Extrusion Welding in a Magnesium Alloy Extrudate

Introduction

One of the challenges in deformation processing of magnesium is its low formability attributed to the hexagonal close packed (hcp) crystal structure. The extrusion process is one of the most suitable forming processes for magnesium because it applies a hydrostatic compression state of stress during deformation resulting in improved workability.

In a hollow-section extrudate shown in **Fig.1,** a magnesium billet was extruded through a porthole die. In this particular porthole die, the material is separated by eight arms into strands and then joined together by high temperature and pressure conditions in the welding chamber within the porthole die. This joining process occurs as solid-state bonding and is known as extrusion welding**.**

Objective

The main objective of this work is to understand the integrity and microstructure of extrusion welding in a magnesium alloy (AM30) hollow-section extrudate (Table 1).

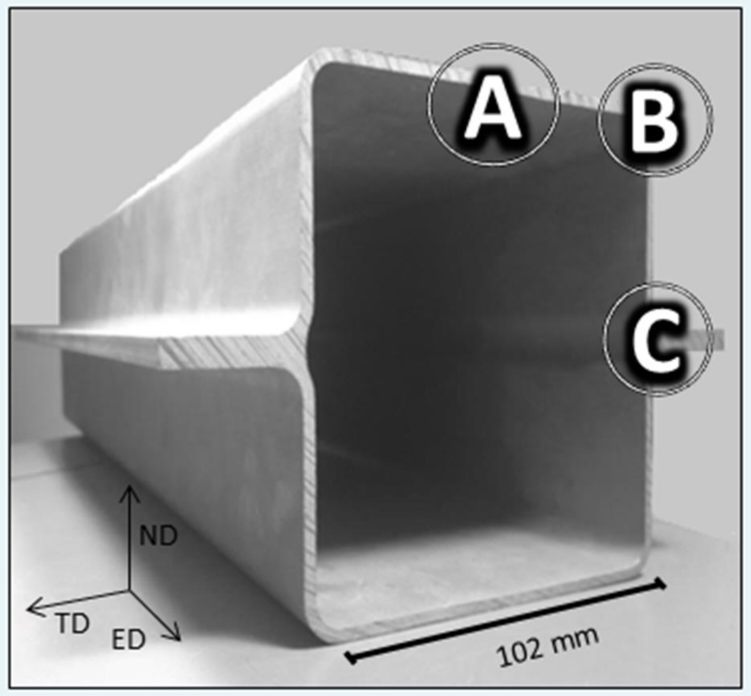

Fig. 1 Locations investigated of the AM30 extrudate

Sample Preparation

Due to the symmetry of the extrusion profile, three locations (A, B and C) in **Fig.1** were metallographically investigated. The specimens were sectioned transversely to the extrusion direction, mounted, ground and polished by using standard metallographic specimen preparation techniques. Then, specimens were chemically polished using 100 mL Methanol, 12mL Hydrochloric acid and 8mL Nitric acid for 10 seconds. Finally, specimens were etched using a solution of acetic picral (4g Picric acid, 5mL Acetic acid, 10mL H_2O, 100mL Ethanol) for 5 seconds.

Table 1 Nominal chemical composition of AM30 (wt %)

