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Effect of Foaming Temperature on the Mechanical Properties of Produced Closed-Cell A356Aluminum Foams with Melting Method

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In this study an attempt was carried out to determine the effect of production temperature on the mechanical properties and energy absorption behavior of closed-cell A356 alloy foams under uniaxial compression test. For this purpose, three different A356 alloy closed-cell foams were synthesized at three different casting temperatures, 650 °C, 675 °C and 700 °C by adding the same amounts of granulated calcium as thickening and TiH_2 as blowing agent. The samples were characterized by SEM to study the pore morphology at different foaming temperatures. Compression tests of the A356 foams were carried out to assess their mechanical properties and energy absorption behavior. The results indicated that increasing the foaming temperature from 650 °C to 675 °C and 700 °C reduces the relative density of closed cell A356 alloys by 18.3% and 38% respectively and consequently affects the compressive strength and energy absorption of cellular structures by changing them from equiaxed polyhedral closed cells to distorted cells. Also at 700 °C foaming temperature, growth of micro-pores and coalescence with other surrounding pores leads to several big voids.

Keywords: foaming temperature, melting, casting, pore morphology, mechanical properties

1. INTRODUCTION

In the last few decades, Aluminum alloy foams have been developed in industries, because of their unique combination of properties [1-2]. Metal foams are categorized as advanced materials in two groups, based on their cellular structure: i) open cell foams, and ii) closed cell foams. Industrial applications of the open cell foams are in the fields of filtration, thermal and ionic exchangers. However, the closed cell foams have applications in impact absorption, sound barriers, and vibration dampers, and they can be used as an energy absorber or the crash box in automobile industries [3-6].

Generally, the process of making closed-cell Aluminum foam with a melting method consists of five individual steps [7]: (i) melting the Aluminum alloy, (ii) increasing the melt viscosity by adding thickening agents like calcium metal, (iii) dispersing a gas releasing agent into the melt, (iv) holding the melt at a specific temperature to allow decomposition of the foaming agent, and (v) solidification of the product. Each of the steps mentioned have important effects on the physical and mechanical properties of the Aluminum foam produced.

Yang and Nakaei studied the influence of the addition of TiH_2 on the cell structure of foamed Aluminum. Their results indicated that the addition of 1.0 and 1.5 wt% TiH_2 induces a greater uniformity of spherical cell distribution [8]. Zu and Yao showed that during the cooling stage, the pores elongated in an upward direction and the cells in the longitudinal and transverse directions have different dimensions. In the longitudinal direction, Al-Si alloy foams can absorb more energy because the plastic collapse of Al-Si alloy foams in the longitudinal direction is greater than that in the transverse direction [9].

Several researchers have studied the effect of the amount of $CaCO_3$and SiC added as a foaming and thickening agent, respectively, on the density and mechanical properties of closed cell Aluminum foams. Their results revealed that decreasing the foaming agent improved the energy absorption of closed cell foams due to increasing density [10].

While some research has investigated the effect of foaming temperature on the pore size of the closed cell pure Aluminum foams [6], results show that they were limited only to small samples and not industrial scale. Therefore a comprehensive study is needed to survey the effect of molten Aluminum temperature on the morphology of cellular structure and its effect on the mechanical properties of produced A356 aluminum

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