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Microstructural evolution during friction surfacing of tool steel H13

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ABSTRACT

Coatings of AISI H13 tool steel were made on low carbon steel by friction surfacing. Detailed microstructural studies and microhardness tests were carried out on the coatings. Studies revealed defect-free coatings and sound metallurgical bonding between the coating and the substrate. In addition, mechanical interlocking on a very fine scale was observed to occur between the coating and the substrate. Coatings exhibited martensitic microstructure with fine grain size and with no carbide particles. Coatings in as-deposited condition showed very high hardness (58 HRC) compared to the mechtrode material in annealed condition (20 HRC). Based on these findings, microstructural evolution during friction surfacing of H13 tool steel is discussed. The current work shows that friction surfaced tool steel coatings are suitable for use in as-deposited condition. Further improvements in coating microstructure and properties are possible with appropriate post-surfacing heat treatment.

1. Introduction

Friction surfacing is an emerging surface engineering technology, developed on the basic principle of friction welding, for depositing wear and corrosion resistant metallic coatings. A rotating consumable rod is fed against a substrate which moves in *X*–*Y* plane. Due to intense frictional heating followed by severe plastic deformation, a thin layer of plasticized metal is deposited over the moving substrate. A schematic of friction surfacing process is shown in Fig. 1. Fine-grained wrought microstructure, zero dilution, absence of porosity, narrow heat affected zone, and high deposition rate are amongst the most important advantages of friction surfacing in comparison with conventional fusion welding based surfacing methods. While friction surfacing was patented way back in 1941, there is renewed interest in this process mainly because of its repair and reclamation capabilities [1].

Tool steels are commonly used for manufacturing moulds, dies and other components because of their high strength and wear resistance. When tool steel dies get damaged during service, processes such as gas tungsten arc welding (GTAW), submerged arc welding (SAW), plasma transferred arc surfacing (PTA) and laser cladding are commonly used to rebuild the worn part. A typical repair operation involves first gouging out the damaged portion by milling or grinding and then filling the missing volume with appropriate filler material [2]. Repair welding of tool steels is a daunting task due to hot cracking and/or cold cracking. Pre-heating can be used to overcome the cracking problems, but it reduces the cooling rates and adversely affects the coating microstructure. Such problems do not arise in friction surfacing as it does not involve melting.

Earlier studies on friction surfacing dealt with stainless steel [3], tool steel, inconel [4], and aluminum [5] coatings on mild steel substrates. Tokisue et al. [6] reported multilayer friction surfacing of aluminum alloys AA5052 and AA2017 on AA5052 substrate. Aluminum matrix composites were also successfully friction surfaced on aluminum [7] and titanium substrates [8]. While these studies clearly demonstrate the capabilities of friction surfacing, more work is needed in order to mature friction surfacing as an alternative to established conventional fusion welding based surfacing processes. In particular, it is necessary to understand microstructural evolution during friction surfacing. Accordingly, the present study focuses on microstructural aspects of friction surfaced H13 grade tool steel coatings on a low carbon steel substrate.

2. Experimental work

AISI H13 tool steel rods, with a chemical composition of 0.37 C, 0.37 Mn, 0.7 Mo, 0.9 Si, 0.8 V, 5.56 Cr, and balance Fe (in wt.%), were used in the present study. The material was supplied in annealed condition with a hardness of 20 HRC, which can be heat treated to higher hardness levels in the range of 46–60 HRC, depending on application requirements. Rods of 18 mm diameter and 100 mm length were prepared for friction surfacing experiments. Rod ends were faced to ensure flatness. A low carbon steel plate (150 mm × 100 mm × 8 mm) was used as the substrate. The substrate was milled and surface ground to obtain a flat, even surface, free from oxide scales. Just before surfacing, both the rod

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