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THE MODEL OF THE FORGING HAMMERS LIKE SYSTEM WITH THREE DEGREE OF FREEDOM

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ABSTRACT

Forging hammers cause very high vibration levels, so vibration control is advisablein nearly all cases. For this reason, in present exist recearch with the object of to decrease and eliminate the shocks and vibration from the technological equipment. These works present the model of the forging hammer like system with three degree of freedom excited with step function.

1. Introduction

The vibrations from the forging hammer are very harmful, so vibration control is advisable:
- if nearby residents must be protected against hammer vibration;
- if the soil has a limited bearing capacity;
- if furnace or other sensitive machinery and equipment in the shop or in the vicinity must be protected;
- if the effects of hammer vibration on people around the forge must be reduced;
- if neighboring buildings are in danger of being damaged by hammer vibration.

A forging hammer (fig. 1) has the next components:
- bed frame
- ram
- anvil block
- felt
- concrete foundation
- visco-elastic elements
- vat

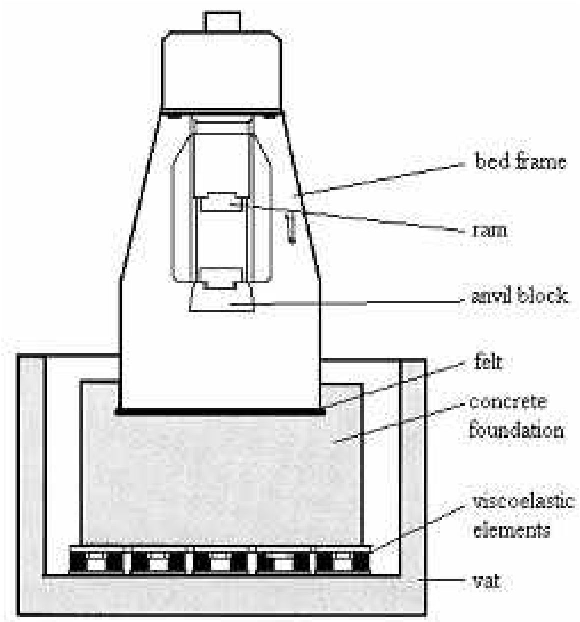

Fig. 1 The forging hammer

2. The physical-mathematical model

The forging hammers can be modeling like a system with two degree of freedom or system with three degree of freedom. The model with three degree of freedom is much closer to real behavior of forging hammers.

In fig. 2 is presented a model with three degree of freedom:
m_1 – mass of the anvil block;
m_2 – mass of the concrete foundation;
m_3 – mass of the vat;
k_1 – rigidity of the felt;
k_2 – rigidity of the visco-elastic elements;
k_3 – rigidity of the soil;
c_1 – damping constant of the felt;
c_2 - damping constant of the visco-elastic elements;
c_3 - damping constant of the of the soil;
F(t) – step force.

The step signal (fig. 3) represents the movement of the ram, with all it characteristic.

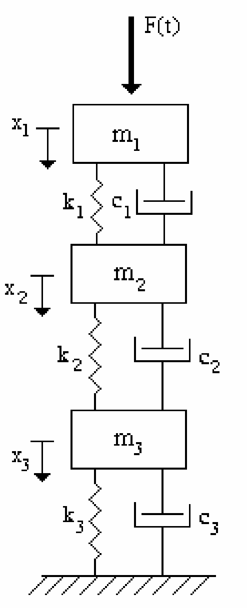

Fig. 2 Physical model of the forging hammer

The mathematical expression of the step function F(t) is:

$$F(t)=\begin{cases} H=2\cdot 10^{6} & \frac{2k\pi-\varphi}{\omega}\le t<\frac{2k\pi+\varphi}{\omega} \\ 0 & \frac{2k\pi+\varphi}{\omega}\le t<\frac{2(k+1)\pi-\varphi}{\omega} \end{cases} \quad k\in Z$$

The transformed Fourier of the step function is:

$$F(t)=\frac{2H}{\pi}\left[\frac{\varphi}{2}+\sum_{i=1}^{\infty}\frac{1}{i}\sin i\varphi\cos i\omega t\right]$$

These transformed although have three hundred of terms he is an approximation (fig. 4). The approximation has not a influence towards system behavior.

