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VIRTUAL SIMULATION FOR STATIC BEHAVIOR OF THE MAIN SPINDLE ASSEMBLY OF A HORIZONTAL DRILLING AND MILLING CNC MACHINING WITH A HIGH-SPEED CUTTING

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***Abstract*—**The research underlying this article focused on the study of elastic system consisting of "main spindle (the first section) - bearing" aimed at determining angular displacements and the specific strains under the action of the torque and external forces (forces due to cutting regime) in the case of horizontal drilling and milling CNC (Computer Numerical Control) machining with a high speed cutting. Thus, due to the impressive development of computer technology, for a numerical analysis of the system was used the finite element method through ANSYS software.

***Keywords*—**machining, high-speed cutting, angular displacements, specific strains

I. INTRODUCTION

The mine spindle performance [1] is fundamental for high-speed processing [2] it having the greatest influence on the performance of the machine tool. The elements that determine the effectiveness of machine tools with high cutting speeds are: main shaft, electric motor drive, tool holder and cutting tool.

Therefore, this article presents research to study the static behavior of the assembly of the horizontal drilling and milling CNC machining with a high-speed cutting conducted by SC SPECIAL MACHINES '95 S.A. Bucharest and are endowed TURBOMECANICA S.A. Bucharest.

The main kinematics chain, (Fig. 1) provides a cutting tool revolution speed in the range 1000...5000 (rev/min), being driven by a servomotor αM12i - FANUC with nominal revolution speed of 4000 (rev/min) and torque of 12 (N×m), have two main components:

1) the main shaft consists of two parts,

2) the reduction gear used for the transmission of the rotary movement of the servomotor to the main shaft gears.

The main shaft ensures the centering and fixing of the tool by means of a cone ISO 40 which is fixed by means of the tensioning manually operated out of reduction gear. The modern industrial logistics combines the new use of AS/RS (Automated Storage/Retrieval System) with the RFID (Radio-Frequency Identification) technology [3], [4].

Roll bearings are done with P4 grade precision bearings, a set of two ball bearings, angular and a radial-axial ball bearing set front and two angular contact ball bearings for rear camp.

Part two of the main shaft connecting the first part (described above) and reduction gear. The introduction it has been necessary to make a forward stroke of 400 (mm) at a speed of advance of the tool within the range of 60...300 (m/min).

The entire assembly of the main spindle is mounted on the sled plate with electromechanical advance with the help of guides while INA gear whose gear ratio is i = 1.25 (30/24), mounted on the back of it. Output maximum revolution speed is 5000 (rev/min) which may be increased by changing the pulleys. It is noted as having a single resilient system, consisting of the main shaft (first section) and its bearings (bearings), which are downloaded from the forces in the reduction gear.

II. STATIC BEHAVIOR MAIN SPINDLE ASSEMBLY AT THE SPEED OF 5000 (REV/MIN)

Based on the overall design of the main kinematics chain (Fig. 1) of horizontal drilling and milling machine CNC, the construction of the spindle (the first section) is made of steel 41MoCr11, according to DIN 17210-69, has a length of 340 (mm) bearing system consisting of: a set of two angular contact ball bearings (7010

ATA.P4.DT, ϕ50 × ϕ80 × 32) and a radial-axial bearing (7010 ATA.P4.DT, ϕ50 × ϕ80 × 16) for the front and set of two angular contact ball bearings (7010 ATA.P4.DB, ϕ 40 × ϕ 68 × 30) from behind.

