



## RESEARCHES CONCERNING THE VIBRATIONS GENERATED BY THE FORGING HAMMERS VIBROAMORTIZED WITH METALLIC SPRINGS

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**Abstract:** The work present the research regarding the forging hammers and the possibilities for vibro-amortization with springs.

**Key words:** forging hammer, vibro-amortization, Runge-Kutta, MathCAD, noise

### 1. THE IMPORTANCE OF THE FORGING HAMMERS

The forging hammers are equipments working with shocks, being used for processing the metals by plastic deformation by forging, through the action of external forces applied to shocks. The forging hammers are generating harmful effects (vibrations, noises, gases, etc.) which affect both the surrounding environment as the people who work in this environment or nearby.

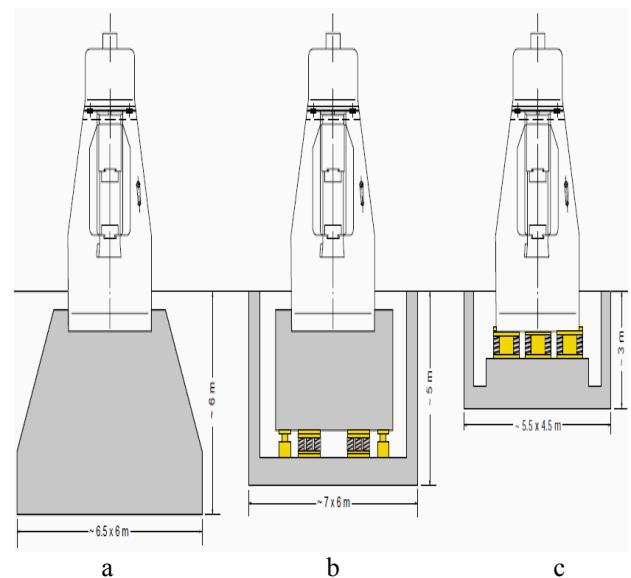
The vibrations generated by hammers can bring damages to the houses' resistance structure which is in the proximity of the forging section to less than 100 meters. Less than 50 meters from the forging section can't be installed equipments that works with precision and also the staff working in the forging section is negative affected.

To eliminate the harmful effects of vibrations generated by hammers are used various foundations and vibro-amortization systems.

The specialized literature presents some solutions of vibro-amortization [3]. In the figure 1, variant a, is proposed as a vibro-amortization solution an beton block as foundation, in the variant b under the foundation' block is proposed an system consisting on springs and an external damper and in the variant c is proposed to place the

forging hammer on a vibro-amortization system consisting of boxes with springs.

Figure 1c is the most suitable variant since the foundation' block size are significantly reduced, until 50% compared to the variant a, that's why in this article we'll show the importance of the vibro-amortization for the forging hammers with boxes which contain metal springs which are frequently used.



**Fig. 1** Solutions for vibro-amortization [3]

In the specialized literature, for the calculations concerning the vibro-amortization with metal' springs [3], [4], is considered that the springs are totally elastics.

## 2. THEORETICAL ISSUES

The calculation of the vibro-amortization with metal' springs starts from the movement equation of the foundation block.

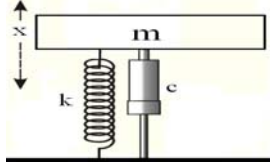


Fig. 2 Model with internal amortization coefficient

$$m \ddot{x} + c \dot{x} + kx = 0 \tag{1}$$

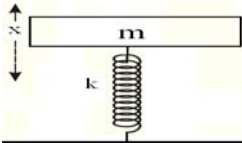


Fig. 3 Model without internal amortization coefficient

$$m \ddot{x} + kx = 0 \tag{2}$$

$m$  - total mass (foundation + hammer);  $x$  - amplitude of the block foundation' movement;  $k$  - elastic coefficient of the springs;  $c$ - internal amortization coefficient of the material' spring.

These equations were solved by he author using the Runge-Kutta method and MathCAD software [1] and the following results were obtained table 1 resolving equation 1 and table 2 resolving equation 2.

Table 1

The maximum amplitude of the block foundation' movement calculated with  $c > 0$

Springs set	4 springs	6 springs	8 springs
Maximum amplitude [mm]	0,524	0,360	0,255
Time for amortization [s]	0,43	0,32	0,27
Internal amortization coefficient [Ns/mm]	9,324	15,579	24,555

Table 2

The maximum amplitude of the block foundation' movement calculated with  $c = 0$

Springs set	4 springs	6 springs	8 springs
Maximum amplitude [mm]	1,032	0,843	0,730

In these calculations were taken into account the coefficient  $c$  of the material' springs, resulting the contraction of the amplitude of the block foundation movement by 50% than the case this coefficient  $c$  is not taken into account.

