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Effect of alloying additions on the porosity of SiC_p preforms infiltrated by aluminium

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Abstract

Infiltrations of SiC powder (SiC_p) preforms by a series of Al-based melts have been carried out in a pressure vessel. Effects of alloying additions (Pb, Mg, Cu and Si) on amount of porosity in the infiltrated preforms were investigated. The porosity measurements were carried out by image analysis using an optical microscope in conjuction with a computer having image analysis software programs. The relationship between the amount of porosity was evaluated in the lights of present understanding of the wetting behaviour of the components. Additions of Pb, increased the porosity while Cu, and Si addition did not effect it appreciably. The porosity were significantly reduced by increasing Mg content of Al.
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Keywords: Metal matrix composites; Melt infiltration; Wetting; Porosity; Aluminium alloys

1. Introduction

Among fabrication methods for Metal Matrix Composites (MMC's), melt infiltration is especially attractive since it is relatively cheap and can accommodate a wide range of materials and processing conditions together with one-step near net shape production and a high volume percent of reinforcement. Wider commercialisation of this technique cannot be fully realised however without improvements in control of the infiltration behaviour and of reinforcement/matrix interactions.

Oh et al. [1,2] and Alonso and co-workers [3–5] used the pressurized infiltration technique to study wetting phenomena in liquid Al-alloy/ceramic particulate systems. Chong et al. [6] reported that the pressure necessary for infiltration of SiC preforms by pure Al and 2014 alloy decreased with increasing particle size, increasing infiltration temperature. Previously, we reported alloying additions affecting threshold pressure (P^*) necessary for infiltration [7], microstructure of infiltrated preforms [8], role of surface tension in relation to contact angle for determination of P^* for infiltration of SiC preforms [9] and mechanical properties of infiltrated SiC preforms [10–12]. Analysis and modelling of infiltration into fibrous or whisker preforms have been reported [13–15]. Resulting porosity in infiltrated ceramic powder preforms is an important issue from the mechanical properties point of view, however, literature on this subject is scarce [7]. Therefore, the aim of this work was to investigate the resulting porosity in infiltrated Al alloy/SiC particle preforms and its relationship with the wetting behaviour of the components.

2. Experimental procedure

Alloying additions to aluminium were selected according to their effect on surface tension of aluminium as "surface active" and "non-surface active" alloying additions. Surface active alloying additions used were Pb, and Mg while Cu and Si were non-surface active alloying additions [16,17]. Al–1.0 Pb, Al–2 to 8 Mg, Al–2 to 8.0 Cu, and Al–2 to 8 Si alloys were made with 99.8% pure Al as 20 mm diameter chill cast ingot. All values of alloying additions are in weight percent unless otherwise stated.

The composites were fabricated by pressure infiltration of pure Al and its alloy melts into α-SiC particle preforms having mean particle diameter of 23 μm. Schematic view of the pressure infiltration apparatus is shown in Fig. 1. Details of the production procedure have been described elsewhere

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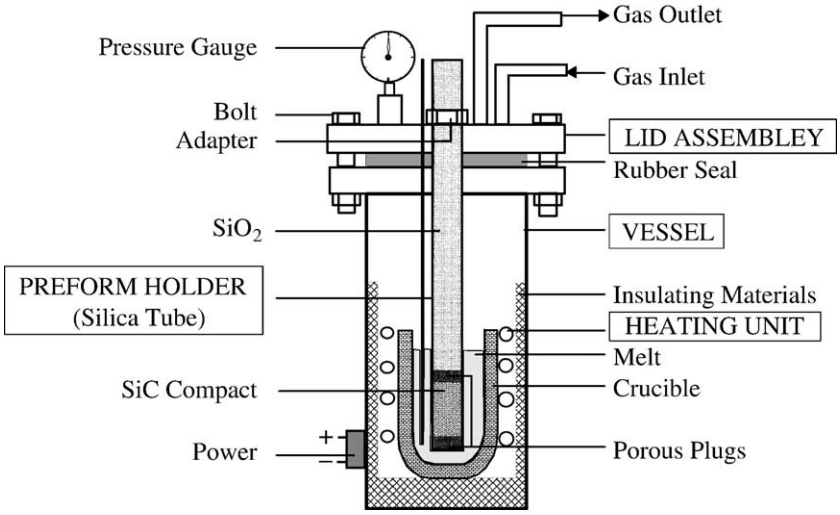

Fig. 1. Schematic of the pressure vessel.

