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CONSIDERATIONS ON THE PROCESSING OF EXPERIMENTAL SIGNAL AND OBTAINED BY SIMULATION SIGNAL, CONCERNING THE IMPACT OF RIGID BODIES

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ABSTRACT

The analysis of impacts of elastic bodies is topical and it has many applications, practical and theoretical, too.

The elastic character of collision is put in evidence, especially by the velocities of some parts of a particular body, named “ring”.

In the presented paper, the situation of elastic collisions is put in evidence by the simulation with the help of the program ANSYS and it refers to the particular case of the ring, with the mechanical characteristics, given in the paper.

1. INTRODUCTION

The modeling consist in the representation of a system or process by another system, named model, which is more easily to be studied, but keeping the relevant characteristics of the original. The study of model can be realized in two ways: analytic and experimental. The experimental study of a model is named simulation and it is preferred in the situations when the study in analytic way is impossible or too laborious. The studied model, named model of simulation, is called mathematical model. The simulation offers the possibility to study a model, when the analytic analysis is not applicable. [1]

The vibrating motion can be expressed by a sinusoidal function or, frequently used in praxis, by superposing many sinusoidal quantities, having different frequencies and amplitudes. The vibrations are dynamic phenomena, which appear in elastic media as a consequence of local excitations and which are propagated in the interior of medium under the form of oscillations. [3] The shock is a special form of vibration, in which the excitation is not periodic; it can be produced under the form of an impulse, a step vibration or a transient vibration. The term of “shock” defines a mechanical phenomenon of high intensity, which takes place in a relatively short period of time. Fro the analytic point of view, the main characteristic of the shock is the fact that the motion of system depends on the frequency of shock, but also, on the eigenfrequency of system. If the excitation is of a short duration, the motion of system is a vibration, having the frequency equal to the eigenfrquency. [2]

The chosen and presented model is a ring, realized in steel, whose dimensions are the internal radius of 0.0455 [m], external radius of 0.050 [m] and width of 0.0153 [m] (Figure 1). On the generating line of the ring an initial fissure of 0.0010 [m] was performed, which can not progress in any direction. Thus, when a force or impulse is applied on the ring, the transfer of energy for the propagation of fissure is, practically, null. For this reason, it is necessary to consider that the forces which result on the two sides of the fissure represent percussive forces, which are transmitted as a shock wave, in the mass of ring.

