powder with Y_2O_3. Elemental Y was also introduced to dissolve within the Fe matrix as an alternative method. These powder precursors were then compacted using Spark Plasma Sintering (SPS) and analysed for their microstructure. The mechanical properties of the resulting compacts were assessed, revealing an initial formation of chromium-containing carbides, likely due to carbon diffusion from the graphite tools used. Both Y_2O_3 and Y were successfully incorporated into a solid solution during mechanical alloying, with precipitation occurring during compaction. The mechanical properties varied based on chemical composition and specific SPS conditions. Homogeneously distributed Y_2O_3 particles were successfully achieved through this powder metallurgy process. Future research will aim to optimize SPS conditions to prevent carbide formation.

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