

EXPERIMENT VERIFICATION REGARDING TO THE STABILITY STUDY OF MOVING MADE BY AN ELECTROMAGNETIC VIBRATOR

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Abstract: In this paper is studied the stability of moves produced by an electromagnetic vibrator using the Matlab software. Used dates for Matlab simulation have been obtained for an acceleration sensor. For an electromagnetic vibrator we study the periodic moves of electromagnetic system, consider the linear magnetic circuit, but take into account the dependence of electromagnetic force with variation of between irons. Write the differential equations of electromagnetic system and after the resolve of this, with help of algorithm wrote in program Matlab.

1. INTRODUCTION

The mechanical vibropercutor systems are much more study while the electromagnetic vibrators there isn't enough study from theoretic point of view. In the work of specialty, the study is made in the theory that the force developed by the electromagnet not depends by variation of between irons. This theory is valid just in the case of very small amplitudes and in this case the force of excitation has a constant component and a harmonic component, which has the frequency equal with double frequency of power tension. One of the methods to reduce the frequency of the force is to power the electromagnet from rectifier. For obtain results very close of reality in study of the electromagnetic vibrators is necessary to take in consideration about the fact that we have to do with electromagnetic systems and must leave from the equations who describe the behavior of all system.

2. DETERMINATION OF MOVE EQUATION

We studied the periodic moves in theory that the magnetic circuit of electromagnet is linear, but take account about the dependence of electromagnet force with the variation of between irons. (Fig. 1).

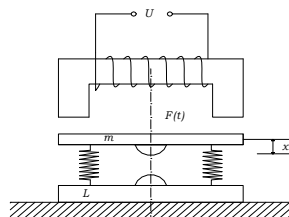


Fig. 1. Electromagnetic vibrator

For to stable the differential equations that describe the behavior of integer electromagnetic system, was used the equations of Lagrange:

$$m\ddot{x} + k(x_0 + x) = -mg + \frac{1}{2} \frac{\partial L}{\partial x} i^2 \quad (1)$$

$$\frac{d}{dt}(Li) + ri = U_0 \sin \omega \cdot t \quad (2)$$

The system of equation obtained is nonlinear, his exact resolve isn't possible, we analyzing the case when the ohmic resistance of electromagnetic coil is negligible [$r = 0$].

In this case from equation (2), from integration will obtain

$$\frac{i}{y} = \frac{2U_0}{\mu_0 A_y w^2 \omega} (-\cos \omega \cdot t + C) \quad (3)$$

The current trough coil is rectified. We will take like origin of time ($t = 0$) begin of a semi period in who the tension start to rice up. In this moment, the electric current i in coil is null. So, for integrate constant obtain the value $C = 1$. In consequence, will have

$$\frac{i}{y} = \frac{2U_0}{\mu_0 A_y w^2 \omega} (1 - \cos \omega \cdot t), \quad (4)$$

And the expression of force F became:

$$F = \frac{1}{2} \frac{\partial L}{\partial x} i^2 = \frac{1}{4} \mu_0 w^2 A_y \left(\frac{i}{y} \right)^2 = F_0 (3 - 4 \cos \omega \cdot t + \cos 2\omega \cdot t), \quad (5)$$

Where $F_0 = \frac{U_0}{2\mu_0 w^2 A_y \omega^2}$.

Can be seeing from (5) like the force has a constant component and two harmonic components from which one has the pulsation of power tension.

Introducing the force F from (5) in differential equation (1), will obtain:

$$m\ddot{x} + kx = -kx_0 - mg + F_0 (3 - 4 \cos \omega \cdot t + \cos 2\omega \cdot t) \quad (6)$$