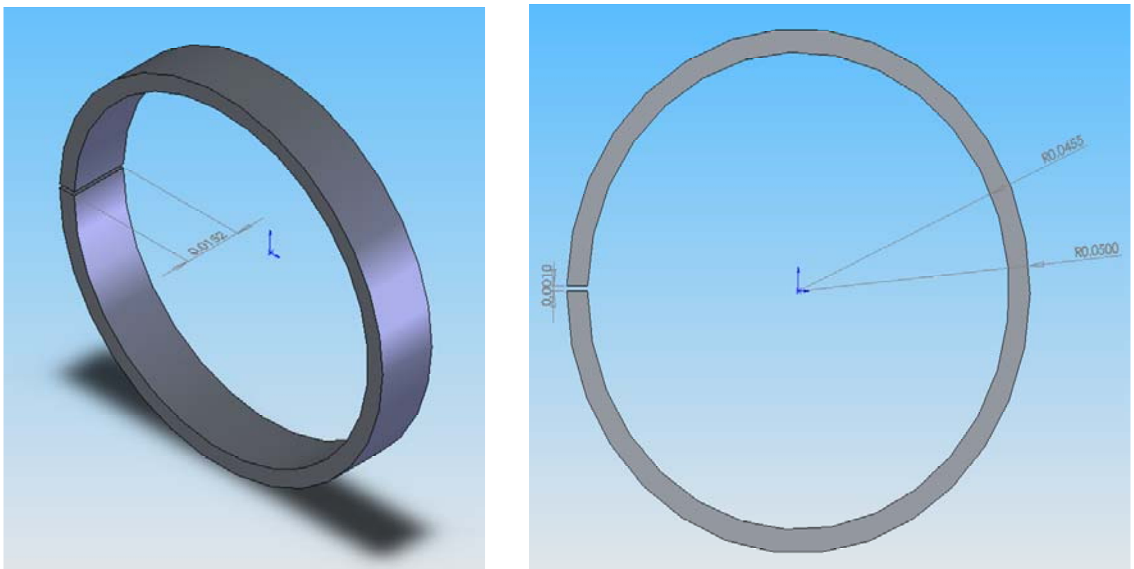


Fig.1 Geometry of studied model

2. PROCESSING OF SIGNALS

If a perturbing force acts on a system, its motion is a vibration. The response of system can be expressed by a displacement, velocity or acceleration, measured in a point. The essential quantities of vibrating motions what are interested to be measured are: linear displacements, velocities, accelerations, angular displacements and frequencies. In the study of vibrating motions, it is useful to know the amplitudes for displacement, velocity or acceleration. The discontinuous graphic which gives these quantities as a function of frequency is called spectrum [4].

2.1. NUMERICAL SIMULATIONS, USING ANSYS LS-DYNA

The increasing of performances of computers has facilitated the development of new methods of calculus of structures. Actually, there is a large diversity of programs, based on numerical analysis. One of these programs is the ANSYS program, which is a general program of analysis with finite elements.

Due to the efficiency of Method of Finite Element, the numerical simulation tends to replace the experiment, from the simplest cases to the simulation of the most complex tests [5].

The problem of considered ring which has a fissure is a problem of contact, because there are collisions between the two surfaces, resulted as consequence of the fissuring. This is the reason for which it was chosen the program ANSYS LS-DYNA – explicit dynamic program. This program assures the simulation of problems of non linear analysis, rapid dynamics, with applications in the simulation of technological processes of cupping, smithing, lamination, etc., simulations with impact.

The process of simulation [6] of a system can be divided in four phases (figure 2):

Fig. 2 Process of modeling of a system

Geometry/Mesh: The objective of the phase is the creation of the finite elements for the physic definition of the studied process. It is evident that, for the creation of the finite elements, it is necessary to elaborate the 2D/3D geometry of the studied element. The creation of the 3D geometry can be realized in different CAD (Computational Aided Design) media of design. More complicated is the creation of the finite elements (Mesh). Practically, all the recognized commercial CFD codes, dispose of the Mesh module, but also, they can import the finite elements, created in other codes, specialized in their creation. The reason is the fact that the quality of the finite element directly influences the results of calculus, respectively the validity of simulation.

Physical Definition – Phase conceived to establish the boundary conditions of the mode of resolving (Solver). In this mode, the first step is the importing of the Mesh file, previously created and after this, the specification of the working medium and the establishing of boundary conditions.

Resolution - Phase conceived, in general, to solve the base systems of equations. The process of solving of the set of equations can be a long duration one, as a function of the complexity of problem, precision of calculus and so one. The results of calculus are saved in a separated file or directly transferred to the module of post-processing.

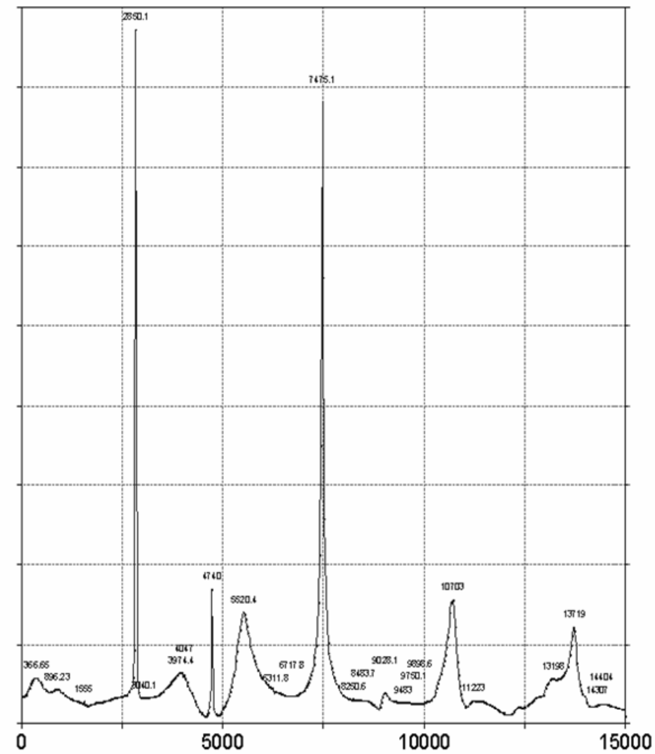
Post-Processing: The phase of post-processing is conceived, in general, for the analysis, visualization of processes of simulation and the interactive presentation of the results of research. Also, in this module, it exists the possibility of animation of the processes of interaction.

