SUPERSOLIDUS LIQUID-PHASE SINTERING OF FE-BASED MMC CONTAINING OXIDE PARTICLES – RELATIONSHIP BETWEEN WETTING, CONSOLIDATION AND ALLOY DESIGN

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ABSTRACT

Iron-based metal matrix composites (MMC) can be consolidated to high density without external pressure by means of supersolidus liquid-phase sintering (SLPS). Political and economic driving forces are encouraging the use of oxides such as alumina (Al_2O_3) and zirconia (ZrO_2) as hard particle reinforcements in wear-resistant Fe-based MMC, instead of the restricted and high cost materials such as tungsten carbide and titanium carbide. Until now, the processing of such materials by SLPS has been limited due to the poor wettability of oxides by Fe–based melts and the resulting weak metallurgical bonding between the oxide particles and the matrix. This paper describes how a proper alloy design can increase the wettability of Fe-based alloys on alumina and zirconia and thus enable SLPS of Fe-based MMC containing oxide particles. This could be achieved by combining thermodynamic calculation tools, in situ high temperature wettability measurements, and sintering experiments.

1. INTRODUCTION

Protecting tools from wear is a major issue in many industrial applications. In the case of severe abrasive wear, which is typical in mineral mining and processing, state of the art wear-resistant materials consist of composites made of ceramic particle reinforcements embedded in a metal matrix. The particles are usually made of transition metal carbides, such as fused tungsten carbide (FTC), WC, TiC, or NbC with the metal matrix of Fe-, Ni-, or Co alloys [1]. The restricted availability and the high and volatile prices of some of the aforementioned materials lead to strong economic and political ambitions to find alternative materials [2,3]. Metal oxides such as alumina (Al_2O_3) and zirconia (ZrO_2) - or eutectic mixtures thereof (in the following referred to as AlZrO) - exhibit promising mechanical properties with a high hardness up to 2100 HV and a sufficient fracture toughness (especially the AlZrO materials with 4 to 5 $MPa\cdot m^{1/2}$ (3.6 to 4.5 $\cdot 10^3$ $psi\cdot inch^{1/2}$)) [4]. In combination with an Fe-based alloy, these oxides could be used as particle reinforcements to produce readily available low-cost composites with high wear resistance. However, the application of such material combinations has been limited so far. This limitation can be explained by the poor wettability of metal oxides by iron-based melts, which leads to high residual porosity and weak