ITP Research Identifies How Sodium Reduces the Strength of Aluminum Alloys

Trace amounts of sodium in Al-Mg alloys can cause a host of problems for aluminum manufacturers, resulting in reduced yields and subsequent reprocessing of material. For example, only few tenths of a ppm of Na can lead to cracking of the alloys during hot rolling processing. Though Na, Ca and Li are known to be harmful impurities, no previous systematic studies of the behavior of these elements during the processing of aluminum alloys had been conducted. Now Zi-Kui Liu, Shengjun Zhang at the Pennsylvania State University and Qingyou Han at Oak Ridge National Laboratory, funded through the Industrial Technologies Program (ITP, Aluminum), have made significant progress on understanding the effect of Na on high temperature embrittlement (HTE) of Al-Mg based alloys.

The development of a thermodynamic database for the Al-Mg alloys allowed the modeling of the correlations between cracking, furnace processing temperature and Na content of an Al-5 wt. % Mg alloy. The simulation indicates that the formation of a liquid Na-containing phase at grain boundaries can occur in the temperature range where the aluminum is worked. The presence of the liquid dramatically reduces the strength of the finished product. This study opens opportunities to use thermodynamic simulations for minimizing defect formation in aluminum, and reducing HTE, which improves hot rolling and improves the energy efficiency of the process. Savings from this work are projected at $42.7M/yr and 6.2 trillion Btu/yr of natural gas by 2015.

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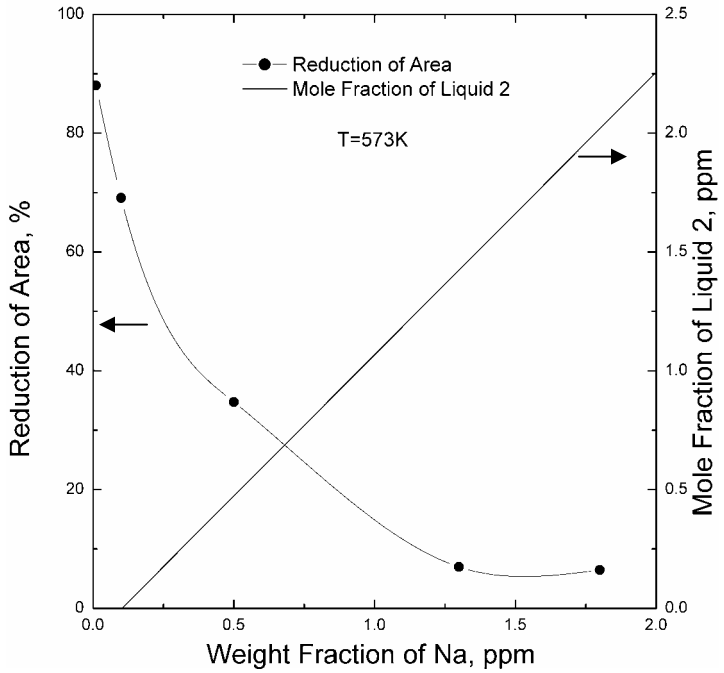
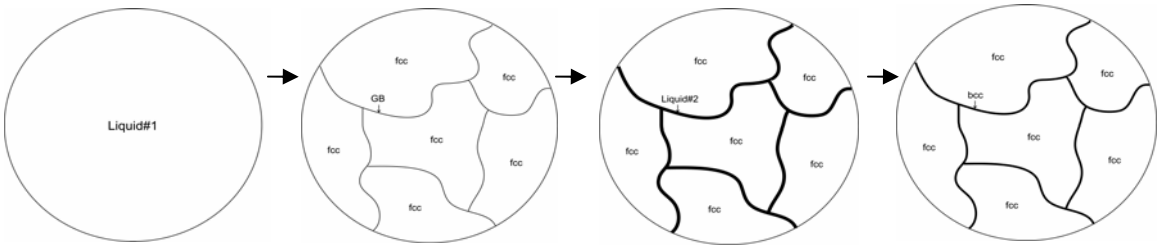
A fact sheet on the project is available at:
http://www.eere.energy.gov/industry/aluminum/pdfs/effectofimpurities.pdf



As Na contamination in Aluminum increases, the amount of a Na-rich liquid phase at grain boundaries increases. The liquid phase leads to decreased ductility (% Reduction of Area), and the increased potential of cracking of the finished product.



Schematic illustrations of solidification from melt through final processing of Na-bearing Al-5%Mg alloys. A) Liquid Melt (liquid 1). B) High temperature solid phase (fcc) showing grain boundaries (GB). C) Structure at processing temperature showing formation of Na-rich liquid phase (liquid #2) at grain boundaries. D) Final two-phase process structure (fcc and bcc) with decreased strength.