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Short Communication

Post-welding formability of AZ31 magnesium alloy

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ABSTRACT

The plastic flow behaviour and formability of friction stir welded AZ31 magnesium alloys were widely investigated. Flow curves were obtained in extended ranges of temperature (250–350 °C) and strain rate (0.001–0.1 s^{-1}) by means of uniaxial tensile tests; furthermore, forming limit curves were determined using the hemispherical punch method in the same range of temperature but with a constant crosshead speed of 0.1 mm/s. The results were compared with those obtained, under the same experimental conditions, on the base material. The flow stress levels of joint and base material are very similar up the peak of the flow curve although the equivalent strains at the peak and to failure are usually lower than those of base material. However, at the highest temperature and lowest strain rate investigated (350 °C and 0.001 s^{-1}), the flow behaviour of the welded joint tends to be similar to the one of the base alloy. Finally, formability of the friction stir welded material, evaluated in terms of forming limit curves, is usually lower than the one of the base material.

1. Introduction

Fuel consumption and carbon dioxide emissions in automotive can be strongly reduced using lightweight components. Magnesium (Mg) alloys, owing to their high specific strength and low density, can allow the achievement of such target. Unfortunately, Mg alloys are characterised by low formability at room temperature due to the hexagonal closed-packed crystal structure. Formability can be improved with increasing temperature since this allows the activation of further sliding planes, as shown in different studies for AZ31 magnesium alloy sheets [1–6]. However, temperatures higher than 200 °C but not superior to 350 °C, ensuring environmental respect and cost energy saving, have been suggested [1].

An improvement stage in obtaining lightweight components is the use of tailor welded blanks (TWBs), consisting in flat sheet metal assemblies of two or more components, also in different materials, and/or thicknesses. Such assemblies can be deformed, with an optimised thickness distribution, in order to get the desired geometry. In particular, the mechanical behaviour of TWBs obtained using laser welding methods for steel sheets was investigated [7] and, similarly, formability and tensile tests on laser welded TWBs steels were performed [8].

The possibility to replace laser or conventional welding with solid state welding in fabricating TWBs can lead to an improvement in their mechanical properties. For this reason, friction stir welding (FSW), consisting in a rotating pin, characterised by the relative motion along the sheet metal edges to be welded, can represent a valid solution [9]. The tool rotational and welding speeds are combined in a way that provides an asymmetric metal flow: the thermal contribution supplied by deformation heating and friction allows the occurrence of the solid state welding without, or minimising, the insurgence of typical defects such as voids or galleries that can occur in conventional welding [9,10].

The chance to perform high temperature deformation of friction stir welded sheets in magnesium alloys, in order to obtain the desired component in one or in very few stages, without post-forming welding operations, could be an actual target. Then, studies concerning the plastic flow behaviour and formability of TWBs after FSW are essential.

So far, very few studies on ductility and formability of friction stir welded flat sheet assemblies are reported. Some authors focused on the post-welded formability of friction stir welded aluminium alloys [11,12], others on the work hardening properties of the friction stir welded magnesium alloys at room temperature [13] as well the room temperature formability behaviour of different friction stir welded automotive materials, included AZ31 magnesium alloy, using numerical and experimental methods [14]. However, the lack of experimental data on formability of friction stir welded (FSWed) joints in magnesium alloy stresses the need towards experimental investigation on this topic.

The present study aims to investigate the plastic flow behaviour and ductility of AZ31 magnesium alloy flat sheet assemblies obtained by friction stir welding, by means of tensile tests performed in extended temperature- and strain rate- ranges. Formability was

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