FRACTURE MECHANICS ASSESSMENT OF AN ALMG4,5MN WELD JOINT

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INTRODUCTION

Because of its excellent low-temperature toughness, good welding characteristics, and resistance to corrosion, the weldable higher-strength aluminium alloy AlMg4,5Mn is finding wide application as a constructional material for chemical reactors as well as for boilers and pressure vessels.

Results of tensile tests, notched tensile tests, notch toughness tests using various notch shapes, and dynamic fracture toughness tests performed at temperatured ranging from room temperature down to -196°C were already reported (1,2,3).

The poster presents the experimental results of additional investigations into the temperature dependence of static fracture mechanics parameters of the base metal and welded joint.

The investigations were made using 6 mm thick AlMg4,5 Mn plate of the soft type (Al 5083-0). Welding was carried out by the gas tungsten-arc process using matching-type filler metal S-AlMg4,5Mn (Al 5183).

RESULTS

Testing was done on 3 PB specimes at room temperature and at -50°C, -120°C and -196°C. J-Δa-curves were plotted by the multispecimen method according to ASTM 813-81 including the potential technique. At the same time, the specimens were evaluated by the crack opening displacement concept according to BS 5762:1979.

The results for the base metal (BM), heat-affected zone (HAZ), and weld metal (WM) are shown in Fig. 1 and 2. For the base metal, the J integral increases as the temperature decreases down to -120°C; at -196°C there is observed a slight decrease in J_{Ic}, but it is still well above the value at room temperature.

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The tearing modulus, T^J, which characterizes the resistance to crack propagation, also increases as the temperature decreases down to -120°C, but tends to fall below the roomtemperature value at -196°C.

The heat-affected-zone properties correspond to the properties of the base metal, with occasional variations lying within the experimental scatter.

For the weld metal, J_{Ic} and δ_i are significantly lower than in the other regions of the weld joint and are virtually constant over the whole range of temperatures from room temperature down to -196°C. However, the temperature dependence of the tearing modulus, T^J, shows that the crack propagation resistance shows a similar type of behavior to that of the base metal and heat-affected zone.

Also plotted were the crack growth curves, da/dN-ΔK, for the base metal, heat-affected zone, and weld metal.

They were determined in the lower regions I and II, including the threshold value ΔK_0, via the dependence of the crack-depth upon the time of resonant vibration. The critical cyclic stress intensity, ΔK_{fc}, was determined by the 3 PB test with optical measurement of crack growth on the specimen surface (Fig. 3 and 4).

It can be seen that the fracture mechanics properties of the base metal, heat-affected zone, and weld metal do not differ significantly under cyclic loading.

The poster also presents detailed fractographic data of base and weld metal fracture surfaces down to fracturing temperatures of -196°C in addition to showing the temperature-dependent formation of the stretch zone.

REFERENCES

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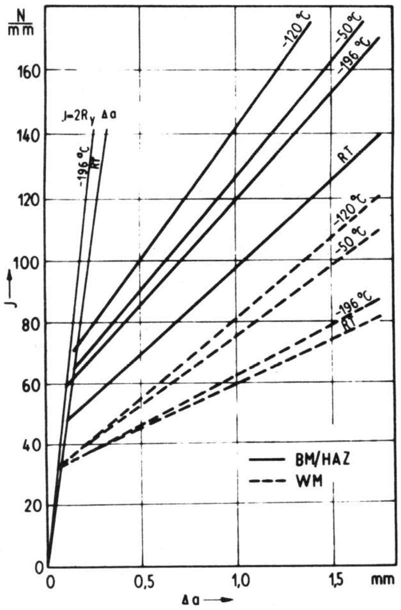


Fig.1 J-Δa curves of an AlMg4,5Mn weld joint

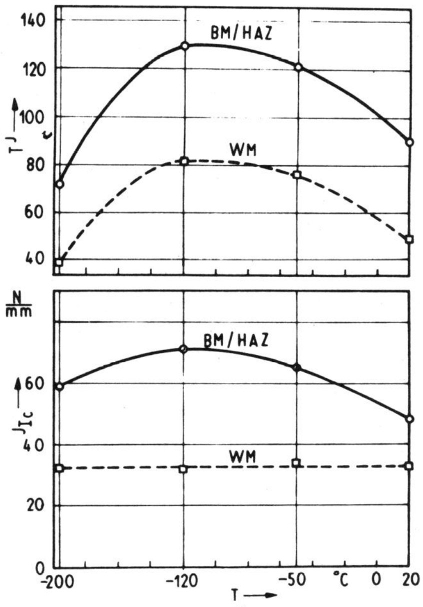
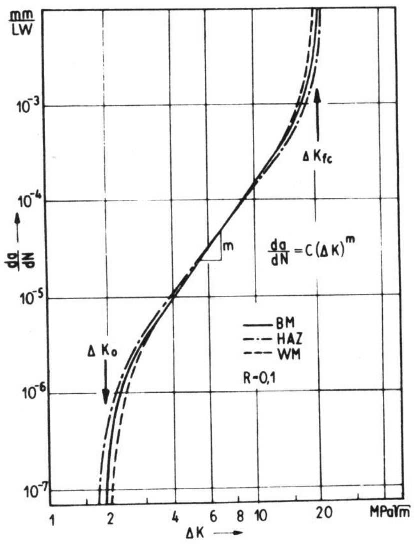


Fig.2 J_{Ic} and T^J-modulus versus temperature



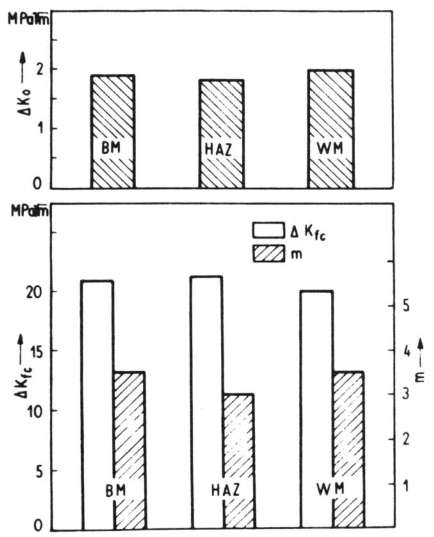


Fig.3 Curves da/dN-ΔK of an AlMg4,5Mn weld joint

Fig.4 ΔK_o,ΔK_{fc} and exponent m of an AlMg4,5Mn weld joint