So, by using the ANSYS LS-DYNA program, it was found the response of system to a certain excitation. At low frequencies it is recommended the measurement of displacements or velocities, and at high frequencies, the measurement of accelerations. For this reason, with the help of this program, in each node of the mesh network, there were saved the respective displacements, velocities and accelerations, under the form of a file, of text type.

The understanding of different results, quantities, phenomena, which take place during the vibrating motions, is easier if graphic representations are used. The most suggestive representation is the graphic x(t), which shows the variation of displacement as a function of time, as well as the analogous graphics, concerning the velocity and acceleration. If at a periodic motion, the frequency is taken on the abscissa, and on the ordinate line, one of the ordinary kinematical quantities (displacement, velocity, acceleration), it is obtained the representation in frequencies. This one shows the amplitudes that different components have, at different frequencies of the motion. [7]

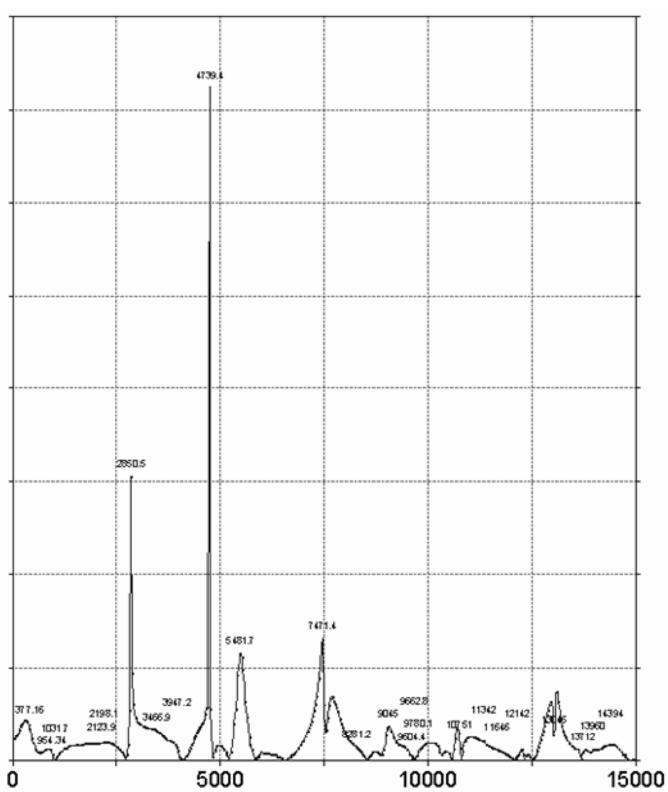
Taking into account these ones, with the help of the program AutoSignal, which is an automat program for the analysis of complex signals (it filtrates, processes and analyses signals with the help of graphics and presents detailed numerical results), there were obtained the velocity, acceleration and displacement of respective node. These ones are presented in figures 3-11.

Velocity:



Frecvențe [Hz]
366.65358272
896.23243345
1555.0494160
2850.1206901
3040.1045691
3974.3642779
4047.0464605
4739.9796742
5520.4000158
6311.8216534
6717.7689205
7475.1359009
8250.5826384
8483.6910696
9028.1168621
9483.0325938
9750.1252176
9898.6096010
10702.973206
11223.080344
13197.668830
13718.941565
14306.846256
14403.764351

Fig.3 Ox



Frecvențe[Hz]
377.15644722
954.33635371
1031.6575821
2123.9198208
2198.0929247
2850.4769387
3466.9452498
3947.1645728
4739.4292123
5481.6685633
7471.4397430
8281.2214927
9044.9551687
9604.3681728
9662.8202218
9780.0517684
10750.975365
11341.546259
11645.575124
12141.589483
13046.245738
13712.338074
13959.964798
14394.354312

