

ABSTRACT

Thermomechanical treatment of ultrafine-grained bainitic steels with metastable retained austenite with strength above 1 GPa

The aim of this work was to develop the optimal chemical composition of steel and thermomechanical treatment parameters that would guarantee an ultrafine-grained bainitic structure with retained austenite, enabling the production of forgings with high mechanical properties. The literature section characterizes both conventional steels intended for die forgings and modern multiphase steels containing retained austenite and a different matrix, demonstrating potential for applications in the forging industry. Time-temperature parameters for isothermal holding were developed for the 0.17C-3.1Mn-1Si-0.55Al-0.22Mo-0.034Ti-0.073V steel enabling the production of a homogeneous, fine-lath microstructure consisting of bainitic ferrite and retained austenite with a small fraction of fresh martensite. The aim of this work was verified based on dilatometric studies, investigations using a Gleeble thermomechanical simulator, detailed structural analysis of the steel and mechanical properties tests. Results obtained using scanning and transmission electron microscopy, EBSD analysis, and measurements of the fraction of retained austenite using X-ray diffraction were crucial to achieving the aim of this work. These data enabled a comprehensive qualitative and quantitative analysis of the structure.

Thermodynamic calculations were performed to determine critical temperatures and compared with the results of dilatometric studies. Based on the DCCT and DTTT diagrams and the X-ray results, the most promising time-temperature parameters of isothermal heat treatment were selected for the stabilization of retained austenite. Based on plastometric studies conducted in a Gleeble 3800 thermomechanical simulator, four variants of forging simulations followed by isothermal holding were developed to produce a bainitic structure containing retained austenite. The developed chemical composition of the steel and the temperature-time parameters of isothermal holding make possible to develop a technology for manufacturing forgings with an ultra-fine lath-type bainitic structure containing retained austenite, guaranteeing high strength properties in a range: YS from 752 to 789 MPa and UTS from 1121 to 1197 MPa.