



## Dynamic Relaxation Spectra in High Damping Mn-Cu Alloys

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### Abstract:

The paper considers investigation by means of the internal friction method of the dynamic relaxation spectra of three high damping manganese based Mn-Cu alloys. Operation diagrams of the damping ability and oscillation absorption coefficient are built for massive specimens. It was found that, Mn-35%Cu alloy has maximum damping properties. The area of the beginning of the “high” damping, related to the high temperature part of the background of internal friction for Mn-35%Cu alloy is about 350°C, for Mn-35%Cu alloy it is about 450°C and for the alloy containing zinc it is about 550°C.

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

## 1. Introduction

The manganese alloys [1-5] find more application as alloys of high damping properties. The purpose of the present efforts is to study the damping abilities of three manganese alloys, manufactured by standard technology and after standard high temperature treatment,

## 2. Material and method

Object of investigation are three manganese high damping alloys 75%Mn and 25%Cu, Mn-22,5%Cu-2,5%Zn and 65%Mn and 35%Cu produced in the Institute of Metal Science –BAS by standard technology.

The specimens (1x1x50 mm) are heat treated under conditions: quenching after 10 min of holding at temperature 800°C and aging for two hours at 400°C.

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 [6].

To define the damping abilities of both alloys the temperature dependencies of the dynamic relaxation spectra are recorded. Fully automated and computerized apparatuses 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<sup>o</sup>/min. At each studied temperature the internal friction values are recorded for ten amplitudes per relative operational from 2.10<sup>-2</sup> to 1.10<sup>-6</sup>.

### 3. Experimental results and discussion

Fig.1-3 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) –  $1 \cdot 10^{-6}$ .

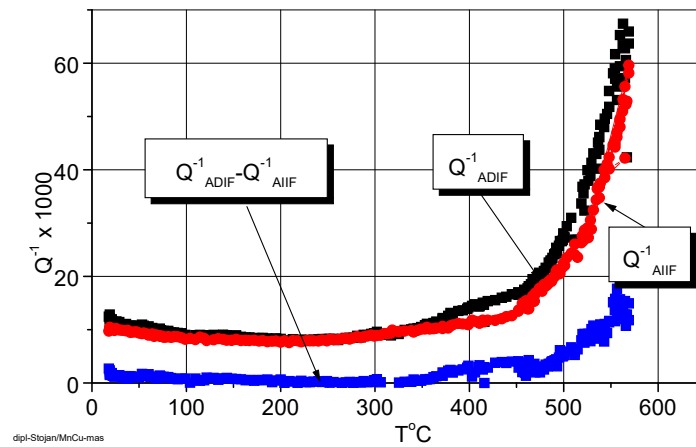


Fig.1. Dynamic relaxation spectra of the Mn- 25%Cu Alloy

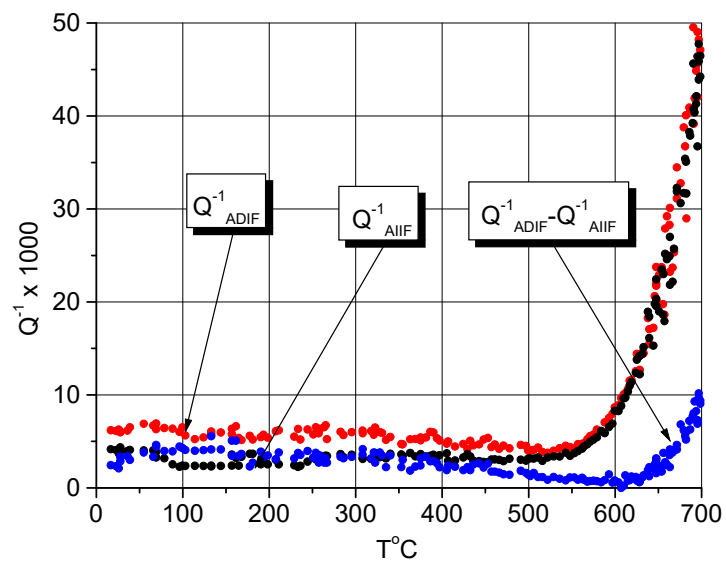
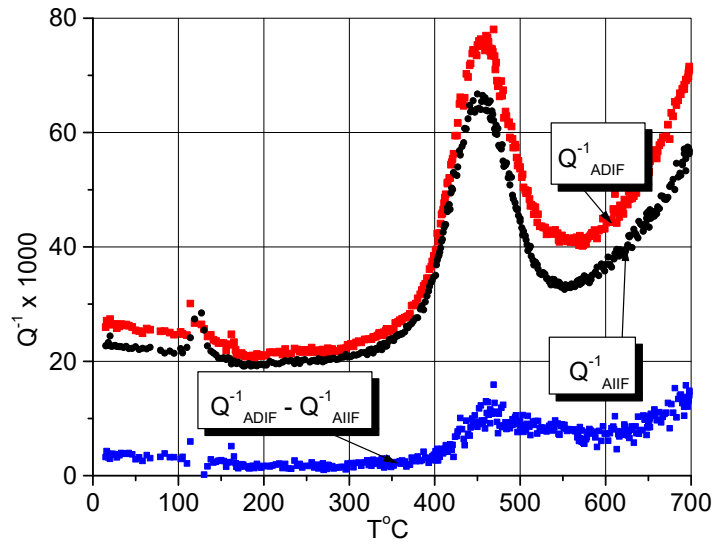


