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New Mechanical Development's to the Hand-Arm System

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***Abstract* — The paper wants to bring into attention the new contributions to the development of the dynamics of the human hand-arm system at seven degrees of freedom. For this purpose are contributors to shaping the mechanics of hand-arm system subjected, exposure of excitation due to vibrating tools (drill) by analyzing the motions of their components.**

We are interested in the action of mechanical system vibrations transmission after the direction of Oz (over the arm) and the possibility that these dose of vibrations, it could be to produce disease.

***Index Terms* — displacements, hand-arm system, vibration**

I. INTRODUCTION

The papers in the field [1-8], [10] reveal various mathematical modeling of the hand-arm system, in particular to adapt them to the robot series systems.

All papers regarding to the hand-arm system analyses through the introduction of the simplifying assumptions e.g., reducing their movement to five degrees of freedom, they are considered a linear joint, its neglect some mechanical characteristics, its make research on particular cases of arm position etc.

This paper brings contributions regarding this aspect, by choosing a mechanic and its treatment as model mathematics, with a very similar model real hand-arm and the introduction of a total of seven degrees of freedom in its analysis.

II. THEORETICAL RESEARCH

A. Mechanical model study

The final model choice mechanic hand-arm system is concertized through its simplify model (Fig. 1) and explaining its initial conditions of motion, as well as choice or determination of the mechanical components of stiffness and damping, as well as those of the anthropometrical parameters. It is believed the use of drills, whose frequent use is made at frequency f = 2500 Hz. It is considering the study with the subject in the vertical position after to the main transmission of vibrations, zh = z-axis (Fig.1) in accordance with the anatomical standards, they are contained in the ISO 5349 /1/2/2001 regarding hand-arm transmission of vibrations [7-9]. There is believed caused by excitation force drill on the wrist and is given by the relation (1).

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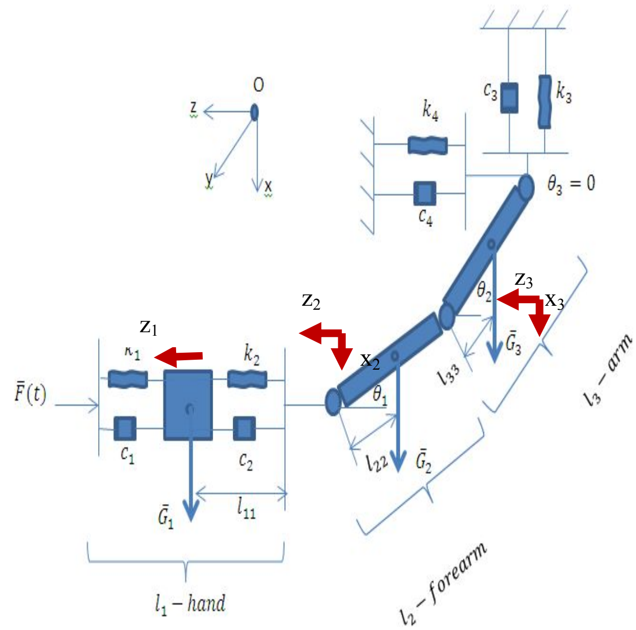


Fig.1 Mechanical model of the hand-arm system.

$$F(t) = z_0(c_0\omega\cos(\omega t) + k_0\sin(\omega t)) \quad (1)$$

where the mechanical characteristics are presented in the table II, and initial hand displacement notated z_0=0.04 mm (this is evaluates of the primary measurements and the considered ω pulsation is:

$$\omega = 2\pi f \quad (2)$$

The subjects taken into study are a group of fifteen men of average stature and age between 40-50 years.

While driving the gear (60 mm diameter) is using 2 hours with brief pause of 2 minute and the fundraising force considered to be 25 N.

Of course, like as simplifying hypothesis in the paper they are considered:

- It neglects the shoulder rotation θ_3=0;
- The hand mass is considering the concentrate in the mass center ($\overline{G_1}$), the forearm and arm are consideration with the distributed masses in the all volume;
- In this study is considering the elbow and wrist rotation of θ_2=90˚ and θ_1= 30˚;
- The fix of the shoulder joint is considering mechanical flush.

B. Mechanical and anthropometrical characteristics

For determining the mechanical properties were addressed notions of mechanical and electrical impedance dates, measured of the components elements of the hand-arm system, and its do not make study of this paper [12-13], [16].

Anthropometrical components namely masses and lengths of the hand, arm and forearm were determined using the notions of spatial geometry for determining the position of the centers of gravity of the component elements of the hand-arm system. The basics of biomechanics dates are determination using medical data from experiments on cadaver provided by medical institutions. All these values anthropometrical and mechanical properties have resulted in table I and table II.

Table I – Anthropometrical parameters of the hand-arm system.

m_1=0.5 kg	l_{11}= 0.092 m	l_1= 0.200 m
m_2= 1.25 kg	l_{22}= 0.185 m	l_2= 0.315m
m_3=2 kg	l_{33}=0.298 m	l_3= 0.355 m

And the moments of inertia mechanical axial reported at the centers of gravity of the forearm and arm, its labeled J_1 and J_2 are considered to be articulated like as rigid beams.

J_2=0.00647 kgm^2; J_3=0.0140 kgm^2.

Table II – Mechanical parameters of the hand-arm system.

N/m	Nm/rad	Ns/m	Nms/rad
k_0=155800	k_{t1}=1.8	c_0=300	c_{t1}=5.2
k_1=155800	k_{t2}=2	c_1=300	c_{t3}=6.14
k_2=23600	k_{t3}=2	c_2=202.8	c_{t2}=4.9
k_3=415400		c_3=164.6	
k_4=5025		c_4=50	

In the table II the parameters are represented:

k_i (i=0,4) – longitudinal elasticity parameter regarding the hand-arm system (k_0 – palm; k_1, k_2 – hand; k_3, k_4 - arm);

k_{ti} (i=1,3) – torsional elasticity parameter regarding the wrist, elbow and shoulder;

c_i (i=0,4) – dumping parameter regarding components of hand-arm systems (c_0 –palm; c_1, c_2 – hand; c_3, c_4 - arm);

c_{ti} (i=1,3) – dumping torsional parameter regarding wrist, elbow and shoulder;

The motions to hand-arm system, giving them the number of degrees of motion, are considered z_i (i = 1,3), x_i (i = 2,3) and rotation after y_2 and y_3 axis.

