INELASTIC DEFORMATION OF LIGHT ALLOYS UNDER DYNAMIC PUNCHING *

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The results of experimental research and numerical simulation of the processes of deformation localization and crack formation under high-velocity punching of a steel indenter to plates made of aluminum-magnesium and magnesium alloys AMg6, AMg3, MA2-1, and MA8 are presented.

The relevance of the research performed is due to the need using of accurate and adequate computer designing methods for predicting possible damage of construction under exploitation loadings and during manufacturing of lightweight and reliable structures of transport equipment, space and aircraft from aluminum-magnesium and magnesium alloys with increased specific strength.

The aim of the study was studying the influence of plastic anisotropy on the mechanisms of nucleation and growth of damage of aluminum-magnesium or magnesium alloys during dynamic stamping and obtaining new experimental data for modification of the constitutive and damage models. Punching tests of alloy plates with a hemispherical indenter having a diameter of 20 mm were performed on samples with diameters 60 mm in accordance with the standards (ASTM E3205, GOST 10510–80) were executed using an Instron VHS 40/50-20 servo hydraulic stand (Instron, High Wycombe, UK) with a force sensor up to 50 kN [1].

Numerical simulation of thin sheet sheets punching conditions was carried out using the LS DYNA solver (ANSYS WB 15.2). The Johnson–Cook model [2] was used to describe the mechanical behavior taking into account the accumulation of damage during plastic deformation of aluminum-magnesium alloys, and for magnesium alloys belonging to the isomechanical group of materials with an hcp lattice, it was used the model [3] was used together with model [4].

The results obtained for coarse grained aluminum - magnesium alloys indicate the relatively low rate sensitivity of flow stress of under strain rates from 0.01 to 1000 s^{-1} and significant strain hardening at these strain rates.

It has been shown that during dynamic punching of thin sheets of aluminum-magnesium alloys AMg6, AMg3, ductile fracture occurs as a result of the nucleation and growth of damage in zones of localized plastic deformation. The formation of localization bands is associated with the instability of the plastic flow process and is accompanied by temperature increasing and changes in the grain structure of the alloy. The anisotropy strain hardening of magnesium alloys under plastic flow at high strain rates assists to the implementation of localized adiabatic shear bands.

It was shown the process of crack formation due to the accumulation of damage in the punching zone was accompanied by a spatially inhomogeneous change in the stress state triaxiality parameter η. Therefore, to improve the accuracy of the prediction of the process of high-speed stamping of light aluminum-magnesium and magnesium alloys, it is necessary to take into account the evolution of the triaxiality parameter of the stress state during the deformation process.

The values of the strains to fracture obtained during testing of samples of aluminum-magnesium alloys significantly exceed the average its values for uniaxial tension of the samples at the corresponding strain rates.

The research results presented in this work can be used when performing numerical predictions of dynamic stamping processes of construction elements from sheet light metal aluminum-magnesium and magnesium alloys.

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