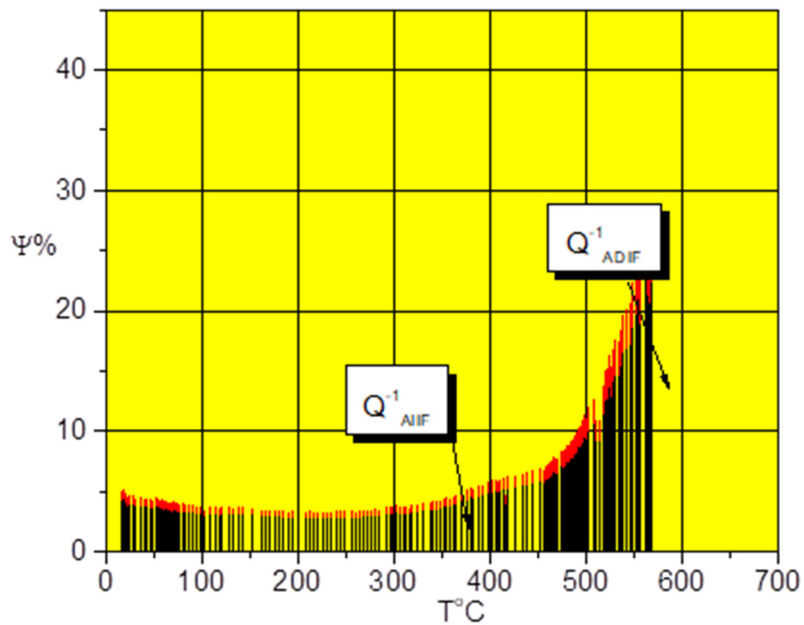
Fig.2. Dynamic relaxation spectra of the Mn-22,5%Cu-2,5%Zn Alloy



**Fig.3. Dynamic relaxation spectra of the Mn- 35%Cu Alloy**

According to the published literature, the absorption coefficient  $\Psi$  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. 4-6** show the calculated values of the temperature dependences of the absorption coefficients  $\Psi$  for the investigated alloys.



**Fig.4. Temperature dependence of the absorption coefficient alloy Mn-25%Cu**

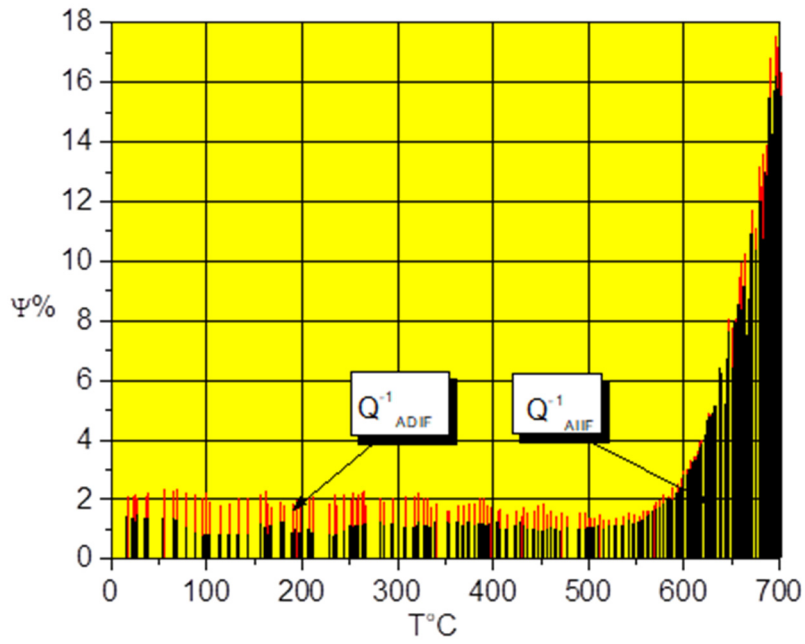


Fig.5. Temperature dependence of the absorption coefficient Mn-22,5%Cu-2,5%Zn alloy

