



Dynamic Relaxation Spectra in Beryllium Bronze

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Abstract:

The paper considers investigation by means of the internal friction method of the dynamic relaxation spectra of beryllium bronze. Operation diagrams of the damping ability and oscillation absorption coefficient are built for massive specimens in vibration range of frequencies above 2,5Hz, relative deformation $\epsilon = 2 \cdot 10^{-2} - 1 \cdot 10^{-6}$ in temperature range 20-600°C. It was found that the area of the beginning of the “high” damping, related to the high temperature part of the background of internal friction for beryllium bronze is about 200°C. In the beryllium bronze a resonance relaxation maximum is observed about 380°C. There are also energy dynamic losses of a hysteresis nature, typical for the amplitude-dependent area. The largest hysteresis energy losses are found in the region of the high-temperature background of internal friction.

Keywords: high damping alloys, internal friction, dynamic relaxation spectra, oscillation absorption coefficient, damping ability

1. Introduction

The beryllium bronze [1-3] find more application as alloys of high damping properties. The purpose of the present efforts is to study the damping abilities of beryllium bronze, manufactured by standard technology and after standard high temperature treatment,

2. Material and method

Object of investigation is beryllium bronze EN CuCoNiBe with certified chemical composition given in Table 1.

Table 1. Chemical composition of the investigated alloy (in weight %)

Designation according EN	Be	Ni	Co	Cu
CuCoNiBe	0,59	1,14	1,05	rest

Specimens for internal friction experiments with the following size- 0,5 x 0,5 x 50 mm are made using electro-eroding machine. After enclosing in vacuum glass tubes they are subjected to standard heat treatment regimens of quenching and ageing. The parameters of the regimes are as follows: quenching temperature – 940°C, holding time – 10 min., quenching media – water, ageing temperature – 480°C and holding time – 120 min.

It is well known that the internal friction value at certain frequency, relative deformation and temperature is directly proportional to the damping properties of the alloys at these conditions [1].

To define the damping abilities of both alloys the temperature dependencies of the dynamic relaxation spectra are recorded. Fully computerized apparatus is used for investigation, built on the principle of reverse balanced pendulum at operational frequency of 0, 5-7 Hz. The relaxation spectra of the specimens are recorded in the temperature range of 20-600°C, at heating rate of 3°/min. At each studied temperature the internal friction values are recorded for ten amplitudes per relative operational from $2 \cdot 10^{-2}$ to $1 \cdot 10^{-6}$.

3. Experimental results and discussion

Fig.1 presents the dynamic relaxation spectra of the specimens. The dependencies shown refer to the maximum degree of relative deformation in the amplitude dependent area of the internal friction ADIF (amplitude dependent internal friction) – $2 \cdot 10^{-2}$ and the minimum in the amplitude independent area of internal friction AIIF (amplitude independent internal friction) – $1 \cdot 10^{-6}$.

According to the published literature, the absorption coefficient Ψ (also known as specific damping capability or loss spectrum) is proportional to the value of internal friction [1] – $\Psi\% = k \cdot Q^{-1} \cdot 100$, where $k=2 \cdot \pi$ – for low values of internal friction, $k=1.08 \cdot \pi$ – in cases of high damping, as it is in the alloys studied by us.

Fig.2 shows the calculated values of the temperature dependencies of the absorption coefficients Ψ for the investigated alloys. The shaded areas demonstrate the entire spectrum of energy losses from oscillations in the material.

