Effect of Homogenization Treatment on Microstructural Evolution of 1050 and 1200 TRC Aluminium Alloys

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Abstract

Gradients in solification rates developed during twin roll casting of aluminium alloys results in concentration gradients throughout the thickness with a supersaturated region of alloying elements near the surface. A series of homogenization treatments is performed on TRC cast 1050 and 1200 aluminium alloys, in order to remove the microsegragation of alloying elements, therby minimize the concentration gradients developed during solidification and ensure an homogeniously distributed particles . Hardness measurements and microstructural studies showed that unpractical homogenization periods is required for all the alloys studied in order to provide a uniform particle size distribution.

Introduction

Due to its lower operational costs and higher productivities, twin roll casting technology offers a high potential in the production of sheet and foil products,being an alternative to the conventional casting processes. In TRC, liquid metal is injected into a gap between two water cooled rolls where it solidifies before coming out as a solid strip. The main problem with this production route is the development of gradients in solidification rates within the solid, being higher at the surface and lower at the center. This gradient in solidification rate will in turn results in concentration gradients of alloying elements across the thickness of the sheet. If not eliminated by down-stream processes, those concentration gradients may lead to some unwanted microstructural features on the final products like orange peel appearance due to abnormal grain coarsening at the surface or formation of pinhole due to center-line segragation in foil products. It has been a few work done in the literature in order to optimize the down stream processes including thermo-mechanical and annealing treatments on TRC cast Al alloys[1-3]. Those efforts are aimed at evening out of the concentration gradients developed during twin roll casting. Our practical studies showed that homogenization treatments applied at thinner gauges are much more effective than those applied at casting thicknesses. In this work, an effort was made to investigate the microstructural evolution of cold rolled AA1050 and AA1200 alloys subjected to a series of homogenization treatments for different holding times.

Experimental Procedure

The chemical compositions of the two alloys cast at a gauge of 5.0 mm using twin roll casting technology, are given in Table 1. A series of samples were cold rolled by 50% using a laboratory scale rolling mill before they were subjected to a homogenization treatment in a laboratory air furnace with controlled heating rates. Both alloys were annelaed at 520 and 560°C for different periods of time,specifically 4, 8, and 16 hrs. Microstructural examination of the as-cast and annealed samples were carried out on cross sections parallel to the rolling direction using an AxioCam optical microscope. The hardness measurements were done on mirror polished cross sections using a load of 25 and 50 g with a loading time of 10 s. The samples were then etched with Barker`s solution in order to study the evolution of recrystallized grain structure with temperature. A JEOL JSM-5600 type scanning electron microscope with EDS capability were used to examine the intermetallic distribution near and at the center of the cross sections of the samples.

Table I. Chemical compositions of 3003 and 8006 aluminum alloys (wt.%).

	Si	**Fe**	**Cu**	**Mn**	**Al**
1050	0.125	0.296	0.017	0.003	99.51
1200	0.120	0.576	0.001	0.003	99.25

Results and Conclusions

Figure 1 shows a typical microstructure of an as-cast 1050 TRC aluminum alloy. The supersaturated region differing in depth owing to different casting parameters such as casting speed, temperature and tip set-back, contains more intermetallics in number and smaller in size compared to the bulk as also evidenced from both electron microscopy and the hardness measurments. While the hardness is found to be as 39 HV at the surface, it decreases by 18% to 32 at the centerline.

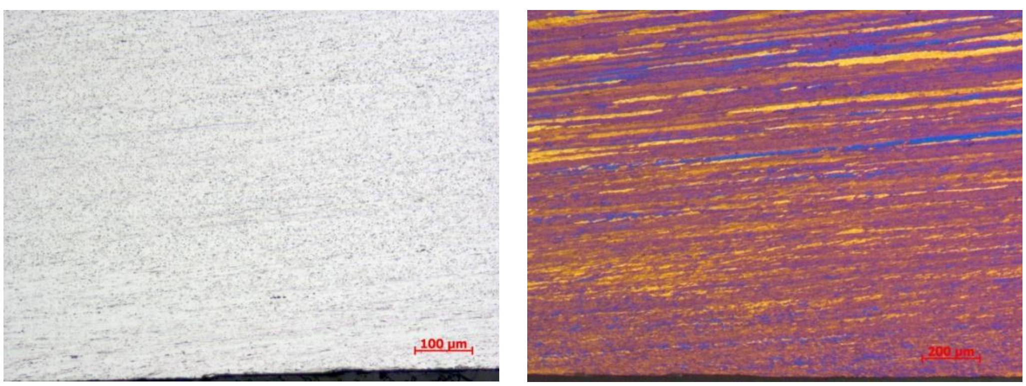

Figure 1. Microstructure of as cast TRC AA1050.