The equations of movement can be written:

$$\begin{cases} m_1\ddot{x}_1+c_1(\dot{x}_1-\dot{x}_2)+k_1(x_1-x_2)=F(t) \\ m_2\ddot{x}_2+c_1(\dot{x}_2-\dot{x}_1)+c_2(\dot{x}_2-\dot{x}_3)+ \\ \quad +k_1(x_2-x_1)+k_2(x_2-x_3)=0 \\ m_3\ddot{x}_3+c_2(\dot{x}_3-\dot{x}_2)+c_3\dot{x}_3+ \\ \quad k_2(x_3-x_2)+k_3x_3=0 \end{cases}$$

This equation system is resolved with the Runge Kutta method in the MATLAB program. For the real case the parameters have next numerical value.

m_1=16t; m_2=194t; m_3=100t;
$k_1=24\cdot10^8$ N/m; $k_2=25\cdot10^8$ N/m; $k_3=30\cdot10^8$ N/m;
$c_1=85\cdot10^5$ Ns/m; $c_2=90\cdot10^5$ Ns/m; $c_3=100\cdot10^5$ Ns/m;
φ=0.3; ω=15rad/s;

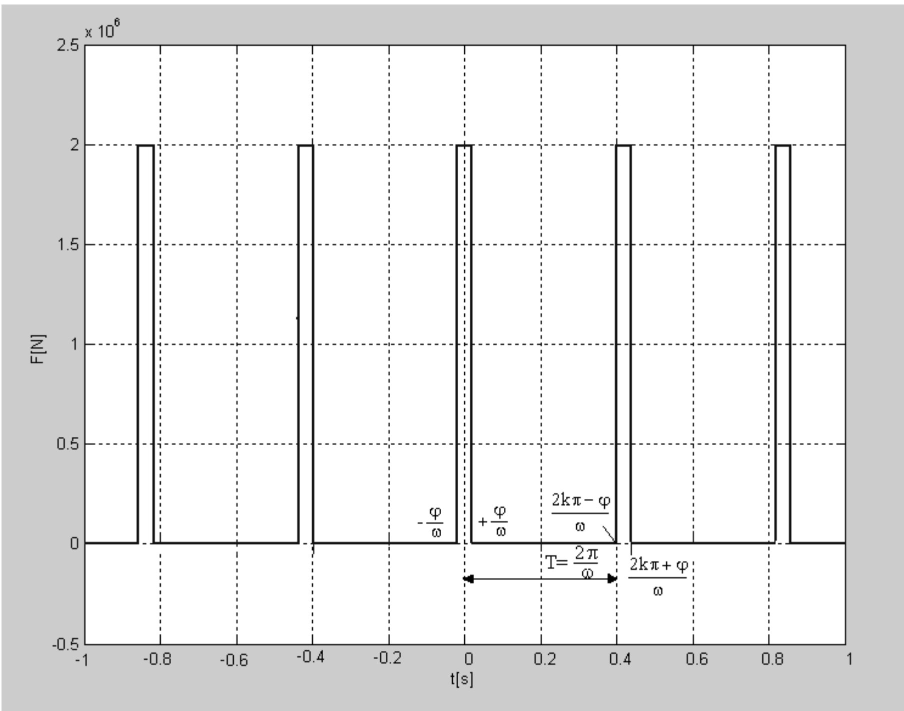

Fig. 3 The step signal

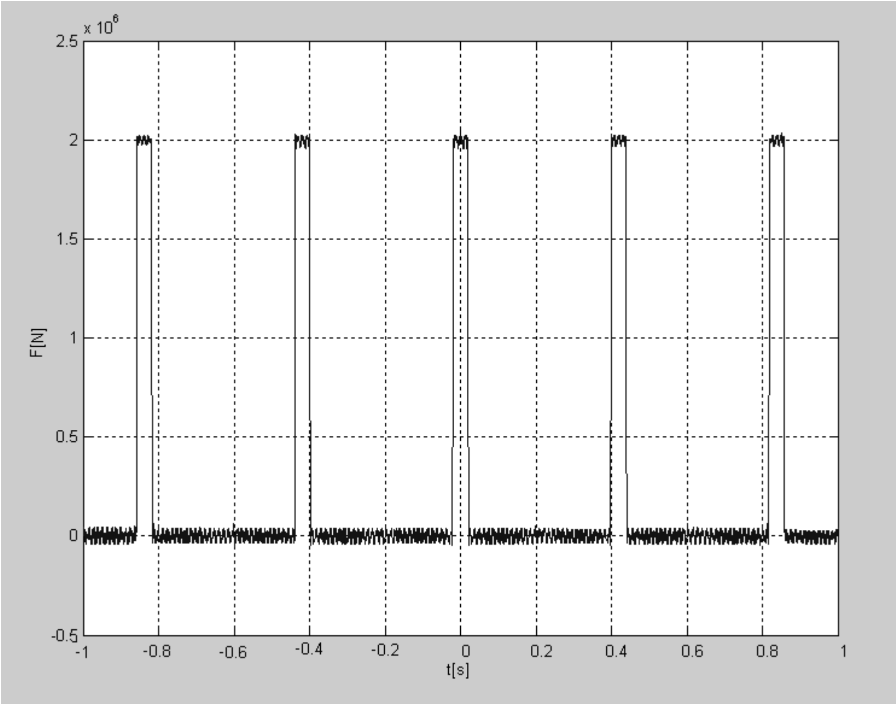

Fig. 4 The step signal in Fourier approximation

3. Obtained results

The movement in time of the mass m_1 is represented in fig. 5. The maximum value of this parameter is 3.2mm. For representation the step function has been translate on Ox axis, because in the zero point function have incomplete step.

In the fig.6 and fig.7 are presents movement of concrete foundations and movement of vats.

The amplitudes of foundation (maximum value 2.5mm) and vat (maximum value 1.2mm) are smaller than anvil amplitude. The movement of the vat is very important because transmissibility is dependent on her.