For the resolve of this differential equations in study [5] has passage to a form with adimension measures who will define the law of movement and the speed:

$$\begin{aligned} z = & -(p + \frac{4\eta^2}{1-\eta^2} \cos \tau_i + \frac{\eta^2}{\eta^2-4} \cos 2\tau_i) \cdot \cos \eta(\tau - \tau_i) + \frac{1}{\eta} (Ru_i + \\ & + \frac{4\eta^2}{1-\eta^2} \sin \tau_i + \frac{2\eta^2}{\eta^2-4} \sin 2\tau_i) \cdot \sin \eta(\tau - \tau_i) + p + \frac{4\eta^2}{1-\eta^2} \cos \tau + \frac{\eta^2}{\eta^2-4} \cos 2\tau \end{aligned} \quad (7)$$

$$\begin{aligned} \dot{z} = & \eta(p + \frac{4\eta^2}{1-\eta^2} \cos \tau_i + \frac{\eta^2}{\eta^2-4} \cos 2\tau_i) \cdot \sin \eta(\tau - \tau_i) + (Ru_i + \\ & + \frac{4\eta^2}{1-\eta^2} \sin \tau_i + \frac{2\eta^2}{\eta^2-4} \sin 2\tau_i) \cdot \cos \eta(\tau - \tau_i) - \frac{4\eta^2}{1-\eta^2} \sin \tau - \frac{2\eta^2}{\eta^2-4} \sin 2\tau \end{aligned}$$

resolve so the obtain system, result

$$p + \frac{4\eta^2}{1-\eta^2} \cos \tau_i + \frac{\eta^2}{\eta^2-4} \cos 2\tau_i = -2\eta \frac{1+R}{1-R} \cot g \pi \eta (\frac{2}{1-\eta^2} \sin \tau_i + \frac{1}{\eta^2-4} \sin 2\tau_i) \quad (8)$$

$$u_i = \frac{4\eta^2}{1-R} (\frac{2}{1-\eta^2} \sin \tau_i + \frac{1}{\eta^2-4} \sin 2\tau_i). \quad (9)$$

The first equation determine the moment of impact, and from second equation result the speed of impact in function of τ_i .

3. THE STUDY OF STABILITY OF PERIODIC MOVES

For to determine the values of parameters system for who corresponded the stable periodic moves, it be proceed so: Give values to the parameters k_1 , R , and n , equation (8) will determine p in function of τ_j . The function $p = p(\tau_j)$ is periodic with period 2π .

The graph represent of the three curves has been realize with the help of an algorithm wrote in the software Matlab 6.5.

As a result of roll over the computer of the program will result the graphs under the forms of those further on:

