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ESTIMATE OF WELDABILITY OF THE HOT WORK TOOL STEELS VIA THE CCT DIAGRAMS

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Abstract: *Weldability represents a very complex property of a material that shows its ability to form a welded joint of certain characteristics, by application of the adequate welding procedure. It can be determined in several ways. The procedure of weldability estimate, based on the transformation diagrams of continuous cooling (CCT-diagrams) and the measured temperature cycles, is presented in this paper. The objective was to determine the weldability to be able to define the optimal hard-facing technology of the thermo stable steels. The temperature cycles were measured and then the obtained values for the critical cooling time t8/5 were entered into the CCT diagrams to estimate the hardness and microstructure of the welded joint's zones. Those two parameters are indicators of the steel's weldability. Experiments were conducted on the multi-layered hard-faced samples made of the steel for manufacturing of the forging dies.*

Keywords: Thermoresistant steels, weldability estimate, hard-facing, temperature cycles, time t8/5,.

1 INTRODUCTION

Weldability, as a very complex technological material property, can be determined in several ways: theoretically by calculations, in laboratory by experiments, by technological tests and by the Continuous Cooling Transformation (CCT) diagram. Considering the fact that the theoretical determination of weldability does not always have to be reliable, the recommendation is to use some other ways to estimate the material's weldability, as well. Theoretical estimate was very reliable for determination of the cooling time t8/5 Ito and Bessyo (1972), since certain output characteristics of the welded joint could be predicted based on that parameter Lazic et al. (2010), (2014a), Arsic et al. (2015a), (2016). However, even that estimate of the critical cooling time in the cited papers was not done purely theoretically, but it was verified by either experimental or numerical investigations. The CCT diagrams could be applied by the similar analogy and constructed for all steels.

The objective of this paper was to point to possibility of the CCT diagrams application for estimate of weldability of the hot work tool steels and their reliability in prescribing the technology for hard-facing of the responsible machine parts. Until now, it was shown that various parts could be repaired by the hard-facing, like forging tools parts Lazic et al. (2014a), Arsic et al. (2015a), (2016), Lazic et al. (2014b), Lazic et al. (2015), , construction mechanization parts Lazic et al. (2011) or the hydro power plants parts Arsic et al. (2014), etc. Here is presented the procedure of using the CCT diagrams to shorten those lengthy and costly experimental procedures. In order to determine the critical cooling time as reliably as possible, it is necessary to record the corresponding temperature cycles. Based on those cycles, the distribution of temperature and heat during the welding/hard-facing could be monitored Kumar et al. (2014), Zimmer et al. (2009), Murugan et al. (2009), Lan et al. (2015) and the certain temperatures could be related to corresponding structures and characteristics of material in individual zones of the welded joint Galatanu et al. (2014), Arsic et al. (2015b).

2 DETERMINATION OF THE HOT WORK TOOL STEELS TEMPERATURE CYCLES

The temperature cycles measurement was done by thermocouples in the hard-faced plates of the two thicknesses, 7.4 and 29 mm, made of the 56NiCrMoV7 (EN 10027-1). The determined temperature cycles and cooling times were entered into the corresponding CCT diagram and the expected micro structure and hardness of steel were obtained.

Electrodes of the two different diameters de, of 3.25 and 4 mm were used for hard-facing and different preheating temperatures and heat inputs were applied, as well. The steel plates of the hot work tool steel were delivered in the tempered condition, with drilled holes for temperature cycles measurement points. The bottom of each hole, into which the thermocouple is being placed, is at a 4 mm distance from the hard-faced layer, i.e. from the welding arc, to secure that the temperature measurements are as accurate as possible. The scheme of the measurement process is shown in Figure 1.

The thermocouple is connected to plotter SERVOGOR S RE 541 Potentiometer recorder, which enables continuous registering of the temperature variation in time. The optimal range of its characteristics (scale type and range, paper speed, etc.) was adjusted.