LOW CYCLE FATIGUE OF A ROLLED MAGNESIUM ALLOY USING ANTI-BUCKLING FIXTURE

T. Libura[1], Z.L. Kowalewski[1], K. Kowalczyk-Gajewska[1], L. Dietrich[1]

[1]*Institute of Fundamental Technological Research, Polish Academy of Sciences, Pawińskiego 5B, 02-106 Warsaw, Poland*

Abstract

Ultralight magnesium alloys with additions of other metals are already used in a variety of aerospace and automotive semi-products, and also in many other industrial applications requiring good properties and high values of the strength to weight ratio. Among the most frequently used magnesium alloys one can indicate AZ31B alloy. It is estimated, that contribution of this material in the allowable total weight of constructions will increase rapidly in the upcoming years. The specific structure of AZ31B is a key factor deciding on its quality and behaviour under loading conditions [1]; that is particularly visible under low cycle fatigue of thin sheets. It should be noted that material testing of flat specimens under compression within a large deformation range procures many difficulties, and the buckling phenomenon seems to be the most important. In order to overcome this problem a new version of anti-buckling fixture was applied to execute experimental investigations of thin AZ31B sheets under tension-compression cyclic loading.

All tension-compression tests were carried out on thin sheet specimens with nominal thickness equal to 1 mm using the new anti-buckling fixture presented in detail in [2]. Cyclic loading was performed under displacement control with the rate of 0.025 mm/s. Boundary conditions were set into the loading controller to limit strain range during cycling. In the first type of cyclic test, 15 cycles within a strain range ±0.04 were planned with the start in tension direction. In the second one, a similar program was arranged, however, with the start in compression direction. All tests were carried out using extensometer with a range of ±0.2. The loading cell was calibrated in the range of ±25 kN. A special set-up for the friction force measurements was applied [3]. It consisted of two coupling bars with strain gauges calibrated in the range of ±2 kN.

The results of first type of test carried out on the AZ31B magnesium alloy under cyclic loading are presented in Fig. 1a. The first cycle

is illustrated by solid black line denoted as (1). In the third cycle represented by black dashed line (2), the magnesium alloy exhibited the highest level of tensile stress and for the rest of planned cycles it remained almost unchanged. A different behaviour may be observed for the compressive stress levels. In this case, a continuous hardening effect was obtained expressed by the gradual increase of the maximum compressive stress in the subsequent cycles denoted by black dotted lines. Figure 1 also presents an evolution of the friction force (grey lines, denoted as (F)).

The results of second type of test are presented in Fig. 1b. Here, the strain-hardening stagnation effect took place for the material in question. It is most remarkable for the first three cycles. During subsequent cycles the tensile stress value in the specimen tested remained at the same level, while for the opposite direction the alloy showed a continuous cyclic hardening.

In conclusion, it has to be emphasised that the magnesium alloy exhibited the visible effect of strain-hardening stagnation observed after change of the loading direction, especially in the first cycle (1). Three dominant deformation mechanisms are presumably responsible for deformation behaviour of the AZ31B alloy: dislocation slip dominated deformation (Slip Mode), twinning-dominated deformation (Twinning Mode) and detwinning-dominated deformation (Detwinning Mode) [1]. A level of the friction force was monitored during each test. Its variation is presented in Fig. 1 a, b. As it is shown, the friction force has a similar course in all cycles, it takes higher values in the case of compression. Since the values of friction force were relatively small, they did not change the cyclic stress-strain characteristic significantly.

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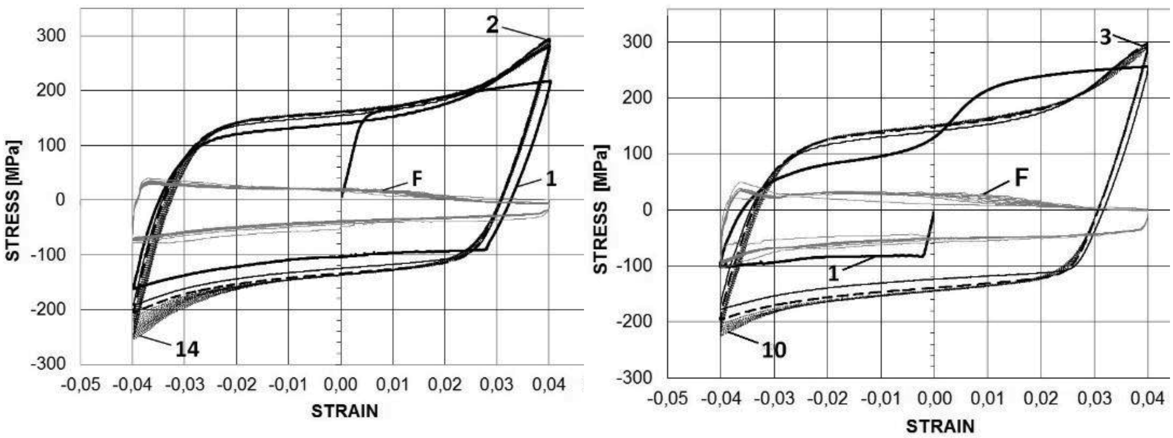

Fig. 1. Hysteresis loops of the AZ31B alloy and friction force variation during test: start in tensile (a) and compressive (b) direction

Authors

Tomasz Libura
e-mail address: tlibura@ippt.pan.pl, tel.: +48-22-826 12 81 w. 347

Zbigniew L. Kowalewski
e-mail address: zkowalew@ippt.pan.pl, tel.: +48-22-826 98 00

Katarzyna Kowalczyk-Gajewska
e-mail address: kkowalcz@ippt.pan.pl, +48-22-826 12 81 w. 435

Lech Dietrich
e-mail address: ldietr@ippt.pan.pl, tel.: +48-22-826 12 81 w. 262

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