Abstract

Improvement of the ductility of high-strength medium-Mn steels through intercritical annealing

The aim of this work was to explain structural phenomena occurring during the intercritical annealing of medium-Mn steel depending on the applied temperature-time parameters and optimization of these parameters resulting in improved steel plasticity. The hot-rolled martensitic alloy containing 0.16C-4.7Mn-1.6Al-0.2Si-0.2Mo was subjected to the tests. The literature part of the work is a review of high-strength steels and a summary of previous research in the field of intercritical annealing of medium manganese steels. Factors influencing the amount and stability of retained austenite were determined. The temperature and time parameters of the process used so far and their impact on mechanical properties of the alloy were analyzed.

In order to prove the thesis of the dissertation, tests of mechanical properties and detailed structural tests of steel were performed. The thermodynamic simulations and experimental tests with the use of scanning and transmission electron microscopy, X-ray tests and EBSD tests allowed to quantify the structural features of steel after various variants of heat treatment. They were of fundamental importance for the implementation of the objective of the work.

The evolution of phase composition and stability of retained austenite was studied as a function of annealing temperature in the range from 640 °C to 1000 °C for 60 min and as a function of soaking time in the range from 1 min to 300 min at 680 °C. The quantitative assessment of the fraction of retained austenite, its chemical composition and its grain size were essential for the implementation of the objective of the work. This made it possible to correlate individual characteristics with the obtained mechanical properties of steel after various treatment variants. It was found that the amount of austenite increases with increasing annealing temperature and soaking time. However, this is associated with a decrease in its stability due to the decreasing enrichment in C and Mn and the increasing grain size. This causes that the retained austenite fraction obtained after cooling initially increases with increasing the annealing temperature and soaking time, and after reaching the limit stability it begins to decrease rapidly. The high stability of the retained austenite inhibits the strain-induced martensitic transformation. On the other hand, its low stability induces the massive martensitic transformation at low strain levels. Both extreme variants result in lowering the steel plasticity. To obtain the maximum elongation of the sample, it is necessary to obtain a compromise between a high proportion of retained austenite and its adequate overall stability controlled by a wide grain size distribution enabling the gradual SIMT within the entire deformation range.