39th Solid Mechanics Conference
Zakopane, Poland, September 1–5, 2014

P102

METAL MATRIX COMPOSITES UNDER FATIGUE CONDITIONS

A. Rutecka, P. Grzywna

Institute of Fundamental Technological Research, Warsaw, Poland

1. Introduction

Metal matrix composites (MMCs) are more and more commonly used in automotive and aerospace industries. The advantages of MMCs over conventional monolithic materials are, among others, improved strength and stiffness and simultaneously weight savings [1, 2]. Moreover, MMCs are often subjected to cyclic loadings. Thus, good fatigue resistance of the materials is required. Therefore, evolution of hysteresis loops under fatigue conditions was investigated as a first step to fatigue damage analysis of the materials [3].

2. Materials and experimental procedure

Metal matrix composites of two different matrixes, reinforced with SiC particles, were investigated. The first one, Al7,9Mg based MMC, was reinforced with 0; 2,5; 5; 7,5 and 10% of SiC. It was produced using the KoBo method. In the first stage of the process powders were blended and pressed. Finally they were extruded in the form of long rods. The second one, AA2124 based MMC, was reinforced with 17 and 25% of SiC. It was manufactured using powder metallurgy. Powders after high-energy mixing were compacted to fully dense billets and subsequently forged and subjected to T6 heat treatment.

Fatigue tests were performed on the MTS 858 servo-hydraulic testing machine. Sine shape tension-compression cycles were applied with frequency equal to 10 or 20 Hz. Tests were stress controlled with stress ratio $R = -1$. Stress amplitudes σ_a were equal to 220 and 240 MPa for AlMg/SiC, and 300 and 330 MPa for AA2124/SiC.

3. Fatigue tests results

During fatigue tests hysteresis loops were observed. AlMg/SiC exhibited three types of material behavior, depending on SiC content and stress amplitude values.

The first one was visible, among others, in the case of AlMg+2,5%SiC subjected to stress amplitude equal to ±240 MPa. Hysteresis loops enlarged during first cycles and cyclic softening was identified (Fig. 1a). Subsequently cyclic hardening occurred (Fig. 2b).

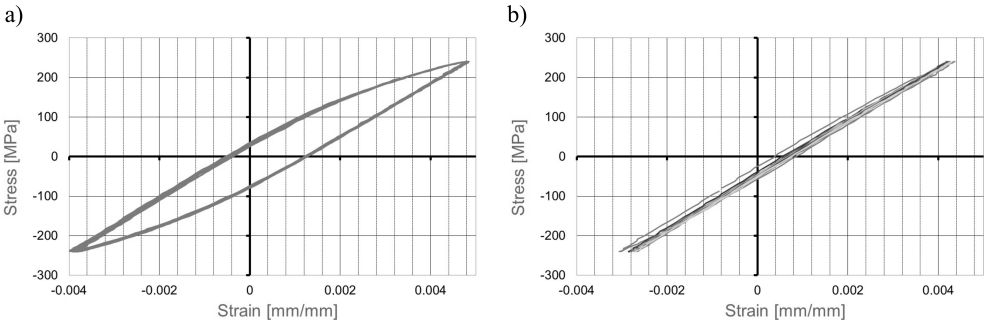

Fig. 1. Hysteresis loops for AlMg+2,5%SiC ($\sigma_a = \pm 240$ MPa): a) below one hundred cycles; b) over one hundred cycles.

The second type was represented by AlMg+7,5%SiC ($\sigma_a = \pm 240$ MPa). Hysteresis loops at the beginning of tests behaved elastically. Subsequently their width enlarged slightly. Above 100 cycles inelastic strain amplitude remained constant, while mean inelastic strain changed insignificantly.

The third type of material behavior was observed for AlMg+10%SiC ($\sigma_a = \pm 220$ MPa) and characterized by ratcheting towards negative values of the strain axis. Inelastic strain amplitude remained constant while mean inelastic strain decreased during subsequent cycles until stabilization.

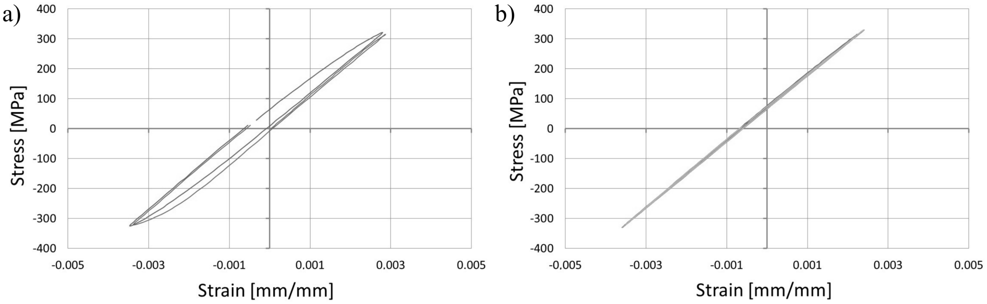

Fig. 2. Hysteresis loops for AA2124+25%SiC ($\sigma_a = \pm 330$ MPa): a) at the beginning of fatigue test; b) over 500 cycles.

In the case of preliminary tests of AA2124/SiC, cyclic plasticity followed by ratcheting was observed under fatigue conditions. Hysteresis loop width enlarged during first cycle towards negative strains (Fig. 2a) Subsequently hysteresis loops widths became narrower during next cycles and ratcheting towards negative strain values was observed (Fig. 2b). Afterwards hysteresis loops stabilized until specimen fracture.

Acknowledgments

The results presented in this paper have been obtained within the project "KomCerMet" (project no. POIG.01.03.01-00-013/08 with the Polish Ministry of Science and Higher Education) in the framework of the Operational Programme Innovative Economy 2007-2013 and within the project "KosDeKom" (project no. 1576/B/T02/2011/40) with the National Science Center, Poland

References

1. T.W. Clyne, P.J. Withers (2003). *An introducrion to Metal Matrix Composites.* Cambridge University Press.
2. N. Chawla, Y.L. Shen (2001). Mechanical Behaviour of Particle Reinforced Metal Matrix Composites, *Advanced Engineering Materials*, **3**, 6, 357–370.
3. A. Rutecka, Z.L. Kowalewski, K. Pietrzak, L. Dietrich, K. Makowska, J. Woźniak, M. Kostecki, W. Bochniak, A. Olszyna (2011). Damage development of Al/SiC metal matrix composite under fatigue, creep and monotonic loading conditions, *Procedia Engineering*, **10**, 1420–1425.