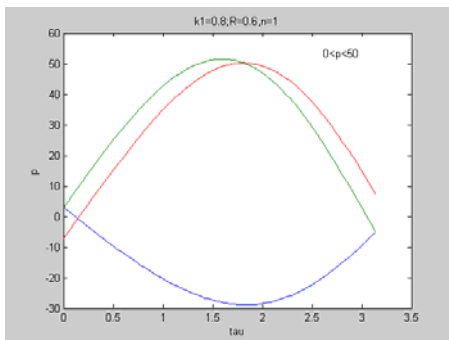


Fig. 2

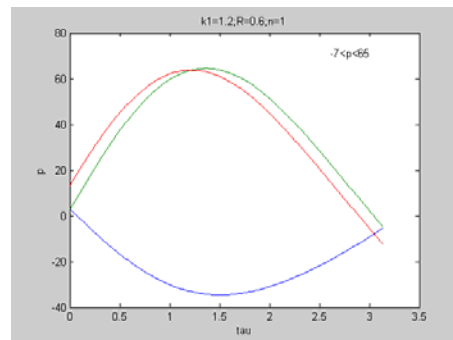


Fig. 3

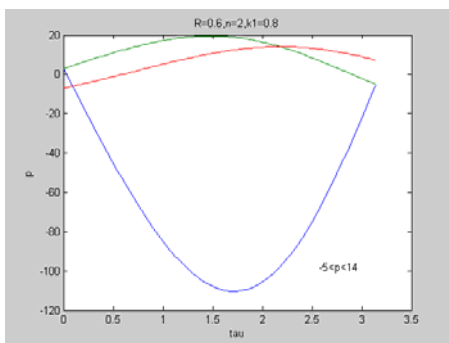


Fig. 4

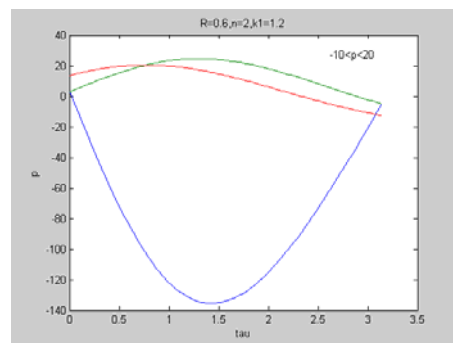


Fig. 5

The domains of instabilities are in the exterior of the curves. From this diagrams result that for a construction give just for some values of the parameter p can appear periodic moves stabile. So, in the case $k_1 = 0,8$; $R = 0,6$; $n = 1$ we must have $0 < p < 50$, and in the case $k_1 = 1,2$; $R = 0,6$; $n = 1$, $-7 < p < 65$.

4. EXPERIMENTAL TEST

For the verification and completion the theoretic results we made experimental tests over an electromagnetic vibrator by type VEM 1. The vibrator over was made the measures is give in figure 6.



Fig. 6. VEM 1 – lateral view

The experimental test was realized for next values of alimentation voltage: 40V, 55V, 62 V, 73V, 84V, 92V, 100V, 110V and 120V. These values cover in totality the domain of variation of alimentation voltage for vibrator.

For each experiment was visualize the signal form give by the translator of acceleration with an electronic oscilloscope, and with help from board of acquisition, set for record a number by 3254 values to a capture, has been storage and save the dates in a text file.

With the help of an algorithm wrote in Matlab has design the curves corresponding with values of accelerates measure with translator of acceleration, and for designer the curve of speed respective the amplitude of vibrations has made in the program of calculus the integration of measure values of acceleration.

The algorithm wrote in Matlab is give here:

```
fopen('H:\Doc\Capturi\capture17.txt','r');
x1 = fscanf(3,'%x');
fclose(3);
x1=x1(1:3254);
t=1:length(x1);
x1=x1-mean(x1);
n1=length(x1);
x2=10*cumsum(x1)./n1;
x2=x2-mean(x2);
x3=10*cumsum(x2)./n1;
plot(t,x1,'r',t,x2,'b',t,x3,'g')
```

In the finally of use the program for every done measure was been obtained the next graphs in terms of voltage:

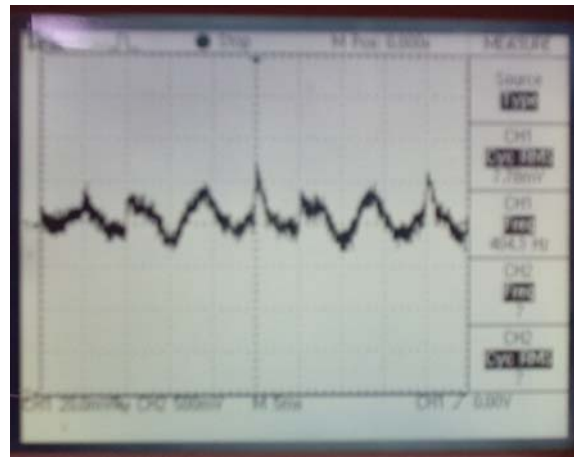
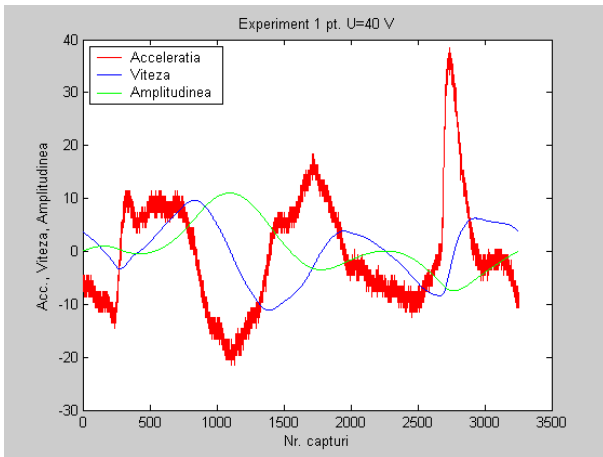