Mg	Al	Mn	Zn	Fe	Ni	Cu
Balance	3.4	0.33	0.16	0.0026	0.0006	0.0008

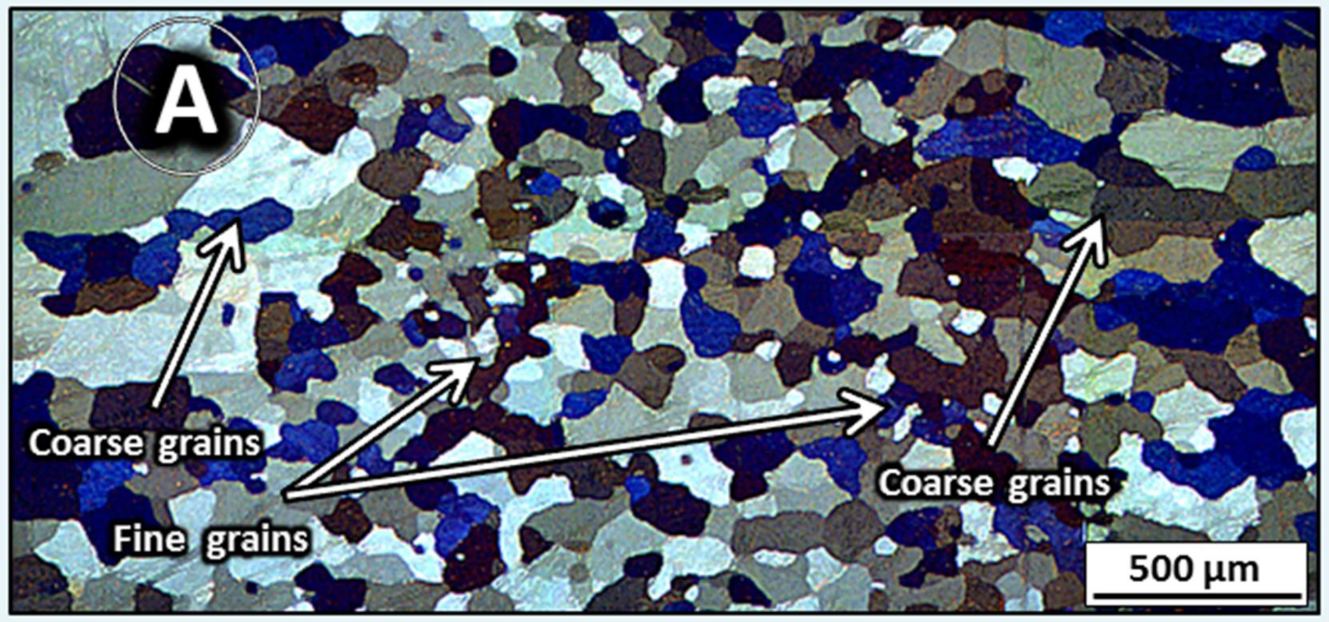

Fig. 2 Polarized LOM mosaic image of location (A) of the extrudate

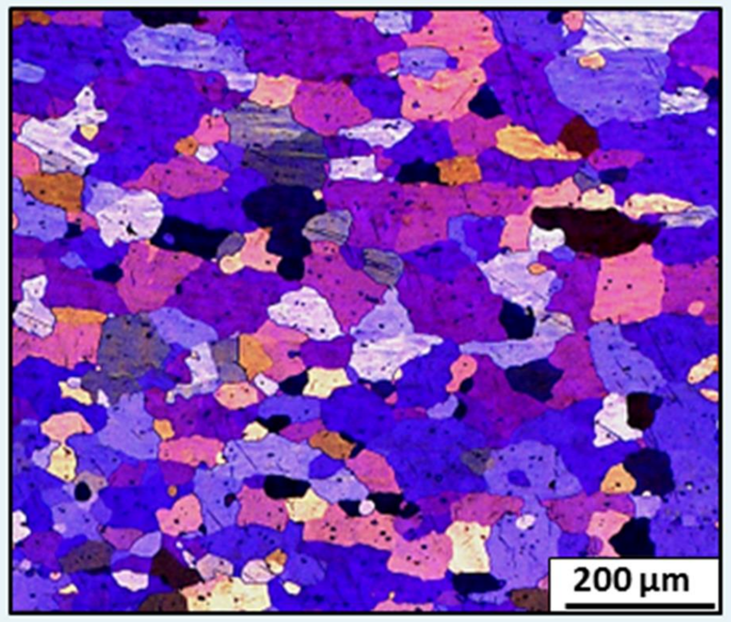

Fig. 3 A good welding integrity in location (A)

