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DETERMINATION OF BOND STRENGTH BETWEEN THE HARD-FACED (HF) LAYER AND THE BASE MATERIAL (BM) OF FORGING DIES

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This paper points out complex working conditions of forging dies, which are the most frequent causes of their damage, and proposes suitable hard-facing repair procedures. The shear strength between the hard-faced layer and base metal has been measured using specially developed tool, and correlation between output results and the applied hard-facing technology is established.

Key words: forging dies, alloy steel, hard-facing, hardness, microstructure

INTRODUCTION

Improved performance and prolonged lifetime of industrial components and machineries, often require different kinds of repairment, particularly for large and heavy installations, [1-15]. The weld deposition of hard-facing alloys is commonly employed in industry, to increase the lifetime of components subjected to different kinds of wear [6,7]. The lifetime of dies, used for production of forged parts, is variable and determined by wear rate, plastic deformation, and thermal and mechanical fatigue. Those tools are subjected to extreme temperature at high unit pressures, for short durations, and must withstand multiple cycles while maintaining dimensional stability. Occurrence of damage on a pair of hot-forging dies has been analyzed in [14]. Three mechanisms of wear were detected on dies surfaces, which are thermal fatigue, mechanical fatigue and abrasion. A couple of important issues in engineering failure analysis of hot forging die failures, for automotive components, are summarized in [14], mainly from authors own experimental results. In this paper, the optimal technology of hard-facing repair of forging dies has been assessed, based on the shear strength. Since some parts of the forging dies are extremely exposed to shear during hot forging, it is vital to establish a relation between the shear strength of base material (BM) and hard-faced layer, hard-facing technology and heat treatment. Toward this aim, a special tool was constructed and mounted on a universal testing machine to enable estimates of absolute and relative bearing capacities of the characteristic cross-sections. This paper also deals with the most frequent causes of damage, types of steel used for forging dies, choice of hard-facing technology and filler metals. All the tests were performed on the same material as the forging dies, enabling output results to be correlated to the chosen procedure and hard-facing technology.

FORGING TOOL MATERIALS AND THEIR PROPERTIES

Hot work steel tools must have good mechanical properties, such as strength and toughness, not only at room temperature, but also at high temperatures. They also must have high resistance to wear, sufficient hardenability, good thermal conductivity, stability during processes of oxidation and decarburization, low coefficient of linear expansion and high resistance to surface cracking at repeated heating and cooling [6,7]. If temper embrittlement appears, it can sometimes be eliminated by technological measures that involve rapid cooling in the temperature range of 500 - 550 ºC. Forging dies and press tools operate at elevated temperatures, up to 600 ºC, and they are subject to static loading and impact. Steel alloys with Cr, V, Mo, and 0,3 - 0,6 % C have good hardenability at elevated temperatures. Hard-facings (HF) of two typical steels used for forging dies were studied: 55CrMo 8 (EN), used for all kinds of forging tools, and X27CrMoV 51 (EN), used primarily for casting dies of nonferrous metals, particularly aluminum alloys and brass. Their chemical composition is given in Table 1, and mechanical properties and microstructure in Table 2.

Since forging dies used in blacksmithing are in quenched and highly tempered condition, all the samples, here used, were also quenched and tempered in order to simulate the real operating conditions. After the

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