

# STUDY OF THE INTERNAL FRICTION OF THE Fe-Mn ALLOYS DESTINATED TO SPRINGS MANUFACTURE

S. M. Bob, V. Constantinescu, L. A. Sorcoi

Technical University of Cluj-Napoca, Romania

**ABSTRACT:** The paper presents a study of the internal friction at the Fe-Mn alloys destined to manufacture springs. The conceived device permits to determine the logarithmic decrement of the damp and so, of the damp factor at these materials. For internal friction and oscillation damp study we take in consideration free type of manganese steel used in current mod like spring. To internal friction study is usual used a torsion pendulum, the sample being in shape of hair. The most little damp is to III manganese steel because a little amount of carbide who contain, beside II manganese steel who has W and who form carbides place to ground boundary. This why give decreasing elasticity modulus, the crystallin ground of different orientation are decreasing himself in viscosity "liquid" form from carbide to the ground boundary. Propose analyse method is quickly and to allow interaction with calculus technique.

**KEYWORDS:** internal friction, damp, Fe-Mn alloys, springs

## 1 INTRODUCTION

In this work is presents a method for internal friction study and capacity of damp at materials subject periodical stress.

Clasical method of study an internal friction which used torsion pendulum. By present method oscillation system is, assume of piezoelectric transducer and electronical procesed. Samples to be analysed is dense materials.

Internal friction study, respective damping, is direct applications in inginerie and is aplications in scientific investigation at to know material properties.

## 2 Fe-Mn ALLOYS FOR SPINGS

Many types of steels are used for springs of different forms (for elastic stress) due to the following properties: high trying capacity, good elasticity and safety against failure in trying beyond elasticity. With the latter, changes in form depend on the average of the elastic modulus.

Materials used for springs must by have the best capacity of damp therefore is higher internal friction.

A high charging capacity demand to the material a high limit of elasticity or at least a high ductility limit ( $R_p 0,2 > 80 \text{ daN/mm}^2$ ) which can be ensured through cold hardening, appropriate chemical composition

or by adequate thermic treatment. In order to be worked through cold deformation (wrapping) steel springs must be elastic enough, must have good elongation and narrowing ( $A > 5\%$ ,  $Z > 20\%$ ) [4].

These conditions are satisfactory for certain steels, including the studied samples (see below Table 1).

Steel springs are usually available as bars, wires and belts (straps) which, when delivery, have the requested properties and they don't need after cold deformation only a stress relief annealing (to 200-300°C) to eliminate internal tensions which, otherwise, reduce the limit of elasticity with until 50 % [3].

**Table 1. Mark, chemical composition and domain of steels for springs**

| Type of steel  | Chemical composition, wt %                                  | Domain   |
|----------------|---|--|
| I. 60CrMnSi17A | 0.55-0.65 C<br>0.60-1.00 Mn<br>1.50-1.90 Si<br>0.25-0.45 Cr | - leaf and spiral springs for motor vehicles and rolling stock; any other spring type,   |
| II. OLC66S     | 0.62-0.70 C<br>0.60-0.90 Mn<br>0.17-0.37 Si<br>0.15 Cr      | - springs with high elasticity and strength, including fatigue strength; ring springs and twisting, usable up to 300°C for valves, |
| III. 652SW     | 0.61-0.69 C<br>0.70-1.00 Mn<br>1.50-2.00 Si<br>0.80-1.20 W  | - thick spirals; spring for rolling materials, high speed motor vehicles; usable up to 300°C and without repeated shocks.          |

For steel springs which are fatigue stressed the following operations are forbidden : welding, quenching, crack and superficials decarburization; all these reduce fatigue strength [1]

### 3 INTERNAL ABRASION IN MATERIALS:

Experience shows that free oscillations of a corp in time. Letting aside the environment influence on oscillations diminishing, the causes are found inside the solid: it was named 'internal friction' [1].

The absorption of the sound through solids, damp of free oscillations of a torsion pendulum is caused by internal friction [2].

