CONCERNING ABOUT THE COMPUTER SIMULATION AND MODELLING IN FEM THE HSM CNC WOODWORKING MACHINE SPINDLE

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Abstract
The paper presents some aspects regarding of some method of computer simulation of HSM CNC wood processing machine.

Key words: computer simulation, FEM, HSM, CNC woodworking machine spindle

INTRODUCTION

Recent studies on the development of dynamic and thermal models for work shafts and ball bearings related to them refer to speeds of up to 20000 rot/min.

The dynamic models treat natural frequencies of shafts and their correspondence with holding systems of tools (three different types of tools) and with the use of various types of ball bearings (including those with ceramic balls). The modeling obtained may be used at the design of a work shaft, the analysis of faults occurred and the improvement of work conditions and of the manufacture process;

Comparing the results of these researches, with the proposed purposes of this work, that is the dynamic behavior of work shafts higher than 20000 rot/min (frequency 1380 Hz), we elaborated a simulation and modeling program, answering this purpose.

MATERIAL AND METHODS

The simulation elaborated through the software COSMOS package and MatLab^{TM} SIMULINK program contains the following chapters:

- Introduction;
- Materials used;
- Properties of the FEM network (Mesh Information);
- Results on the relative displacements;
- Final results of abnormalities in relation to the frequency.

We present in short the FEM analysis of main shaft reference

Chart 1

Material name	Plain Carbon Steel
Description	
Material Source	Library files
Material Library Name	coswkmat.lib
Material Model Type	Linear Elastic Isotrope

Property Name	value
Elastic modulus	2.1e+011 N/m^2
Poisson’s ratio	0.28
Tangent module	7.9e+010 N/m^2
Mass density	7800 kg/m^3
Tensile strength σ_r	3.9983e+008 N/m^2
Yield strength σ_{02}	2.2059e+008 N/m^2

Materials used

Chart 2.

Nr.	name	Material	Mass	Volum
1	Part1	Plain Carbon Steel	10.9165 kg	0.00139955 m^3

Mesh information

Chart 3.

Mesh Information	
Mesh Type:	Solid Mesh
Mesh Used:	Standard
Automatic Transition :	Off
Include Mesh Controls:	On
Smooth surface:	On
Jacobian Check:	4 points
Element Size:	11.188 mm
Tolerance:	0.55941 mm
Number of elements:	9425
Number of nodes:	16422

Chart 4.

Solver Information	
Solver Type:	FFE Plus
Number of frequencies::	10

Hereinafter we will present the application modality of the axle forces and bending forces on the shaft in two different cases: in the first case, the forces are applied on the assembly of ball bearings, and in the second case, we have the forces applied in the piece assembling zone, as well as bending forces in the fixation zone of shaft in console.

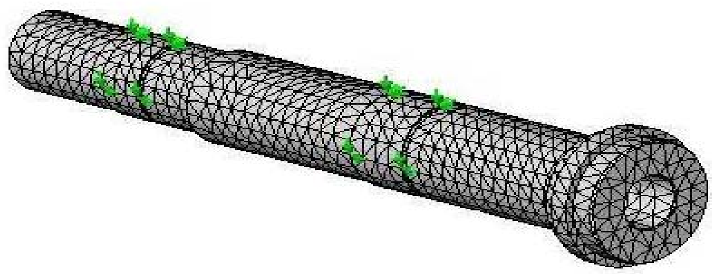

Image 1. MESH network properties of the work shaft .

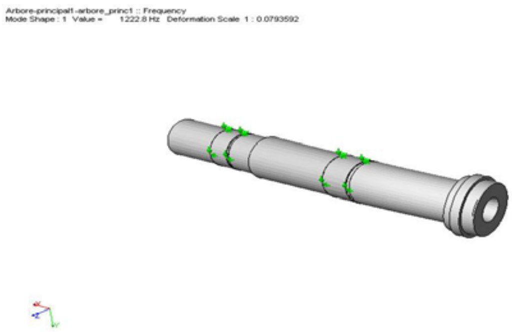

Image 2. Application modality of axial forces and bending forces on a work shaft, actioned through the transmission belt

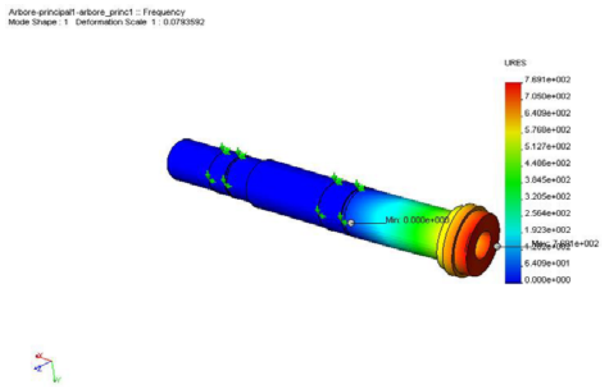

Image 3. The vibration modes of the work shaft operated through a transmission belt at relatively reduced speeds, 1500 rot/min