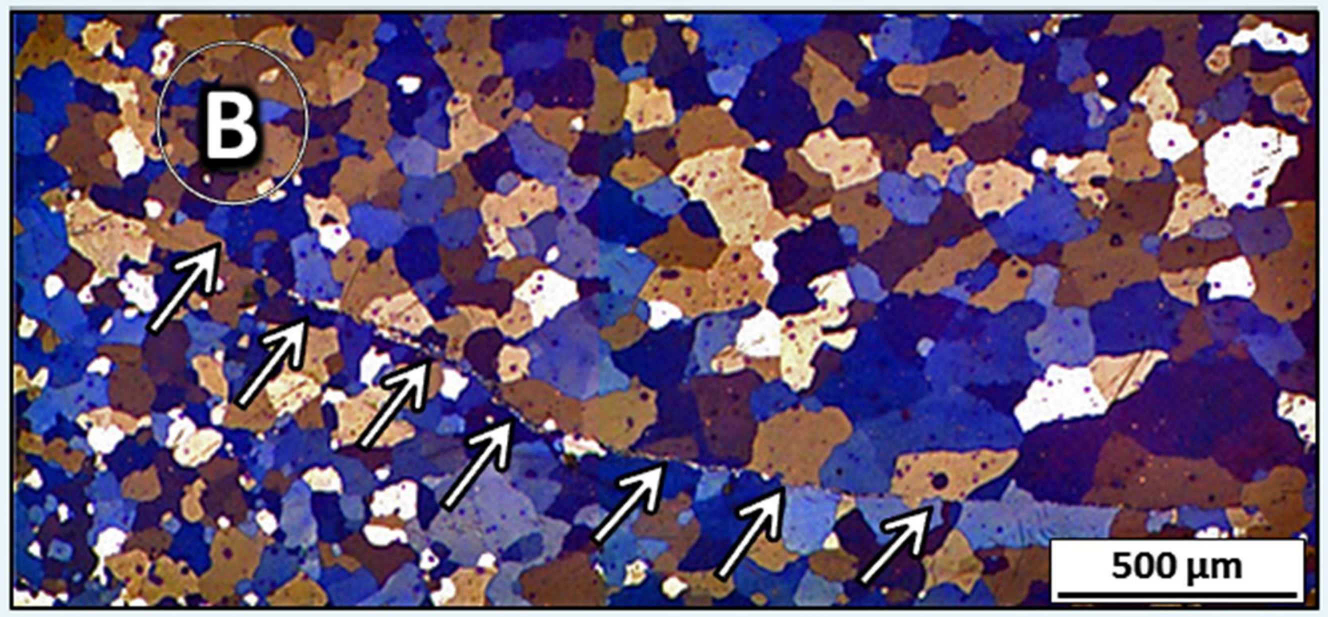

Fig. 4 LOM mosaic image shows curved weld line in location (B)

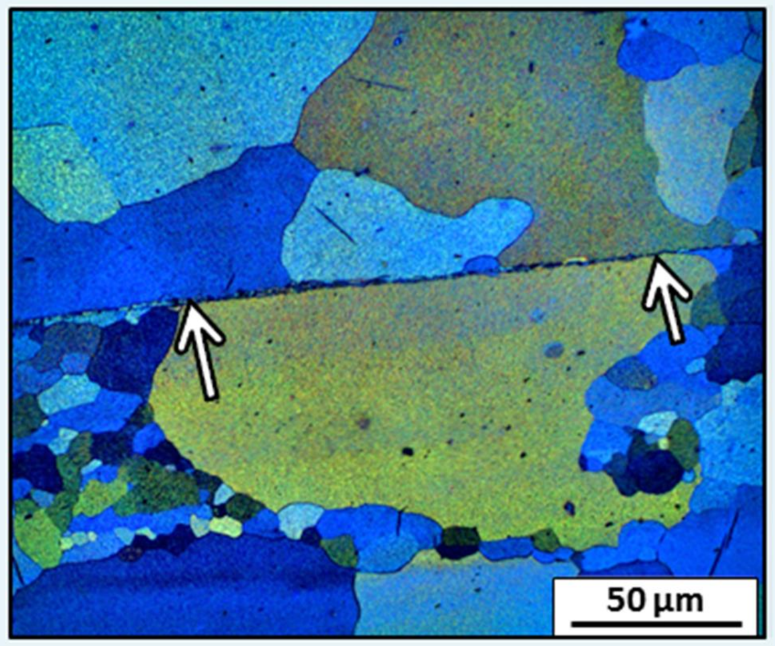

Fig. 5 Straight extrusion weld line in location (B)

