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SELECTION OF THE OPTIMAL HARD FACING (HF) TECHNOLOGY OF DAMAGED FORGING DIES BASED ON COOLING TIME $t_{8/5}$

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In exploitation, the forging dies are exposed to heating up to very high temperatures, variable loads: compressive, impact and shear. In this paper, the reparatory hard facing of the damaged forging dies is considered. The objective was to establish the optimal reparatory technology based on cooling time $t_{8/5}$. The verification of the adopted technology was done by investigation of the hard faced layers microstructure and measurements of hardness within the welded layers' characteristic zones. Cooling time was determined theoretically, numerically and experimentally.

Key words: Forging dies, hard facing, cooling time $t_{8/5}$, hardness, microstructure

INTRODUCTION

The subject of this paper was problems related to hard facing of the damaged forging dies. These tools are exposed to extremely high temperatures, as well as to high compressive and shear loads, including impact loads. Steels that are used for manufacturing of such tools have to sustain high impact loads, to be resistant to wear and thermal fatigue, while maintaining the good mechanical properties at the same time, what was the main research topic in [1]. Similar problems were considered in paper [2], namely an analysis of stresses and failure causes during exploitation was done at cemented carbide punch used for the manufacturing of the airbag container type parts. Thermal fatigue was also cause of failure of a tool for pressure casting analyzed in [3]. Analysis of crack appearance after certain number of cycles was done for the aluminum casting process. In paper [4] is given the procedure for analysis of failure causes of a device for soil Tamping Tool, where the failure occurs due to very harsh mechanical and tribological working conditions. Forging dies are subjected to all of the mentioned damages, and for them in [5], based on model investigations, the hard facing technology was prescribed [5]. For production of forging tools alloyed steels are usually used, which do not possess very good weldability. Due to alloying, those steels are prone to self-hardening. In order to obtain good properties of the hard faced layer it is necessary to determine the temperature cycles beneath it, as well as the cooling time between 800 and 500 ºC, the so-called $t_{8/5}$. Influence of $t_{8/5}$ on mechanical properties of the hard faced layer is significant, while the methodology for its determination could be different. In papers [6,7] is presented a method for determination of the temperature cycle by the Smitweld simulator, on a certain number of samples, with variation of the maximal temperature and holding time. In paper [8] is shown the possibility of simulation of a temperature cycle by the thermo-mechanical device controlled by the Rikalin's mathematical model. Numerical analysis can be also reliably used for determination of temperature cycles, what was shown in paper [9] for the hard facing process and in paper [10] for the friction stir welding. Besides the optimal hard facing technology and selection of filler materials, it is also necessary to define the corresponding heat treatments. One has to determine the temperature cycles that appear during the hard facing, in order to avoid appearance of undesirable phases in the layers structure. The objective was to define the optimal hard facing technology for reparation of forging dies based on the cooling time $t_{8/5}$. To achieve that, the temperature cycles were investigated and the critical cooling time $t_{8/5}$ was determined theoretically, based on the Rikalin's formula, formula for the limit thin sheet's thickness and the Ito-Bessyo formula, [11], as well as numerically and experimentally. The criteria of the executed hard faced layers' quality were hardness and microstructure in layers of the applied hard faced welds and in the heat-affected zone (HAZ) under the weld.

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HARD FACING PROCEDURE

The forging dies usually operate at temperatures higher than 300 °C. Commonly used steels are 55NiCrMoV6 (for dies, pressing molds, dies holders), 56NiCrMoV7 (for dies and their inserts of extremely loaded pressing tools, press dies and extruders), X40CrMoV51 (for dies and their inserts for forging machines, casting