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HIPIMS-Deposited Nanoscale Multilayer Coatings to Improve the Quality of Friction Stir Welds in Aluminium Alloys

Arutiun P. Ehiasarian[1], Arunprabhu Sugumaran[1], Yashodhan Purandare[1], Papken Eh. Hovsepian[1], Peter Hatto[2], Jeroen DeBacker[3]

[1]Sheffield Hallam University, Sheffield, United Kingdom [2]Ionbond UK, Consett, Co. Durham, United Kingdom [3]The Welding Institute, Rotherham, United Kingdom

a.ehiasarian@shu.ac.uk

Friction stir welding (FSW) is a joining technology whereby the two counterparts are mechanically intermixed by a probe which is plunged and rotated into the solid material. The appearance of the welds is improved significantly if material flow to the periphery of the probe is constricted using a stationary non-rotating shoulder. However, due to the extreme forces required to rotate through a solid piece, the material of the joint is brought close to the melting point and reacts aggressively with the shoulder material and builds up causing a rough surface finish and fast wear of the probe.

In this work, coating formulations have been tested on H13 probes and shoulders in order to reduce the friction coefficient and hinder reactions with the shoulder material, reduce sticking and improve the surface finish of the weld. High Power Impulse Magnetron Sputtering (HIPIMS) was used to produce TiAlN/VN nanoscale multilayer coatings with an engineered interface to provide good adhesion to the substrate and a smooth surface of the coating. The tests extended to DLC produced by a plasma-enhanced chemical vapour deposition process (PACVD), AlTiN by pulsed cathodic arc evaporation, TiB_2 by chemical vapour deposition (CVD) and TiBN by CVD. The best weld finish was found for TiAlN/VN and DLC coatings with low weld roughness and limited buildup on the shoulder. The lowest wear on the probe was found for AlTiN, TiB_2 and TiAlN/VN. The wear initiated at the sharp edges of the probe.

The microstructure, texture, hardness and wear rates of the coatings are discussed. There was no intermixing zone between the coating and the workpiece material. The performance in weld tests correlated well with high-temperature tribological performance both in air and vacuum.

Keywords
HIPIMS
friction stir welding
microstructure