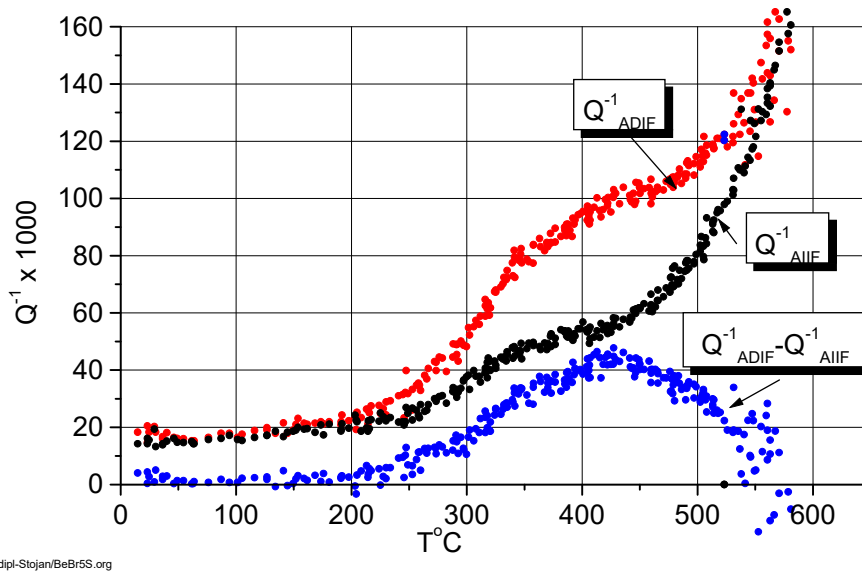


Fig.1. Dynamic relaxation spectra of internal friction

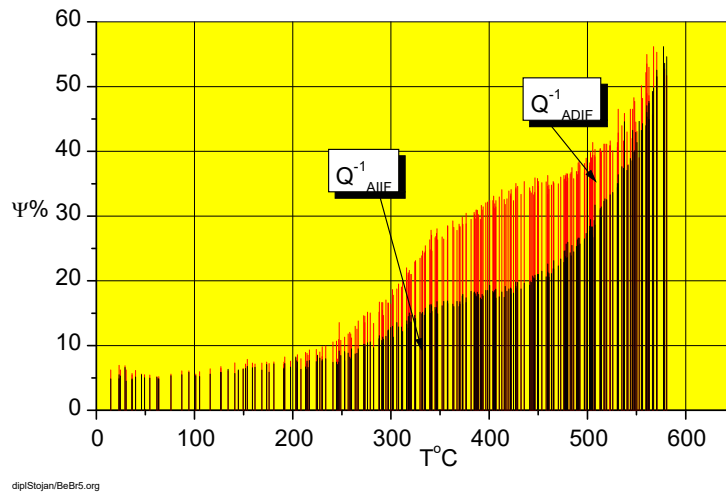


Fig.2. Temperature dependence of the absorption coefficient

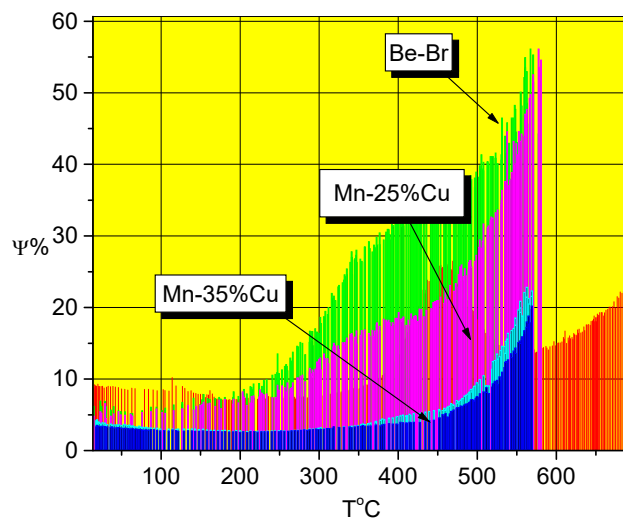


Fig.3. Comparison of the temperature dependences of the absorption coefficients of the beryllium bronze and two Mn-Cu alloys [4]

The obtained relaxation spectra and absorption coefficient are characterized by the following features:

- They are typical of metals and alloys – a low- and high-temperature background of the internal friction and resonant relaxation maximum, which is superimposed on the background (Fig.1-2) [5].
- From the values of absorption coefficients of the investigated alloy, it was established that the beryllium bronze has maximum damping property compared to the two manganese alloys (Fig. 3).
- The area of the beginning of the “high” damping, related to the high temperature part of the background of internal friction for beryllium bronze is about 200°C.

- For all studied alloys the values of the high-temperature background of internal friction, which are proportional to the dissipated energy caused by the non-conservative movement of dislocations, increase sharply.
- In the beryllium bronze a resonance relaxation maxima is observed about 380°C.
- In the beryllium bronze there are also energy dynamic losses of a hysteresis nature, typical for the amplitude-dependent area of internal friction (**Fig. 1-2**). It was found that they depend on the temperature and the strain amplitude, but do not depend on the measurement frequency.
- The largest hysteresis energy losses are found in the beryllium bronze in the region of the high-temperature background of internal friction (**Fig.1-2**).
- The most thermally unstable is the dislocation structure of beryllium bronze, where significant damping values are observed even at temperatures of the order of 150-200°C (**Fig.1-2**).

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