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Influence of loading rate on hardening process of Al–Zn metal layered composite

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ABSTRACT

In the paper the influence of the loading rate of metal layered aluminium–zinc (Al–Zn) composite on its mechanical properties was tested. Loading, as monotonic tension with constant rate of the stress increment was carried out on plane specimens of Al–Zn composite, aluminium, zinc and Al–Zn set when the layers weren't joined permanently on the measuring length in the range $\dot{\sigma} = 0.6—18.0$ MPa/s. Connection of layers in Al–Zn composite was obtained by gluing aluminium and zinc strips together using glue for metal named JB Weld CX-80 (on the basis of epoxy resin). Additionally, the above mentioned specimens were tested at kinematic forcing, with the rate of loading $\dot{\varepsilon} = 2 \times 10^{-3}$ 1/s. It was found, that applying a specific method of loading significantly influenced the shape of deformation characteristics of all the tested materials and on the values of coefficients of their hardening curves. The data obtained from the experiments was compared with the values calculated from the law of mixtures. It was noticed, that only for rapid tests carried out on samples with loading rate $\dot{\varepsilon} = 2 \times 10^{-3}$ 1/s and $\dot{\sigma} = 0.6$ MPa/s the law of mixtures correctly describes mechanical properties of Al–Zn composite and Al–Zn set. In the paper, values of the uniform strain ε_u (correspond to the unstable state of Al–Zn composite), determined on the basis of the experiment were compared with the values obtained analytically by using the condition of the maximum loading. The coefficient of material sensitivity to the change of the loading rate $\dot{\sigma}$ was defined and determined for tested materials.

1. Introduction

In the technique, replacing the monolithic structure with the composite structure is one of the ways of limited use of the rare and expensive metals with complex chemical structure. Thanks to modern technologies of joining the layers of metals (welding, rolling, plating, gluing together) it is possible to get the structure with the equally resistant cross section as a monolithic material. It is possible to shape geometry and the structure sensibly in order to select the appropriate kind of material for individual layers in accordance with its purpose. Producing metal layered composite, at the appropriately applied technology of joining layers is very profitable economically.

In order to guarantee the maximum safety, during building and exploitation of the structure, which was constructed from a metal layered composite, the knowledge of its mechanical properties and the differences of component properties are necessary. On the other hand, in order to ensure appropriate processing conditions during the ultimate shaping process the knowledge about deformation properties is essential. Processes applied in present technologies, connected with plastic shaping of material do not take into account the nature of the composite in the internal structure. It is necessary to seek appropriate parameters and conditions of carrying out such processes as rolling, drawing, pressing.

The majority of papers referring to metal layered composites described research findings of their mechanical properties [1–3]. Some of them presented the technological aspects connected with their industrial production [4–7]. Materials, created by joining layers of alloy of aluminium and stainless steel, aluminium and copper or steel in different grades, are frequently tested. The monotonic uniaxial tensile test is a basic test used for the identification of the mechanical properties of composites, carried in the room temperature with the axial load parallel to the stratification [1,8]. In the study of Yoshida et al. and Lamik et al. [9–10] bimetallic materials were described under the cyclical load. The process of bimetal deformations concerned with the conditions of the plane stress state was described by Yoshida et al. [7] and Semiatin and Piehler [11]. The law of mixtures to describe mechanical properties of composite, including the property of components was frequently applied [3,8,12]. Information about the behaviour of these materials, at different ways of loading, was obtained from experiment or by means of analyses using finite elements method (FEM) [3,10].

The aim of the study was the assess of the influence of the monotonic stress rate on the basic mechanical properties of the metal layered Al–Zn composite. The composite was produced by gluing together layers of aluminium and zinc.

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