metals

MDPI

Article

Assessment of Steel Subjected to the Thermomechanical Control Process with Respect to Weldability

Jacek Górka

Welding Department, Silesian University of Technology, Konarskiego 18A, 44-100 Gliwice, Poland; jacek.gorka@polsl.pl

Received: 24 January 2018; Accepted: 7 March 2018; Published: 9 March 2018

Abstract: The study is concerned with the assessment of the weldability of steel S700MC subjected to the thermomechanical control process (TMCP) and precipitation hardening and characterised by a high yield point. Appropriate mechanical and plastic properties of steel S700MC were obtained using the thermomechanical control process through precipitation, solution, and strain hardening as well as by using grain-refinement-related processes. Constituents responsible for the hardening of steel S700MC include Ti, Nb, N, and C. The hardening is primarily affected by (Ti,Nb)(C,N)-type dispersive precipitates sized from several nanometres to between ten and twenty nanometres. The welding process considerably differs from TMCP conditions, leading to the reduction of plastic properties both in the heat-affected zone (HAZ) and in the weld area. This study demonstrates that in cases of TMCP steels, where the effect of precipitation hardening is obtained through titanium and niobium hardening phases, the carbon equivalent and phase transformation γ–α cannot constitute the basis of weldability assessment. The properties of welded joints made from the above-named group of steels are primarily affected by the stability of hardening phases, changes in their dispersion, and ageing processes. The most inferior properties were identified in the high-temperature and coarse-grained HAZ area, where the nucleation of hardening phases in the matrix and their uncontrolled reprecipitation in the fine-dispersive form lead to a sharp decrease in toughness.

Keywords: weldability; TMCP steel; HAZ

1. Introduction

The mechanical properties and the quality of products made of low-alloy fine-grained steels strongly depend on their microstructure, controlled through the use of appropriate thermomechanical processing. The thermomechanical control process (TMCP) is a technological process where intended changes in structure and properties of metallic materials result from the combined effect of plastic and heat treatment [1–6]. As regards temperature at which plastic straining takes place, the thermomechanical control process can be divided into high- and low-temperature thermomechanical processes. If the process involves multistage straining, it is referred to as the combined thermomechanical control process constituting the basis of thermomechanical rolling. If the process involves straining with austenite recrystallisation following successive strains, it is referred to as the thermomechanical control process constituting the basis of rolling with controlled recrystallisation. The possibility of controlling microstructural transformations results from the appropriate selection and adjustment of steelmaking conditions including heating, straining, and cooling. The ultimate structure depends on the chemical composition of steel and the cycle of the thermomechanical control process. The obtainment of a fine-grained structure is closely related to the structure of austenite, formed during hot working. The proper course of the thermomechanical control process should involve thermally