Fig.4. Oy

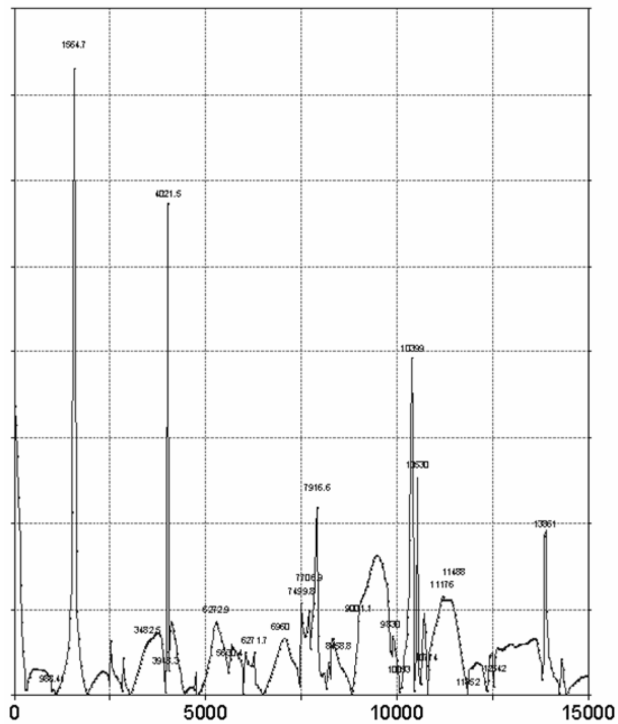


Fig.5 Oz

Frecvențe[Hz]
988.40653173
1564.6582398
3482.4612078
3948.3406750
4021.5384862
5272.9446629
5630.4410523
6271.7117011
6960.0403478
7499.7857239
7706.8700849
7916.5592557
8458.7699341
9001.0719990
9830.0140930
10053.301105
10398.861020
10530.460106
10773.568954
11176.497053
11488.078253
11852.027750
12541.579581
13861.373650

Acceleration:

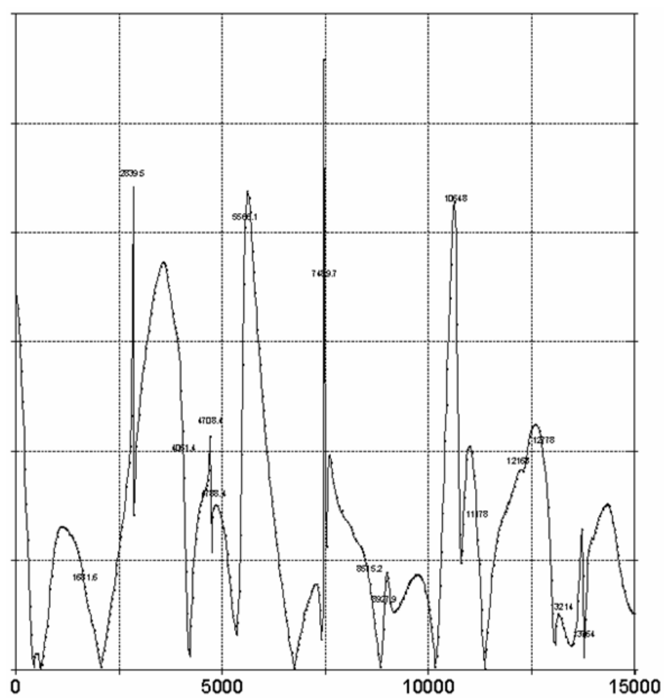
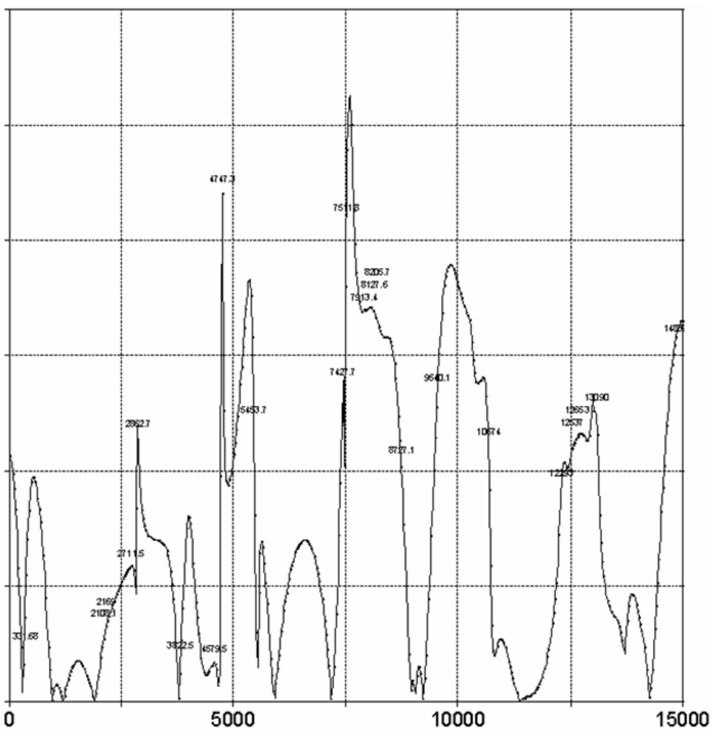


