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Physical simulation and development of processing of high-strength steels during 25 years

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ABSTRACT

Modern advanced high-strength steels are commonly produced by thermo-mechanically controlled processing (TMCP) that necessitates strictly controlled rolling reductions in desired temperature regimes followed by controlled cooling in air or with water. Due to the numerous adjustable parameters, process simulation is very beneficial in the design of TMCP schedules. At the University of Oulu, physical simulation and modeling have become important tools for steel research and development in collaboration with many universities, research institutes, and companies worldwide since the beginning of 1990s. The first Gleeble-1500 unit was installed in April 1991 and replaced by a Gleeble-3800 in 2010. During 25 years, various steel types have been investigated, such as low-carbon C–Mn microalloyed grades (YS up to 500 MPa), bainitic (YS 960 MPa), martensitic (YS 1100 MPa), dual phase, TRIP, Q&P, and TWIP steels, in addition to austenitic stainless steels, where enhanced strength with high TRIP ductility was realized by grain size refinement to sub-micron scale through martensitic reversion.

From the beginning, collaboration with Harbin Institute of Technology (Prof. Jitai Niu), McGill University (Prof. John Jonas), and the University of Sheffield (Prof. Mike Sellars), among many others, has been intense. The research has been funded by national sources and the European Commission. During this quarter century, results have been reported in more than 200 journal and conference papers, including ICPNS conferences. This paper will present examples of physical simulation driven research for the development of innovative high-strength steels and acknowledge the collaboration with numerous colleagues that contributed to its success.

KEYWORDS: physical simulation, modelling, thermomechanical processing, steels