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Mechanical properties and thermal fatigue behavior of a novel hot work tool steel SDH68 for die casting applications

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The production cost of aluminum die casting is largely influenced by the raw materials used in the die steel. Due to the high temperature and pressure conditions, die-casting moulds require frequent replacement. In this study, a novel hot work die steel, SDH68, was developed, offering lower raw material costs compared to conventional H11 steel. Thermal fatigue is the most prevalent failure mechanism in die casting, and the carbides precipitated in high-alloy tool steels have a significant impact on the thermal fatigue resistance of the die steel. The high-chromium H11 steel precipitates substantial amounts of Cr-rich M23C6 carbides during thermal fatigue testing. These precipitates coalesce and grow rapidly at elevated temperatures, leading to a reduction in the hardness of the die steel. Consequently, SDH68 steel has a lower Cr content to enhance thermal stability. By maintaining similar levels of Si and Mn, close to 1%, the strength of the die steel is improved. The reduced carbon content and overall alloy composition contribute to good thermal conductivity and lower material costs. Niobium microalloying modifies the carbide type and enhances the thermal fatigue resistance of the die steel. The study found that SDH68 steel consistently maintained good thermal stability at high temperatures, which may be attributed to grain boundary strengthening and the nature of the carbides. The contributions of grain boundary strengthening and precipitation hardening to the strength of SDH68 and H11 steels were calculated and verified against experimental measurements. The carbide evolution of SDH68 steel at high temperatures was characterized and analyzed. Furthermore, SDH68 steel demonstrated superior performance in thermal fatigue testing compared to H11 steel.

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