ALUMINUM

Project Fact Sheet

Rolling Process Design Tool

Benefits

The potential benefits to the domestic4 aluminum industry assuming a 10 percent4 increase in hot roll yield:4

- •4 Annual cost savings to the domestic4 aluminum industry of $105 million4
- •4 Annual manufacturing energy savings up4 to 12 trillion Btu4

Applications

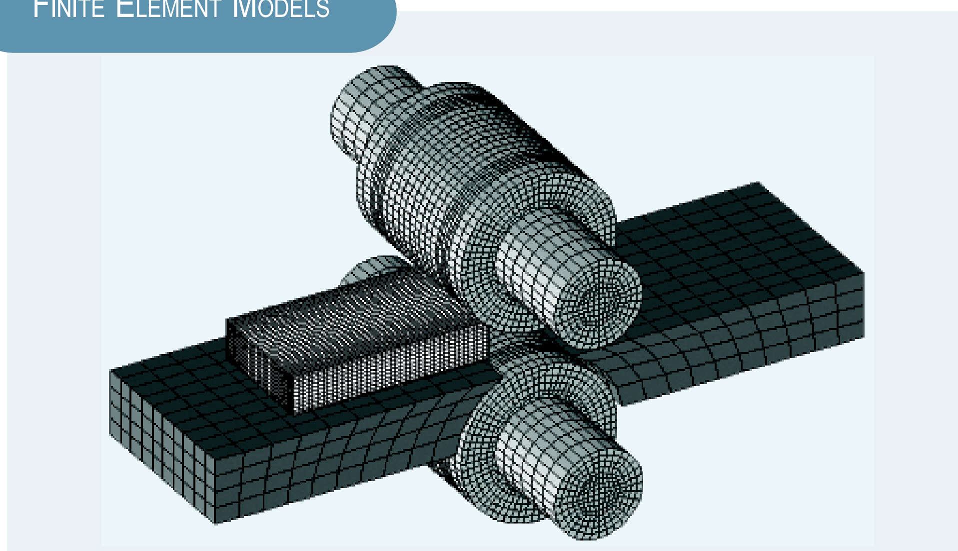
One of the principal forming processes for4 aluminum is the hot rolling of ingot into thick4 slabs and further rolling to form plate and4 sheet material of various thickness.4 Approximately 45 percent of produced4 aluminum ingot material passes through this4 process. This project's new technology4 could improve the competitive position of the4 domestic aluminum industry in the4 transportation, packaging, building and4 construction, and other industries.4

Development of a rolling process design tool for use in improving hot roll slab yield

Multiple passes in a reversing rolling mill of a hot slab are used to produce semi-finished aluminum plate. However, the large deformations encountered while rolling may lead to failure modes that result in loss of part or even all of the slab. The formation of defects within the plate, such as edge cracking, delamination, alligatoring (center splitting near the front and rear), and the formation of undesirable rolled end shapes, all lead to product losses. Critical equipment downtime is also associated with several failure modes. Typically, rolling plant yield from ingot to final production is about 50 percent. Rejected material is recycled and melted to form new ingots. Improving yield would lower the overall energy used in processing aluminum.

Processing parameters could be chosen that minimize loss of product and significant improvements in energy efficiency could be attained if the slab material response to the hot rolling process was sufficiently well understood. Currently, processing parameters are optimized by trial and error or from empirical evidence. Project partners will develop a rolling process design tool for use in improving hot roll slab yield. Numerical simulation of the full thermal-mechanical process will play a major role in optimizing the process to increase product yield. The material forming experience and the numerical simulation capabilities developed from this project, can be used in other aluminum-forming processes and will provide significant energy benefits.

Finite Element Models



A finite element model representing rolls, slab, and supports is illustrated. The rolling tool model will include formulae of material properties, structural response, friction, and heat transfer.

Project Descriptiong

Goal: The project goal is to develop a numerical modeling capability to optimize the hot rolling process used to produce aluminum plate. This tool will be used in the forming process so that loss of product will be minimized. Product lost in the rolling process requires the energy-intensive steps of remelting and reforming into an ingot. The modeling capability developed by project partners will be used to produce plate more efficiently and with better properties. The major objectives in achieving the goal of this project are to:

- predict temperature, stress, strain, strain rate history and damage evolution of slab material as it evolves through multi-pass rolling.
- determine the effect of initial slab shape and rolling pass schedule on fracture and internal product integrity.
- demonstrate the utility of a numerical model as a forming process optimization tool.

Progress and Milestonesg

- Determine material constitutive properties. Conduct uniaxial hot compression tests, model data and incorporate into slab modeling code.
- Determine material fracture properties. Conduct uniaxial hot tension/ compression/torsion tests including directionality. Determine model constants and implement model in code.
- Implement friction model. Incorporate state variable friction model in code.
- Characterize the hot rolling process by determining boundary and initial conditions. Develop geometric configuration, heat transfer description and initial temperatures of slabs and rolls.
- Produce rolling data for code validation. Characterize microstructure evolution and fracture initiation and growth.
- Validate finite element model. Compare to rolling data and to uniaxial hot tensile fracture data. Produce initial and boundary conditions for rolling data validation studies.
- Apply model to production rolling configuration. Define initial and boundary conditions. Produce finite element model and compare predicted material properties with observed properties.
- Perform parameter studies by evaluating temperature distribution, roll speed, ingot geometry, pass schedule and roll gap geometry.

Commercialization Plang

The rolling process design experience developed by project partners will be made available to the aluminum community through journal publications and/or technical presentations. The Alcoa Technical Center will perform analysis of production environments at its rolling plants to produce better process design guidance for use at their plants.

PROJECT PARTNERS

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