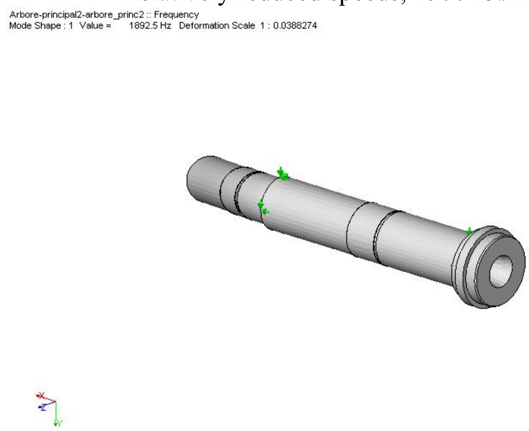

Image 4. The application modality of axial forces and bending forces on a built-in work shaft, in vertical position

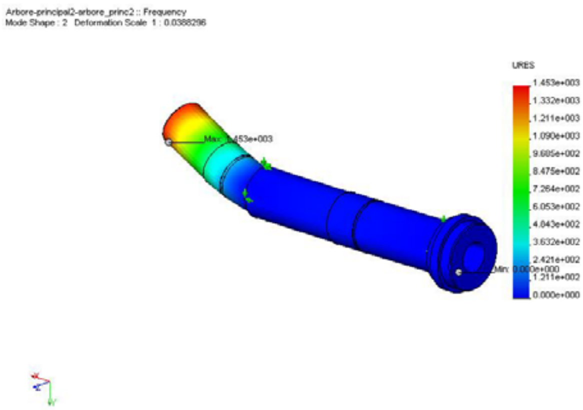

Image 5. The vibration modes of the tool holding system at speeds ranging between 20000-30000 rot/min

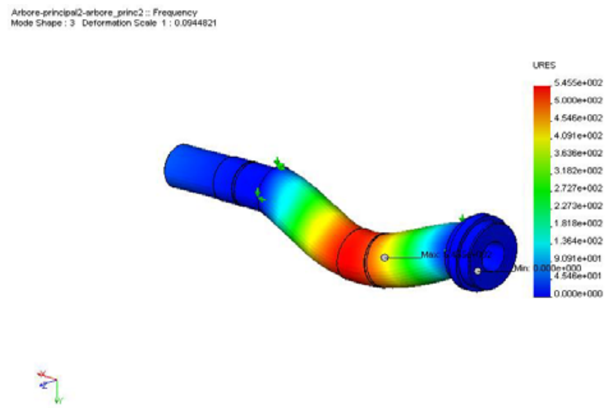

Image 6. Vibration modes of the work shaft on the area of ball bearings and rotor assembled on axle at speeds > 40000 rot/min, in vertical plan

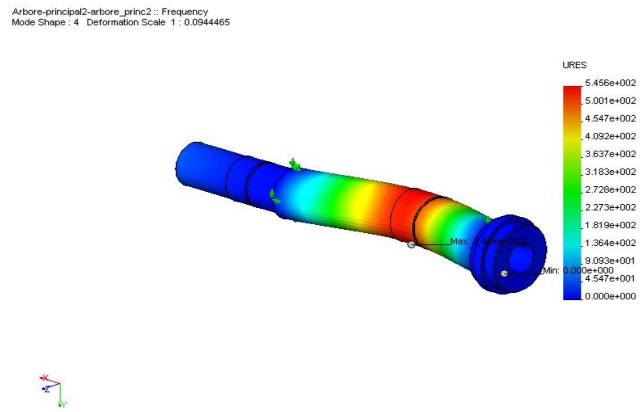

Image 7. The vibration modes of work shaft in the area of ball bearings and rotor assembled on axle at speeds > 40000 rot/min, in horizontal plan

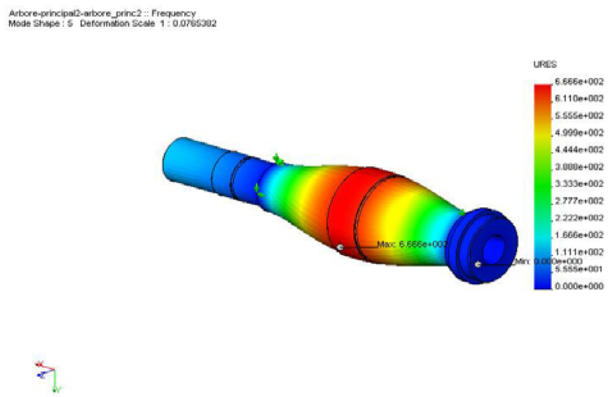

Image 8. The vibration modes of work shaft in the area of rotor assembled on shaft at speeds > 50000 rot/min

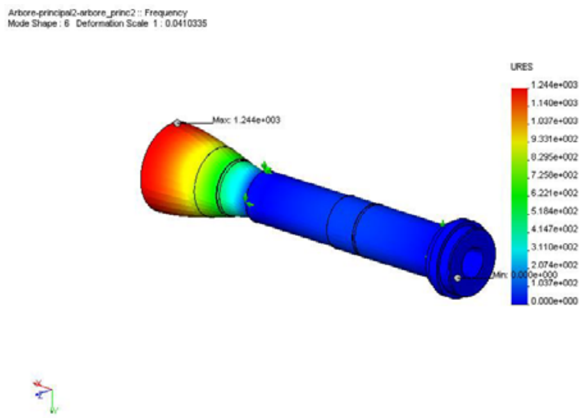

Image 9. The vibration modes of the work shaft in the area of rotor assembled on axle at speeds 50000- 60000 rot/min

