Design and Development of Hybrid Stir Casting Process

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ABSTRACT

The widespread adoption of particulate metal matrix composites (MMCs) for engineering applications has been hindered by the high cost of producing components of complex shape. Casting technology may be the key to overcoming this problem with stir casting. But the problem arises with stir casting is wettability and porosity. To overcome the problem of porosity a hybrid casting process is needed. So, hybrid stir casting process was developed to produce a silicon carbide particulate aluminum alloy composite. In this paper, the authors have discussed the various parts like Muffle Furnace, Thermocouple, Electric motor Impeller & Stirrer, Crucible, Vacuum pump, Nitrogen gas, and Lifting mechanism of the Hybrid Stir Casting process.

Keywords: Engineering Applications, Hybrid, Muffle Furnace, Silicon Carbide Particulate Aluminum Alloy-Metal Matrix Composites (Al/SiC-MMC), Stir Casting

INTRODUCTION

Metal matrix composites have received much research interests over several years due to their excellent mechanical and thermal properties compared with the conventional materials. By suitable arrangement of metal matrix and ceramic addition, it is possible to obtain desired properties for a particular application.

The aim involved in designing metal matrix composite materials is to combine the desirable attributes of metal and ceramics. The addition of high strength, high modulus refractory particles to a ductile metal matrix produce a material whose mechanical properties are intermediate between the matrix alloy and ceramic reinforcement (Wei Yueguang, 2001; Ghosh & Ray, 1988; Mares, 2001). Metals have a useful combination of properties such as high strength, ductility and high temperature resistance but sometimes have low stiffness, whereas ceramics are stiff and strong though brittle. SiC particle reinforced aluminum composites have received more commercial attention than other
kinds of MMCs due to their high performance viz. high mechanical properties, wear resistance, low coefficient of thermal expansion and high thermal conductivity. They are remeltable and that can be produced by large quantities by the process analogue to that used for commercial aluminium alloys at cheap cost. Therefore, they are more competitive on the MMC market and find wider application in industries (McDanel, 1985; Ibrahim, Mohamed & Lavernia, 1991; Lloyd, 1994) such as aerospace, automotive and electronics industries. The reinforcing ceramic can be continuous or discontinuous fibers in metal matrix materials. The latter is usually termed as particulate metal matrix composite (PMMC).

LITERATURE SURVEY

There have been numerous studies in the literature investigating various aspects of the AA6063 metal matrix composites. The studies generally concentrated on how the ceramic particles (SiC) affect the mechanical and thermal properties of the PMMCs which are usually aluminum based (especially AA6063). Experiments conducted with Al and Mg alloys showed that addition of ceramic particles considerably increases the tensile strength of the alloy (Ding, Liew & Liu, 2005; Quan Yanming & Bangyan, 2003; Hung, Loh, & Xu, 1996). McDanel (1985), Yang, Cady, Hu, Zok, Mehrabian, and Evans (1990), Doel and Bowen (1996) showed that fine SiC particles with 10 µm particle diameter yield higher fracture toughness and strength than those with coarse particles. The uniform distribution of particles in the final product is essential in the PMMCs to obtain desired mechanical and thermal properties. However, investigations showed that there is usually particle clustering or agglomeration occurs in such composites. This clustering significantly decreases the local property of the PMMC. Lloyd, lagace, Mcleod, and Morris (1989) indicated that damage in the composite initiates at the particle-clustered regions. Clyne and Withers (1993) proposed that the behavior of a single particle in the clustered region depends on the cluster size, volume fraction of particles and arrangement of particles in the cluster. Prangnell, Barnes, Roberts, and Withers (1996) experimentally and theoretically showed that during compressive deformation of aluminum alloy reinforced with SiC particles, damage formation is concentrated at particle-clustered regions. The particle fracture and void form at particle interface depending on the particle size. The particle with larger size may crack under stresses leading to higher void fraction in the system. The distribution of reinforcement materials (SiC), one of the problems encountered in metal matrix composite processing is the settling of the reinforcement particles during melt holding or during casting. This arises as a result of density differences between the reinforcement particles and the matrix alloy melt. The reinforcement distribution is influenced during several stages including (a) distribution in the liquid as a result of mixing, (b) distribution in the liquid after mixing, but before solidification, and (c) redistribution as a result of solidification.

The vortex method is one of the better known approaches used to create and maintain a good distribution of the reinforcement material in the matrix alloy. In this method, after the matrix material is melted, it is stirred vigorously to form a vortex at the surface of the melt, and the reinforcement material is then introduced at the side of the vortex (Dolata-Grosz, Hufenbach, Elezion, Gude & Czulak, 2009; Mares, 2001). Harnby, Edward, and Nienow (1985) studied different designs of mechanical stirrers. Among them, the turbine stirrer is quite popular. During stir casting for the synthesis of composites, stirring helps in two ways: (a) transferring particles into the liquid metal, and (b) maintaining the particles in a state of suspension. A vigorously stirred melt will entrap gas which proves to be extremely difficult to remove as the viscosity. In preparing metal matrix composite by stir casting
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