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LINEAR HAND-ARM SYSTEM STABILITY

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Abstract: The paper presents a study regarding a simplify method of system hand-arm analyzing. In this scope, it was studied the stability of the linear hand-arm system. The results demonstrated that linear hand-arm system is stable of point of view mechanical characteristics used in the system.
Keywords: linear, hand-arm system, stability of hand-arm system.

1. INTRODUCTION

The human extensive exposure of the mechanical vibrations could cause in time the grave injuries about health of persons, like sanguine, muscular or bone affections [3]. These affections have name in the medical terms “professional injuries” and they do not be treat, only improved it. For this scope the paper proposed to study a linear hand-arm system, respectively the stability of this, in the work place condition, respectively excitation source provide of the machine-tool.

It well known that the hand-arm system is a complex system, it having the complicate mechanical characteristics, respectively visco-elastically coefficients of the system, especially difficult of determinate for the joint. For these reasons, the paper analyzed a simplifying model, linear model of hand-arm system, that model does not use the joint visco-elastically coefficients. And the paper analyzes the stability for such system.

2. SYMPLIFING MODEL REGARDING HAND-ARM SYSTEM

The figure 1 presents the vibrations transmissibility of the hand – arm system, in conformity with standard named SR EN 5349/2001 [6, 7]. In the figure 1, z axis represents the vibrations transmissibility along of the hand-arm system, the y axis represents the vibrations transmissibility from the right to left of the hand - arm system, and finally the x axis represents the up to down of hand-arm system direction of vibrations transmissibility.

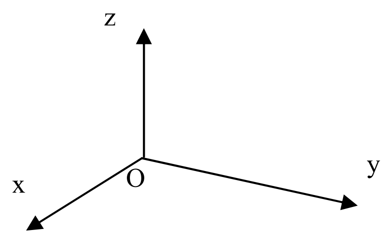

Fig. 1 The directions of vibration transmissibility to hand-arm system, in conformity with ISO 5349/2001.

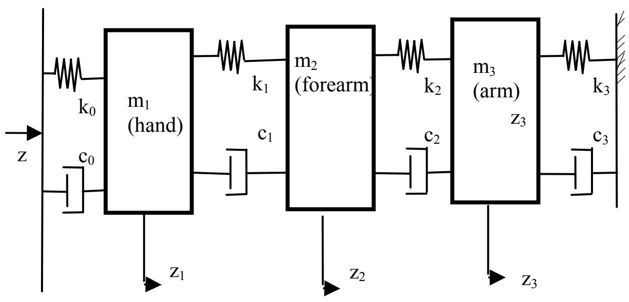

Fig. 2 Linear hand-arm system.

The figure 2 represents a simplifying model of the hand-arm system, respectively a linear model having three degrees freedom [1, 2, 5]. For these studies, it were analyzed only *z* axis the vibration transmissibility, along of the hand-arm system, respectively to shoulder joint. In this figure the z_1 represents the vibration transmissibility of the hand, z_2 to the forearm and z_3 to the arm direction.

The mechanical characteristic, respectively visco-elastically coefficients (c_i and k_i, i = 0, 1, 2, 3) were taking of the specialty literature, and the anthropometrically characteristics were determinates in the other studies that, do not make object of this paper.

The relation (1) represents the dynamical, differential equations system of second order, that characterized the model of hand-arm system presented in the figure 2.

$$\begin{aligned} &m_1\ddot{z}_1+(c_0+c_1)\dot{z}_1+(k_0+k_1)z_1-c_1\dot{z}_2-k_1z_2=z_0(c_0\omega\cos\omega t+k_0\sin\omega t)\\ &m_2\ddot{z}_2+(c_1+c_2)\dot{z}_2+(k_1+k_2)z_2-c_1\dot{z}_1-k_1z_1-c_2\dot{z}_3-k_2z_3=0\\ &m_3\ddot{z}_3+(c_2+c_3)\dot{z}_3+(k_2+k_3)z_3-c_2\dot{z}_2-k_2z_2=0 \end{aligned} \quad (1)$$

In the relation (1) the excitation representation in the figure 2 with *z*, calculated for the 400 rpm (rotation per minute), represents a harmonically signal, respectively:

$$z = z_0(c_0\omega\cos\omega t + k_0\sin\omega t) \quad (2)$$

3. THE STABILITY OF THE HAND-ARM SYSTEM

This paper analyses of the hand-arm system stability, respectively stability of the model presented in the figure 2. In this scope it removed the generalized coordinates (z_i, i= 1, 2, 3) with the variables ae^{rt}, be^{rt} and ce^{rt}. Solve the characteristic determinant, that results of the equations system given by relation (1), it obtained *r* roots.

It observed that system have six real and complex roots, but all of these have the real part of root negative. The complex parts, respectively ± 527.056 and ± 692.855 represent the owner pulsations (ω) of the system, measured in Hertz. For these values is well to avoided the excitation sources in the system, because in the other way appear the resonance phenomena. This fact represents that the system is stable or is to stable limits.

$r_{1,2} = -416.268 \pm 527.056i$
$r_{3,4} = -344.878 \pm 692.855i$
$r_5 = -223.278$
$r_6 = - 13.255$

4. STABLE GRAPHICAL REPRESENTATIONS

In the figures 3, 4 and 5 are represent the stability of linear hand-arm system, respectively the stability for hand given by generalized coordinate z_1, for the forearm given by generalized coordinate z_2 and finally the generalized coordinates z_3 corresponding to the arm.

