Published in the Proceedings of the 16th International Aluminum Alloys Conference (ICAA16) 2018
ISBN: 978-1-926872-41-4
by the Canadian Institute of Mining, Metallurgy & Petroleum

STUDY ON MICROSTRUCTURES CONTROL OF HIGH STRENGTH ALUMINIUM ALLOYS BILLET WITH MAGNETIC TREATMENT

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INTRODUCTION

The use of high strength wrought aluminum alloys is increasing in automotive body and chassis, as well as the aerospace sector. Future vehicles are required to be lightweight by high strength aluminum alloy to improve fuel efficiency and CO_2 emissions reduction. But high strength aluminum alloys has a low productivity because of poor extrusion characteristics. High strength aluminum alloys of 7000 series are required the addition of a lot of elements such as Zn, Mg, Cu and the mushy zone is very wide. This aluminum alloys billet by the conventional DC process can't avoid the weak dendrite, segregation and casting defects. To improve formability of this alloy is necessary study on the refine and homogenization of microstructure and processing technology for controlling casting defects.

The microstructures of the conventional DC cast billets have typical dendrite and heterogeneous structure, but billet by electromagnetic treatment is homogeneous in both surface and center and fine and equiaxed structure. Grain size of alloy is refined and homogenized from 400 to 100 μm by electromagnetic treatment in billet continuous casting of high strength aluminum alloy. This electromagnetic processing aluminum alloys are increased extrusion speed without crack when the billet is extruded and it is possible to improve the productivity of high strength aluminum alloys.

EXPERIMENTAL PROCEDURE

As an alloy for the real experiments was selected and tested high-strength 7000 series wrought aluminum alloys with different content 5.5–8.5% Zn, 2–3% Mg and 1.5–2.3% Cu with no more 0.2% Zr.

For effective controllable electromagnetic melt stirring into vertical water-cooling cylindrical, with 225 mm height Cu-crystallizer, for 7 inch continuous billet casting, has been develop an original design of 3-phases 6-poles electromagnetic stirrer (EMS), located around of the vertical crystallizer in horizontal plane. EMS comprised means of the magnetic core adjusting for using of the 3 types crystallizers for casting billets from 2 to 10 inches. The main, around located magnetic core has been divided to 3 similar mechanically and electrically independent C-type magnetic core parts, consisted radial main and two length-adjustable axial magnetic poles core.

Experiments conditions includes as DC without electromagnetic stirring and at the application conventional rotary melt stirring by means running electromagnetic fields facilities, at the powering it's coils by the 3-phase electrical current with ordinal frequency 60 Hz. The electromagnetic intensity was in the range of 0.05–0.1T, the casting speed of the billet was 60–80 mm/min, and the temperature of aluminum alloy was maintained at 695–705°C.

RESULTS AND DISCUSSION

Analysis facilities 7 inch billet formation from alloys melted in conventional melting furnace by applying rotary electromagnetic stirring (REMS) at 0.05T and 0.1T in the continuous casting machine were performed by microstructural means at its cross cutting. As well, for case DC casting without artificial electromagnetic stirring melt into crystallizer it has been dedicated occurring hot cracks inside billet, serious radial structural segregation. Applying EMS, comprised ordinal rotary electromagnetic stirring by the means running 60 Hz magnetic field, also have some limitation by the intensity of magnetic field, wherein value of the melt stirring should not exceed critical velocity (e.g., 0.05–0.1 m/s). Mechanism occurring crack for 0.1T EMS can be explained by the high intensity melt stirring, wherein already solidified melt are disconnected from liquid in mushy zone due to big difference in viscosity in the semi-solid state area.

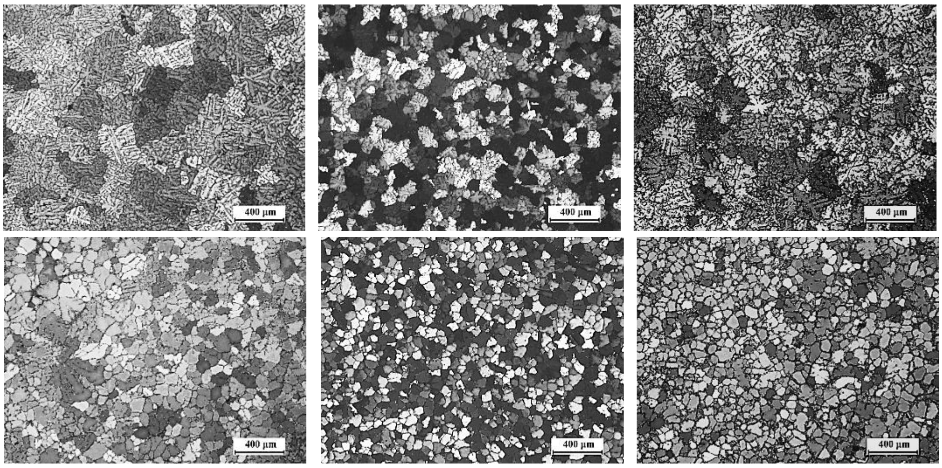

Figure 1. Microstructure of 7 inch billet at DC cast without EMS and with applying 0.05T and 0.1T REMS

As shown in Figure 1, the microstructure of surface of 7 inch sized billet treated conventionally DC cast without electromagnetic treatment has a very coarse grain size of 400 μm and a typical dendrite structure; some inclusions are observed. The grain sizes of the surface and center of the billet treated with 0.05T of electromagnetic intensity were very fine at 100 and 80 μm and uniformly distributed. At rotary EMS with 0.1T to shown on surface of billet also some dendrite microstructure, someone compacted then DC with grain size 200–400 μm, however for case REMS with 0.05T intensity the size dendrites seriously reduced in 5–6 times with grain sizes in ranges 100–250 μm. As well, center and middle 7 inch billet cross-section for DC conditions have not homogeneity mixed dendrites and non-dendrite grains (150–200μm). For case applying REMS 0.05T and 0.1T in middle and center billets part microstructure transformed to the non-dendrite state, compact and homogeneity distributed, but most compact state up to billet center at grain size 50~90μm has been achieved for REMS 0.05T, instead 80–100 μm for REMS 0.1T.

CONCLUSIONS

Analysis microstructure of the 7 inch billet from 7075 melt has shown for DC conditions the dendrite structure with grain size over 500 μm on surface. Applying rotary electromagnetic stirring with 0.05T intensity of magnetic field (60 Hz) showed that size dendrites on billet surface has been seriously reduced in 5–6 times with grain sizes 100–250 μm. As well, for middle and center 7 inch billet part by means rotary EMS 0.05T~0.01T the in 2–3 times most compacted non-dendrite structure with grain size in range 50–90 μm and 80–100 μm was achieved in uniform state with small equalized grains, instead 150–200 μm for DC casting. For prevention occurring hot-cracks into billet the intensity of magnetic field (60Hz) at REMS not should be provide exceed an critical velocity, for example 0.05–0.1 m/s at over 0.05T.

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KEYWORDS

High-strength aluminum alloys, Micro alloying, Microstructure, Electromagnetic stirring, Grain size