During the damp of free oscillations, the macroscopic energy is transformed step by step being absorbed by microscopic systems of atoms, or even by detached atoms, give an equivalent quantity of heat. The internal friction processes are so irreversible [1].

The internal damping (internal friction) of materials is a propertie with many implications in technical, intern friction, witch can serv to: determination of the diffusion coefficient in crystalline materials measuring sollubility to some solid sollutions, determination of the same impurities, crystalline nets, their defects and their interaction and so on [1].

The damp oscillations can be studied on base of an material point model on witch actions elastic force and a strength force proportional with the velocity.

The differential equation of the movement is:

$$\frac{d^2x}{d\tau^2} + 2n \cdot \frac{dx}{d\tau} + p^2x = 0. \quad (1)$$

Noting,  $x$  - elongation,  $m$  - mass,  $k$  - elastic constant value,  $h$  - proportional constant value to viscous resistance,  $p$  - pulsation of the system,  $n$  - factor of damping,  $\tau$  - time it results;

$$x = a \cdot e^{-n\tau} \sin(p_1\tau + \delta) \quad (2)$$

Graphic plot of equation is give in next way (see Fig.1.):[1]

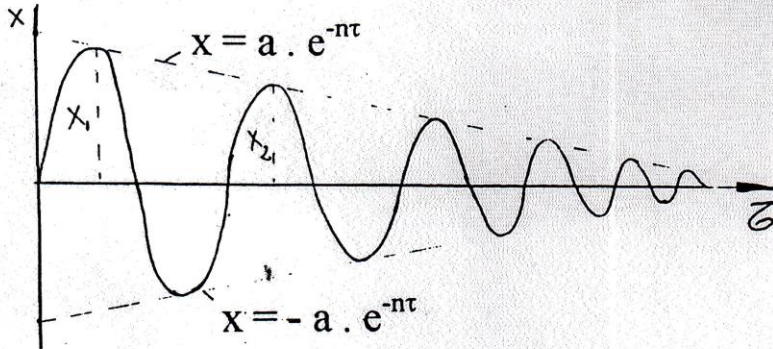


Fig.1. Deaden oscillation curve.

The pulsation of damp movement is:  $p_1 = (p^2 - n^2)^{1/2}$  and is lower than  $p$  pulsation of the undepleted system..

The period of damp movement :

$$T_1 = 2\pi/p_1 > T;$$

$$T = 2\pi/p; \quad p_1 < p.$$

Usually,  $n$ , the factor of damp is low, so the difference between  $p$  and  $p_1$  is extremely low.

The ratio of the two successive amplitudes gives a hint on the damp intensity:

$$\frac{x_1}{x_2} = \frac{a \cdot e^{-n\tau}}{a \cdot e^{-n(\tau+T_1)}} = e^{nT_1} = \text{constant}, \quad (3)$$

that  $i$  means the amplitude decrease in geometrical progression, the ratio of two consecutive numbers (amplitudes) being constant.

The logarithmic decrement of the damp is give by:

$$\delta = \ln \frac{x_1}{x_2} = nT_1 = 2 \frac{\pi m}{\sqrt{p^2 - n^2}} = \pi Q^{-1}, \quad (4)$$

where  $Q$  is the logging between tension and specific deformation [1]. It can be seen that if there are known two successive amplitudes and the period  $T_1$ , it can be determined the factor of depletion  $n$  [2].

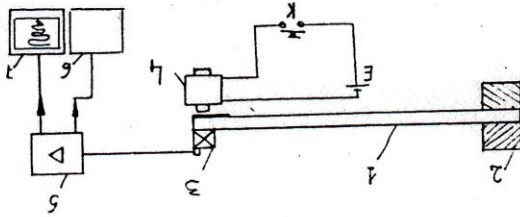
#### 4 EXPERIMENTAL RESULTS:

It was made an experimental stand given in Fig.2, to find the internal friction.

It was followed experimentally;

- to determine record the vibrogram of the free damp vibrations

- to determine the logarithmic decrement ( $\delta$ - is the ratio of two successive amplitudes) with the relation (4)
- to determine the damp factor ( $n$ )
- from the relation of the logarithmic decrement it can be established the own pulsation ( $p$ ) and the logging  $Q$ .



