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Technical Report

Developing Temperature–Time and Pressure–Time diagrams for diffusion bonding AZ80 magnesium and AA6061 aluminium alloys

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ABSTRACT

The principal difficulty when joining magnesium (Mg) and aluminium (Al) lies in the existence of formation of oxide films and brittle intermetallic in the bond region. However diffusion bonding can be used to join these alloys without much difficulty. In this investigation, an attempt was made to develop Temperature–Time and Pressure–Time diagrams for diffusion bonding of AZ80 magnesium (Mg) and AA6061 aluminium (Al) dissimilar materials. The bonding quality of the joints was checked by microstructure analysis and lap shear tensile testing. Based on the results Temperature–Time and Pressure–Time diagrams were constructed. These diagrams will act as reference maps for selecting appropriate diffusion bonding process parameters to join AZ80 magnesium alloy and AA6061 aluminium alloy without trial experiments.

1. Introduction

Magnesium (Mg)–aluminium (Al) alloys have good features such as low density, good damping characteristics, dimensional stability, machinability and low casting costs and hence recently attracted greater attention in academic research and industrial applications [1]. The research and application of Mg and Al alloys have been extended from navigation and military fields to civil products of high additional value such as automobile, computer and communication equipments. Dissimilar welding of Mg and Al alloys would achieve weight reduction and high efficiency of production by substitution of Mg and Al alloys for steels [2].

However, the refractory oxide film of Mg and Al results in inclusions at the weld metal. Moreover, the conventional fusion welding technique causes severe thermal cracking and easy formation of brittle intermetallics in the joints produced. Therefore the welding of Mg and Al dissimilar materials by the fusion welding method is very difficult [3]. Hence, the researchers recommend diffusion bonding technique to join these dissimilar materials. The selection of diffusion bonding process variables affecting the interfacial structure, compound formation and morphology is critical to attain good quality bonds [4].

The predominant process parameters in diffusion bonding process are: (bonding) temperature, (bonding) pressure and (holding) time [5]. From the literature review, it is understood that the reported literature [6–9] on diffusion bonding of Mg–Al dissimilar materials could be counted with fingers. Moreover, those literatures are focusing on microstructure analysis, phase formation studies, hardness survey at the interface and their subsequent influence on bonding strength. Mahendran et al. [10] developed diffusion bonding windows for joining AA2024 aluminium and AZ31B magnesium alloys. However, no literature was found on constructing Temperature–Time (T–t) and Pressure–Time (P–t) diagrams for joining Mg–Al dissimilar materials. Hence, the present investigation was carried out to construct T–t and P–t diagrams for joining two important alloys, namely AZ80 magnesium alloy and AA6061 aluminium alloy and the details are presented in this paper.

2. Experimental work

Square shaped specimens (50 mm × 50 mm) were machined from rolled plates of 10 mm thick magnesium (AZ80) and 6 mm thick aluminium (AA6061) alloys. The chemical composition of the base metals used in this investigation is shown in Table 1. The bonding surfaces of samples were ground flat by 200#, 400# and 600# grit SiC papers and cleaned in acetone prior to diffusion bonding [11]. Then the polished and chemically treated specimens were stacked in a die made up of 316L stainless steel and the entire diffusion bonding setup, shown in Fig. 1, was inserted into a vacuum chamber (vacuum pressure of −29 mm Hg was maintained).

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