IMPROVING TRIBOLOGICAL PROPERTIES OF STEEL THROUGH NANO-PARTICLES ALLOYING

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Summary

The aim of this research work was to investigate the possibility and effect of nano-particles on mechanical and anti-wear properties of steel, when applied in a low-cost conventional casting process. Steels investigated included stainless steel, high-strength Mn-Cr steel and creep resistant steel, reinforced with Al_2O_3, TiO_2, TiB_2, TiC and Y_2O_3 nano-particles introduced through different casting methods. Strengthening effect was evaluated in terms of steel microstructure, hardness, strength, fracture toughness and abrasive wear resistance under dry sliding conditions.

Keywords: nano-particles, metal matrix nanocomposite, steel, abrasive wear, microstructure

Abstract

In the last decade, considerable efforts are made in the development of high and even ultra-high performance steels. Part of the demand is due to the need for more compact low-weight design and cost reduction in the automotive industry and part due to environmental concerns. The environmental aspect is related to reduced CO_2 emission and improved fuel consumption. In this respect, using lighter components and reducing vehicle weight is one of the key elements. However, lighter components require high strength materials where improvement in strength should not degrade other properties such as toughness, fatigue and above all wear resistance.

Current focus in high strength steel design is on the manipulation of microstructure at the nano-scale through innovative processing techniques and adoption of novel alloying strategies, with the final steel properties mainly depending on the type, size, shape, stability and uniformity of the precipitated particles. However, exceptional progress in the field of nanotechnologies offers further possibilities in modifying steel microstructure through direct nano-particles alloying and incorporation, i.e. in metal matrix nano-composites. Therefore, the aim of our research work was to investigate the possibility and effect of nano-particles on mechanical and anti-wear properties of different type of steel, when applied in a low-cost conventional casting process.

Materials included in the investigation comprised stainless steel, high-strength Mn-Cr steel and creep resistant steel, alloyed with different types of nano-particles (Al_2O_3, TiO_2, TiB_2, TiC, Y_2O_3). Investigation was focused on the possibility of obtaining homogeneous distribution of nano-particles within the steel matrix, thus different methods of inserting nano-particles in the melt were explored. Effect of nano-particles type as well as insertion method was evaluated in terms of steel microstructure (Fig. 1), hardness, strength, fracture toughness and wear resistance under dry sliding conditions (Fig. 2), with the results being inter-correlated.

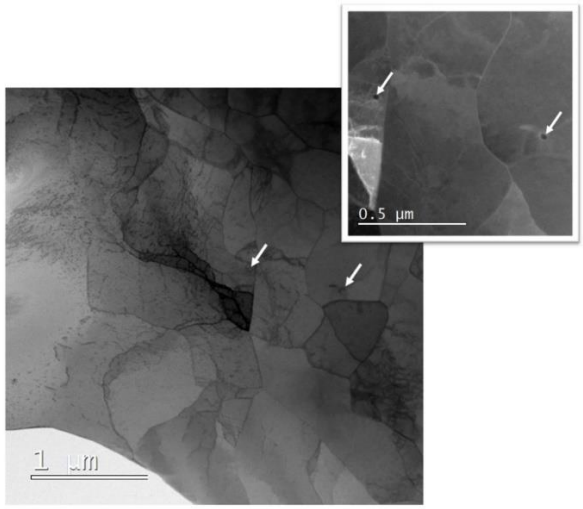

Fig. 1 Steel microstructure with the incorporated nano-particles

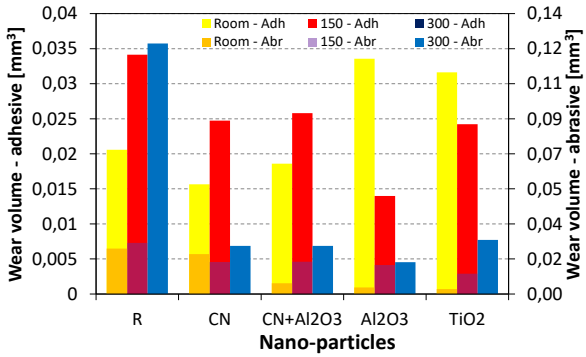

Fig. 2 Wear resistance of reference (R) and nano-particles reinforced steel

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