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IMPACT OF THE HARD FACING TECHNOLOGY AND THE FILLER METAL ON TRIBOLOGICAL CHARACTERISTICS OF THE HARD FACED FORGING DIES

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Subject review

The forging dies are parts, which are operating at elevated temperatures, while simultaneously subjected to variable loads that can be compressive - even impact and shear. Impact of the hard facing technology is very strong since varying of the hard facing parameters directly affects the output characteristics of the hard faced layers. The criterion for estimating that impact was based on results of performed tribological investigations. The tribological parameters that were monitored were the friction coefficient, the wear scar/trace width and the wear area of the hard faced layers, with the two different types of lubricants. Hard facing technology implied selection of the welding process, filler metals, preheating temperatures and other parameters of the hard facing process. The influence of the proposed hard facing technology was determined by monitoring hardness, microstructure and wear resistance of the executed joints after the hard facing and after tempering. The objective of this work was to establish the correlation between the selected hard facing technology, filler metals and applied heat treatment on mechanical and tribological characteristics of the executed hard faced layers.

Keywords: *forging dies; friction coefficient; hard facing; hardness; microstructure; wear resistance*

Utjecaj tehnologije navarivanja i dodatnog materijala na tribološke karakteristike navarenih kovačkih alata

Pregledni članak

Kovački alati su dijelovi, koji rade na povišenim temperaturama, dok su istodobno izloženi promjenljivim opterećenjima, koja mogu biti tlačna - čak i udarna i smična. Utjecaj tehnologije navarivanja je vrlo jak, pošto se variranjem njegovih parametara direktno utječe na izlazne karakteristike navarenih slojeva. Kriterij za procjenu tog utjecaja bio je utemeljen na rezultatima obavljenih triboloških ispitivanja. Praćeni tribološki parametri bili su faktor trenja, širina traga (brazgotine) habanja kao i površina habanja navarenih slojeva, uz uporabu dva tipa maziva. Tehnologija navarivanja je podrazumijevala selekciju procesa zavarivanja, dodatnih materijala, temperature predgrijavanja i ostalih parametara procesa navarivanja. Utjecaj predložene tehnologije navarivanja je određivan praćenjem tvrdoće, mikrostrukture i otpornosti na habanje izvedenih spojeva, nakon navarivanja i nakon otpuštanja. Cilj ovog rada bio je uspostavljanje korelacija izabrane tehnologije navarivanja, dodatnih materijala i primijenjene toplinske obrade s mehaničkim i tribološkim karakteristikama izvedenih navarenih slojeva.

Ključne riječi: *faktor trenja; kovački alati; navarivanje; mikrostruktura; otpornost na habanje; tvrdoća*

1 Introduction

The subject of this work was to determine the optimal reparatory technology by hard facing of the damaged forging dies based on tribological investigations of the performed test welds. Steels that are used for producing the forging dies must be able to sustain high impact loads, while simultaneously preserving the good mechanical properties. They also must be resistant to wear and thermal fatigue. That was the main research topic in [1]. Similar problems were considered in paper [2], namely an analysis was conducted of behaviour of a material deposited on the copper alloy. Thermal fatigue was also cause of failure of a tool for pressure casting analysed in [3] and analysis of crack appearance after certain number of cycles was done for the aluminium casting process. Besides the thermal fatigue, wear appears as the frequent cause of damages to this type of tools. The wear of forging dies, due to abrasion and adhesion, was the subject of research in [4], where the hard facing was applied as a method for recovery of the sustained damages. To extend the service life of the forging dies, their wear was analysed numerically in [5] during the final phase of forging. By comparing the numerical results with the measurements taken from the worn die, the wear coefficient has been evaluated for different points of the die surface and finally a value of wear coefficient is suggested.

Paper [6] represents the first part of investigation of this group of authors, related to prescribing the optimal reparation technology of the forging dies by hard facing. In [6] the optimal technology was considered based on criterion of the cooling time between 800 and 500 °C, $t_{8/5}$, for the same steels that are considered in this paper (proposed hard facing technology is described in details in ref. [6], so presenting of certain data about it is avoided in this paper).

Alloyed steels are usually used for producing the forging dies. They do not possess very good weldability. Any hard facing reparation of pieces made of those steels requires specially prescribed technology, adjusted to that piece, since certain alloying increases proneness of those steels to self-hardening [7÷9]. Some authors have also dealt with hard facing of alloys like Inconel and Stellites, investigating the prescribed technologies and selected filler metals. Those materials harden during operation and thus they increase strength and resistance to wear and impact loads. Alloys Inconel 625 and Stellite 21 had the best wear resistance [8, 9]. Besides the optimal hard facing technology and selection of filler metals [9, 10], it is necessary to define the adequate heat treatment – before, during and after the welding [11÷13]. Resulting welds, after the hard facing and the final heat treatment, were tested in tribological conditions, to establish their wear resistance, as well as by destructive methods to obtain the hardness distribution in the cross section,