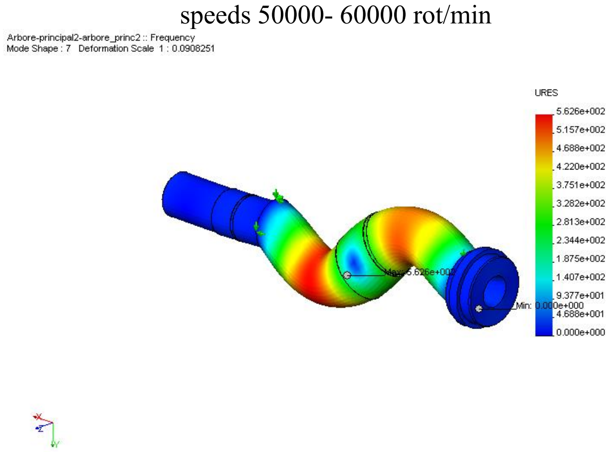

Image 10. Vibration modes of work shaft in the area of rotor assembled on the axle at speeds > 60000 rot/min, visualized in vertical plan

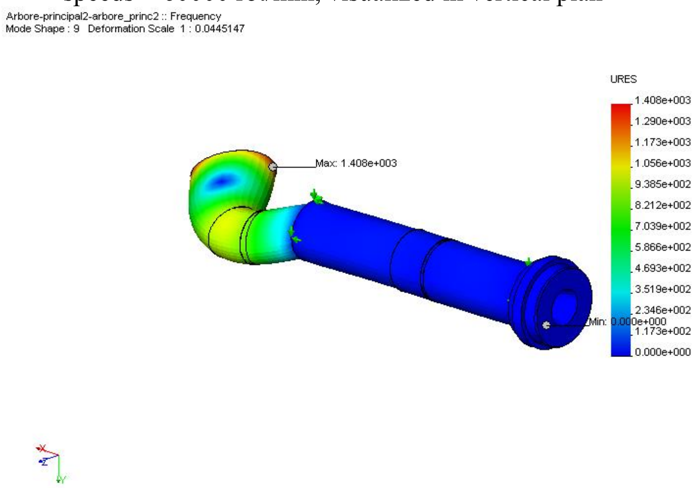

Image 11. The vibration modes of the system for holding the tool at speeds > 60000 rot/min

In the graphic results obtained, we have the configuration of abnormalities, their position on the shaft axle, relative abnormality corresponding to a certain speed, respectively to a certain frequency.

RESULTS AND DISCUSSION

Results on relative displacements: final results of abnormalities in relation to the frequency are emphasized in the following chart.

Chart 5.

Mode List	
Mode Number	**Frequency in Hertz**
1	1892.5
2	1893.1
3	2536.2
4	2538.3
5	4941.9
6	5351.8
7	5940.3
8	5944.7
9	7364.6
10	7368.1

CONCLUSIONS

From the FEM analysis we obtain certain results regarding the requests and abnormalities a shaft is subject to at high speeds:

- at speeds ranging between 20000-40000 rot/min the requests are maximum in the area of tool holding system, requiring improved constructive solutions on this area (image 5)

- at speeds ranging between 40000-60000 rot/min the requests are maximum in the area of ball bearings, but also thermal dilatation abnormalities occur in the area of induction engine directly assembled on the work shaft, requiring the use of radial ball bearings with ceramic balls and the elaboration of a successful cooling system of rotor in case of metal processing (image 6. – 8.);

- at speeds higher than 60000 rot/min abnormalities and dilatations occur in the area of holding of tool and important twist abnormalities of axle accompanied by thermal phenomena in the area of non-synchronous electric engine, which assumes finding a constructive solution regarding the construction of tool holding system (HSK system), as well as the use of pairs of special ball bearings, in the area of electric engine. Also, it is very important to create a unique cooling system of the work shaft, in the area of ball bearings, electric engine, as well as in the tool holding area (img 9–11.);

- by using the solution of built-in the shaft in vertical position, we eliminate the twist requests in the central area of the shaft, obtaining a very good stability in the built-in area of the shaft;

- by using the adoption of tool holding system type HSK, the dynamics of shaft and tool are stabilized, eliminating the effects of bending and thermal dilatation requests;
- from a theoretical point of view, in the present case, the best stability limit is obtained at speeds ranging between 40000-60000 rot/min, and at speeds ranging > 70000 rot/min, we cross into the marked instability area.
- from an experimental point of view, the results of modeling and simulation will have to be validated and the limits of SLD diagram specified, as well as the CNC stability reserves, meaning at which speed during the functioning of the equipment, at backlash and during processing, we enter into the instability area.

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