Fig. 7

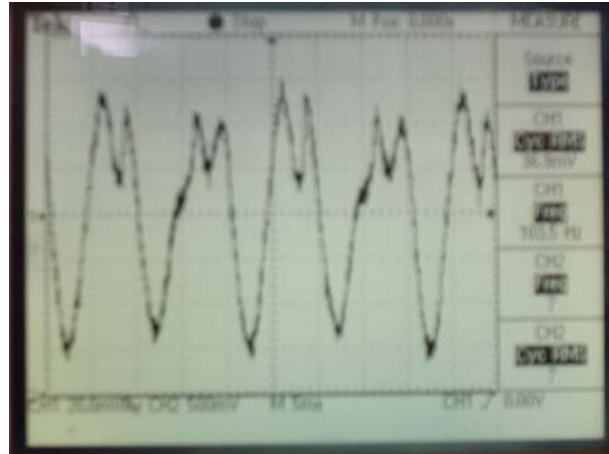
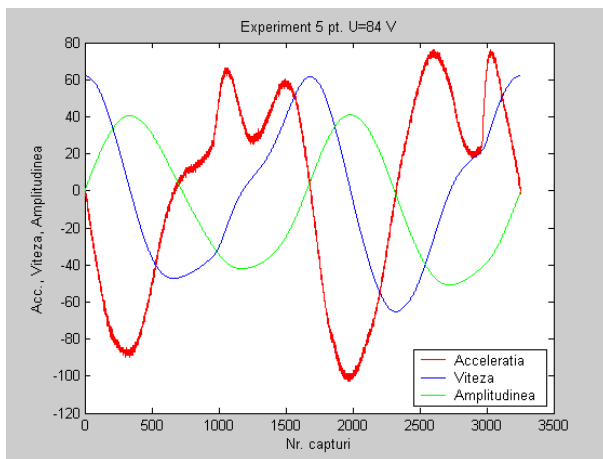


Fig. 8

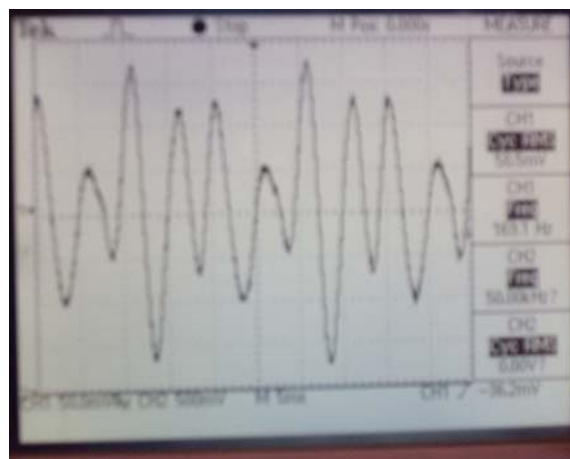
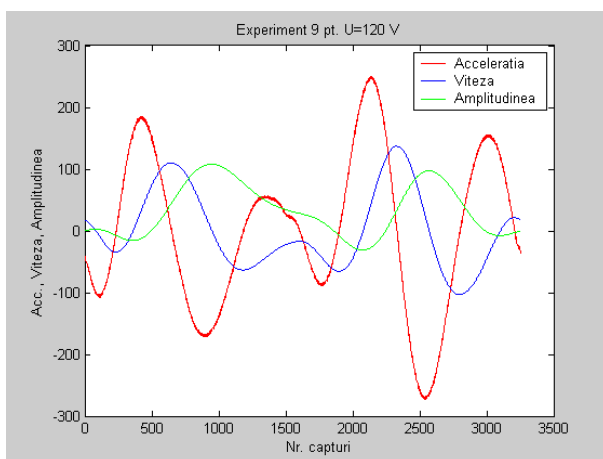


Fig. 9

For check up the stability of periodic moves and theoretic results, with the help of experimental results has draw for each experiment the trajectory by phase. Below we reproduce four cases, two corresponding to the minim and maxim values of the supply voltage (experiment 1 and 9) for vibrator and other two for function of vibrator on intermediate values of voltage (experiment 5 and 7).