C. Mathematical model

Taking into account the mechanical model presented in the Fig.1 and applying fundamental laws of dynamics of kinematic torque theorem and impulsive theorem have written the explicit form of equations dynamical motions of hand-arm system presented in the Fig 1.

$$m_1\ddot{z}_1 + (c_1 + c_2)\dot{z}_1 + (k_1 + k_2)z_1 -$$

$$(c_1 + c_2)\dot{z}_2 \quad (k_1 + k_2)z_2 = F(t) \qquad (3)$$

$$m_2\ddot{z}_2 + c_2\dot{z}_2 + k_2z_2 - m_2l_2\sin(\theta_1)\ddot{\theta}_1 - \\ -m_2l_2\cos(\theta_1)\dot{\theta}_1^2 + k_2l_{22}\cos(\theta_1) - \\ -c_2l_{22}\sin(\theta_1)\dot{\theta}_1 - m_2g\sin(\theta_1) = 0 \qquad (4)$$

$$m_2\ddot{x}_2 + c_2\dot{x}_2 + k_2x_2 + m_2l_2\cos(\theta_1)\ddot{\theta}_1 + \\ +m_2l_2\sin(\theta_1)\dot{\theta}_1^2 - k_2l_{22}\sin(\theta_1) + \\ +c_2l_{22}\cos(\theta_1)\dot{\theta}_1 + m_2g\cos(\theta_1) = 0 \qquad (5)$$

$$m_3\ddot{z}_3 + c_3\dot{z}_3 + k_3z_3 - m_3l_3\sin(\theta_2)\ddot{\theta}_2 + \\ +m_3l_3\cos(\theta_2)\dot{\theta}_2^2 + k_3(l_3 - l_{33})\cos(\theta_1 + \theta_2) - \qquad (6) \\ -c_3(l_3 - l_{33})\sin(\theta_1 + \theta_2)\dot{\theta}_2 + m_3g\cos(\theta_1 + \theta_2) = 0$$

$$m_3\ddot{x}_3 + c_4\dot{x}_3 + k_4x_3 + m_3l_3\cos(\theta_2)\ddot{\theta}_2 - m_3l_3\sin(\theta_2)\dot{\theta}_2^2 + \\ +c_3(l_3 - l_{33})\cos(\theta_1 + \theta_2)\dot{\theta}_2 - k_3(l_3 - l_{33})\sin(\theta_1 + \theta_2) + \\ -m_3g\sin(\theta_1 + \theta_2) = 0 \qquad (7)$$

$$(J_2 + m_2l_2l_{22}\sin(\theta_1)\cos(\theta_1) - m_2l_2l_{22}\sin(\theta_1)\cos(\theta_1))\ddot{\theta}_1 -$$

$$-2m_2l_2l_{22}\sin(\theta_1)\cos(\theta_1)\dot{\theta}_1^2 + [-c_2l_{22}^2\sin(\theta_1)\cos(\theta_1) + c_{t1} + c_{t2})\dot{\theta}_1 +$$

$$+[-k_2l_{22}^2\sin^2(\theta_1) + k_{t1} + k_{t2})\theta_1 + m_2l_2\cos(\theta_1)\ddot{z}_2 +$$

$$+c_2l_{22}\cos(\theta_1)\dot{z}_2 + k_2l_{22}\cos(\theta_1)z_2 - m_2l_2\sin(\theta_1)\ddot{x}_2 -$$

$$-c_3l_{22}\sin(\theta_1)\dot{x}_2 - k_3l_{22}\sin(\theta_1)x_2 = 0 \qquad (8)$$

$$(J_3 + m_3l_3l_{33}\sin(\theta_2)\cos(\theta_2) - m_3l_3l_{33}\sin(\theta_2)\cos(\theta_2))\ddot{\theta}_2 -$$

$$-2m_3l_3l_{33}\sin(\theta_2)\cos(\theta_2)\dot{\theta}_2^2 +$$

$$+[-c_3l_{33}^2\sin(\theta_2)\cos(\theta_2) + c_4l_{33}^2\sin(\theta_2)\cos(\theta_2) + c_{t2} + c_{t3})\dot{\theta}_2 +$$

$$+[-k_3l_{33}^2\sin^2(\theta_2) + k_4l_{33}^2\cos^2(\theta_2) + k_{t2} + k_{t3})\theta_2 +$$

$$+m_3l_3\cos(\theta_2)\ddot{z}_3 + c_3l_{33}\cos(\theta_2)\dot{z}_3 + k_3l_{33}\cos(\theta_2)z_3 -$$

$$-m_3l_3\sin(\theta_2)\ddot{x}_3 - c_4l_{33}\sin(\theta_2)\dot{x}_3 - k_4l_{33}\sin(\theta_2)x_3 +$$

$$+2m_3(l_2 - l_{22})^2\cos(\theta_1 + \theta_2)\ddot{\theta}_1 - m_3(l_2 - l_{22})^2\sin(\theta_1 + \theta_2)\dot{\theta}_1 -$$

$$-c_{t1}\dot{\theta}_1 - k_{t2}\theta_1 = 0 \qquad (9)$$

The general matrix form regarding the relations (3)-(9) could be written:

$$[M]\left\{\frac{d^2U}{dt^2}\right\} + [C]\left\{\frac{dU}{dt}\right\} + [K]\{U\} = \{F\} \qquad (10)$$

where [M], [K], [C] are inertial matrix of the masses, dumping and elasticity of the hand-arm system, {F} – is the excitation force matrix having the (7x1) dimensions, and [U] represents matrix of the generalized coordinates of the hand-arm system, it notated $\{U\} = \{z_1, z_2, x_2, z_3, x_3, \theta_1, \theta_2\}$.

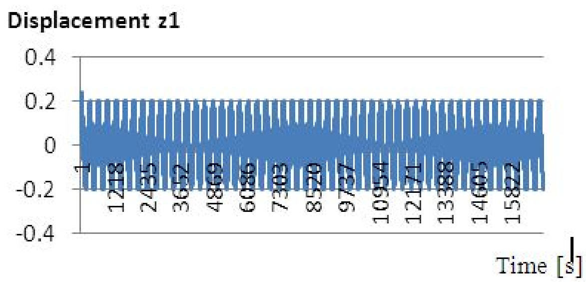
D. Theoretical results

The roots equations of motion given by relations (3) to (9) were obtained through a double integration method with

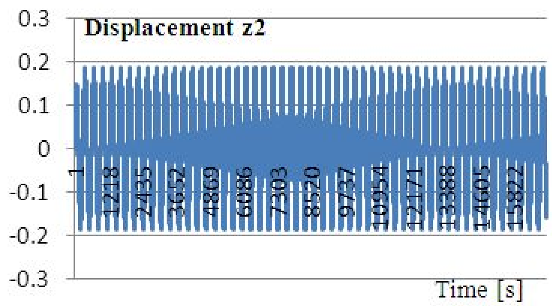
Runge-Kutta of order 4-5, it taking into account the initial conditions by Matlab (using ODE45) [5], [15].