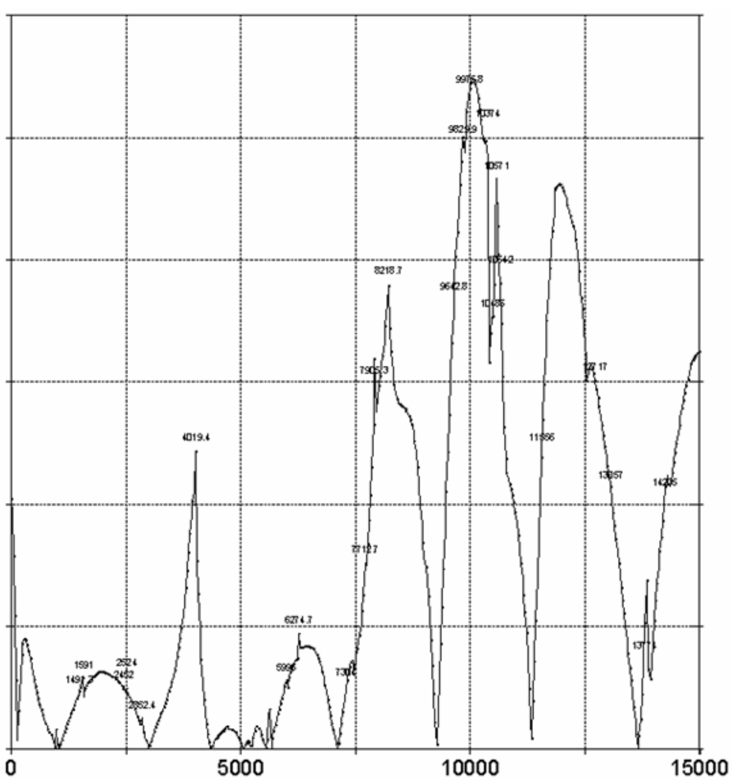
Fig.6 Ox

Frecvențe[Hz]
1681.64642
2839.48286
4061.43221
4708.44574
4788.36694
5566.05270
7489.66469
8575.22189
8927.94917
10648.0559
11177.7078
12167.6063
12778.0568
13213.9915
13763.8748



Frecvențe[Hz]
331.680237
2108.06560
2169.01058
2711.54863
2862.71900
3822.47657
4579.45717
4747.25457
5453.65112
7427.72241
7511.80228
7913.39179
8127.61312
8205.66201
8727.06817
9540.10413
10674.3960
12292.8136
12536.8005
12652.7863
13089.9987
14839.4532

