Project 19 – Simulation of microstructure and yield stress during natural and artificial aging of Al-Mg-Si automotive sheet

AMAP Advanced Metals and Processes

Motivation

- Understanding of the age hardening behaviour of Al-Mg-Si alloys, in particular the process of clustering during natural aging and its impact on a subsequent “high” temperature treatment
- Numerical description of the evolution of micro-structure and mechanical properties during solution heat treatment and beyond offers a great potential for industrial application
- Property driven optimization of alloy composition and heat treatment processing parameters by micro-structure based simulation tools

Goal

- Development of a simulation tool describing the evolution of microstructure and yield stress in Al-Mg-Si alloys
- The tool shall combine predictive capability, short calculation times, and usability for an industrial application
- The tool shall consider the composition range of AA6016 and complex heat treatments, i.e. solution heat treatment, natural aging and artificial aging

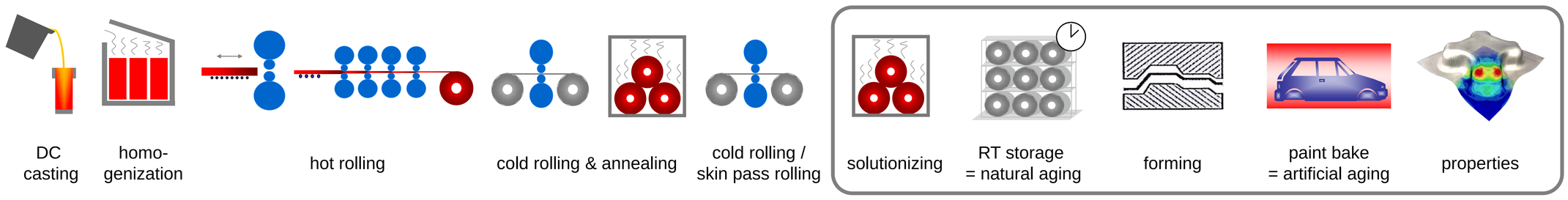

Figure 1: Typical process chain of automotive sheet production (processing steps considered in AMAP P19 are highlighted).

Process – Microstructure – Mechanical Properties

- Precipitation sequence and precipitation kinetic strongly depend on aging temperature and alloy composition

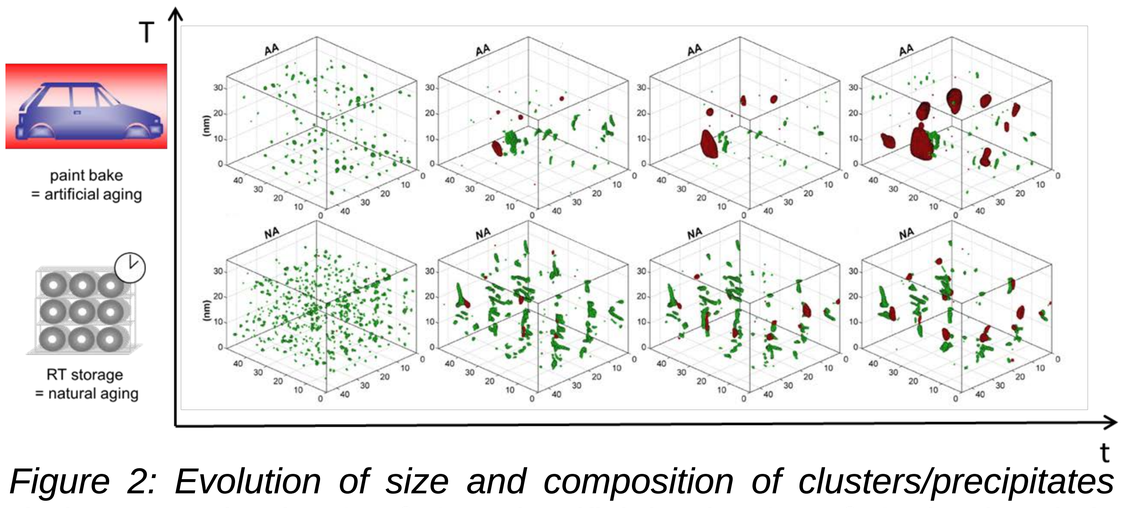

Figure 2: Evolution of size and composition of clusters/precipitates during natural aging (25 °C) *and artificial aging* (180 °C) *simulated via Phase-field crystal method (PFC). Mg atoms are highlighted in red and Si atoms in green [1].*

- Size and number density distribution of clusters/ precipitates determines the mechanical properties, i.e. yield stress

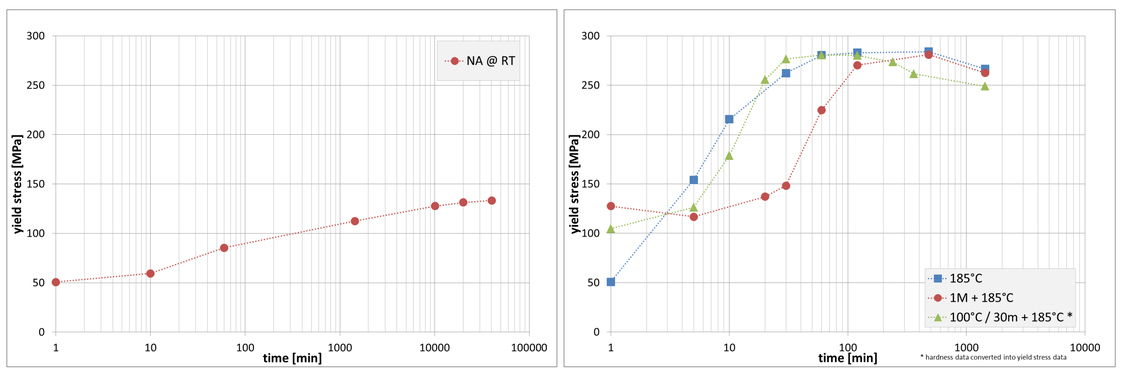

Figure 3: Evolution of yield stress in time for different single- and multi-step heat-treated samples of AA6016. Single-step: natural aged (NA) at room temperature (RT) (left, red) and artificial aged (AA) at 185 °C (right, blue). Multi-step: NA for 1 month at RT and subsequent AA at 185 °C (right, red); Pre-baked for 30 minutes at 100 °C and subsequent AA at 185 °C (right, green).

Major Work Packages

- Literature review on physical mechanisms controlling the age-hardening behaviour in Al-Mg-Si alloys
- Identification of relevant thermodynamic databases
- Experimental investigation of age-hardening behaviour of two alloy compositions during various complex heat treatments
- Development, implementation and validation of microstructure model
- Development, implementation and validation of microstructure-based yield stress model

Timeline

- The AMAP project 19 runs between May 01, 2017 and October 31, 2019.

Consortium

Industry: Aleris, HYDRO

University: ibf | RWTH AACHEN UNIVERSITY

The AMAP project 19 consists of 3 partners:

- Aleris Rolled Products Germany GmbH
- Hydro Aluminium Rolled Products GmbH
- Institute of Metal Forming, RWTH Aachen University

[1] V. Fallah et. al., Acta Materialia 103, pp. 290–300, 2016

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