The optical micrographs in Fig 2 show the particle distribution and the grain structures at the surface for homogenized TRC AA1050 at 520 C for different period of times. A deformed layer of approximately 125 μm is clearly seen after cold rolling. The second phase particles are aligned with the rolling direction forming colonies of clusters. In the case of insufficient homogenizing temperatures, those clusters of intermetallics will in turn results in recrystallized grain growth in the rolling direction since those clusters inhibit the growth in the normal direction. Although the grains are heterogeneously distributed with newly recrystallized and already grown ones for samples homogenization treated(HT) for 4 and 8 hrs, those HT for 16 hrs are much finer,equiaxed and homogeneosuly distributed throughout the thickness.

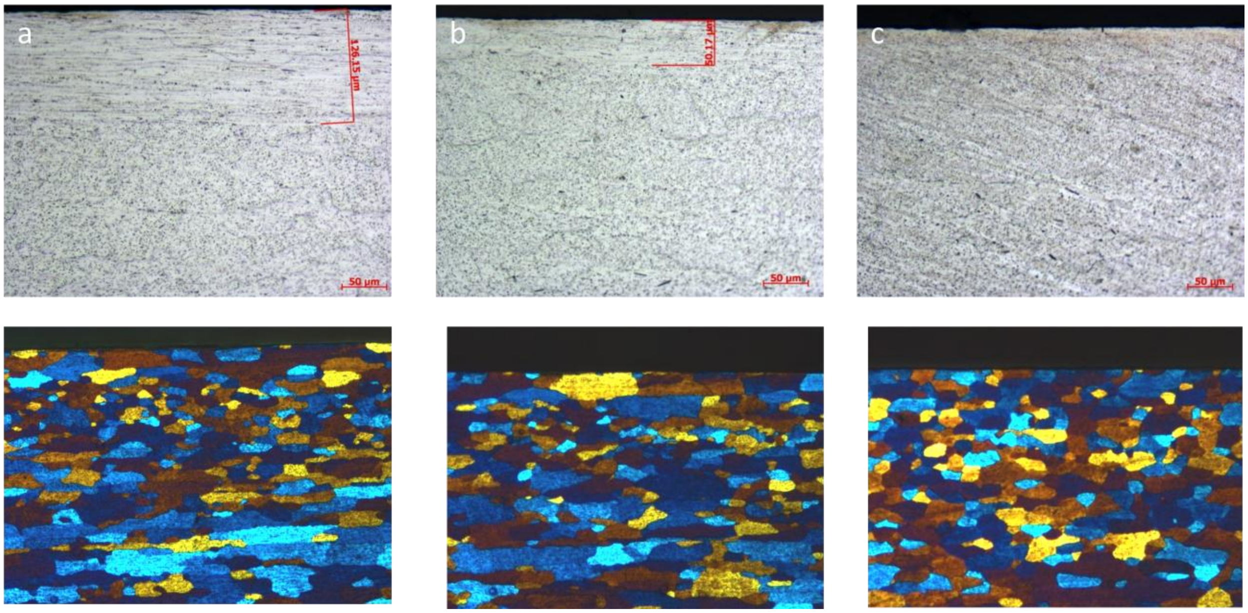

Figure 2. Evolution of the recrystallized grain structure by homogenization treatment at 520 °C for a) 4hrs b)8 hrs c) 16 hrs

The grains just underneath the surface for samples subjected to HT for 4 and 8 hrs are coarser and elongated in the rolling direction compared to the ones at the surface. The discrepancy in grain size is closely related to the concentration gradients developed during casting and amount of subsequents cold rolling operations. The concentration gradients are totaly eliminated in case(c). This is attributed to the coarsening and/or precipitation of second phase particles out of the supersaturated zone forming potential nuclei for particle stimulated nucleation(PSN)[4].