[11,12]. Briefly, the SiC particles were compacted into a cylindrical fused silica tube having inner diameter of 7 mm, which was used as the preform holder. The vessel was pressurized with argon to 575 kPa at a rate of approximately 170 kPa/s for the infiltration of the SiC preforms at 750 °C. The applied pressure was sustained for 2 min then the pressure was released from the vessel at a rate of approximately 210 kPa/s. The composites were then detached from the vessel and cooled in air.

Microstructures of the composites were examined by Nikon Epiphot 200 type light optical microscope (LOM) and Jeol JSM-6335F type scanning electron microscope (SEM). In order to investigate resulting porosity, infiltrated samples were cut longitudinally. Volume fraction of porosity was measured on

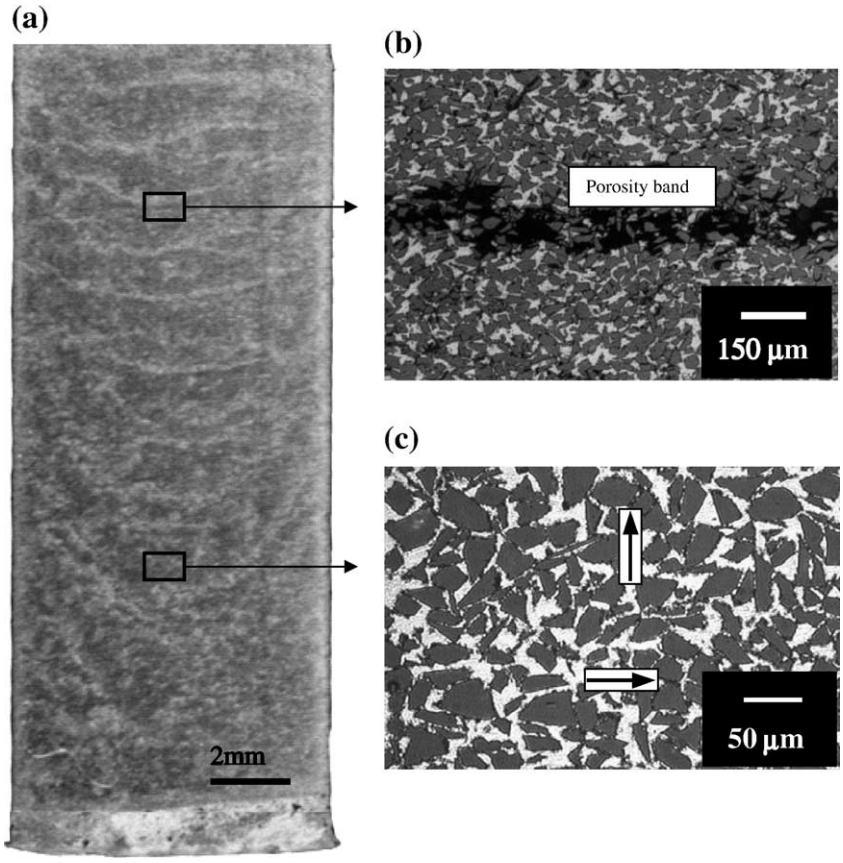

Fig. 2. a–c. Longitudinal section (a), enlarged region of porosity bands (b) and general microstructure (c) of the pure Al/SiC preform infiltrated at 750 °C (Infiltration direction is upwards, arrows are showing location of porosity).

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