There are double integration of generalized coordinates of movement resulted 14 linear or angular solutions, of which seven for velocities and seven for displacements of mobility's system.

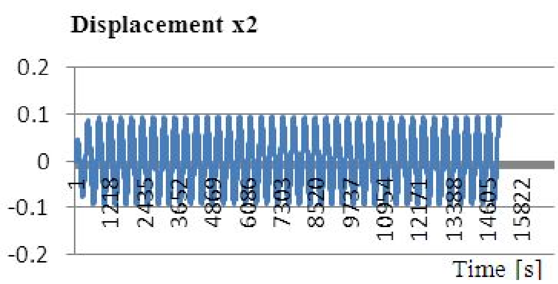
In the following it presents the graphs of linear and angular displacements resulting from excitation frequency of the drill of 2500 Hz and 5s for integration, but after 2s the motions are stabilized.



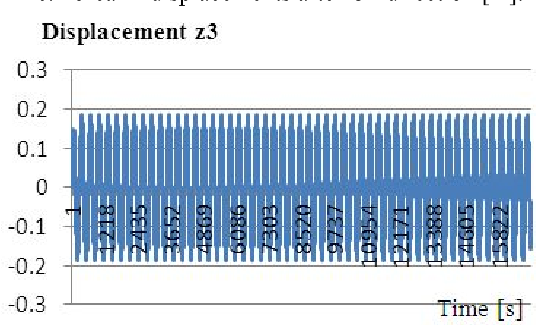
a. Hand displacements after Oz direction [m].



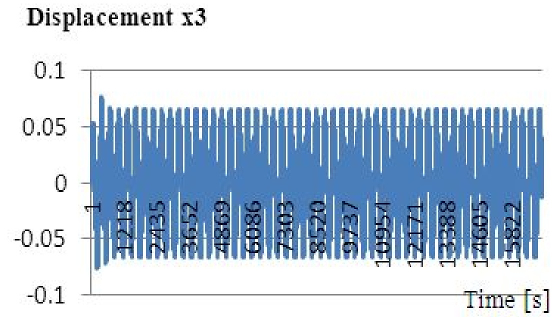
b. Forearm displacements after Oz direction [m].



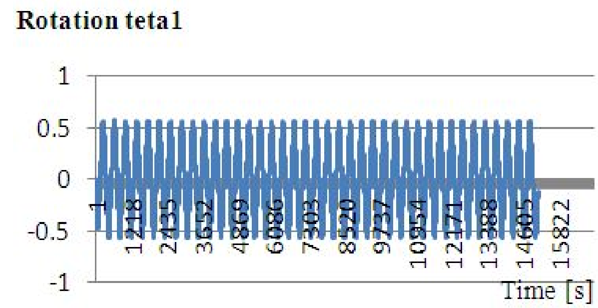
c. Forearm displacements after Ox direction [m].



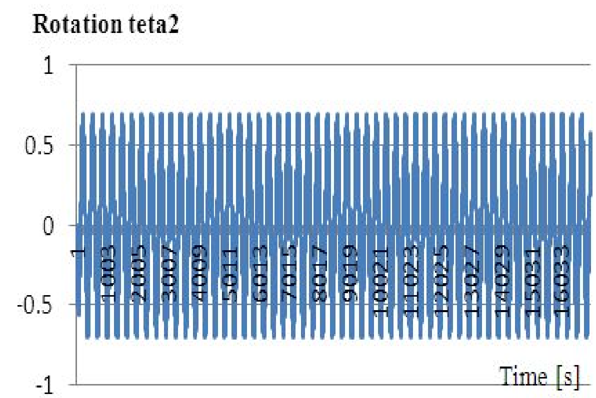
d. Arm displacements after Oz direction [m].



e. Arm displacements after Ox direction [m].



f. Forearm rotation after Oy direction (wrist joint) [rad].



g. Arm rotation after Oy direction (elbow joint) [rad].

Fig. 2 Theoretical solutions of the hand-arm system.

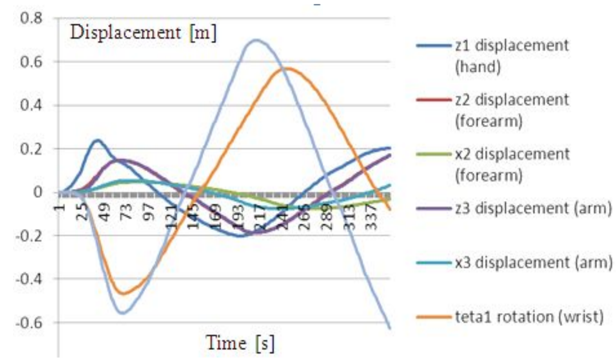
Figs. 2a-2g represents the linear and angular displacements of the hand-arm system for an excitation frequency of 2500 Hz, at a drill.

The harmonically forms is unstable as arousal even at the beginning of the movement, but it immediately stabilizer.

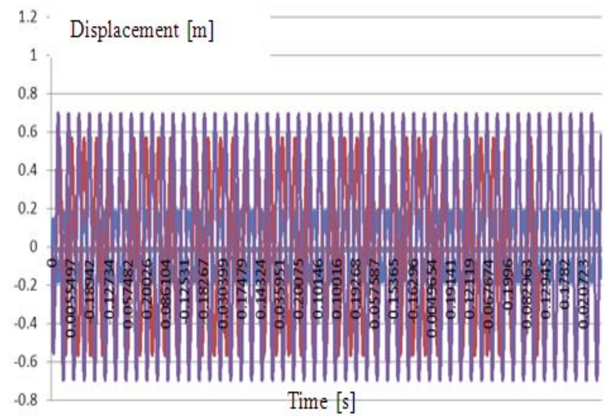
Note that the largest displacements of the hand-arm system are after Oz anatomical axis of the system such as, around to 0.002 m after the Oz, around 0.001 m after Ox direction and in the joints they are around value 0.6 rad.