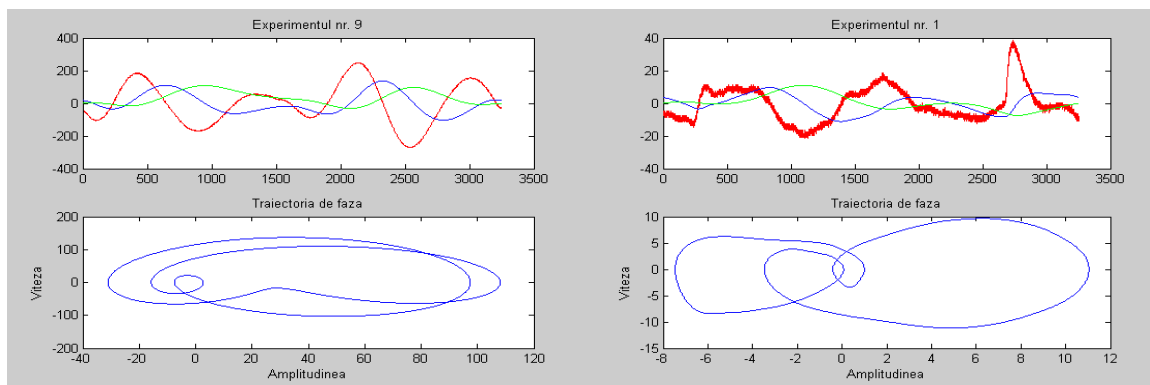


Fig.10

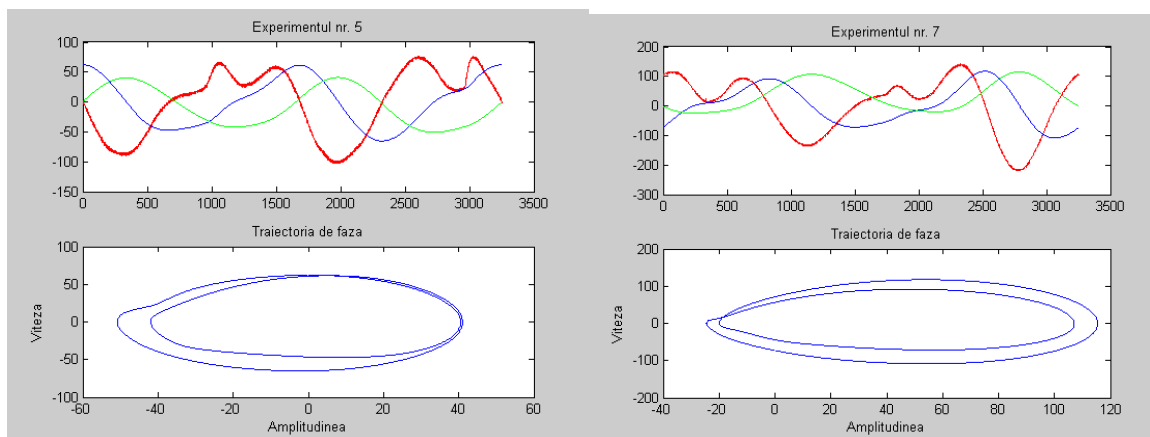


Fig. 11

5. CONCLUSION

From the analysis of these diagrams result that once with grown of alimentation voltage appears a modification of move amplitude generate by electromagnetic vibrator.

Also, with help of experimental results has traced the phase trajectories who return more quickly the move stability and the amplitude values from each experiment in part.

It has observed that for experiments 1 and 9 the move isn't stable, these being to the extremities of voltage domain applied to the head of action VEM 1. For the other experiments has result stable moves how appears from graphics.

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