## 3. EXPERIMENTAL RESEARCHES

The experimental researches were conducted into two parts. In the first part were made measurements of the amplitude of the block foundation' movement, this one was placed on a vibro-amortization system consisting of four, six and eight springs, the measurements being made with each set of springs. Then were measured the vibrations passed in soil, the measurements were made in the soil near the foundation block at one and two meters from these, in two variants: one with the foundation block placed on a vibroamortizing spring system and the another variant with the foundation block placed directly on the ground.

In the second part of the researches were made noise measurements at various points near the forging hammer. These were made on a stand with an forging hammer with linear electrical engine, existing within the laboratory of the Technical University of Cluj-Napoca with the following characteristics: hammer with ram mass = 85 kg, ram weight = 2.5kg, ram movement = 0.250m, number of hits per minute 60 hits / min, block foundation weight.= 270kg. The value of the amortization coefficient of the material of the springs set was determined by calculation as experimentally, by recording the amplitude variation of the foundation block movement [6].

In order to achieve the measurements for the amplitude block foundation movement, was used the stand from Figure 4 in the version 1. The foundation block was placed on a vibro-amortization system consisting on 4, 6 and 8 springs, the measurements being performed for each set of springs.

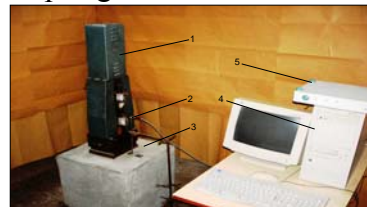


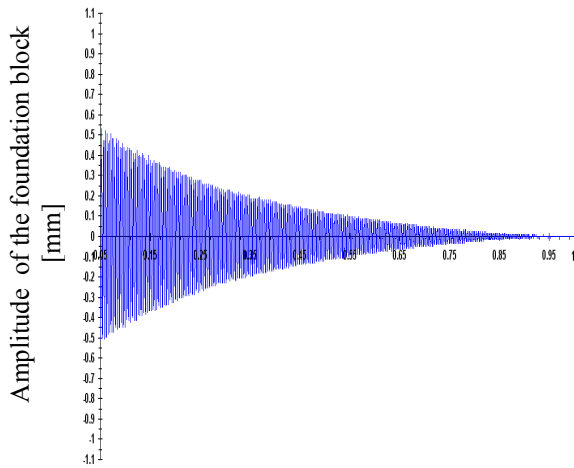
Fig. 4 Version 1 -stand for measuring the movement amplitude of the foundation block

1-hammer with linear electrical engine, 2- transducer stroke, 3- foundation block, 4-PC with purchasing board 5 - digital converter (Spider8).

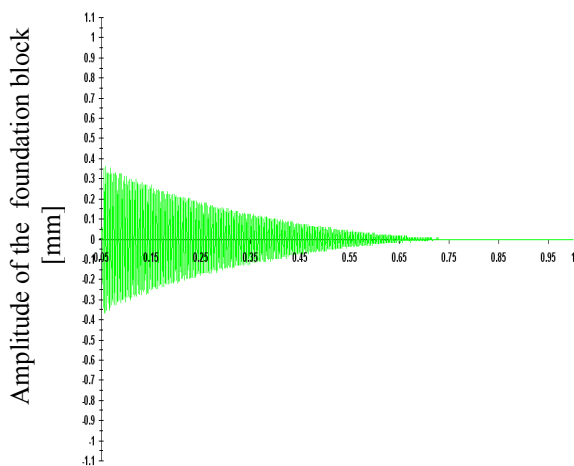
To these measurements were obtained the bellow values of the foundation block amplitude (Table 3).