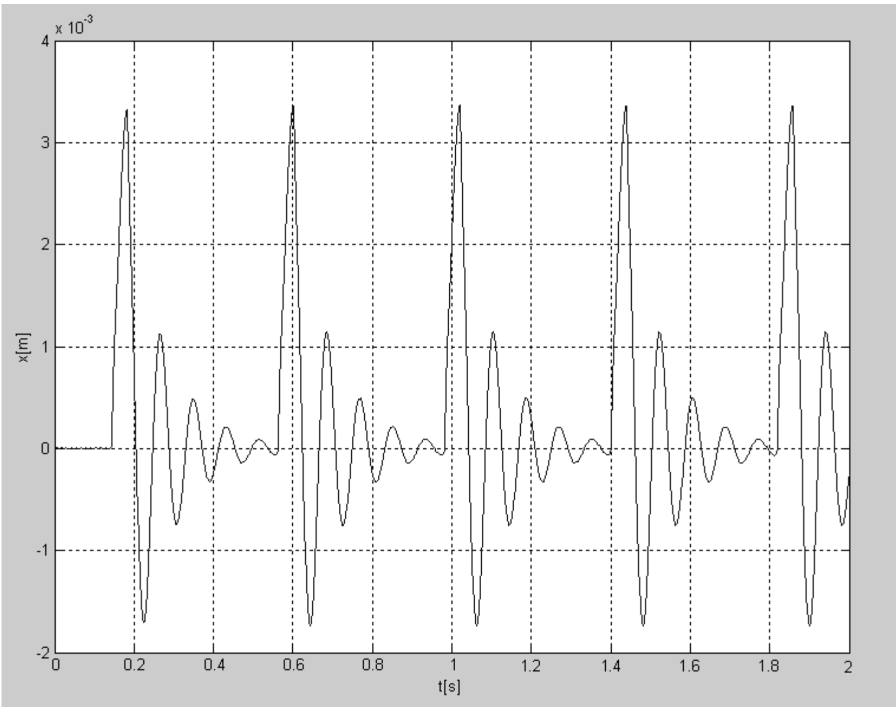

Fig. 5 The movement of mass m_1 – anvil block

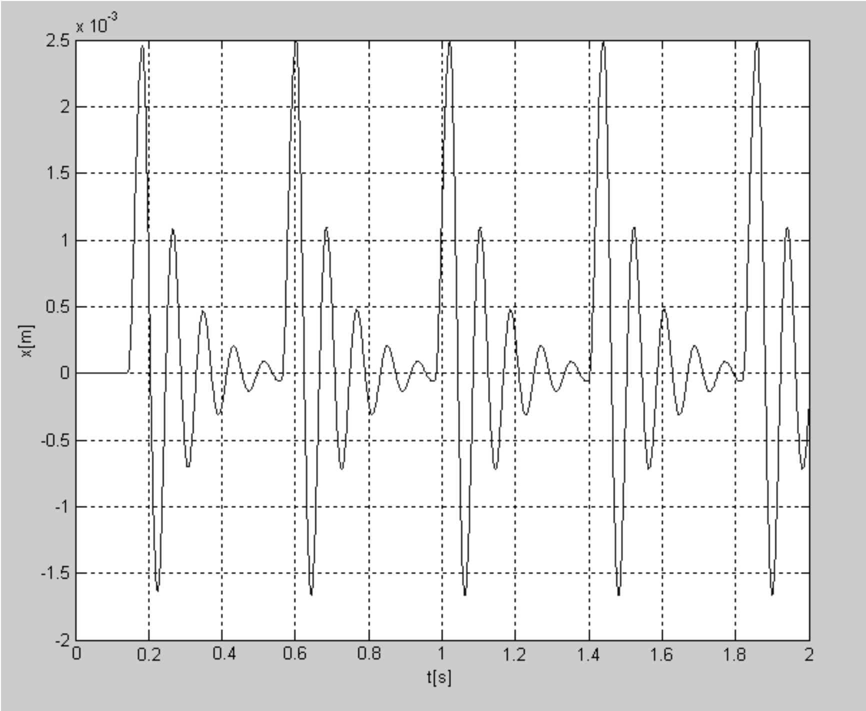

Fig. 6 The movement of mass m_2 – concrete foundation

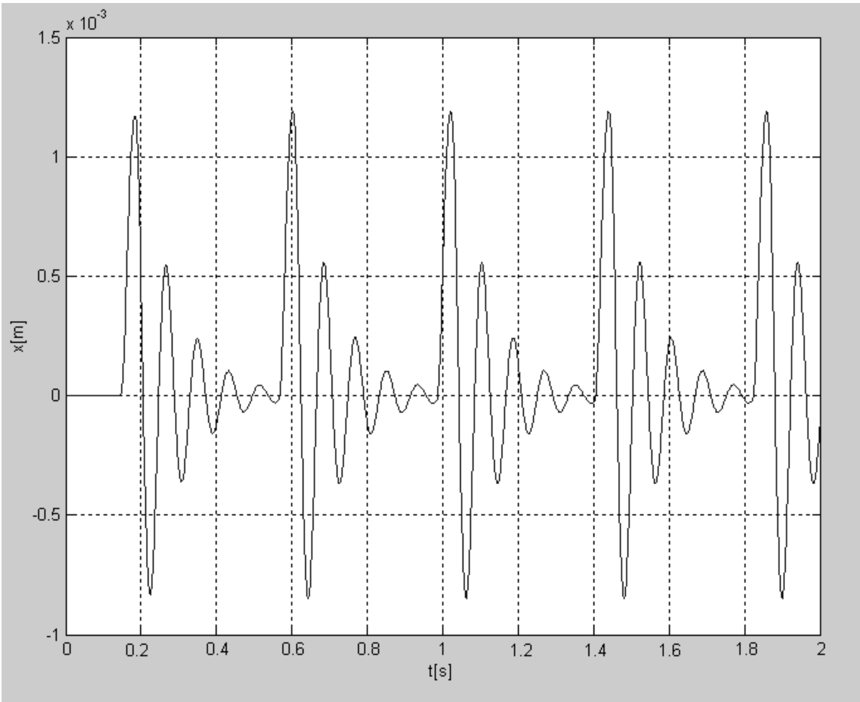

Fig. 7 The movement of mass m_3 –vat

4. Conclusions

This dynamical model of the forging hammer makes possible the calculus of the most important parameter on system: movements, speeds, and accelerations. In this way can be evaluate the functional parameters of the felt and visco-elastic elements.

This model can be amending through introducing excited force with other expression.

5. References

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