These look like the vibrations from hand-arm in the Oz direction are diminishes through the system, which is only natural, but not significantly, because the long exposure (8 h) they affect system stability [7-8]. Thus the highs achieved in study, at hand are z_1 = 0.002 m at forearm z_2 = 0.0018 m keeping the range accord and to the arm (z_3) too.

It notes also, that rotations in the elbow are significant value, compared with the one in the wrist.



a.



b.

Fig.3 - a. zoom of 80% of Fig. 3b; b. Overlay theoretical results of the hand-arm system (displacements and rotations).

Fig. 3b presents a graphic overlay of the displacement's system elements hand-arm of the Fig.2a-2g, and Fig. 3a is a zoom of its, such movements for a total of 360 ranges from the 17000 integration intervals, whether to highlight how to stabilize the displacements on the hand-arm system elements and their characteristics to the starting of movement.

III. Experimental Results

A. Simulate modeling

In the order of simulation of movements defining the anatomical elements (hand, forearm, arm) of the hand-arm system, using the same simplifying conditions used as in the mechanical model from Fig.1, as the same mechanical parameters (viscous-elastic coefficients), masses, lengths, etc., one method developed in Simulink-SimMechanics [3-5], [15]. This way, the model (scheme) developed in SimMechanics it representing a hand-arm model Fig.4.

The results obtained by simulation of the hand-arm system displacements (linear and angular displacements) [5-7], [15], are graphically represented by Scope Blocks in SimMechanics. Respectively, for the hand (z_1) displacement, for the forearm (z_2, x_2) displacement, for the arm displacements (x_3, z_3), and rotation (θ_1, θ_2) for the Oy – angular displacement produced in the wrist and elbow joint.

Therefore, *ensemble 1,* notated 1, contains in SimMechanics the blocks Env and Ground specific for the source of excitation (machine-tool), and the Signal block where it is imposed at simulation the frequency or the excitation pulsation. The source of excitation is considered for this model frequency of 2500Hz (Fig.4) similar to the theoretical model studied at the mechanical model presented in the Fig.1.

For this paper it chose the Matlab simulation program (its Simulink), because this presents a friendly interface and, more importantly, has blocks (Table III) that display the mechanical point of view for the system masses Mass Block (a.), the mechanical characteristics (Elastic and Damping Block – b.), the connecting blocks that can copy the mechanical model in Fig.1, respectively Weld Blocks (c.) and Cylindrical Joints (Joint elbow and Shoulder Block d1. and d2.). Also, it presents blocks that allow setting the displacement or rotation direction of the system as a Prismatic Block (e.). In other words, the connection between the blocks creates the same model as the theoretical model resulted from the mathematical modeling (Fig.1). Also, it can intervene in this system by imposing entry conditions that is Oz direction and the input frequency or pulse given by the Ground Block (f.), Machine Environment Block and Signal Generator (g1. and g2.).

By accessing any of these blocks, a window opens in which it can input the mechanical theoretical model characteristics given by Fig.1, Tables I, II. Subsequently, this model will simulate the displacements of the system created by Simulink. The Joint Actuator Block and Body Sensor Block (h1. and h2.) take over the displacements of the masses and convey it to the Scope Block (i1. and i2.). This displays graphically the displacements of the center of these masses. Main displacement is imposed by the Prismatic Block (e.), which, in the case of this paper, is the z-axis that is along the hand-arm system. In this case, the selection of the x, y, z coordinates in the data window will be: x = 0; y = 0; z = 1. It notices that only the wrist and elbow joint that is the m_2 and m_3 masses of the forearm and arm displacements (displacements of the mass center are presented in i2. block) along all three axes. For this reason, it selects x = 1, y = 1 (displacements given by the angle θ_1, θ_2), and z = 1.

Ensembles 2, 3, and 4 notated in the Fig.4 with 2, 3 and 4, comply with the same anthropometrical properties from theory study, as in the mechanical model proposed by Fig.1, respectively the Body Blocks with the masses m_1, m_2, m_3.