*Table 3*  
**The amplitude of the foundation block – vibro-amortization with 4, 6 and 8 springs**

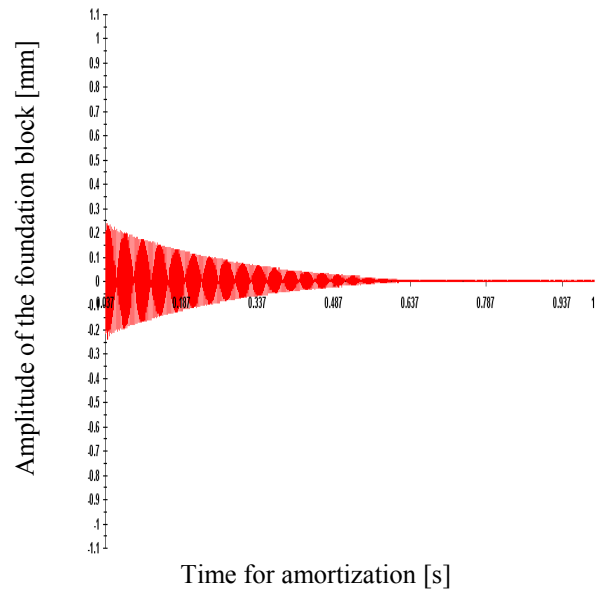
Set of measurements	Dimension [mm]		
	Spring set 4 springs	Spring set 6 springs	Spring set 8 springs
<b>I</b>	0.535	0.367	0.254
<b>II</b>	0.523	0.364	0.256
<b>III</b>	0.537	0.36	0.249
<b>Average value [mm]</b>	0.532	0.364	0.253



Time for amortization [s]  
**Fig.5** Amplitude variation of the foundation block movement -vibro-amortization with 4 springs



Time for amortization [s]  
**Fig. 6** Amplitude variation of the foundation block movement -vibro-amortization with 6 springs

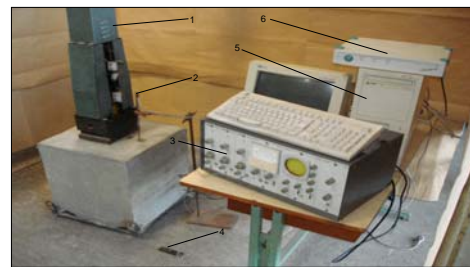


Time for amortization [s]  
**Fig. 7** Amplitude variation of the foundation block movement -vibro-amortization with 8 springs

In the figures 5, 6 and 7 are shown the amplitude variation of the foundation block movement for 4, 6 and 8 metal springs.

These reveal that the amplitude of the block foundation movement and the time of amortization is reduced according to the set of springs used in the vibro-amortization system.

In order to measure the vibrations passed on the soil was used, in plus to the stand from Figure 4, an accelerometer and a signal generator 11 013 RTF (Figure 8).



**Fig. 8** Version 2 - stand for measuring the vibrations in the soil

1-hammer with linear electrical engine, 2- transducer stroke, 3-signal generator (RTF 11 031), 4-accelerometer, 5-PC with purchasing board, 6 - digital converter (Spider8).

The table 4 shows the variation of the vibration amplitude passed in soil using an vibro-amortization system with a set of 4 springs. The vibrations values have been recorded only next to the foundation' block (0 meters). For one and two meters distance could

not be recorded any value because these were very small.

Table 4

Measurements for the vibration amplitude passed in soil using vibro-amortization with 4 springs

Set of measurements	Distance of measurement between the foundation' block and accelerometer [m]	Measured value [mm]	Average value [mm]
I	0	0.0003	0.0003
		0.0003	
		0.0003	
II	1	0	0
III	2	0	0

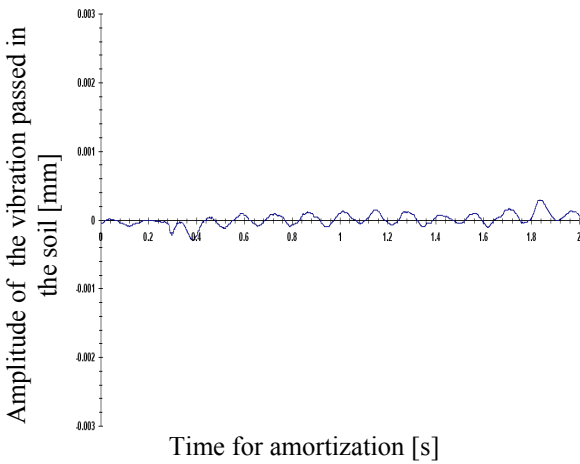


Fig. 9 Variation of the vibration amplitude passed in soil measured at 0 m from the foundation block – vibro-amortization with four springs