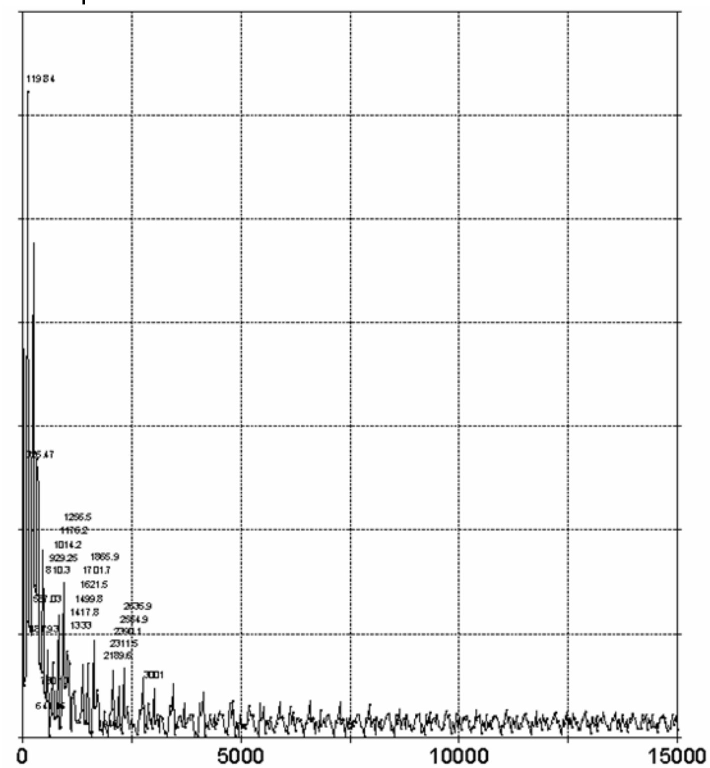
Fig.7 Oy



Frecvențe[Hz]
1491.30343
1590.98741
2452.01018
2523.98918
2852.40243
4019.36895
5995.99416
6274.66818
7303.99123
7712.74356
7905.29612
8218.66240
9642.79599
9829.91139
9975.79070
10373.6655
10485.4291
10570.7940
10641.9965
11556.4213
12716.5936
13057.1924
13774.1434
14235.2806

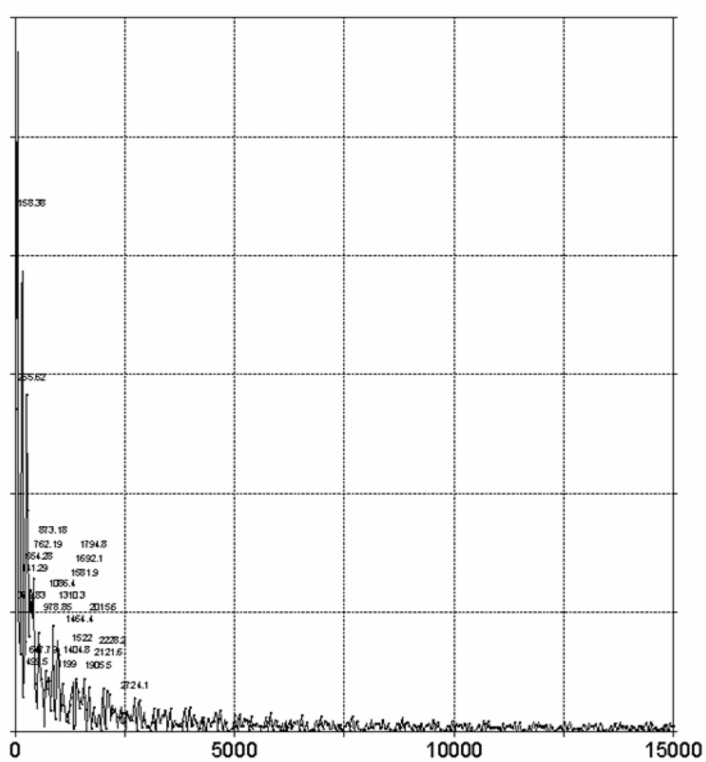
Fig.8 Oz

Displacement



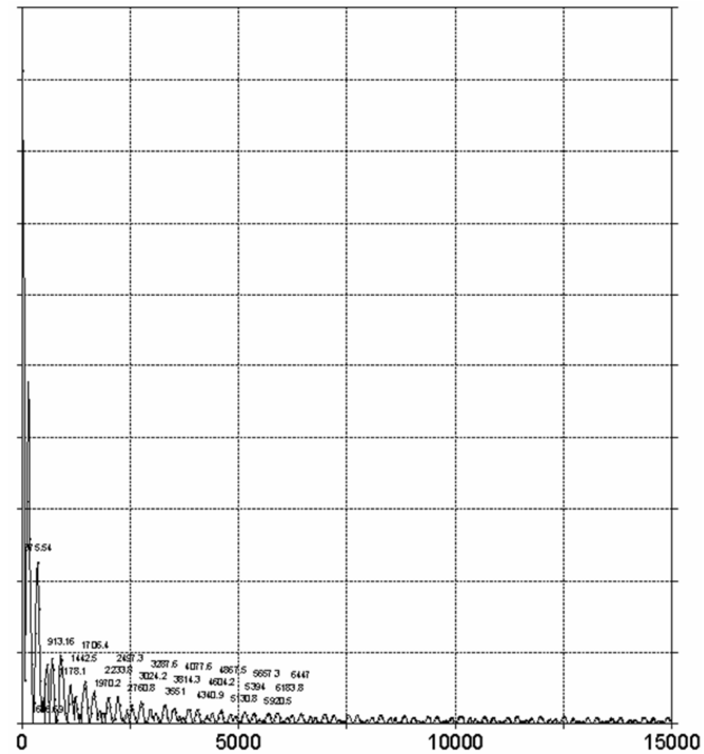
Frecvențe[Hz]
119.84351205
326.46557532
484.92502697
567.02697978
644.15884766
730.12643968
810.30468783
929.24950942
1014.1982700
1176.1807810
1256.4536599
1332.9953543
1417.7723020
1499.7924203
1621.4706884
1701.7484492
1865.9263719
1945.9537533
2189.6031568
2311.5404108
2390.1460321
2554.8830555
2635.9379183
3001.0477743