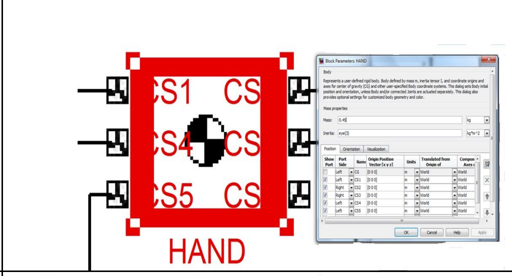
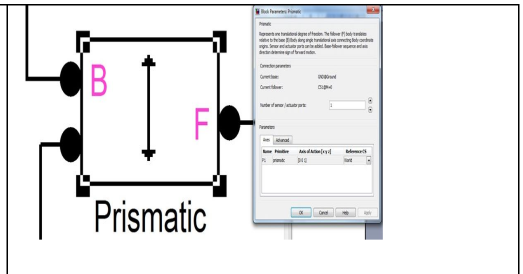
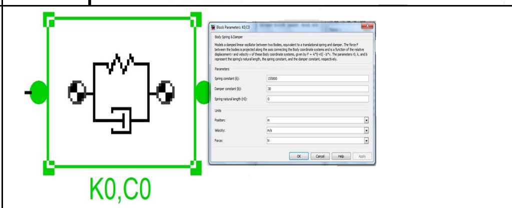
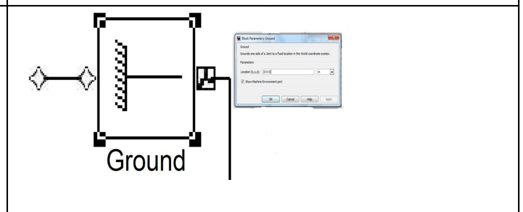
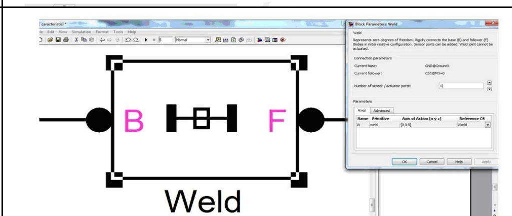
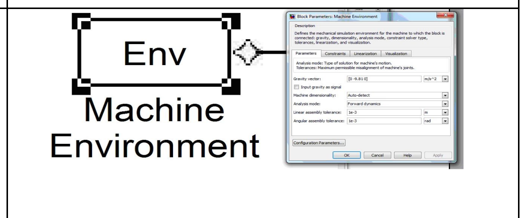
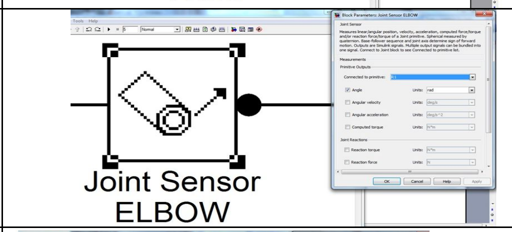
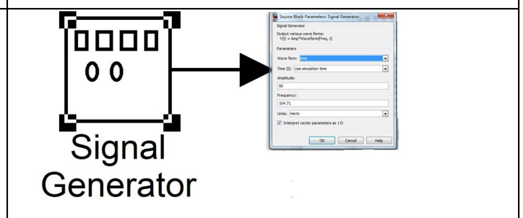
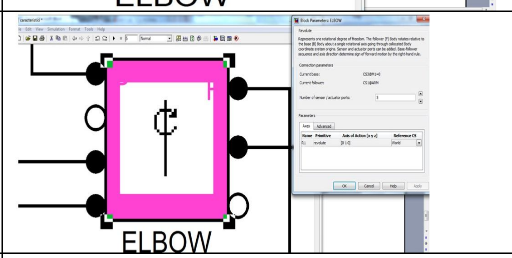
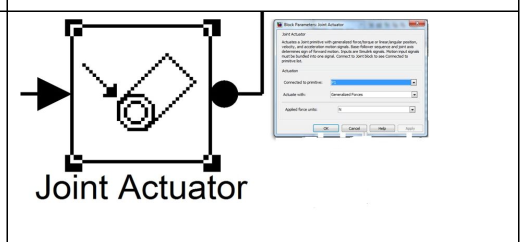
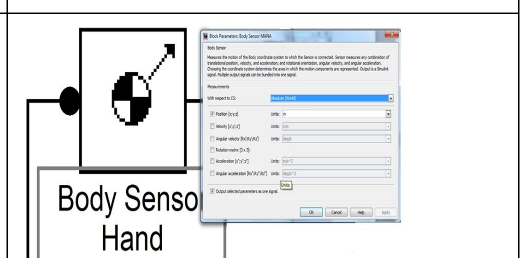
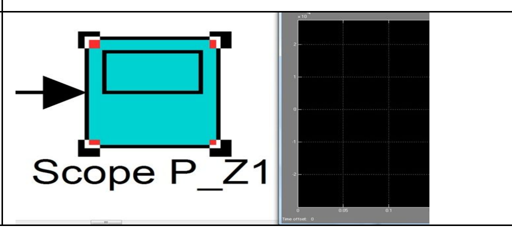
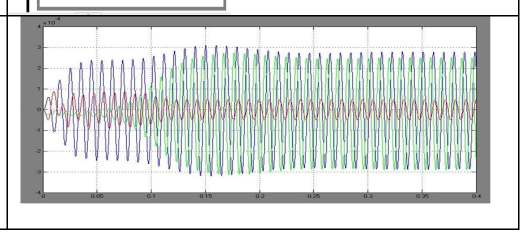
The Body Sensor and Scope Blocks are necessary for the visualization of individual solutions, on the anatomic elements: hand, forearm, and arm, respectively the visualization of solutions (linear and angular displacements) of the system, obtained in SimMechanics.

In the study of the block scheme, the simplifying conditions imposed by the mechanical model in Fig.1 were complied with, so it was considered the rotation in the shoulder joint of 0°, and in SimMechanics this was represented by Weld and Ground Blocks of ensemble 4 (Fig.4).

In the figures 5a-5c can be observed the movement of the hand (z_1 displacement) for the rotation of the machine-tool of 2500 Hz frequency. The z_1 displacement takes a maximal value of the graphic (Fig.4a) around 0.003 m. The displacements after Ox and rotations after Oy are in according with the theoretical figures 2a-2g, respectively around 0.001 m and 0.006 rad. These simulating solutions are validating the theoretical solutions given as by displacements of the Fig.2.

In the next step, it could try to validate these solutions with the experimental research.

Table III - The main simulating blocks in the Simulink used in the Fig.4.

a.		e.	
b.		f.	
c.		g1.	
d1.		g2.	
d2.		h1.	
	-	h2.	
i1.		i2.	

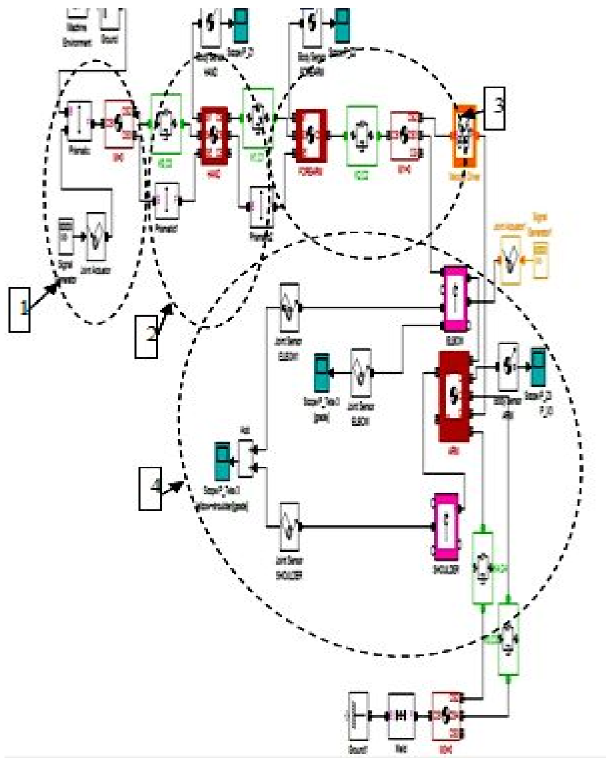


Fig.4 Simulating mechanical model taking in account Fig.1 and table III.