Experimental stand is compound by:

- 1 – sample to be analysed, size: 100 x 30 x 3 mm;
- 2 – clamping ends;
- 3 – piezoelectric transducer;
- 4 – electromagnet;
- 5 – amplifier;
- 6 – computer;
- 7 – recorder;
- E – power supply;
- K – switcher.

**Fig. 2. Experimental stand for measuring the internal friction.**

In Table 2 is given experimental results and determinations.

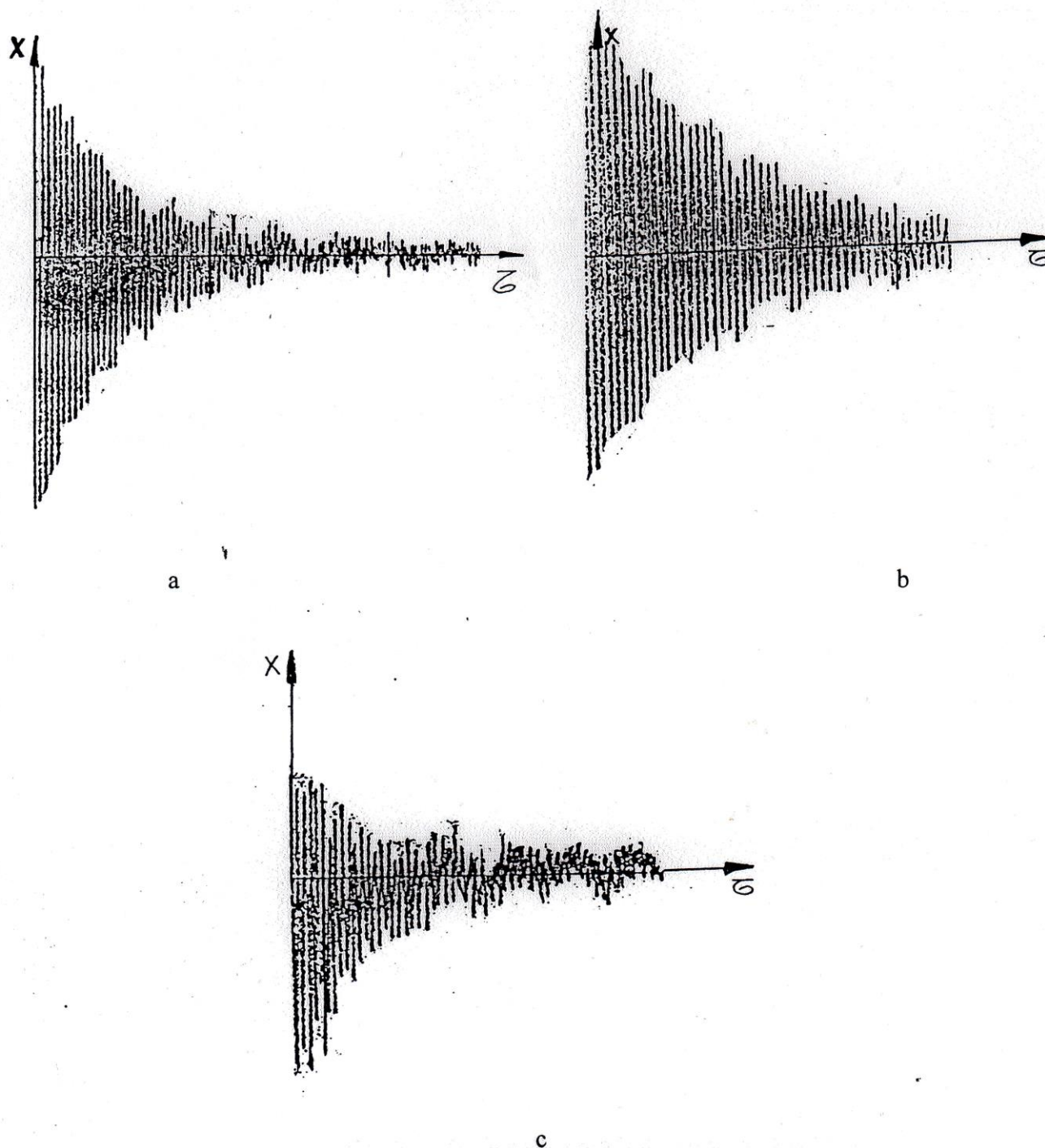
**Table 2. Experimental result**

| Material            | $x_1$<br>[mm] | $x_2$<br>[mm] | K  | $T_1$<br>[s] | $\mu$<br>[Hz] | $\delta$ | N<br>[Hz] | p<br>[Hz] |
|---------------------|---------------|---------------|----|--------------|---------------|----------|-----------|-----------|
| Manganese steel I   | 21.5          | 2.5           | 32 | 0.0031       | 320           | 0.0672   | 21.677    | 2026.97   |
| Manganese steel II  | 10            | 2             | 34 | 0.0029       | 340           | 0.0473   | 16.322    | 2026.97   |
| Manganese steel III | 32            | 2.5           | 34 | 0.0029       | 340           | 0.0749   | 25.820    | 2165.67   |

- where: - $x_1, x_2$  - amplitudes;  
 - K - number of periods;  
 -  $T_1$  - movement period;  
 -  $\nu$  - frequency;  
 -  $\delta$  - logarithmic decrement;  
 - n - damping factor;  
 - p - pulsation.

We observe in Table 2 the little damping is to manganese steel II. Logarithmic decrement of damping, is the higher to manganese steel II, so that with how  $\delta$  or n are more higher with that damp is the best.

In Fig. 3. It is shown some vibrograms recorded experimentally.



**Fig. 3. Vibrogrammes for: manganese steel I, II, III (a,b,c).**

Above internal friction have influence the alloy element from material. From composition of Table 1, the structure is ferritic ( $Fe \alpha$ ). Alloy elements are dissolved in ferrite, modifying crystalline parameter so: W, Mn, Cr - increasing crystal parameter and Si decreasing crystal parameter net. The modifying of ferrite net crystal parameter determines important modifications of damp factor too. Concomitantly Si increasing hardness and elasticity limits of steels.