Fig.9 Ox



Frecvențe[Hz]
158.38155875
265.61857915
379.83118050
441.28879162
499.49524498
554.28406284
647.79265694
762.19172116
873.18297915
978.84604396
1086.3594695
1199.0188864
1310.3207843
1404.8381768
1464.3619513
1522.0361155
1581.9378257
1692.0893806
1794.8460860
1905.5110824
2015.5825007
2121.5660611
2228.1541468
2724.1330853

Fig.10 Oy



Frecvențe[Hz]
375.53938781
646.69464320
913.16167300
1178.1367794
1442.4630571
1706.4280796
1970.1850801
2233.8136659
2497.3265743
2760.7970941
3024.2198413
3287.6093023
3550.9647466
3814.3009063
4077.6191915
4340.9229023
4604.2145802
4867.4962122
5130.7693729
5394.0353246
5657.2950894
5920.5495031
6183.7992541
6447.0449136

Fig.11 Oz

2.2. EXPERIMENTAL STUDY

In order to analyze the data, there are necessary the experimental installation, system of data acquisition, package of software for the control of system of data acquisition and processing.

The experimental stand is composed of the sonometer (device which measures the level of acoustic pressure, expressed in [dB]), acquisition plate and computer.

The acquisitioned signal by the acquisition plate is taken over, filtered and saved by a virtual device, created by the author, in the program TestPoint, a package of software which accompanies the acquisition plate and is dedicated to data acquisition. The device contains blocks, put at the disposition of user by the program, which permit the modification of number of channels on which the acquisition is made, rate of acquisition, total duration of acquisition, filtration of data in order to eliminate the “noise”, inherent to any acquisition and saving of data under the form of files of text type. This one is conceived to have four distinct modules: module of data acquisition and visualization, module of filtration, module of transformation of electric quantities to mechanical quantities, module of saving of data under the form of files of text type (ASCII).

In this way, it was obtained the level of sonorous pressure in figure 12.

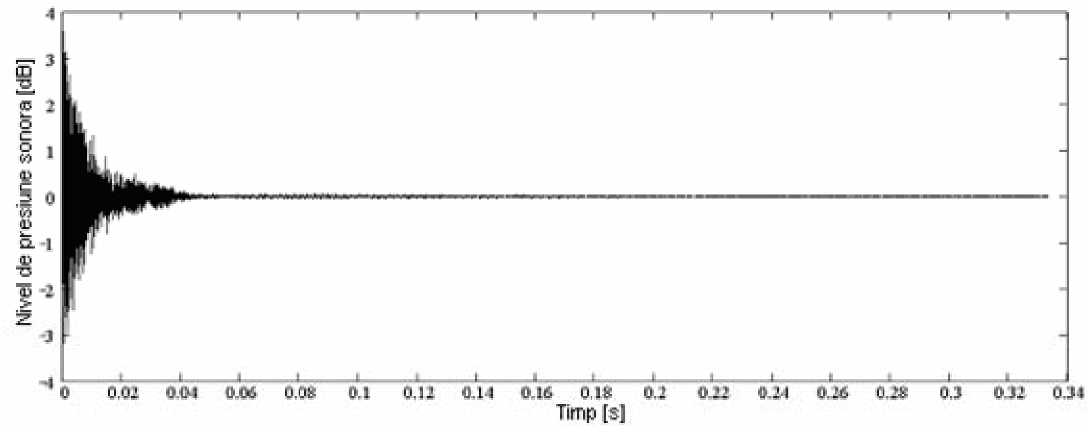


Fig.12 Level of sonorous pressure

By processing of signal with the program MATHCAD, which is a reading of mathematical commands, with friendly interface and which displays data and expressions in a natural form, it was resulted the diagram of frequencies in figure 14.