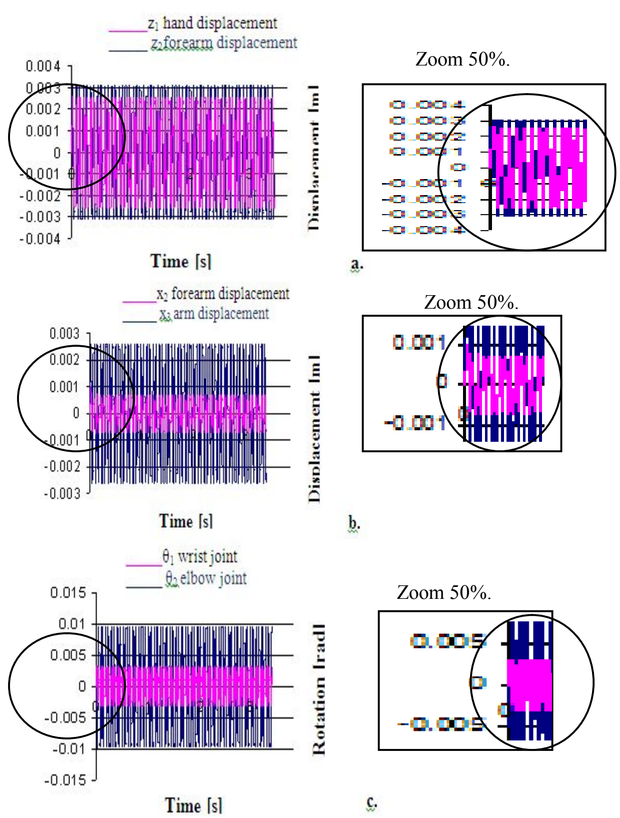


Fig.5 Simulating results, displacements and rotations.

B. Experimental model

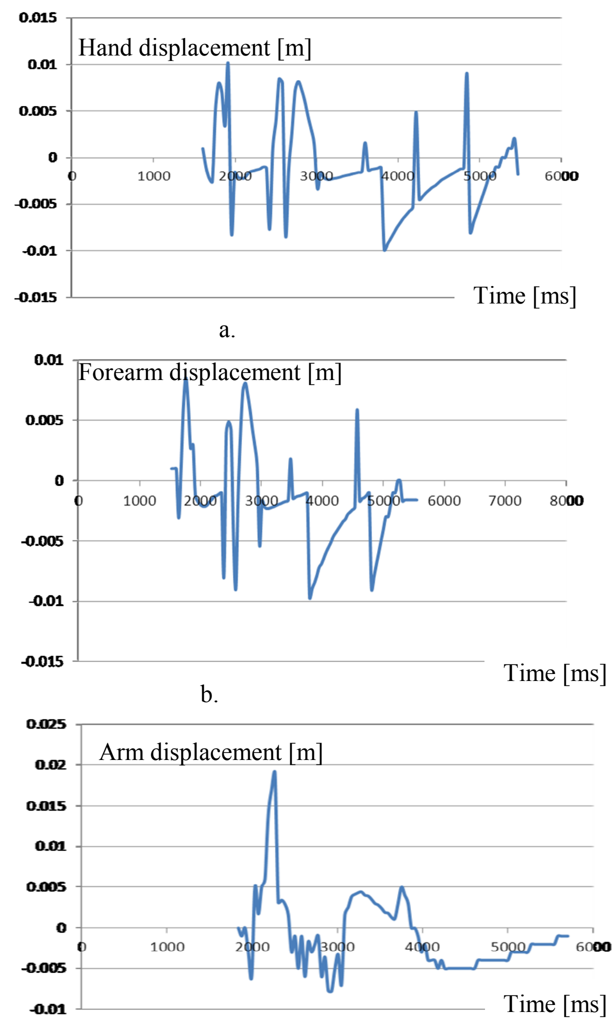
The researches regarding the transmissibility of mechanical vibrations to the arm-hand system have been performed by measuring the mechanical vibrations using a drilling machine. The machine drilled through a chemically treated MDF board using a 10cm drill. The experiment measured the vibrations transmitted by the machine when operating without it percussion (Fig.6).

The transducer was fixed of the hand, forearm and arm with the elastically bands, directly of the skin. This was measurement of the three directions after Ox, Oy and Oz axis [5], [10], [17-19], [20-22].

It observes that on the arm, after Oz direction, the vibrations are minimized (Fig. 6c) in comparison with the z1-hand and z2-forearm. These phenomena are corrects, because the vibrations must be minimize after this direction , respectively till arm.

Whether, these vibrations, in time, their effects accumulate in the hand-arm system and produce the sanguine and nerve affections [11].

We observed that the experimental results are in theoretical scale, but the obtained values are in concordance with the simulating and theoretical model, and they remained in the ISO standard (5349/2001) scale, yet.



c.

Fig.6 Experimental results, displacements only Oz direction.

IV. Conclusions

The paper wants to inform readers about a new mechanic of hand-arm system, this having seven degrees of freedom.

The paper presents the behavior of dynamic of system under the mechanical vibration's action. They are caused by the using of drills. We are interesting in the vibration's transmission action regarding the mechanical system after the direction Oz (over the arm). The possibility like these vibrations can be to dose, because they do not producing diseases.

We analyzed theoretically mathematical model of the hand-arm system by writing and solving the equations of motions. These were compared with the results of a pattern rendered similar mechanical model (Fig.1) achieved with Matlab (Simulink) and eventually, comparison with the measurements of vibration, they are made on the hand-arm system. Experimental measurements have been carried out, only after the main direction of transmission their (Oz direction), respective along the arm.

It has been observed that the theoretical results and simulated values are very close, and they are in the same approximate scale in comparison with those obtained after the same direction, based on experimental dates. This fact can be derived from the fact that modeling still have considered insignificant simplifying assumptions, they have determined the parameters of mechanical elasticity and stiffness, which may not coincide entirely with the real ones.

The paper has achieved its intended purpose thus: he presented a new mechanic model that corresponds more closely to the one the real behavior of the hand-arm system. It is determined of the experimental and theoretically solutions regarding it. It is noting that if vibration's exposure is not long (2 hours >) exposure, but these vibrations are very harm to the system, causing disease [11-13], [14] in the other cases.

V. Discussions

Occupational illnesses of the hand [11], [14] start by the loss of dexterity when handling working instruments and devices and they lead to the weakening of the grip of the fist, and the weakening of the grip in the fingers accompanied by fatigue etc. [11]. In time, all these symptoms could to degenerate in occupational disorders, such as VWF and other professional illnesses (affecting the nervous and circulatory systems, spine, hearing and sight etc.).

For these reasons the literature proposes and shows that the protective means against mechanical vibration transmission at the workplace, with respect to the safety of the operator, it can be divided into two sub-categories:

a) Protective equipment, meaning protective clothing as safety means: for example overalls, boots and gloves. The gloves are used to avoid or rather to dissipate (absorb) the vibrations from vibratory workplaces (for example mining, constructions, lathe working, etc.), vibrations that are transmitted from tools and machine – tools, directly to the hand of the human operator.

b) The second category refers to the protection or safety means, that are incorporated in tools and vibrating equipment from the design phase. These are called dampers and it could to take different shapes and dimensions and can be made from various materials.

