ABSTRACT

Thesis: 89 pages, 26 figure, 11 tables, 69 references.

Objective: To study the electrical signals in metals and amorphous alloys with mechanical and laser pulse action.

Methods: method of pulse stretching; method of pulsed laser deformation; radiography.

Purpose of the study: Electrical signals metals in their plastic deformation.

Scientific novelty: A new technique of removing signals metals plastically deformed by a laser pulse and mechanical impact; shown that signals compressive and tensile impact regardless of the method have similar options.

Practical task: to analyze the signals to estimate the passage of each stage of deformation of metals.

Results: The basic relationship between the electrical signal from the sample and sample parameters, and new and improved existing methods such studies, given new research directions.

X-RAY ANALYS, LASER IMPULSE INFLUENCE, CONTACT WELDING, SPEED-UP DIFFUSION

ACCESSION

Important role in the development of both science and technology play a fundamental research is survey of directly are not aimed at the practical use and to grasp the laws of nature and, if possible, an understanding of the processes that people have been using or have pespektyvu use later.

The essence of the effect under study is the difference in the occurrence of electric potentials at the ends sample plastically deformed with a relatively high speed (10 ~ - 10 3 s -1).

Despite the fact that the direct effect elektroplastychnyy used for a long time (at least 80 of the last century), the reverse effect is almost not studied for two reasons unclear prospects for practical use and imperfections equipment.

The complexity of the processes occurring at the atomic level with impulse effects, makes it difficult to get their rigorous analytical description. The development of computer technology allows to receive signals with very high accuracy, which greatly facilitates their analysis. Merge multiple methods can more accurately analyze the effects occurring in metallic specimens deformed, and give as much accurate explanation of this phenomenon.

Object of study: the formation of potential differences in the sample during deformation by stretching and by pulsed laser heating.

Purpose of the study - the mechanism of electrical impulses in amorphous alloys and polycrystalline metals and alloys with their high-speed deformation.

In this paper, we used the following methods:

- method of pulse compression shock load with dual recording signal;
- method of pulse stretching samples;
- deformation method laser strike;
- radiography.

Literature review

Electromagnetic effects that accompany the motion of defects in crystals, are the subject of intensive study in modern solid-state physics. These phenomena in solids, deformable studied for a long time both in terms of fundamental [2,3], and in connection with applications, emerging as an example in geophysics [4], fracture mechanics, structural materials [5,6] and others. Among the recent years are achieved should be noted experimental setting [6-8] and theoretical study [9, 10] mahnitoplastychnoho effect in ionic crystals and metals, as well as a detailed experimental study of the electromagnetic emission of dislocations in the cracks [10,11]. Note that these phenomena are essentially dynamic in nature and are of great interest for understanding the nature of plastic deformation of solids.

One interesting dynamic effects in deformed crystals is the radiation of electromagnetic waves accompanying the motion of dislocations. Moving dislocations causes a disturbance of the crystal lattice and electron subsystem of the crystal. It is clear that this process will lead to the emergence of crystal elastic waves and electromagnetic emissions origin, the nature of which will depend on the individual properties of dislocations and properties of the medium in which it is distributed.

The emergence of a potential difference in deformed specimens with no piezoelectric materials - takes place and in their dynamic loading.

Latest mention the origin of electromagnetic signals with a load of metals are presented in the works of foreign authors [7, 22].

In [23] experiment was conducted as follows: metal samples for tensile testing machines collapsed. The emerging pattern of destruction at the site of radiation recorded photomultiplier tube, which was used as a photomultiplier-28 and-71 photomultiplier. All specimens subjected speed (brittle) fracture, at the time of destruction recorded pulse intensity electromagnetic radiation (Fig. 1.2). With slow (viscous) destruction of the sample emission intensity decreases sharply, and there is bias radiation spectrum in a large wave region. The authors made the following conclusions: as a result of destruction of metal perturbed electronic states arise as a consequence of the break atomic bonds. Relaxation perturbed electron states formed on the surface rupture accompanied by electromagnetic emission from the upper limit frequency corresponding to the binding energy of atoms in the metal.

In [24], the authors noted that the shock pressure welding current pulse is growing almost 4-fold (Fig. 1.3). The authors note that the momentum appears only during the deformation of the metal (t = 10 s -2), and the value and duration depends essentially on the physicochemical properties of the material and the rate of deformation. It has been suggested that the observed "mehanoelektrychnyy effect" must be observed at all kinds of welding pressure during rapid deformation.

Similar data are presented in [25], when struck by the hammer textolite copper insulated shaft at a speed of 1 m / s in the core of an electric current of about 2,4 · 10 -3 A. The emergence of the current pulse author explains the inertia of the charge distribution in the conductor.

An interesting effect was discovered in 1977 by electron-deformation effect - the process of electron drift velocity under the influence of plastic deformation of the material. If the metal is the opposite phenomenon of electron-plastic effect (electron-effect plastic Trinity). The mechanism of electron-deformation effect on the difference of electron-plastic effect is that the plastic flow zones dislocations and other defects moving carries with it the free electrons. Electron-deformation effect realized with high-speed guided deformation of the metal (at least 10 2 -10 3% per second). The author suggests that a possible observation and in crystal twinning or slip bands while driving, as well as cervical motion or deformation zones in broaching the workpiece. Electron-deformation effects recorded on a micro-site strain or compensating their potential difference. These data are OA Trinity [26], but it should be noted that in addition to this mention of the effect of references to more recent work has been found.

