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THEORETICAL STUDY OF DYNAMIC BEHAVIOR FOR A MULTIFUNCTIONAL MACHINE TOOL

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Abstract: *This paper is based on a CNC multifunctional machine tool. One of the news brought by this machine is that its structure is made mostly, of composite materials. To see the dynamics behavior of this machine, it was done a study by finite element method, in order to determinate their modes of vibration.*
Keywords: *multifunctional machine, vibration, modal analyses, finite element. .*

1. INTRODUCTION

The first step in analyzing a real structure, consists in developing a model based on which can be explained, possibly anticipated, its subsequent behavior. Models can be theoretical or physical.
Theoretical models are mathematical models with which can be studied indirectly, the behavior structure. This represents an intermediate link between experience and theory.
The model development for calculating the resistance of a structure should be rigorous correlated with the method of calculation which will base on calculation, because the model will reflect the assumptions, limitations, advantages and disadvantages specific to the method.
The elasticity problems in the bidimensional area were the first examples of successful application of finite element method FEM [1]. In the branch literature, the method exposure for plane state is made for triangular finite element, which is considered to be the simplest case, but the approach of the method is general. The basic idea of FEM is that any movement of a component within the body, varies according to a known abstract theorem, the polynomial form: Hermite, Lagrange, Pascal, etc.
At the plain of stresses and strains displacement field is uniquely determined by the displacements u and v, in directions X and Y of the cartesian system of reference. Should be taken into account only the three components of strains and tensions that appear in the plane (xy).
FEM has a large swift implementation that allows a mesh with a variable geometry, and simultaneous use of any type of finite elements for an adequate modeling of the structure.
Lately, the substructurare and condensation techniques have a considerable reduction of the computing time and the data volume, especially for the elements of structure in which there are a large number of identical substructures. This made possible the details and the modification the areas that have an important contribution to the static, dynamic and thermal deformation of the structures, the separation the areas with a linear behavior, exploiting the symmetry properties of the structure.
Another technique that reduces the computing time is the veining structure technique which consists in dividing the model of the portant element in a main structure and a number of mutually separable substructures. The veining structure are attached to the main structure by the superior cores. The main structure and the veining structures are, in this case, independently meshed in elements conveniently chosen, taking into account only by the superior cores from their common boundaries.
The simplified mashed model is built based on drawings or 3D model of the structure. In numerical calculations, a series of parameters can be varied until the dynamic characteristics of the structure corresponding to the measurements.

A machine tool is competitive, should satisfy a number of requirements that lead to the obtaining of specific components in terms of shape and size, but also from the point of view of surface quality, in conditions of productivity and increased accuracy. To answer to these requirements, researchers in this field look for solutions, new materials. In the field of structural elements of machine tools, have recently imposed a number of materials with special properties. Lately, it took into account the replacement of parts of traditional materials with some new material.
The theoretical study regarding the dynamics behavior will be on a multifunctional machine MULTICUT developed to ICTCM [2]. To obtain a reduced weight of the machine, the cradle was developed as a complex structure made of composite materials, especially combined with the adoption of solutions to reduce the vibration and providing the necessary rigidity.
These composites materials are pultrusionat profiles formed by rovings of glass by spun glass embedded in a resin thermal mass[3]. For the purpose that the pultruzionate profiles were designed, they are built by dragging the rovings of spun glass after the fibers were molten by resin, through a special molds where is determinate the designed profile and, after heating with melting fibers through resin, stabilization occurs with cooling profile shape, sizing and cutting it to length, which gives them the end of manufacture very high stiffness elements.

2. THE MODAL ANALYSIS OF THE MULTIFUNCTIONAL MACHINE STRUCTURE

In order to achieve the study, first it was made the 3D model of the machine – fig. 1. The developed model copies the structure of the structural elements of the machine-tool, which are necessary to get some results very close to the reality for the dynamic behavior.

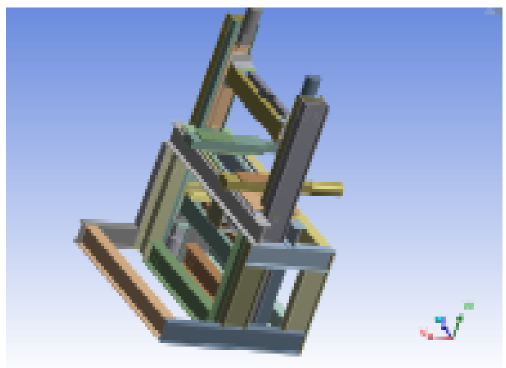

Figure 1: Geometric model of the multifunctional machine structure

The minimum and necessary characteristics of the finite element analysis for the composite material which enter in the composition of the structure's elements, are given in the table 1.

Table 1: Material's data

		[MPa]
Elasticity module	E	23 000 / 28 000
Tangential elasticity module	G	3 000
Poisson coefficient	v	0.23

Also, it was necessary the material density: 1,655 kg/dm^3.
The mashing was made manually controlled, because the automated mashing achieved by the finite elements programs is not good enough for obtaining concluding results, using elements of tetrahedron type. The structure was mashed in a number of 28084 elements and 61082 cores.
The determination of the frequencies and of the proper modes of vibration can be achieved by the modal analyses. The natural frequencies and the vibration modes are very important parameters for the designing phase because it provides information about the behavior of analyzed structures in dynamic regime.
The modal analyze is a linear analyze. Any non- linear issue, as the plasticity and the contact elements are ignored even if they are defined.
The modal solution is obtained after a modal analyze which suppose the following steps:

- the model construction;
- the lads' appliance and the determination of the solution by structural analyze;
- the modes expanding;
- results' visualization.