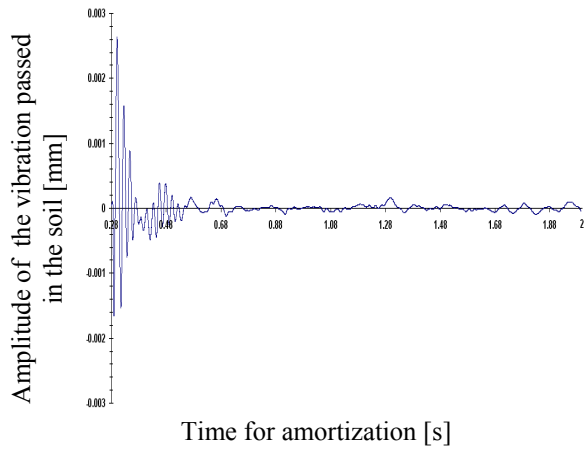


Fig. 10 Amplitude of the vibration passed in the soil [mm] measured at 0 m from the foundation block –without vibro-amortization –the foundation is placed directly on the soil

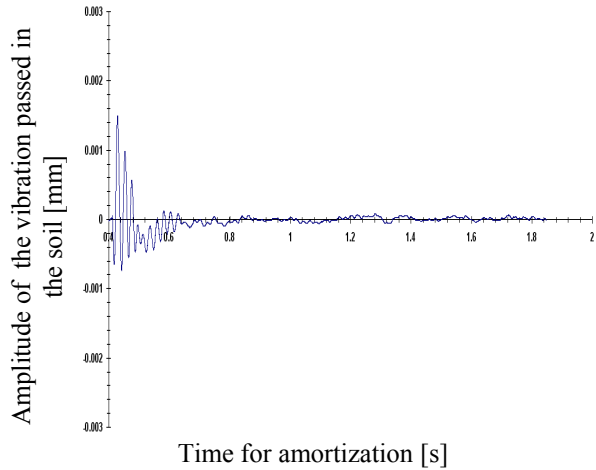


Fig. 11 Amplitude of the vibration passed in the soil [mm] measured at 1 m from the foundation block –without vibro-amortization –the foundation is placed directly on the soil

Tabel 5

Measurements for the vibration amplitude passed in soil without using vibro-amortization system - the foundation is placed directly on the soil

Set of measurements	Distance measurement between the foundation' block and accelerometer [m]	Measured value [mm]	Average value [mm]
I	0	0.00248	0.00252
		0.00261	
		0.00248	
II	1	0.00147	0.00134
		0.00119	
		0.00137	
III	2	0.00038	0.00043
		0.00045	
		0.00045	

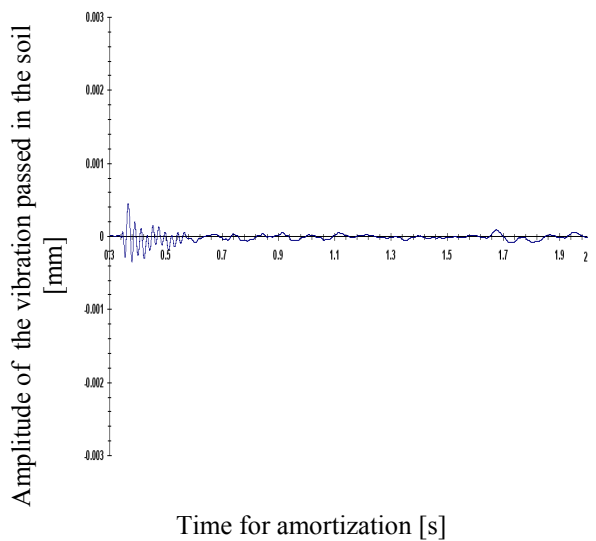


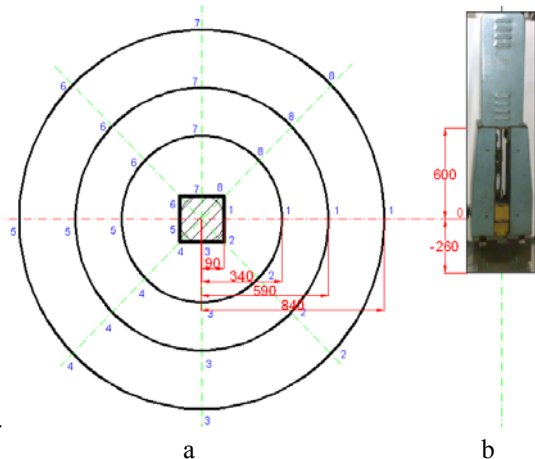
Fig. 12 Amplitude of the vibration passed in the

soil [mm] measured at 2 m from the foundation block  
 –without vibro-amortization –the foundation is placed directly on the soil

The table 5 shows values of the the amplitude of the vibrations passed in the soil without using an vibro-amortization system, the foundation is placed directly on the soil. The values measured are small, but without an vibro-amortization system during the technological process, the forging hammers induces vibrations in the environment.