- Further research in this field will contribute to the new ergonomic and esthetical part of the attenuated device etc.

References

[1] S. Adewusi, S. Rakheja, P. Marcotte, M. Thomas, *Distributed vibration power absorption of the human hand-arm system in different postures coupled with vibrating handle and power tools*, International Journal of Industrial Ergonomics, Volume 43, Issue 4, July 2013, pp. 363–374.

2] Cossets B., *Bicycles measure the quality of cycle paths in Belgium*. ELTIS the Urban Mobility Portal [internet] 201, Available from: http://www.eltis.org/index.php?id=13&study_id=3168.

[3] A. F. Cristea, A. Truța, M.Arghir, *The mechanical stability for the hand-arm system*. Vol.8. 1: 79th Annual Meeting of the International Association of Applied Mathematics and Mechanics (GAMM). Bremen.Germany,(2009), http://www3.interscience.wiley.com/journal/122217852/abstract?CRETRY=1&SRETRY=0, Article first PAMM published online: 25 FEB 2009, DOI: 10.1002/pamm.200810187, (2009), pp. 10187–1018.

[4] Cristea A. F., Morariu-Gligor Radu, *The simulation of vibration attenuator in the hand-arm system*, UPB Scientifical Bulletin, ISSN 1454-2331, B+, index SCOPUS, Inspec, SCIENTIFIC BULLETIN Series D: Mechanical Engineering, vol. 3, ISSN (print): 1454-2358 / (online): 2286-3699, pp. 19-30. www.scimagojr.com/journalsearch.php?q=21639&tip=sid).

[5] Cristea Aurora Felicia, *Study Regarding the Transmissibility Vibrations about Hand-Arm System, Using Vibration Attenuation*, Interdisciplinary Research in Engineering – Step towards Breakthrough Innovation for Sustainable Development (INTERIN 2013), Cluj-Napoca, Special Issue – Advanced Engineering Forum Journal, Switzerland, (http://www.ttp.net/2234-9898.html), , ISI WEB of Knowledge, Special Issue "Advanced engineering forum" vols. 8-9 (2013) pp. 421-436.
Online available since 2013/Jun/27 at www.scientific.net© (2013) Trans Tech Publications, Switzerland, ISSN: 2234-991X doi:10.4028/www.scientific.net/AEF.8-9.421www.TTP.NET/2234-9898.HTML).

[6] Cristea Aurora Felicia, *Theoretical and experimental analysis methods applied to hand-arm system subjected to mechanical vibrations*, ESCTAIC 2011- The 22 Annual Meeting Conference Erlangen, Germany 12-15 Oct. 2011, pp. 63-64.

[7] Cristea Aurora Felicia, *Analysis of methods of hand-arm system subjected to vibrations by mechanical modelling and simulation*, ESCTAIC 2011- The 22 Annual Meeting Conference Erlangen, Germany, 12-15 Oct. 2011, pp. 65-66.

[8] Dettori NJ, Norvell DC. *Non-traumatic bicycle injuries: a review of the literature. Sports Medicine*. 2006; 36(1), pp. 7-18.

[9] M. J.Griffin, **Hand-transmitted Vibration: Occupational Exposures and their Health Effects in Great Britain**, 2001. University of Southampton, U.K. (1999).

[10] Herbert Martins Gomes*; Daniel Savionek, *Measurement and evaluation of human exposure to vibration transmitted to hand-arm system during leisure cyclist activity*, Rev. Bras. Eng. Bioméd. vol.30 no.4 Rio de Janeiro Oct./Dec. 2014 http://dx.doi.org/10.1590/1517-3151.0546, Print version ISSN 1517-3151.

[11] U.S, Katu, R.G. Desavale and R.A. Kanai, *Effect Of Vehicle Vibration On Human Body* – RIT Experience
Department of Mechanical Eng. Rajarambapu Institute of Technology Sakharale-415414.
http://www.nacomm03.ammindia.org/Articles/Nav001.pdf.

[12] H. Liu, P. J. Ellison, H. Xu,, *Coupling of dynamics and contact mechanics of artificial hip joints in a pendulum model,* Proceedings of the Institution of Mechanical Engineers. Part H: Journal of Engineering in Medicine August 1, 224, DOI:10.1243/09544119JEIM687, (2010), pp. 989-1003.

[13] P. Marcotte, J. Boutin, S. A. Adewusi, S. Rakheja, *Vibration transmissibility characteristics of the human hand-arm system under different postures, hand forces and excitation levels*, Journal of Sound and Vibration, Vol. 329, no. 14, 2010, doi:10.1016/j.jsv.2010.02.001, Copyright © 2010 Elsevier Ltd. pp. 2953-2971.

[14] H. Mao, K. H. Yang, I. Albert, *Computational neurotrauma—design, simulation, and analysis of controlled cortical impact model*, http://www.Springerlink.com, Received: 4 August 2009 / Accepted: 19 March 2010 / Published online: 7 April 2010 © The Author(s), 2010.

[15] B. Rong, X. Rui, G. Wang, *New efficient method for dynamic modeling and simulation of flexible multibody systems moving in plane*, Multibody System Dynamics. 24: Number 2. DOI: 10.1007/s11044-010-9196-9, Biomech Model Mechanobiol (2010) 9:763–772, DOI 10.1007/s10237-010-0212-z, (2010), pp. 181-200.

[16] A. M. Sims, T. Stait-Gardner, L. Fong, *Elastic and viscoelastic properties of porcine subdermal fat using MRI and inverse FEA Biomech Model Mechanobiol.* 9, DOI 10.1007/s10237-010-0207-9. Received: 17 November 2009 / Accepted: 4 March 2010 / Published online: 23 March 2010 © Springer-Verlag, (2009), pp. 703–711.

[17] D. Tarnita,D. B. Marghitu, *Analysis of a hand arm system, Robotics and Computer-Integrated Manufacturing,* Volume 29, Issue 6, December 2013, Pages 493–501.

