acta phys. slov. 43 (1993), No. 5, 351–356

# TEMPERATURE DEPENDING INTERNAL DAMPING INVESTIGATION[1]

E. Tillová, P. Palček, O. Bokůvka, T. Liptáková

*Department of Materials and Technology,*
*Technical University of Transport and Communications,*
*Veľký Diel, 010 26 Žilina, Slovak Republic*

Received 31 December 1992, in final form 1 June 1993
Accepted 17 June 1993

The work deal with an influence of the intersticial atom concentration (C) in ferrite on the temperature course of internal damping. The experiments were done in the temperature range from 0°C to 250°C. The activation energy of interstic. atoms was determined from the measured values.

## I. INTRODUCTION

With regard on the atoms construction of crystals the internal damping is caused by a different structure defect motion, when the external periodic changing forces are acting. It is property of solid material to dissipation irreversible the energy of mechanical oscillation.

By evaluating of the internal damping measurement, the important mobility information, dissipation and interactions of material defects are obtained. It is effect of vacancies, interstitial atoms, dislocations, grain boundaries, Bloch walls, e.t.c.

The measure of the internal damping intensity is dimension less quantity expressed by relation:

$$\psi = \frac{\Delta W}{W}, \tag{1}$$

$\Delta W$ - the magnitude of absorption (scattered) energy, $W$ - potential energy of body corespondending maximal deformation in the same cycle, where $W$ was estimated like $\Delta W$, $\psi$ - (coefficient) a factor of damping.

To simplify calculation in the case of dynamic measurements the values is substituted by values $Q^{-1}$:

$$Q^{-1} = \frac{1}{2\pi} \cdot \psi, \tag{2}$$

[1]Contribution presented at the 13th Conference on the Utilization of Ultrasonic Methods, August 1992, Žilina,ČSFR

This values is used by electrotechnics.

This value expresses the integral activity of the single parts of internal damping. They are or not dependet on frequency.

The internal damping measurement can be used in solutions of following the problems:

- investigation of elementary operations kinetics of microplasticity connected with dislocation motion and their interactions with different crystal defects [1],
- investigation of the physical reasonable criterions of fatique failure and kinetics of a demage accumulation at different loading amplitudes [2],
- research and development of the new materials with high damping properties in the zone of the acoustic loading resonance, to reach decreasing of undesirable segmets vibrations, machines and constructions,
- in physics for studying of solid solutions, diffusion, thermal activated parameters, phase changes, removing of point defects, dislocation structure [3,4],
- the influence of the temperature, hydrogen, deformation, cyclic and radiation loading [4],
- in limited state it helps to evaluate a defect of elasticity modules, damping capability, relaxation, creep and resistance against crack origin [5],
- in vibroacoustics to evaluate the quality of system or defects.

## II. EXPERIMENTAL PROCEDURE

Internal damping has been measured according Mason [6]. The base of this method is exciting of the mechanical vibrations in a resonance system with the characteristic curve of the deviation and deformation amplitude. The equation is valid for internal damping:

$$Q_V^{-1} = k_1.Q_{MNV}^{-1} - k_2.Q_{MN}^{-1}, \tag{3}$$

where $Q_V^{-1}$ - internal damping of sample, $Q_{MNV}^{-1}$ - internal damping of whole system, $Q_{MN}^{-1}$ - internal damping of system without a sample, $k_1$, $k_2$ - constants of acoustic system quality.
Internal damping of a resonance system is given by this equation:

$$Q_{MNV}^{-1} = \frac{k_{MNV}.U_a}{fr.U_{pu}}, \tag{4}$$

where $U_a$ is the stress amplitude, $U_{pu}$ is maximal stress on the resonance, fr is resonance frequency and $k_{MNV}$ is coefficient, calculated by

$$k_{MNV} = \frac{U_{pu}}{U_a} \cdot \Delta fr. \tag{5}$$



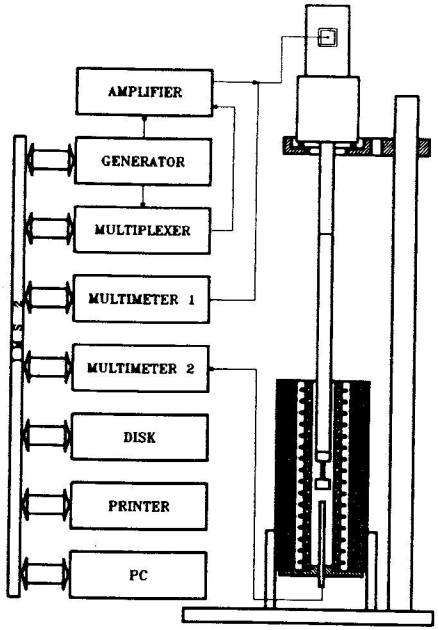


Fig. 1. The experimental equipment

Tab. 1
The chemical composition

| element | C | Mn | Si | P | S | Cr | Ni |
|---|---|---|---|---|---|---|---|
| % | 0.07 | 0.27 | 0.03 | 0.013 | 0.018 | 0.07 | 0.0064 |

$\Delta fr$ is the three decibel deviation from resonance frequency. An elastic area of loading was measured only.

The equipment used for measurement - Fig.1. [2], is controlled by computer (runing) automatically according a programs.

Internal damping was measured in the temperature interval since - $50^0$C to $400^0$C. The samples were made from low carbon ferritic steel ČSN 41 2013. The chemical composition is in tab.1.

Several peaks were observed on the curve $Q^{-1} = f(T)$ in this temperature interval, Fig.2.