For the second part of the measurements we have used a RION NL-32 sonometer in order to measure the maximum noise produced by the hammer with electric linear engine. The measurements were made in three stages:

- the first stage of measurements were made near the ram hitting table which is the level "0", the measures of the noise being made in eight points, as shown in the Figure 13.
- the second stage was moved down the measuring level by 260 mm from the level "0", being made the measurements of the maximum' noise produced by the hammer with linear electrical engine in the 8 points defined as points of positioning of the sonometer.
- in the last stage was moved up the measuring level with 600 mm from level "0", making measurements on the same points as in the first stage and second stage.



**Fig. 13** Plan of the sonometer measurements  
 a The measurement plan with the the 8 points established for the sonometer positioning, b. Hammer with linear electrical engine used for measurements

In the table 6 are presented values of the noise produced by the hammer to an hit. It is

noted that the strongest noise is 108dB measured to the “0” level, on the points 1 and 5 that means right next to the ram hitting table.

Table 6

Values for the noise measured with the sonometer on level " 0 "

Measuring distance from the center of the ram hitting table	90 [mm]		
	Measuring points	Measured noise [db]	Noise intensity I [W/m <sup>2</sup> ]
1	108	0.0630	0.01
2	104	0.0251	0
3	104	0.0251	0
4	105	0.0316	0
5	108	0.0630	0.01
6	105	0.0316	0
7	104	0.0251	0
8	104	0.0251	0

The noise produced by the hammer with linear electrical engine is high and exceeds the accepted limit of 70 dB [3].

#### 4 THE CALCULATION OF THE ENERGY CONSUMPTION

In the table 7 was calculated the energy consumption of the vibro-amortization system composed by 4, 6 și 8 springs, for the stand with the hammer having the linear electrical engine, for one of his hits.

Since the purpose of this calculation is to check, which is the energy consumption of the vibro-amortization system for one hit, the values related to the rubbing, for plastic deformation and energy losses were considered negligible.

The biggest energy consumption, according to the table 7, is on the vibro-amortization system composed by the set of eight springs.

Table 7

Energy consumed by the vibro-amortization system with springs (c > 0)

Spring set	4 springs	6 springs	8 springs
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Energy consumed [J]	2,68	3,23	5,07
Speed of the foundation block at the maximum amplitude [m / s]	0,123	0,135	0,169
The energy consumed by the vibro-amortization system reported to the hitting energy of the ram (6.13 J) [%]	43,7	52,6	82,7

Table 8

Energy consumed by noise (c=0)

dB [max]	W [max]	t [s]	Energy consumed by noise [J]	The energy consumed by noise reported to the hitting energy of the ram (6.13 J) [%]
108	0,063	0,25	0,01575	0,256
		0,5	0,0315	0,513
		0,75	0,0475	0,774
		1	0,063	1,027

In the table 8 is shown the energy consumed by noise during one second hit. Although the value obtained is small, in the energy balance calculation for the forging hammer this can influence the result.

## 5. CONCLUSIONS

From the specialized literature analyze we can see that solutions to reduce the vibration propagation generated exists, but any improvements, even in a small measure, are welcomes.

Thereby, the amortization coefficient of the set of springs material should not be neglected in the vibro-amortization calculations because it can influence the amplitude of the foundation block movement as the mass of the foundation

block which is very important in the design phase.

The measured values gives validity to the calculations made, the error is within 1.44% ... 0,791%. The energy balance shows that the vibro-amortization consumes the largest energy generated by the hammer hitting. This leads to the conclusion that is needed to find ways to increase the amortization coefficient  $c$  of the vibro-amortization (materials, construction solutions, and so on).

The level of sound vibrations generated by the hammer analyzed, but also the forging hammers in general, require their endowment with sound isolation materials (eg. soundproofing panels) [5].

## 6. REFERENCES

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Cercetări privind vibrațiile generate de ciocanele de forjat vibroamortizate cu arcuri metalice

**Rezumat:** Lucrarea prezintă cercetări privind vibrațiile ciocanelor de forjat vibroamortizate prevăzute cu arcuri metalice.

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