RESEARCH ARTICLE

Investigating the Effect of Particle Shape and Distribution on Recrystallization and Texture in Aluminium Alloys

L. Dwyer, J. D. Robson, J. Quinta da Fonseca, G. E. Thompson, T. Hashimoto
LATEST2, The University of Manchester

Large particles in wrought aluminium alloys are critically used to control the microstructural evolution during processing, in particular to tailor the final grain structure and crystallographic texture. This is especially important in 3xxx aluminium alloy sheet, where particle stimulated nucleation of recrystallization (PSN) is exploited to give a balance of texture components to produce the high level of formability required for can production.

Although the basic principles of PSN are established for idealized spherical particles, little is understood about the influence of the true particle morphologies and distributions encountered in 3xxx aluminium alloys. An improved understanding of these effects is necessary to develop accurate models that can correctly predict the effect coarse particles will have on PSN and texture evolution in real industrial alloys.

In this study, 3-dimensional imaging using X-ray tomography and serial block-face (SBF) sectioning in the scanning electron microscope (Figure 1) has been used to understand the true 3-D particle shapes and distributions encountered at different stages during processing. For the first time it has been possible to image at a sufficiently high resolution to capture both the coarse intermetallics and fine dispersoid particles, which interact in the development of the final grain structure (Figure 2).

It has been demonstrated that the assumption of a spherical morphology is a poor approximation in the case of most of the large particles in real 3xxx alloys, and the particle orientation with respect to the slip bands developed in each grain during deformation therefore becomes important in determining their potency in stimulating recrystallization of a new grain.

More realistic particle morphologies extracted from the SBF data (Figure 3) have been used as inputs to a crystal plasticity finite element model (CPFEM) to help predict the effect of particle shape and orientation on deformation zone formation and hence the likely potency of a particle to initiate PSN. This work is ongoing, with the eventual aim of producing an improved model for PSN that correctly accounts not only for particle size but also for shape and orientation.

This work forms a component of an integrated through process model (TPM) for rolling of 3xxx aluminium alloy sheet being developed in collaboration with Novelis and a consortium of Canadian universities.

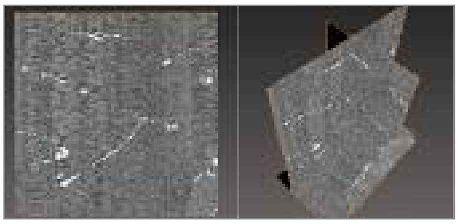

Fig. 1 Image from a single slice (left). More than 500 such slices are used to characerize the microstructure in 3-dimensions (right).

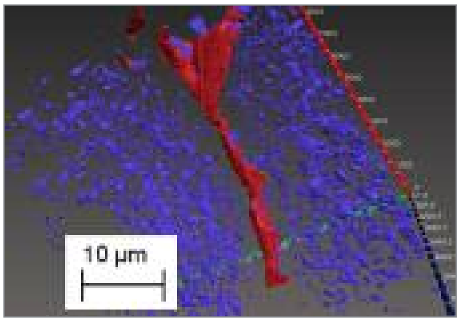

Fig. 2 3-dimensional visualization of large intermetallic constituents (red) on a grain boundary and dispersoids (blue) after homogenization of a 3xxx Al alloy. The dispersoid free zone adjacent to the grain boundary is clearly seen.

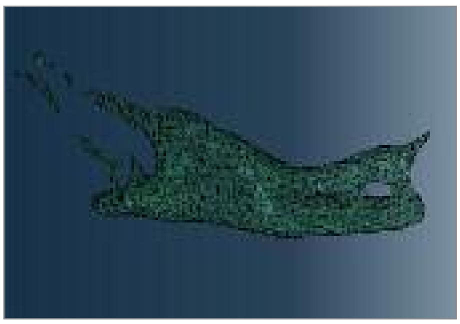

Fig. 3 Particle of complex geometry extracted from 3-dimensional dataset and meshed for use in a finite element model.

Acknowledgements: This LATEST2 project was performed through the EPSRC Centre for Doctoral Training in Advanced Metallic Materials with support from Novelis

Publications: J. D. Robson, J. Q. da Fonseca, L. Dwyer, T. Hashimoto, G. E. Thompson, N. Kamp, Constituent Particles and Dispersoids in an Al-Mn-Fe-Si Alloy Studied in Three-Dimensions by Serial Sectioning, Materials Science Forum 765, 2013, p. 451-455