Improvement in the corrosion resistance of AA2024-T3 aerospace sheet

Investigation of the influence of grain size and shape on the corrosion behaviour of AA2024-T3 sheet.

AA2024 alloy is the most important sheet material for aerospace applications. However, it is susceptible to intergranular corrosion (IGC) attack. IGC is a localized attack along or adjacent to grain boundaries, while the bulk of the grains remains largely unaffected.

A recent publication investigated the influence of grain size and shape on the material properties responsible for damage tolerance, as well intergranular corrosion resistance in AA2024-T3 sheet material [1]. Two different conditions with variations in microstructure were produced on an industrial scale. The grain size in condition "A" is smaller and more equiaxed than in condition "B", which shows a coarse grain structure elongated in the rolling direction (L). The fine-grained condition "A" demonstrates pitting corrosion and intergranular corrosion, whereas the coarse grained condition "B" merely shows pitting corrosion with only sporadic formations of intergranular corrosion attack. Clearly, with its coarse grain structure elongated in the rolling direction, condition "B" exhibits resistance to intergranular corrosion attack, which is superior to that of the fine-grained equiaxed condition "A".

Solution heat treatment with subsequent water quenching was identical for condition "A" and "B" and therefore there might be a geometrical factor responsible for the occurrence of the different IGC behaviour. The "Brick Wall Model" [2] explains the different IGC susceptibility in strongly textured microstructures (Fig. 2).

Corrosion is anisotropic, with the fastest IGC growth rate in the longitudinal direction (L) and the slowest in the short transverse direction (S). A fact explained by the straight IGC path in the L direction and the circuitous path in the S direction [2, 3]. Since it seems reasonable to consider the local intergranular growth rate as being the same everywhere, the highest overall IGC corrosion rate can be assumed to correspond to the minimum IGC path length. In our experiments this is the case for condition "A" (Fig. 1).

Conclusions:

Resistance to local corrosion such as intergranular corrosion attacks can be enhanced by modifying fine-grained and equiaxed microstructures into coarse-grained structures that are elongated in the rolling direction. These measures contribute to the service reliability of components made from AMAG 2xxx-alloys. AMAG covers all established 2xxx-alloys and heat treatment tempers and can therefore satisfy most customer requirements.

References

[1] J. Berneder, R. Rachlitz, C. Melzer, H. Antrekowitsch, P.J. Uggowitzer: "Influence of the Grain size on the IGC, crack propagation and fracture toughness behavior of AA2024-T3 sheet material", Proceedings TMS 2010, Seattle, USA.

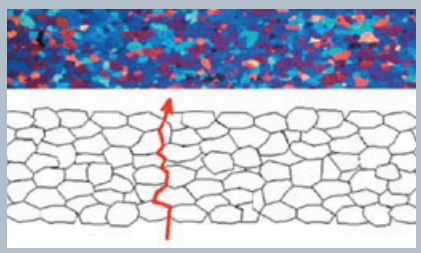
[2] S. Zhao, A. Douglas, T. Huang, G.S. Frankel: "Generalized model for IGC growth in aluminium alloys", Journal of Statistical Planning and Interference 137 (2007), pp. 2405-2412.

[3] M.J. Robinson, N.C. Jackson: "The Influence of grain structure and intergranular corrosion rate on exfoliation and stress corrosion cracking of high strength Al-Cu-Mg alloys", Corrosion Science 41, 1999, pp. 1013-1028.

Condition A

Condition B

Figure 1: Typical appearance of pitting and IGC attack in Condition "A" and "B"



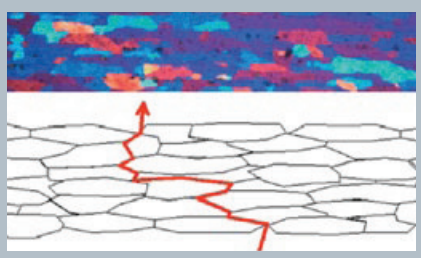


Figure 2: Schematic demonstration of the "Brick Wall Model" [2]