## III. RESULTS AND DISCUSSION

The activation energy was calculated for every peak. These values of activation

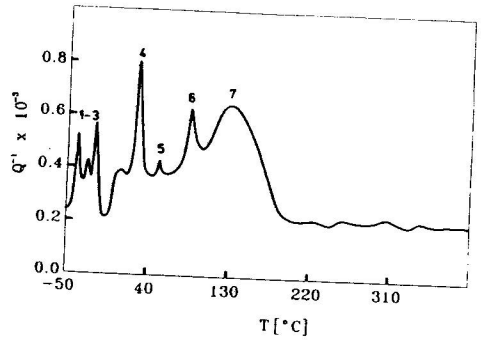


Fig. 2. The temperature dependence of $Q^1 = f(T)$ in interval ($-50^0$C $-400^0$C)

Tab. 2

| Maximum | Action H calculated [KJ.mol$^{-1}$] | The table activation H [KJ.mol$^{-1}$] | element |
|---|---|---|---|
| 1-3 | 16.399 | 12.14 | H |
| 5 | 76.872 | 79.93 | N |
| 4 | 138.566 | 138.10 | C |
| 6 | 241.627 | 224.50 | Mn |

energy were compared with the table one. Elements wich created the peaks were by this way. The calculated and table values of activation energy $H$ are in the tab.2. The great attention was paid to carbon peaks 4 and 7 [4]. The peak 4 (Snoek peak) with its shape and position corresponds to the carbon relaxation peak. This peak is caused by mechanical energy dissipation in solid. This fact is due to carbon atoms diffusion from the pressed to extendet positions in the lattice.

The height of a peak depends on the carbon concentration in ferrite and at the same carbon concentration it depends on the grain size.

The shape and position of the peak 7 corresponds with Snoek - Köster peak. This peak is due to local internal microstress of material and can be observed only in predeformed material [7]. The interaction of these microstreses and external streses create the effect streses in microvolumes, which are necessary for dislocations and defects motion in the same time. The height of Snoek - Köster peak increases with the interstitial atoms concentration in a solid solution and oposite. The maximum after annealing disappears.

The measurements were performed in the temperature interval from $0^0$C to $250^0$C. The influence of testing cementit separation was observed (by artificial ageing) on the high of Snoek and Snoek - Köster peaks.

For the tested material was used heat treatment to obtain saturated solid solution of ferrite ($730^0$C/h, cooling in water). The artificial ageing was performed



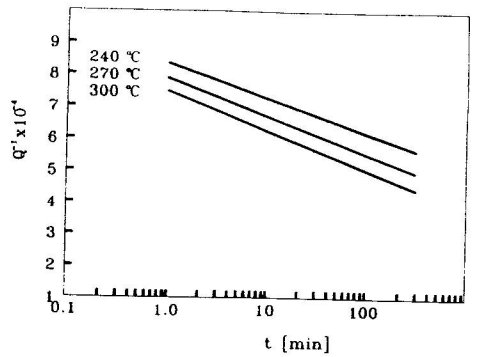


Fig. 3. The influence of ageing on the Snoek maximum heigh

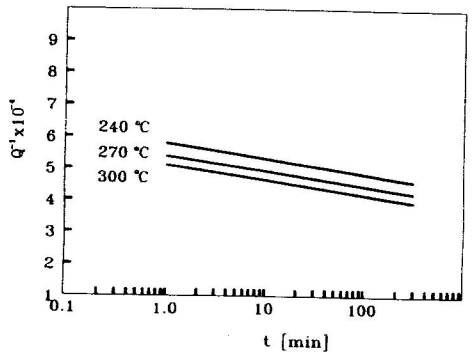


Fig. 4. Influence of ageing on the change Snoek - Köster maximum

at temperatures 240, 270, $300^0$C in time intervals 10, 20, 40, 80, 160, 320 minutes. The measured values of internal damping peaks in dependence on the time of annealing are showed in Fig.3 and Fig.4.

This curve show the classical course of relaxation processes. The carbide $Fe_3C_{III}$ is separated from solid solution at different temperature of annealing (240, 270, $300^0$C). The matrix is depleted by carbon and the Snoek and Snoek - Köster carbon peaks decrease.

## IV. CONCLUSIONS

The described methods make abe to ascertain a relax processes course of low-carbon steels after ageing, carbon concentration and temperature influence too. By this way can be widened the possibilities in study of the relax and diffusion processes.


### Acknowledgement

This work has been supported by a grant of Slovak ministry of the education, youth and sport No. 1/312/92.


## REFERENCES


[1] A. Seeger , C. Wüthrich : Il nuovo cimento, *vol.33B* (1976)

[2] O. Bokůvka , A. Puškár , P. Palček , J. Meško : Near threshold fatigue crack growth in construction steels, *In.10 th. congress on material testing, Budapest* (1991)

[3] P. Palček , I. Emri : On the influence of deformation amplitude on the variation of internal damping, *In. 10 th. internal modal analysis conference, San Diego, CA* (1992)

[4] P. Palček , E. Tillová , O. Bokůvka : Temperature depending internal damping of low carbon steels, *In. CONMETT 92, Brno* (1992)

[5] P. Palček , O. Bokůvka ,T. Liptáková : Internal damping in the feritic and austenitic steel, *In. 9 th. coloq. Advanced manufacturing and repair technologies in vehicle industry, Budapest* (1992)

[6] W.P. Mason : Advances in materials research, *vol.2, New York, J. Willey* (1968)

[7] L.B. Magalas , S. Gorzyca : Journal de physique, *C10, N$^0$12, T 46* (1985)