The effect of electron-plasticity referenced OA Trinity is that during active deformation of samples switching pulse current leads to an abrupt increase in deformation and the associated jump deforming stress. The dependence of this effect on current amplitude and duration of current pulses is a threshold character that lies within 250-400 A / mm 2 for various metals, and time at 50-100 ms. These characteristics electron-plastic effect explains enthusiastically author of dislocations conduction electrons in the current direction. However, the effect on the current dislocation involved in plastic deformation, is not equivalent to just attached to it additional mechanical stresses.

In [27] presents the results of an experimental study of electromagnetic phenomena accompanying deformation speed different in their physical nature of materials. It is shown that a high-speed deformation of various substances as shock and quasi-static accompanied by electromagnetic radiation, which is generated by the deformed material. The paper noted that the timing of the registered electromagnetic radiation signal correlated with the time parameters of the mechanical deformation process. Scheme shock deformation speed is shown in Fig. 1.4, the essence of which is to impact the specimen moving at a certain speed, at a target.

The typical oscillogram changes over time E (t) in the sample about hitting a target. Time parameters pulse electric field E (t) correlates well with the time parameters of the mechanical process of penetration into the sample target: the beginning of the pulse E (t) and its duration coincide with the start time and spivudaru inhibition pattern in the target.

Mechanical pulse effect

For experiments on mechanical pulse stretching as sample used aluminum wire with a diameter of 1 mm, covered with insulating varnish as insulation. This metal is widely used in the industry and it received a lot of data on the effects of pulsed loads on the mechanical and physical properties, structure, mass transfer, and more.

For the basis on which namotuvavsya wire used for tension pin M10 Steel 20 samples cut at 20 mm height. Dan pin was chosen due to its rather high plasticity, accessibility and ease of processing.

Using these data, the analysis of new results facilitates interpretation and allows you to get a more complete picture of the processes occurring in the metal.

Laser treatment

For surface treatment using laser "GOS-301" with modified resonator, in which between 100% mirror and the active element of neodymium glass slide placed fototropnyy (rys.2.3). It obtaining radiation pulse duration τ = 5 × 10 -8 sec at wavelength - λ = 1,06mkm, energy E iq = 1Dzh, pulse power density - W p = July 10 W / cm 2 diameter area that processed Page, was d = 2mm, through the lens of focal length f = 50 mm.

Lasers can operate in modes: continuous, pulsed mode free running mode modulated merit.

Research Methodology

From contacts glued to the sample in the experimental laser pulse, the signal was recorded using the line input and software PowerGraph 2.1 along with two channels. This arrangement made it possible to accurately record the voltage change over time, getting schedule signal with sufficient accuracy, and attempt to evaluate this method for strain rate signal delay between 2 channels.

In an experiment with mechanical tension scheme was similar, but used a single-channel recording.

Results

In experiments on pulsed mechanical stretching was performed following stages: manufacturing and preparing samples of proper mechanical tensile wire parallel recording voltage at its ends, the measurement of absolute and relative elongation samples.

The samples were produced from material spray pins and parameters specified in the previous section. After cutting the pins on the workpiece, end their grind on turning stall and polished with sandpaper in order to ensure maximum slip ends at impact to ensure uniform deformation height of the sample.

Great interest is obtaining secondary and tertiary signals that explains drummer shot from the sample and subsequent stroke. For secondary and tertiary delay signals relative to the initial calculation was conducted rebound height of the formulas of classical mechanics of body movement - namely free fall.

Using an analog oscilloscope allows you to achieve much greater accuracy, but is limited to the recording and therefore does not reflect the secondary and tertiary signal from these blows striker in the sample, allowing a record to a line input.

Get rid of these shortcomings allows recording on a digital oscilloscope, which is 2 orders of magnitude in looking for resolution in time and unlimited recording time.

In experiments with laser pulse strain used 2 fundamentally different materials: amorphous and polycrystalline, whose composition and location of the experiment are given in the previous section. It was expected that irradiation of amorphous foil laser pulse electrical signal is absent as amorphous material has dislocations movement which, as expected, is the cause of electric current in the sample during deformation.

Laser impact carried out in two modes: short pulse duration of 50 ns, corresponding unsteady regime and quasi-stationary mode - 1 ms.

A short pulse duration of 50 ns leads to the generation of shock waves in polycrystalline foil and as a result, a large number of mobile dislocations. There is a large amplitude signals.

In the quasi-stationary mode using pulse duration of 1 ms and missing all this electrical signal in accordance smaller.

In the amorphous foil inverse situation - short pulse duration of 50 ns does not generate dislocations, so the signal does not exceed the background. As seen from the X-ray amorphous samples before and after irradiation, in this case there was no crystallization - foil and remained amorphous. These results together with the following confirmed dislocation theory of electric signal in metals and alloys under impulse deformation.

The irradiation of amorphous films laser pulses in quasi-stationary pulses of 1 ms contrast observed occurrence of an electrical signal, which, combined with the analysis of X-ray film samples, which are clearly visible lines corresponding crystallized region in place of irradiation, allows conclusions that long enough first heating laser pulse irradiation region to the formation of the crystal structure of it, and then it also led to dislocation motion, which, in turn, as mentioned above, leads to an electrical signal in the sample.

Conclusions

This work it is very actually to contemporary development of science for example in researching of laser impulse alloying and accelerated mass transfer.