The natural frequencies, obtained as the result of modal analysis with the program ANSYS WORKBENCH, are presented in Table1, with the mention that the first 6 frequencies are the frequencies of rigid body (6 degrees of freedom=3 rotations+3 translations).

Table 1

Mod	Frequency	Mod	Frequency	Mod	Frequency
7	201.73 Hz	13	2632.38 Hz	19	7602.4 Hz
8	341.11 Hz	14	2925.67 Hz	20	9299.61 Hz
9	440.16 Hz	15	4260.95 Hz	21	9592.75 Hz
10	987.52 Hz	16	4637.23 Hz	22	11786.76 Hz
11	1148.37 Hz	17	5822.67 Hz	23	11825.33 Hz
12	1828.59 Hz	18	6912.04 Hz	24	14177.46 Hz

By superposing the experimental results to the ones, obtained by using the program ANSYS WORKBENCH, it is obtained the diagram of frequencies in figure 14.

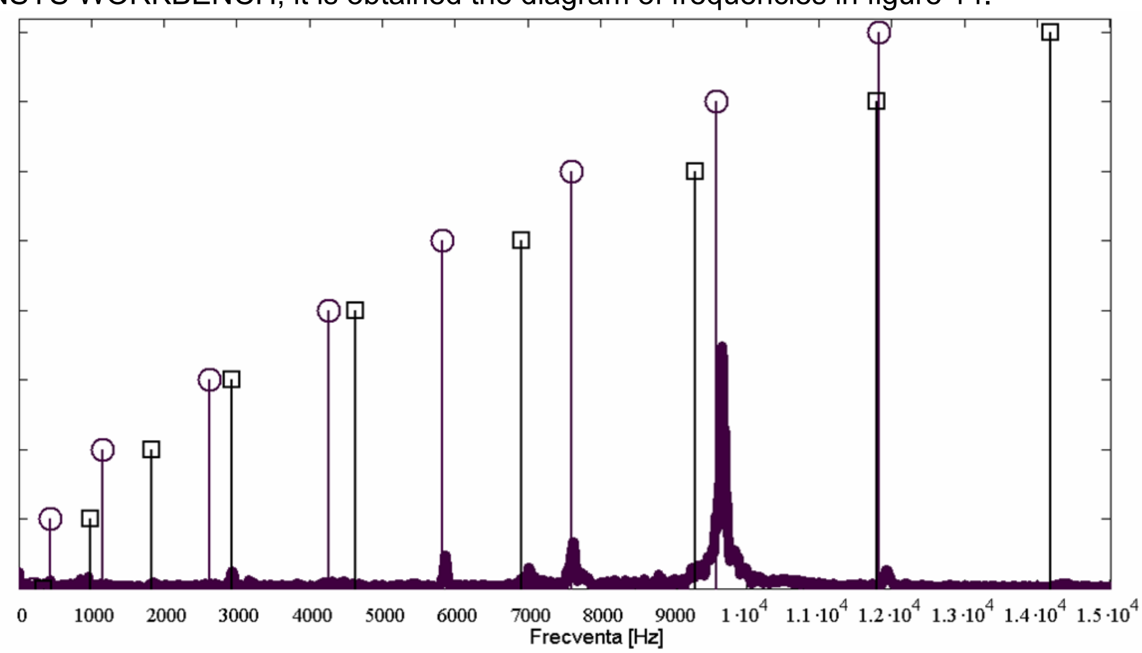


Fig.14 Spectrum of frequencies

3. CONCLUSIONS

The modeling, realized within the framework of the paper is for the model of a ring with well defined dimensions and mechanical characteristics. The experimental study of this model is preferable to be made by simulation, because the study, realized by analytical methods is too laborious.

The efficiency of Finite Element Method in the numerical simulation, in general, substitutes the experiment, in many cases and at complex tests.

The choosing of ANSYS LS-DYNA program is realized because it comes very well to problems of contact/impact of elastic bodies, problems from which the problem of the considered ring makes part.

The analysis of signals, obtained by applying an impact force on the generating line of the ring, was realized with the help of the program AutoSignal. These experimental and simulated elements are presented within the framework of figures in the paper. From their analysis, it results the proper modes of vibrations, as well as the spectra of frequencies, where the ring has dynamic behaviors, which are not enough known.

These results were obtained within the framework of the Laboratory of Vibrations and Vibroimpacts of the “Politehnica” University of Timişoara.

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