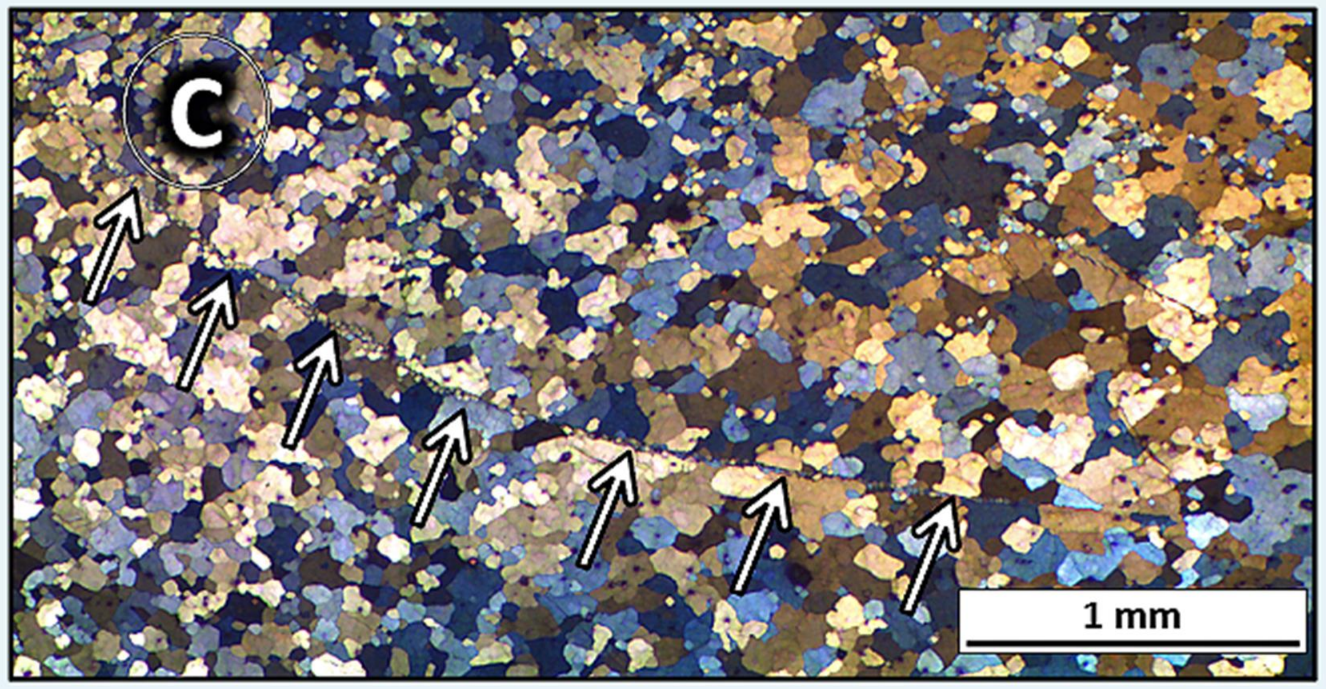

Fig. 6 LOM mosaic image shows curved weld line in location (C)

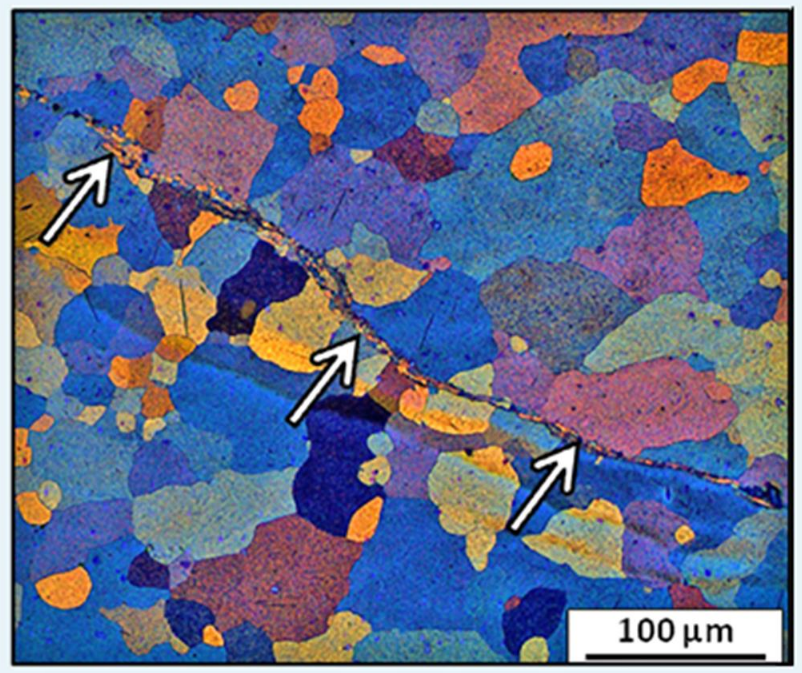

Fig. 7 Tortuous extrusion weld line in location (C)

Results

Fig.2, Fig.4 and **Fig.6** are collages of polarized light optical microscopy (LOM) images in each location (A,B and C) and show the different types of extrusion welding observed. **Fig.2** shows the difference in grain sizes between the middle of the image where the extrusion welding has taken place and the rest of the extrudate near the edge of the image. **Fig.3** is a magnified image that was captured from the middle of the specimen in location (A) which shows extrusion welding with good integrity and no visible weld line. On the other hand, **Fig. 4 and Fig. 6** show different types of extrusion welding with a curved weld line. The presence of the line is most likely due to the oxidization of the strands' surfaces or insufficient pressure and temperature. These lines could be straight or tortuous depending on the velocities of the two strands, roughness of the strands surfaces and applied stresses. **Fig.5** shows some coarse grains along the extrusion welding lines. In contrast, necklacing of small grains appear along the extrusion weld lines **Fig.7,** which could be represent recrystallized grains.

Conclusions

Different samples from three locations of a hollow section magnesium alloy extrudate were investigated by using polarized LOM and the following features were observed:

- Two types of extrusion welding were observed: one without a weld line which indicates preferred extrusion welding, and the other with a weld line which could be a potential defect
- Straight and tortuous weld lines were observed at extrusion welding locations with coarse and fine grains surrounding the weld line

Class 1