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Short Communication

Investigation of microstructures and mechanical properties of A356 aluminum alloy produced by expendable pattern shell casting process with vacuum and low pressure

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ABSTRACT

In this study, microstructures and mechanical properties of A356 aluminum alloy obtained by expendable pattern shell casting process with vacuum and low pressure (EPSC-VL) were investigated. Meanwhile, microstructures and mechanical properties of A356 alloy among EPSC-VL, expendable pattern shell casting process under gravity casting (EPSC-G), lost foam casting with vacuum and low pressure (LFC-VL) and lost foam casting under gravity casting (LFC-G) were compared. The results showed that the microstructure of A356 alloy fabricated by EPSC-VL was finer and denser than the products from EPSC-G, LFC-G and LFC-VL processes, and its grain size was only 147.2 μm compared to LFC-G (327.1 μm). Moreover, its porosity defects were greatly reduced (0.16%) compared to LFC-G (1.97%). The tensile strength, elongation and hardness of castings produced by EPSC-VL were all considerably higher than the products from EPSC-G, LFC-G and LFC-VL. The A356 alloy made by EPSC-VL exhibited morphology of dimple fracture that was very deep and well-distributed. In addition, the castings produced by EPSC-VL process had better surface quality compared to LFC castings.

1. Introduction

It is well known that cast aluminum alloys possess many benefits such as excellent castability, better corrosion resistance and high strength to weight ratio [1–5]. Therefore, the demands for complicated and thin-walled aluminum precision castings are greatly increased with the rapid development of aerospace and automotive industry. However, it is very difficult to produce these castings under gravity casting. Because of the serious oxidation and inspiration of the molten metal of aluminum alloy at high temperatures, it is prone to generating the misrun, porosity and oxide inclusion defects during the pouring process. As a result, the mechanical properties of these castings are lower.

At present, die casting, permanent mold casting and sand casting are usually employed for producing the aluminum and magnesium alloys components [6–8]. However, die casting method is costly and time-consuming because of the design and recurring modifications of dies. Moreover, the die castings can not carry out heat treatment due to gas trapping [9]. In addition, permanent mold casting is usually difficult to manufacture complicated castings because of high solidification velocity of the melt metal. Furthermore, sand casting can not meet the demands of dimensional accuracy and surface roughness for aluminum and magnesium alloys precision components.

Lost foam casting (LFC) has been regarded as a near net shape method for manufacturing complicated aluminum and magnesium alloys precision castings without the need for cores [10,11]. Unfortunately, the decomposition of the foam pattern during the pouring process could result in some defects such as pores, slag inclusions [12,13], and the pouring temperature of LFC is usually higher than that of traditional cavity casting in order to overcome heat absorption from the decomposition of the foam pattern. In addition, the cooling speed of liquid metal during solidification process is very slow due to the adoption of dry sand molding. Therefore, it is a major problem that coarse grains and porosity defects of LFC castings lead to poor mechanical properties. LFC could turn to be a preferred casting method of the future if it will overcome the above major problem.

The purpose of this study is to develop a new casting process to improve the production of complicated and thin-walled aluminum and magnesium alloys precision castings and overcome the problems of LFC process as well as obtain higher quality castings. The expendable pattern shell casting process with vacuum and low pressure (EPSC-VL) process combines foam pattern preparation of LFC, thin shell precision fabrication of investment casting and vacuum and low pressure casting technology. It has some advantages such as flexible design and low cost of the foam pattern, shell

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