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ABSTRACT:

Microstructure, Tensile Behavior and Electrical Conductivities of Permanent Steel Mold Cast Al-0.3Mn Alloy with Varying Section Thicknesses

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The advancement of lightweight aluminum alloys, characterized by high electrical conductivities, strong tensile properties, and cost-effectiveness, is crucial for expanding the market of battery-powered electric vehicles (BEVs) with small and powerful electric motors (EMs) in the automotive industry and ensuring durable transmission lines in the electric power industry (EPI). In this study, an Al Alloy containing 0.3 wt% Mn (Al-0.3Mn) was prepared by permanent steel mold casting (PSMC), of which had three different steps with the section thickness of 6, 10 and 20 mm for potential application in electric motors. The numerical simulation of the solidification showed that the cooling rate of the step casting increased to 23.8 oC/s for the 6-mm section from 8.3 and 2.1 oC/s for the 10 and 20-mm sections, respectively. The microstructure of the as-cast alloy analyzed by the optical microscopy and scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS). The microstructure analyses indicated that all three sections of the cast Al-0.3Mn alloy consisted of the primary Al phase, micron Al-Mn-Fe intermetallic phase, and nano-sized Al-Mn intermetallic phase. But, the intermetallic contents increased and the dendrite sizes and the porosity levels decreased, as the section thicknesses reduced. The results of the tensile testing showed that the ultimate tensile strength (UTS), yield strength (YS), modulus, resilience, toughness, increased significantly to 88.9, 38.7 MPa, 69.9 GPa, 10.7 kJ/m3, 18.3 MJ/m3 from 59.2, 12.4 MPa, 59.6 GPa, 1.3 kJ/m3, 11.0 MJ/m3, when the section thickness decreased to 6 from 20 mm. The electrical conductivities for the 6, 10 and 20-mm sections were 45.77, 45.57 and 45.36 %IACS, respectively. Although the effect of the section thicknesses on the elongation and electrical conductivity of the alloy was limited, the fine dendritic structure, high intermetallic content, and low porosity level should be responsible for the high tensile properties and relatively high electrical conductivities of the thin section.