Two-scale Thermomechanical Finite Element Analysis of Texture Evolution in the Rolling Process

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ABSTRACT

Recently, the crystallographic structure control in the aluminum alloy sheet during rolling process has become a key technology in the aluminum industries, which is applied to design and produce a sheet metal having high formability and high strength. We develop a new computational tool for the process metallurgy simulation of hot and warm rolling processes, which consists of the two-scale finite element method based on the thermo coupled elasto-crystal plasticity-analysis and the dynamic-explicit finite element procedure [1]. It can predict the evolutions of plastic work-hardening, heat generation and plastic anisotropy at the macro-scale and the crystal texture evolution depending on the heat generation and strain rate at the micro-scale. Further, our two-scale analysis can be used for the formability and strength assessment of a newly generated aluminum alloy sheet.

In the application of our multi-scale thermomechanical FE code, the hot and warm rolling process of 6000 series aluminum alloy sheet was analyzed to predict the deformation, straining and the heat generation under the adiabatic and heat conductive conditions [2]. Additionally, the dynamic recrystallization process is analyzed based on the heat generation and the evolution of preferred crystal orientation. We employed the conventional elasto-plastic constitutive equation at the macro-scale, and the crystal plasticity one at the micro-scale. By using the experimental results of stress-strain relationships under widely changed temperature and strain rate, we identified the strain rate and temperature dependent constitutive equations for crystal and macroscopic scales. This newly developed texture evolution prediction method can apply to the crystal structure control to design a sheet metal having high formability and strength through the hot and warm sheet rolling processes and the heat treatment. Numerical results of thermo-elasto-plastic two-scale finite element analyses revealed the heat generation, heat conduction and the texture evolution. Through the comparison with the computational results and experimentally observed results, it was confirmed that our process metallurgy analysis code can well predict the microscopic crystal texture evolution in the industrial hot rolling process.

REFERENCES

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