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Short Communication

Influence of thermal rate treatment and low temperature pouring on microstructure and tensile properties of AlSi7Mg alloy

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ABSTRACT

The combination of thermal rate treatment and low temperature pouring was proposed in the present work, and the effects of the novel melt thermal treatment on microstructure and tensile properties of AlSi7Mg alloy have been investigated. The grain size and microstructure of AlSi7Mg alloy were examined by optical microscopy (OM) and scanning electron microscopy (SEM). It was found that the grain size obviously reduced and the growth of the columnar dendrites changed into equiaxed ones by low temperature pouring, especially the novel melt thermal treatment, by which a maximum microstructure refining effect could be obtained. The refinement can be attributed to the multiplication of the nuclei in the melt. Furthermore, the morphology of eutectic silicon changed little, but the size of silicon phase was finer due to the refinement of the grain size and higher cooling rate. Because of the refinement of the grain size and eutectic silicon, the tensile properties were improved, and the ultimate tensile strength and elongation increased by 11.7% and 35.3%, respectively.

1. Introduction

Hypoeutectic Al–Si casting alloys constitute a significant proportion of lightweight metals used in industry due to the low density, excellent castability, low thermal expansion, corrosion resistance, and good mechanical properties [1,2]. The mechanical properties of Al–Si alloys mainly depend on the microstructure, including grain size, secondary dendrite arm spacing (SDAS), interdendritic porosities, and morphology of eutectic silicon [3–5]. A lot of efforts have been made to refine the microstructure of the castings in order to enhance the mechanical properties of Al–Si alloys. Refinement and modification are common practice to improve the mechanical properties of Al–Si casting alloys in industry [6–9].

The microstructure in the solid state is influenced by the liquid structure before solidification [10,11]. In recent years, various melt thermal treatments are proposed to refine the microstructure of Al–Si alloy hence improving its mechanical properties, especially the thermal rate treatment [12,13]. The thermal rate treatment is such a technology that the melt is first superheated to a very high temperature, usually more than 300 °C above its liquidus, keeping the temperature for several minutes, and then cooled quickly to a pouring temperature prior to pouring [10,13]. By the thermal rate treatment technology at 875 °C, the modified structure of an Al–13 wt.% Si alloy was obtained without any addition of modifying elements [10]. The solidification structure of hypoeutectic Al–Si alloys including grain size and microstructure of primary α-Al phase were refined remarkably after thermal rate treatment, and the mechanical property was improved due to the microstructure refinement [14,15]. However, the melt for thermal rate treatment is required to superheat to a very high temperature and the superheating means the energy consumption and a complicated technology.

In general, the low temperature pouring is proposed for preparing the semi-solid slurries [16,17]. The low temperature pouring can not only increase the nucleation rate greatly, but also promote the direct globular growth of the grain, and the resulting microstructures exhibit the characteristics of fine, equiaxed and non-dendrite, which are benefit for the tensile properties of AlSi7Mg alloy [18–20]. It is found that above liquidus the grain size decreases with decreasing the pouring temperature [20,21]. Nevertheless, the fluidity of the melt also decreases with decreasing the pouring temperature [22,23], and the lower pouring temperature results in the feeding incomplete and shrinkage.

Taking the characteristics of thermal rate treatment and low temperature pouring into account, the combination of thermal rate treatment and low temperature pouring is proposed in the present work. Through reasonable choosing of the processing parameters [24], the thermal rate treatment and pouring temperature was determined at 730 °C and 650 °C, respectively. In this way, the superheating is not required in the thermal rate treatment meanwhile the melt still exhibits enough fluidity. The aim of the present work is to investigate the effects of the novel melt thermal treatment on microstructure and tensile properties of AlSi7Mg alloy.

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