Dynamic analyze of the machine-tool suppose the determination of the structure's proper frequencies, to which the structure of the machine can enter in resonance with important implications towards the work process. At the resonance frequency, the structure's deformations can be bigger than the static deformations, and this leads at large processing errors. There were determined ten proper frequencies, but there were enough 4, because these frequencies are increasing, and the work frequencies area is in the area of the first four proper frequencies. The proper modes of vibrations are shown in figure 2.

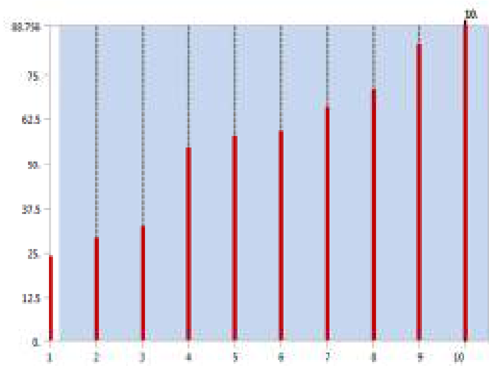

Figure 2: The proper frequencies spectrum

The deformation mode of the structure according to the first mode of vibrations of 24.023 Hz, there is presented in figure 3. It can be noticed that this mode is specific to the left lateral pillar for the Z axis.

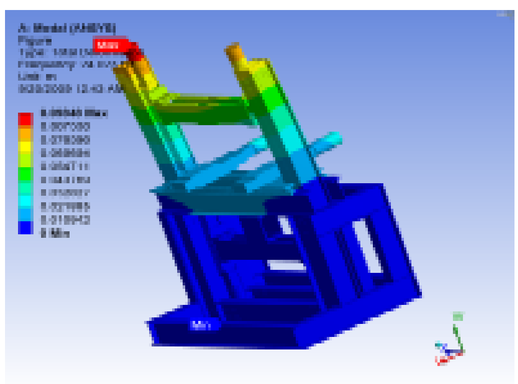

Figure 3: The first vibration mode

The second vibration mode, shown in figure 4, there is specific to Y axis and it has a value of 28,887 Hz.

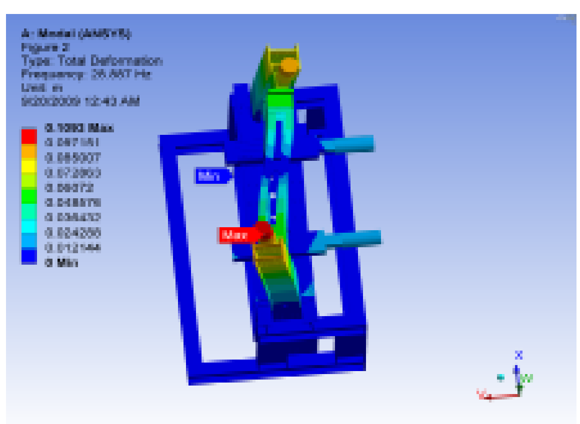

Figure 4: The second vibration mode

The third vibration mode there is presented in figure 5, but with a smaller displacement. The value of the obtained frequency is 32.166 Hz.

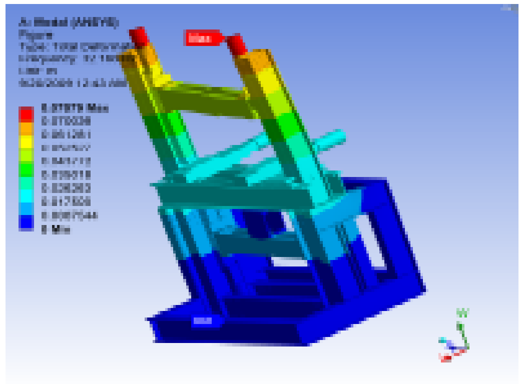

Figure 5: Third vibration mode

The fourth vibration way resulted from analyze occurs in the inferior traverse area and its value is 54.441 Hz.

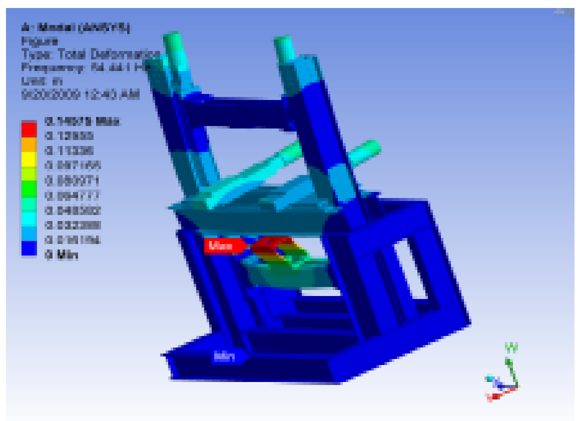

Figure 6: The fourth vibration mode

3. CONCLUSION

In modal analysis, there were achieved the proper frequency modes, which if it coincides with the work frequencies may lead to the phenomenon of resonance, a phenomenon that leads to endless displacements for unredeemable structures and big displacements, for the redeemed structures. Desirable is that the proper frequencies do not overlap with work frequent field, for this purpose in pursuing the growth of these so that they will be working over frequency or lower than this. If the resonance frequency can not be avoided, it aims to increase the damping by introducing external damping [4]. After the study is seen as the proper frequencies of the structure are small, but the resonances effect can be reduced by increasing the external damps. However, the composite material that is made the cradle is a good damper vibration. The proper frequencies which can not be modified can be removed by CNC and used software.

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