Another cause of internal friction is constitute by the ground boundary in polycrystalline metals. Ground boundary with so different orientation has behaviour like a thin layer of very viscosity liquid.

Internal friction is generated to ground boundary and W, Cr, carbide, in general, are fixed to limited of ground boundary (in function by thermal treatment) and action like an viscosity "liquid", increasing internal friction. The carbide hardening and crack steel decrease elasticity modulus.

## 5 CONCLUSIONS

For internal friction and oscillation damp study we take in consideration free type of manganese steel usually used like spring .

To internal friction study it used usual a torsion pendulum, the sample being in shape of hair. In paper samples submissive determinations are in shape of paralelipipedic bar more easy to create it.

The most little deaden is to III manganese steel because a little amount of carbide who contain, beside II manganese steel who has W and who form carbides place to ground boundary.

This why give decreasing elasticity modulus, the crystalline ground of different orientation are decreasing it self in viscosity "liquid" form from carbide to the ground boundary. Proposed analyse method is quicker and allows interaction with calculus technique.

## REFERENCES

1. G Matei, Teoria structurală a proprietăților metalelor, Universitatea Tehnică, Cluj-Napoca, (1986), vol.1, p. 7-93.
2. N. Geru, Teoria structurală a proprietăților metalelor, Editura Didactică și Pedagogică București. (1980), p. 15-94.
3. O. Aczel și C. Bozan, Dislocațiile și frecarea internă la metale, Editura Facla Timșoara (1974), p. 201-283.
4. M Birker, Untersuchugen des umwandlungverhaltens von eisen -mangan - legierungen durch dampfungsmessungen im hertzbereich, doctoral dissertation, Stuttgart, (1965), p.3-85.