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Microstructural, elemental, mechanical and structural attributes of AA1100/17-4 PH stainless steel composites fabricated via friction stir processing

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ABSTRACT

A 100% overlap double pass friction stir process technique was developed for the fabrication of AA1100/17-4 PH stainless steel composites, using an H13 tool steel cylindrical threaded pin with shoulder diameter of 21 mm, pin diameter of 7 mm and pin height of 5 mm. Grooves of 2 mm width and 3.5 mm depth were machined on the 6 mm thick AA1100 plate, where the 17-4 PH stainless steel powder was packed and compacted using a pinless tool. Friction stir processing was conducted at rotational speeds of 2100, 2450 and 2800 rpm, while the travel speed of 20 mm/min, tilt angle of 2.5° and plunge depth of 0.2 mm, were kept constant. Investigations were carried out on the microstructure, elemental composition, and tensile testing and microhardness as well as structural analysis using X-ray diffraction. Defect-free micrographs with good mechanical and metallurgical connections were obtained from all the employed process parameters. However, agglomeration of reinforcements became noticeable at 2450 and 2800 rpm. Uniform distribution of reinforcements were observed at 2100 rpm. Elemental analysis confirmed matrix and reinforcements blending and mixing. Superior SZ hardness of as high as 4 times that of the base metal were achieved, while ultimate tensile strength properties with joint efficiencies as high as 97.29% were attained at 2450 rpm. However, the percentage elongation of the fabricated samples dropped by around 10% due to the reinforcements-induced hardness. Nonetheless, the fabrications retained superior mechanical properties. All the X-ray diffractograms had 5 intense peaks with different phases and crystal planes. However, an Al syn (111) crystal plane was common to all diffractograms at around 39° 2θ range. The obtained crystallite sizes of as small as 4 nm revealed the attainment of ultrafine grains, while the observed high dislocation densities and micro strains gave an indication that the fabricated AA1100/17-4 PH stainless steel composite is of high strength.

1. Introduction

Over the years, there has been growing interest across several metal industries towards the use of lightweight metals, mainly due to their low density, high strength-to-weight ratio and the associated cost-effective benefits. Among these, aluminium (Al) and its alloys, offer the much needed benefits, hence their present standing as workhorse metals for multiple industrial applications. Aluminium alloys are well known for their low density of around 2.7 g/cm^3, abundance, high strength-to-weight ratio, ability to resist oxidation and to self-heal when scratched, good corrosion resistance, good appearance, high

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