THE DEPENDENCE OF INTERNAL DAMPING IN ALLOY AW 2007 ON THE NUMBER OF LOADING CYCLES

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1. Introduction

Aluminium alloys have been already known few decades and they are widely used in the automotive and aviation industries. The growing interest of these industry departments for Al alloys is due to a goal to reduce fuel consumption of cars and exhaust emissions. The properties that make aluminium alloys the most economical and attractive for a wide variety of uses are appearance, light weight, fabricability, physical and mechanical properties and corrosion resistance [1].

Vibration analysis is an important tool for calculation own frequencies of the systems and stress distribution in material. By this technique one can determine if the parts or whole components would function, for which they were made. One can also predict results of dynamic loading, such as dynamic strain, fatigue life or noisiness. Optimization of the internal damping of material through changes in the structure is an effective way for controlling and limiting the amplitude of vibrations. [2].

Internal damping depends on many factors, such as temperature, purity, grain size, mechanical and heat treatment of the material. Temperature dependence \( Q^{-1} = f(T) \) is important for the evaluation of the mechanical relaxation processes. Progress of dependence \( Q^{-1} = f(\varepsilon_a) \) is a function of many structural and substructural factors, as a type of chemical composition, mechanical and heat treatment of experimental material, overlapping various partially mechanisms from mechanical dissipation of energy [3].

2. Experiments and Results

The aluminium alloy EN AW-2007 was used for internal damping measurement. Experimental alloy was founded on the Al-Cu-Mg base with addition of lead to improve machining. Internal damping specimens were machined out of extruded rods without heat treatment. The chemical composition of this material is given in Table 1.

<table>
<thead>
<tr>
<th>Si</th>
<th>Fe</th>
<th>Cu</th>
<th>Mg</th>
<th>Pb</th>
<th>Mn</th>
<th>Zn</th>
<th>Al</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.8</td>
<td>0.8</td>
<td>3.3-4.6</td>
<td>0.4-1.8</td>
<td>0.8-1.2</td>
<td>0.5-1.0</td>
<td>0.8</td>
<td>rest</td>
</tr>
</tbody>
</table>

The microstructure of experimental alloy consists of substitute solid α phase and intermetallic phases. In as cast state it is possible to identify some intermetallic phases, primarily based on: Al-Cu (MgPb), Al2Cu, Al-Cu (FeSiMn). The extruded material has been deformed by very high speed. The plastic deformation arises and new deformed structure (fibrous structure) emerges [4].

The measurement of amplitude dependent internal damping (ADID) was done on equipment used on Department of Material Engineering. The method of resonant system quality was used for the internal damping measurement. On this equipment it is possible to investigate amplitude, temperature and time dependence of internal damping. For this method it is necessary to use a specimen, frequency of which is similar to the frequency of the whole resonant system, which was about 20400 Hz. During the measurement, the resonant frequency of specimen little decreased due to microplastic deformations. The resonant system was actuated by piezoceramic elements. The vibration amplitudes of specimen were forced by loading voltage amplitude and measured by electric current in circuit. The experiment was controlled by computer [5].

At the maximum stress amplitude the specimen is held for about 5 minutes. Last, the stress amplitude decreases. Next measurement run follows after 30 minute break due to relaxation of dislocation structures into steady state.

The ADID curves were measured after annealing (at 250 °C for 2 hours). Fig. 1 shows characteristic amplitude dependence loops measured in cycles. The annealing temperature 250 °C was sufficiently high for removing residual stress after mechanical treatment and dislocation forest relaxation. Annealing at the sufficiently high temperature has significant
effect on dislocation structure. All slip systems are activated in material and thermally activated dislocation transport also occurs.

At the same time the annihilation of dislocations with opposite direction occurs. The Frank-Read sources are removed due to shortening of the length of dislocations. After quenching at the room temperature the relatively immobile dislocation forest is present in the material that does not contribute to the internal friction and does not generate new dislocations. Preliminary deformation of material is needed to create a balanced structure of mobile dislocations.

**Conclusions**

This contribution presents amplitude dependence internal damping curves measured on the extruded aluminium alloy AW-2007 after annealing. From these measurements we can make the following findings:

- The ADID curve after annealing at temperature of 250°C was observed and described.
- The annealing temperature has significant influence of dislocations density, structure of dislocation forest and also their mobility. During annealing, the density of dislocation and residual stress decreases.
- During measurement the displacement of characteristic triangle shape was observed. This displacement is linked with cyclic microplastic deformation of experimental material and increases with critical amplitude of vibrations $\varepsilon_{cr}$.
- Cyclic microplasticity does not influence the basic value of internal damping at low deformations amplitudes. After break the damping is little higher than on the end of previous cycle.
- Specimens pass through fatigue process during measurement. They were loaded approximately $1\times10^7$ cycles in each measured run.

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**References**