Decomposition of the supersaturated zone combined with particle coarsening can aso clearly be seen for TRC AA1200 subjected to HT of 560 °C for 4 to 16 hours(Figure 3). The imprints formed by dimand pramid during hardness measurments was intentially shown in Figure 3(a) to give an idea where the hardness measurements were taken. At 8 and 16 hrs of homogenziation, coarser intermetallics starts to form by solute diffusion from the solid solution. As by the same mechanism mentioned above, this lead to recrystallization nucleated around those particles and resulted in more uniform grain size distribution through the thickness. Scanning electron microscopy showed that the precipitated particles ranged from 1 to 2 µm in size which in turn acts as nucleation sites for particle stimulated nucleation of recrystallisation.(Figure 4) Energy dispersive analysis of X-rays revealed that the intermetallics contain mainly aluminium,silicon and iron. Previous works showed that them to be specifically cubic α phase[4]. Figure 4 shows clearly the evolution of those intermetallics with heat treatment. The heterogeneously distributed strings of intermetallics lying in planes parallel to the rolling direction are completely replaced with homogeneously distributed coarser particles after 16 hours of homogenization at 560 °C. The eutectic microstructure at the centerline decomposes into colonies of individual particles.

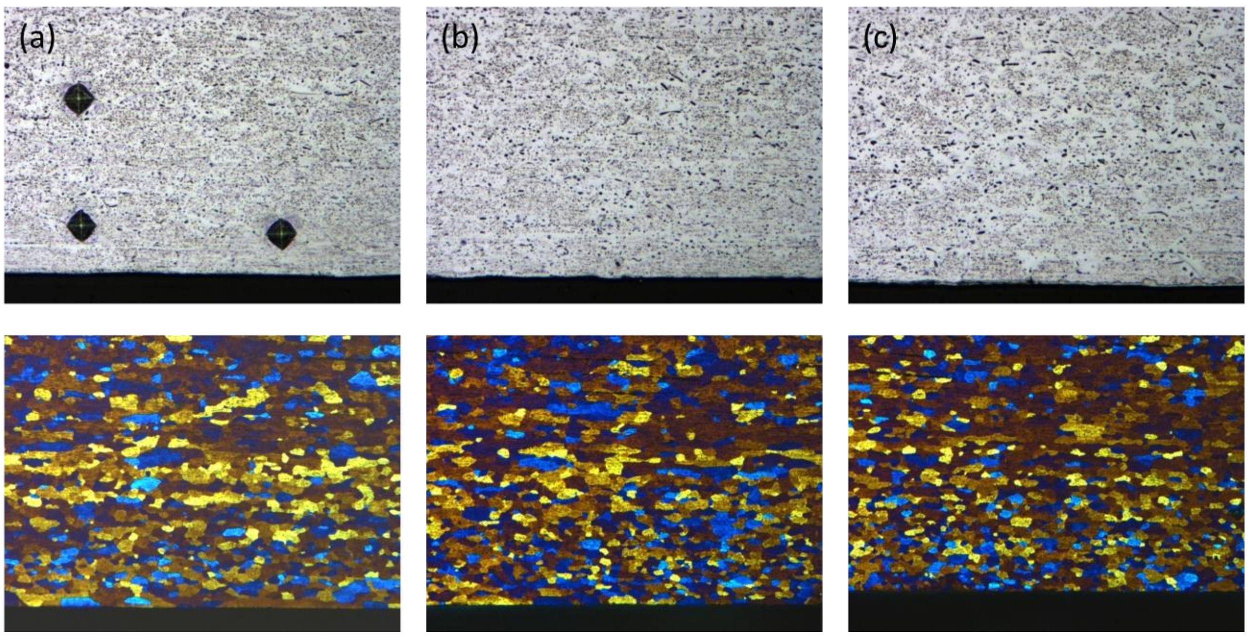

Figure 3. Evolution of the recrystallized grain structure by homogenization treatment at 560 °C for a) 4hrs b) 8 hrs c) 16 hrs