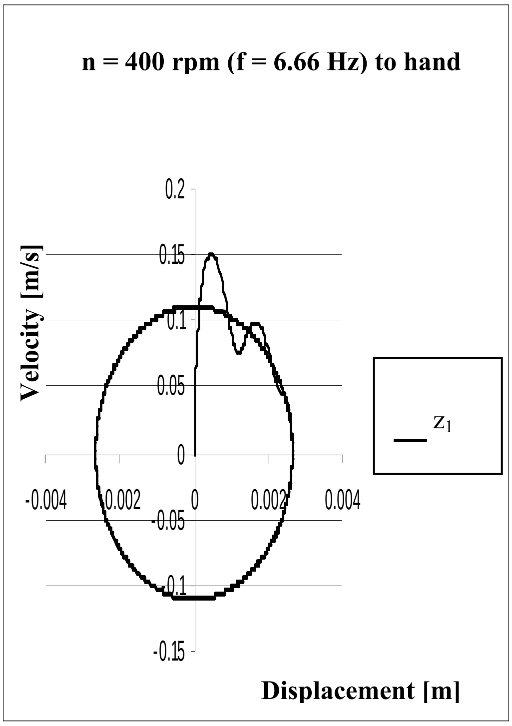

Fig. 3 Stability of the hand.

The figures 3, 4 and 5 have represented the displacement of the *x* axis values; they resulted of the double integrations of the system given by relation (1). Also the velocities after *z* axis, they result after the same equation system (1), of the first integration.

The figure 3 represents the stability of the hand, after model of the figure 2. It can observe that the displacement values have the small dimension of the millimeters order, that is very well, and the graphic after a short transition movement were stabilization.

The figure 4 represents the stability of the forearm, after the same model of the figure 2. It can observe that the displacement values have the small dimension of the millimeters order too, like in the figure 3, that is very well, and the graphic after a short transition movement were stabilization too.

The figure 5 represents the stability of arm, after model of the figure 2. It can observe too, that the displacement values have the small dimension of the millimeters order, and the graphic after a short transition movement was stabilization.

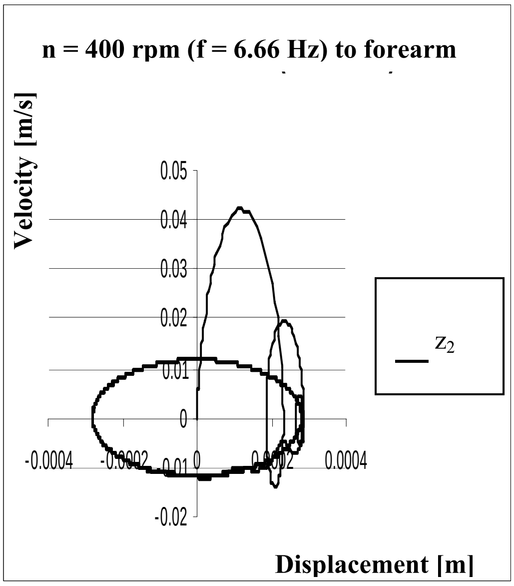

Fig. 4 Stability of the forearm.

The figures 3, 4 and 5, in comparison, it can observe that the displacement values are decreasing from z_1 – hand (0.003 mm) to z_3 – arm (0.00001 mm), that is very well, because the vibration transmissibility from the excitation source (of the hand) till arm (shoulder joint) for the linear model of the hand-arm system were decreasing, arrived of the values very small (1×10^{-4} mm). It can observe, in comparison with the figure 3 and 5 that only the transition movement for the forearm is the bigger, but finally this was stabilization.

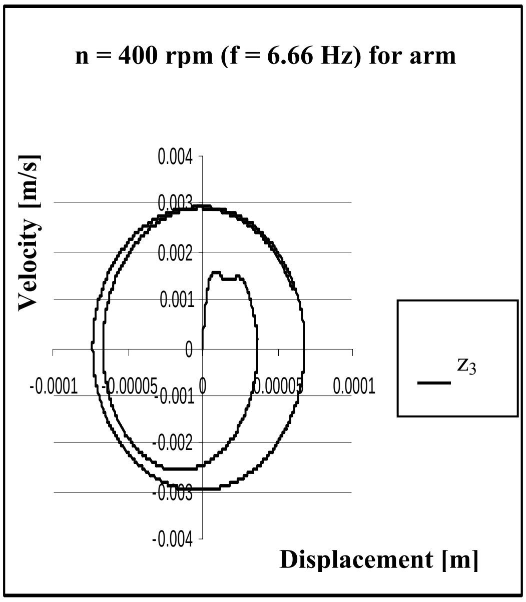

Fig. 5 Stability of the arm.

5. CONCLUSIONS

The paper wished to present a method of the stabilization a model of the hand – arm system. This is a very simplifying model, but it demonstrated that using the mechanical characteristics known of the specialty literature, and solved analyzing system, this was keeping the stabilization movement [4].

In the future of the study, the author wishes to complicate the hand-arm model till the nonlinear model and analyzing this fact, probably with the other mechanical characteristics, determinate in laboratory.

A sure stability regarding the hand-arm system, it could reduce the professional illness that appears, having reason the strong transmissibility vibration in the work place by the hand-arm system. Professional affection like a Vibration White Finger named (VWF) or the other bones or muscular affections that could appear to hand-arm system at the work place, when the person exposure of vibration is prolonged in time.

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Stabilitatea sistemului linear mână-braț

Rezumat: Lucrare prezintă un studiu privind analiza unui sistem simplificat al sistemului mână-braț, respectiv un sistem linear. In acest scop, s-a studiat stabilitatea acestui sistem linear al mâinii şi al brațului. Rezultatele obținute au demonstrat că sitemul propus în studiu este stabil şi din punctul de vedere al caracteristicilor mecanice utilizate pentru rezilvarea acestuia.

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