[18] SREN 5349-2:2003: *Mechanical Vibrations. Measurements and evaluation of human exposure at vibrations transmitted of hand.*

[19] SRCR 10 30-2:2000: *Hand-arm vibrations. Indications for reduce vibration risk. Part 2: the measure of prevention regarding the working place.*

[20] SR ISO 7962:1996: *Mechanical vibrations. Transmissibility of mechanical vibrations of human body after z direction.*

[21] SR ISO 8727:2001: *Mechanical vibrations and shocks. Human exposure, biodynamical system coordinates.*

[22] http://ergo.human.cornell.edu/studentdownloads/DEA3250pdfs/ Human%20Vibration.pdf (06.05.2

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- Negrean, I., Kacso, K., Schonstein, C., Duca, A., Rusu, F., *Cristea*, F., Haragâş, S., New Formulations on Acceleration Energies in Analytical Dynamics, The third International Conference of Mechanical Engineering, ICOME 2015, ISI journal, Volume 823 of Applied Mechanics and Materials (Trans Tech Publishing House, *Switzerland*), ISSN print 1660-9336, ISSN web 1662-7482, ISSN cd 1660-9336, pp. 43-48, doi:10.4028/www.scientific.net/AMM.823.43
- Negrean, I., Kacso, K., Schonstein, C., Duca, A., Rusu, F., *Cristea*, F., Haragâş, S., New Formulations on Motion Equations in Analytical Dynamics, The third International Conference of Mechanical Engineering, ICOME 2015, ISI journal, Volume 823 of Applied Mechanics and Materials (Trans Tech Publishing House, *Switzerland*), ISSN print 1660-9336, ISSN web 1662-7482, ISSN cd 1660-9336, pp. 49-54, doi:10.4028/www.scientific.net/AMM.823.43.
- *Cristea* A. F., Morariu-Gligor Radu – „The simulation of vibration attenuator in the hand-arm system", UPB Scientifical Bulletin, ISSN 1454-2331, B+, index SCOPUS, Inspec, SCIENTIFIC BULLETIN Series D: Mechanical Engineering, vol. 3, ISSN (print): 1454-2358 / (online): 2286-3699, pp. 19-30. www.scimagojr.com/journalsearch.php?q=21639&tip=sid).
- *Cristea* Aurora Felicia – „Study Regarding the Transmissibility Vibrations about Hand-Arm System, Using Vibration Attenuation" - Interdisciplinary Research in Engineering – Step towards Breakthrough Innovation for Sustainable Development (INTERIN 2013), Cluj-Napoca, Special Issue – Advanced Engineering Forum Journal, *Switzerland,* (http://www.ttp.net/2234-9898.html), , ISI WEB of Knowledge, Special Issue "Advanced engineering forum" vols. 8-9 (2013) pp. 421-436.
  Online available since 2013/Jun/27 at www.scientific.net© (2013) Trans Tech Publications, Switzerland, ISSN: 2234-991X doi:10.4028/www.scientific.net/AEF.8-9.421 www.TTP.NET/2234-9898.HTML).
- Monica-Carmen Balcău, Aurora Felicia Pop (Cristea) – „Particular Case Study of Dynamic Absorber", Annals of DAAAM for 2010 & Proceedings of the 21-st International DAAAM Symposium, 20-23 October 2010, Zadar, Croatia, ISSN 1726-9679, pp.0827-0828, www.scimagojr.com/journalsearch.php?q=21100297597&tip=sid&clean=0)
- Aurora Felicia Pop (Cristea), Mariana Arghir – „Hand Arm Simulation, under the Vibration Action with Vibration Flow Divider" - 2010 IEEE International Conference on Automation, Quality and Testing, Robotics AQTR 2010 - THETA 17th edition-May 28-30 2010, Cluj-Napoca, Romania, ISBN: 978-1-4244-6724-016, pp.348-351.

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The relevant papers:

- Nedelcu M., *Buckling mode identification of perforated thin-walled members by using GBT and shell FEA*, Thin-Walled Structures, vol. 82, pp. 67–81, Elsevier Science Publisher, UK, 2014, http://dx.doi.org/10.1016/j.tws.2014.04.005, Scor relativ de influenţă: 1.724
- Nedelcu M., Hortensiu L. Cucu, *Buckling modes identification from FEA of thin-walled members using only GBT cross-sectional deformation modes*, Thin-Walled Structures, vol. 81, pp. 150–158, 2014, http://dx.doi.org/10.1016/j.tws.2013.06.007
- Nedelcu M., *GBT-based buckling mode decomposition from Finite Element Analysis of thin-walled members*, Thin-Walled Structures, vol. 54, pp. 156-163, Elsevier Science Publisher, UK, 2012, http://dx.doi.org/10.1016/j.tws.2012.02.009
- Nedelcu M., *GBT formulation to analyse the buckling behaviour of isotropic conical shells*, Thin-Walled Structures, vol. 49, nr.7, pp. 812-818, Elsevier Science Publisher, UK, 2011, http://dx.doi.org/10.1016/j.tws.2011.02.006
- Nedelcu M., *GBT formulation to analyse the behaviour of thin-walled members with variable cross-section*, Thin-Walled Structures, vol. 48, nr.8, pp. 629-638, Elsevier Science Publisher, UK, 2010, http://dx.doi.org/10.1016/j.tws.2010.03.001
- Nedelcu M., *A GBT-based adaptation of the Ayrton-Perry formula for the Global-Distortional buckling*, 8 th International Conference on Advances in Steel Structures, Lisbon, Portugal, 22-24 July, 2015
- Nedelcu M., Crisan A., Ungureanu V., Dubina D., *Analysis of Storage Rack Members by Using GBT and Shell FEA*, 7th International Conference on Thin-Walled Structures, Busan, Korea, 28 September - 2 October 2014
- Nedelcu M., Chira N., Popa A.G., Cucu H.L., *Buckling mode decomposition of thin-walled members with arbitrary holes*, Proceedings of the 7th European Conference on Steel and Composite Structures - Eurosteel 2014, Napoli, Italy, 10-12 September 2014
- Muntean A.M., Mihali A.C., Nedelcu M., *Experimental and Numerical Analysis of a Small Scale Model of a Reinforced Concrete Beam*, C60 International Conference "Tradition and Innovation - 60 Years of Civil Engineering Higher Education in Transilvania", Cluj-Napoca, Romania, 7-9 November 2013
- Nedelcu M., Sauca A., Chira N., *Tension Estimation of Cables by Vibration Analysis*, C60 International Conference "Tradition and Innovation - 60 Years of Civil Engineering Higher Education in Transilvania", Cluj-Napoca, Romania, 7-9 November 2013.