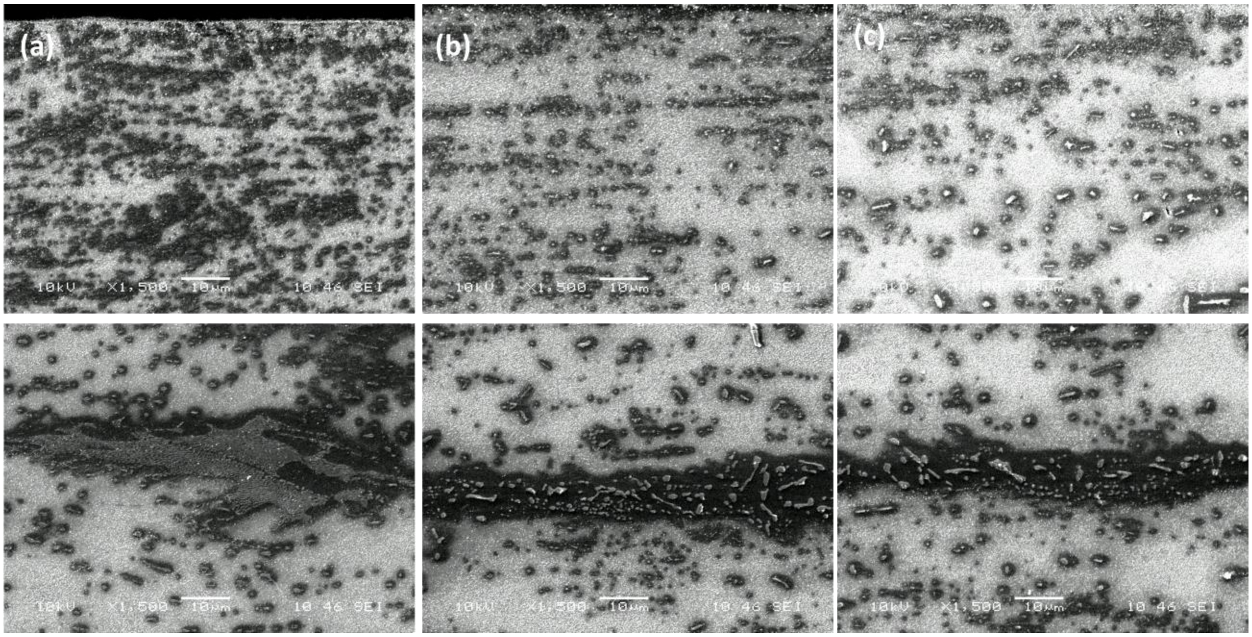

Figure 4. Scanning electron microscopy images showing the evolution of second phase morphology with homogenization temperature. a)as-rolled b) 560°C/4hrs c) 560°C/16hrs

Figure 5 shows the variation of through thickness hardness values with holding time at 560 °C. While the hardness drops by almost 8% very near the surface for samples homogenized for 4 and 8 hours, it is equilized at a lower values for samples homogenized for 16 hrs as in case (c).

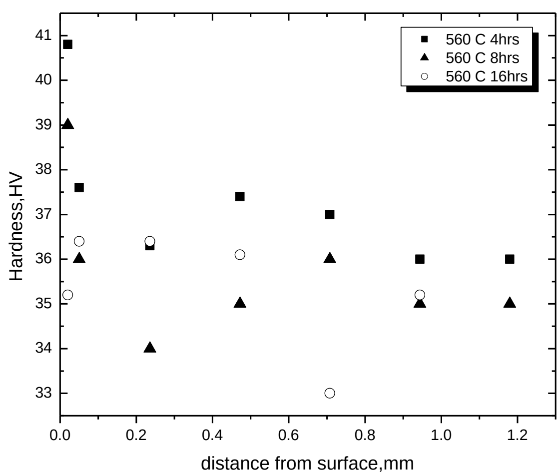

Figure 5. Variation of hardness across the thickness of cold rolled TRC AA1200.

Conclusions

Present work investigated the effect of homogenization treatment on the precipitation behavior in twin roll cast 1050 and 1200 aluminimum alloys. Homogenization treatments performed at thinner gauges found to be effective in prevention of abnormal grain coarsening at the surface by promoting the nucleation and precipitation of the intermetallics in the supersaturated zone. Longer holding times are found to be required however, in order to fully eliminate the solute and “strain” supersaturation developed during casting and subsequent operations at the surface, therby to obtain a more uniform grain structure through thickness for both alloys studied.

References

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