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Technical Report

The effects of the welding current on heat input, nugget geometry, and the mechanical and fractural properties of resistance spot welding on Mg/Al dissimilar materials

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ABSTRACT

Investigating the joining capability of magnesium AZ31 alloy sheets and aluminium 1350 alloy sheets with the application of resistance spot welding was the objective of this study. The weld current values used in the welding process of Al–Mg sheets were 22, 23, 25, 27, 29, 31, and 33 kA. The studies examined the nugget geometries of joined specimens, recorded the scanning electron microscopy (SEM) images of the welded zone and the fracture surface, and recorded the energy-dispersive spectroscopy (EDS, semi-quantitative) analyses. The results of the experiment confirmed that nugget geometry was different for the Al and Mg sides. Tensile shear tests carried out on the welded joints determined their strength and failure mode. The increase in the weld current and duration resulted in an increase in the nugget size and the weld strength. According to observations, the tensile load bearing capacity (TLBC) increased up to 29 kA of the weld current value. It was also found that tearing during fracture occurred in two different ways.

1. Introduction

The automotive industry is one of the industries most affected by the energy, oil, and financial crises experienced in recent years. The fluctuations experienced in fuel prices, in the last 30–40 years, due to crises have compelled countries to take economic precautions. In this respect, the increase in taxes and decrease in purchasing power make saving fuel a current issue for consumers. Although steel is the main material used in automobile production, materials such as aluminium, magnesium, plastic, and composites are utilised to reduce the vehicle weight [1–8]. Due to being lightweight [9], its high resistance against corrosion, its durability, its low-cost maintenance, and its recovery potential the use of Al alloys has gradually become widespread. Another type of alloy that is widely used in manufacturing automobiles is Mg alloys. This is due to their low density and high strength/weight ratio compared to steel and Al. Magnesium is a potential candidate to be used in all types of metal component applications in automobiles [3,9,10].

In automobile manufacturing, welded joining is one of the most important factors affecting the lifespan, safety, endurance, and quality of a vehicle. The most common welding method in the automotive industry, after the laser welding method, is the resistance spot welding method. Resistance spot welding is a joining technique applied for almost all known metals, and one of the oldest electric welding processes in use today. The weld is made by the combination of heat, pressure, and time [11–14]. It is known fact that approximately 5.000 resistance spot welding processes are performed in manufacturing an automobile.

Several studies are available in literature regarding the processes used to join Al to Mg, among which are methods such as diffusion [4], laser [7,15], friction stir [9,16,17], and TIG welding [18]. However, there is no trace of a detailed study on resistance spot welding investigating nugget geometry and fracture mechanism. Considering this information, this study can be accepted as unique. The deformation and fracture of the resistance spot welded joints of these materials have great significance, especially in the automotive and aviation industry. Thus, investigated in this study, are the mutual resistance spot welding capabilities of Al–Mg materials and the mechanical and fracture properties of welded joints.

2. Experimental procedure

In the present study, a 1.7 mm thick AZ31 magnesium alloy and a 1.5 mm thick AA1350 aluminium alloy were used. AZ31 and AA1350 alloy sheets with chemical compositions and thermo-physical performances indicated in Table 1 were utilised.

The Mg and Al sheets were cut into 100 × 30 mm pieces. Specimens were welded using a pneumatic phase-shift controlled resistance spot welding machine, and an AC spot welding machine, with a capability of a 0–40 kA effective weld current and a capacity of 120 kVA. For joining, a 15 cycle welding time was applied, while

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