ABSTRACT

Recycling of metallic scrap has increasingly attracted the attention of industries following the global policy to reduce energy consumption as well as environmental impacts. Among the recycled metals, aluminum (Al) has nowadays become one of the popular materials owing to its wide applications. Several recycling technologies have been developed, including those that are based on the remelting and casting process. One major challenge in the aluminum recycling process is the significant variation in scrap compositions and the presence of impurity elements. In this research, direct chill (DC) casting technology was introduced as a tool for recycling aluminum scrap into an as-cast billet alloy. The direct chill method is a promising approach for producing wrought aluminum billets, known for its high efficiency and suitability for large-scale production. This study aims to investigate the casting defects and determine the optimum casting parameters during casting processes. The microstructure and mechanical properties of four locations along a cross-section of the as-cast billet radius were evaluated. The temperature distribution from start-up until the final casting process was also presented in this work. Non-uniform temperature distribution in DC casting resulted in varied microstructures across the as-cast aluminum billet's cross-section i.e., coarse columnar grains at the periphery, feathery grains in the middle, and coarse equiaxed grains at the center. Microstructures of as-cast billet showed a Chinese-script-like structure, comprising α-Al and intermetallic phases along grain boundaries. The results of the composition and microstructural analysis showed that the as-cast billet in this research was composed primarily of α-Al and the intermetallic phases such as α-Al_8Fe_2Si, α-$Al_{12}Fe_3Si_2$, Al_3Fe, and Al_4MgSi. The ultimate tensile strength (UTS) and the hardness at the region near the surface were lower than those at the bulk of the billet. Meanwhile, micro-sized pores were also reported in the region near the surface of the as-cast Al billet. The average grain size of the as-cast Al billet was slightly larger in the middle, increasing from surface to center. Near-surface region exhibited lower ultimate tensile strength (UTS) and hardness than the bulk, with values increasing from the center to the surface. Si showing negative macrosegregation towards the surface, positive in the middle, and negative at the center. Mg content displayed negative segregation, while Fe content increased from surface to center. Recycling aluminum scrap into billet using direct chill casting is a promising method for the future. However, based on the findings in this research, the presence of the β-Al_5FeSi intermetallic phase and the macrosegregation elements in as-cast billet are a problem that needs to be handled since it has a detrimental effect on the mechanical properties of the

DC casting as-cast billet. Further efforts should be made to improve the quality of as-cast aluminum billet by utilizing aluminum scrap. Several works can be done such as controlling the raw material scrap, standardizing the alloy composition, refining the grain structure, and homogenizing the recycled as-cast billet after the direct chill casting process.

Keywords: direct chill casting; aluminum scrap; recycling; microstructure; mechanical properties