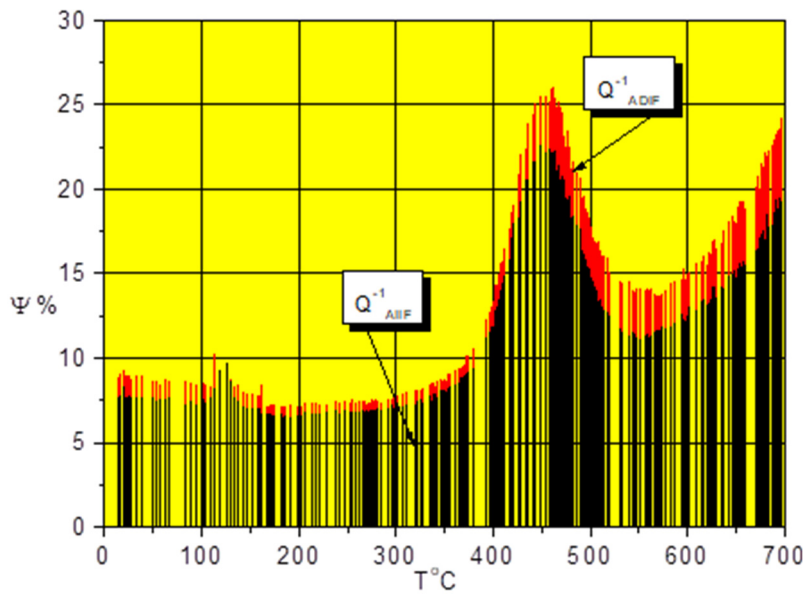
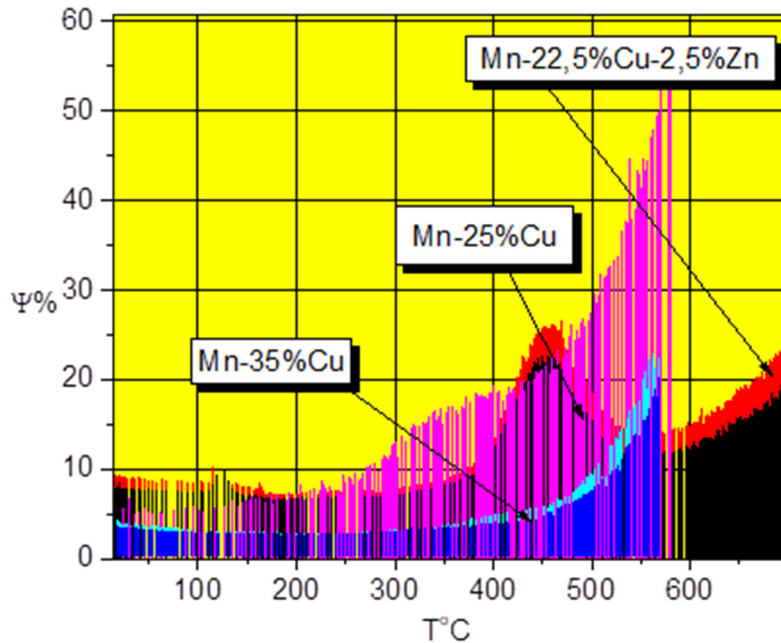


Fig.6. Temperature dependence of the absorption coefficient – Mn-35%Cu alloy



**Fig.7. Comparison of the temperature dependences of the absorption coefficient of the investigated alloys**

The obtained relaxation spectra are characterized by the following features:

- They are typical of metals and alloys and consist a low- and high-temperature background of the internal friction and a resonant relaxation maximum, which is superimposed on the background [6].
- From the values of absorption coefficients of the investigated alloys, it was established that the Mn-35%Cu alloy has maximum damping properties. At room temperature, the absorption coefficient is between 2 and 4 times higher than that of the other two alloys.
- The area of the beginning of the “high” damping, related to the high temperature part of the background of internal friction for Mn-35%Cu alloy is about 350°C, for Mn-35%Cu alloy it is about 450°C and for the alloy containing zinc it is about 550°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 Mn-35%Cu alloy, a resonance relaxation maxima is observed, which is absent in the Mn-Cu-Zn alloy and is insignificant in the Mn-35%Cu alloy.
- In all alloys, there are also energy dynamic losses of a hysteresis nature, typical for the amplitude-dependent area of internal friction – Fig. 4-6. 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 Mn-35%Cu alloy in the region of the resonance maximum and in the region of the high-temperature background of internal friction – Fig.6.

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