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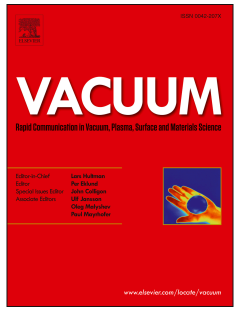

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PII: S0042-207X(16)30775-8

DOI: 10.1016/j.vacuum.2016.12.038

Reference: VAC 7258

To appear in: *Vacuum*

Received Date: 31 October 2016

Revised Date: 23 December 2016

Accepted Date: 24 December 2016

Please cite this article as: Chen G, Zhang B, Wu Z, Shu X, Feng J, Microstructure transformation and crack sensitivity of WC-Co/steel joint welded by electron beam, *Vacuum* (2017), doi: 10.1016/j.vacuum.2016.12.038.

Microstructure transformation and crack sensitivity of WC-Co/steel joint welded by electron beam

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The 30 mm thick WC-Co cemented carbide and AISI 1045 steel were electron beam welded (EBW) with and without Ni-based filler metal. Welding-brazing joints of WC-Co and steel were obtained as the molten pool wet and spread on the unmelted WC-Co base metal. The WC loose areas formed at the WC-Co interface have guaranteed the effective metallurgical bonding. According to simulation results, the thickness of filler metal should be less than 1mm to avoid unbonding. The direct EBW WC-Co/steel joint was mainly composed of martensite, residual austensite and herringbone M_6C carbides. The bulk brittle phases η-Fe_3W_3C increased the joint brittleness and crack sensitivity. With Ni-based filler metal, the microstructure of the joint was mainly composed of γ-Fe and herringbone carbides FeW_3C. No η-Fe_3W_3C formed at WC-Co interface because of the metallurgical blocking effect. The plastic property of the joint was improved, and WC-Co/filler metal/steel EBW joints with no crack were obtained.

Keywords: WC-Co; AISI 1045 steel; EBW; filler metal; η phase

1. Introduction

Welding of WC-Co cemented carbide to steel is of critical importance in industrial applications of mine exploration and excavating machinery, etc[1,2]. However, the welding of WC-Co to steel is of great challenge due to the large residual stress, which caused by considerable difference in linear expansion coefficient between the two base metals and brittle phases that formed in the joints[2-4]. The application of WC-Co and steel joint by fusion welding was restricted by a series of difficulties. Defects such as dislocation, cracks and porosities easily occurred in the joints of laser beam welded WC-Co to steel joint[5], and large amounts of brittle η phases that formed at the WC-Co interface have adversely affected the joint properties[6]. Ni-Fe-C filler metal was designed to inhibit the formation of η phases by Xu[7] et al in tungsten inert gas (TIG) welding WC-Co and carbon steel. Results indicated that η phases formed at the WC-Co interface were effectively inhibited and the mechanical properties of the joints were relatively improved. Usually, interlayer with good plastic properties would be applied in the joining of dissimiliar materials to improve the weld microstructure and decrease residual stress [8-11]. Currently, vacuum brazing and diffusion bonding are the preferred methods to join WC-Co cemented carbide and steel. By selecting double layered Cu alloy and amorphous Ni alloy as inert metal to minimize the residual stress near the bond zone of WC-Co/carbon steel brazing joint. Lee et al[12,13] successfully achieved the effective bonding of WC-Co and steel, and no defects such as cracks and voids formed near the bonded zone. The diffusion bonding of WC-Co/90MnCrV8 steel with Ni-Cu interlayer by Barrenad[14] showed that cyclic load would continually decrease the residual stress of the joint and extend the elemental diffusional process, and effective diffusion zones formed at the joint interface. Jiang et al[15] achieved the bonding of WC-Co and carbon steel with Ag-based alloy

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