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Microstructure and properties of austenitic stainless steel reinforced with in situ TiC particulate

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ABSTRACT

Austenitic stainless steel reinforced with 5 vol.% TiC particulate was in situ synthesized by in situ reaction during melting process successfully and its microstructure, mechanical properties as well as oxidation behavior were investigated. Microstructure observations revealed that in situ TiC particulates with an average size of 2–10 μm distributed uniformly in the matrix and the interface boundaries between TiC particulates and austenite matrix were clean without any impurities and contaminations. Addition of TiC particulates refined the grain structure of austenitic matrix, but did not cause formation of any new phases in microstructure. Beneficial effects of TiC addition to austenitic stainless steel on both mechanical properties and oxidation resistance were found. Both at ambient and elevated temperature, tensile strengths of the steel with TiC addition were notably higher than those of its matrix alloy, however, a decrease in ductility also appeared, as exhibited by other particulate reinforced alloys. Besides tensile strengths, creep resistance of austenitic stainless steel was also significantly increased by TiC addition at elevated temperature of 923 K. Oxidation test at 1073 K revealed that TiC addition to austenitic stainless steel raised the oxidation resistance of the steel remarkably.

1. Introduction

Titanium carbide is considered as a good reinforcement for the development of particulate reinforced iron based materials due to its high hardness, high melting point and relatively high thermal and chemical stabilities [1–5]. In addition, TiC particulates show excellent wettability in iron melt, where the wetting angle θ between TiC particulates and molten iron is less than 50° even at high temperature and many different kinds of atmosphere [6]. TiC particulates can be introduced by the technique of in situ reaction, which is a process where reinforcements are synthesized in metallic matrix by chemical reactions between Ti and C in the iron melt [7–13]. Compared to other particulate reinforced alloys, steels with TiC addition are easier to be industrialized with lower cost in fabrication. As for TiC particulates reinforced steels, the current research is mainly concentrated on their wear resistance [2–4,11,12], while less work has been carry out on their mechanical properties, especially at elevated temperatures.

Austenitic stainless steels have been widely used in industries owing to their excellent corrosion resistance, heat resistance and workability. However, the strength of austenitic stainless steels is relatively lower than other alloyed steels, which restricts the further extension of their applications. In the present investigations, TiC particulate reinforced austenitic stainless steel has been fabricated using the technique of in situ synthesis and its microstructure, mechanical properties as well as oxidation resistance have been studied.

2. Experimental procedures

The matrix alloy used in this work was a commercial 304 austenitic stainless steel (304SS), which chemical composition was given in Table 1. For the production of in situ 5 vol.% TiC particulate reinforced austenitic stainless (TiC-304SS), 304SS ingot, titanium powders, graphite powders and iron powders were used to be the raw materials. In the experiment, TiC particulates were introduced to the 304SS by adding preformed blocks to the melt, which made from powders of titanium, graphite and iron. The particle size of graphite, titanium and iron powders was about 10, 90 and 100 mm respectively. To fabricate these performed blocks, a homogeneous mixture with desired composition was conducted drily in powder-mixed machine for 8 h and subsequently compacted in a mold with 12 mm in diameter.

After the matrix alloy 304SS had been melted in a medium frequency vacuum induction melting (VIM) furnace at 1873–1923 K, the preformed blocks were introduced into the melt. The self-propagating high-temperature synthesis (SHS) reaction between Ti and

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