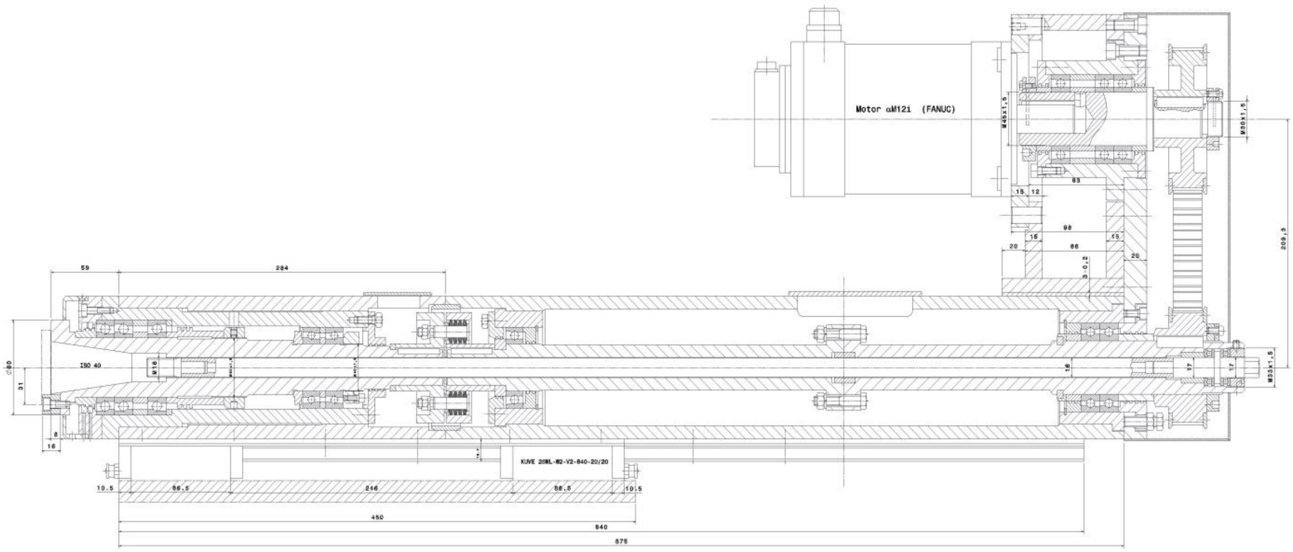


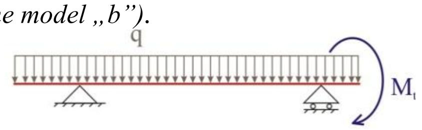
Fig. 1. The main kinematics chain.

For the finite element analysis [5] based on real structure design, we have developed two models of computation, effectively summarizing all available and also approximates actual geometric and mechanical structure, which is mathematical models about the main shaft subject to the study.

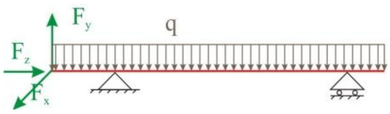
Thus, it has been proposed:

1) model „a” – statically indeterminate main spindle with two points of the fulcrum and the request is composed of the weight evenly distributed q and the torque equivalent M_t (Fig. 2 the model „a”),

2) model „b” – statically indeterminate main spindle with two points of the fulcrum and the request is composed of the weight evenly distributed q and the forces which occur during the generation of the surface (Fig. 2 the model „b”).



The model „a”



The model „b”

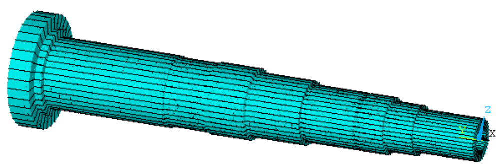
Fig. 2. Calculation models.

Knowing the power of the electric motor driving the main kinematic chain and rotation speed we have determined the torque equivalent M_t, (M_t = 57300 (N×mm).

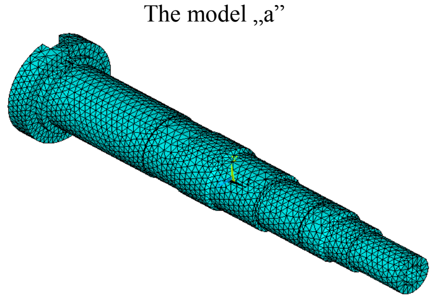
Also, taking into account the material to be processed, the used cutting tool (milling cutter with the diameter of 20 (mm)) and the number of teeth, the depth of cut and feed per tooth, and using literature [6] determined the forces which occur during the production of the surface (F_x = 5500 (N) – cutting force X axis, F_y = 4400 (N) – cutting force Y axis and F_z = 11000 (N) – cutting force Z axis). Regarding q, q = 0.12 (daN/mm), it was established taking into account the total length of the shaft, l = 340 (mm), and weight of 3.45 (kg).

Meshing shaft is required fundamental approach by MEF (Finite Element Method) and consists in the transition from the structure continues to discrete model with a finite number of points (nodes) [7].

This operation is "covering" model with a mesh network and is justified by the fact that from engineering structure sufficient information (eg. knowledge the values of the displacements and the tension) in a certain number of points of the model number of which can be as high.



The model „a”



The model „b”

Fig. 3. Meshing structure.

After the meshing (Fig. 3), in Table 1 reveals that the number of nodes and assets increase significantly in the case of the b (~ 2.26 fold increase for nodes and ~ 4.32 fold increase for elements).

Also, for this model, external forces (forces that arise during the production areas) are applied to the nodes of the model; if their number is high the network is fine and approximation are better [8], [9].

TABEL 1
NUMBER OF NODES AND ELEMENTS

	The model „a”	The model „b”
Number of nodes	3.473	7.072
Number of elements	1.536	30.621

III. DETERMINE THE ANGULAR DISPLACEMENTS AND SPECIFIC DEFORMATIONS

The first step of the analysis [10] was to study an elastic system consisting of the spindle (the first section) - bearing aimed at determining angular displacements and specific deformations of the structure for models developed and presented in Fig. 2.

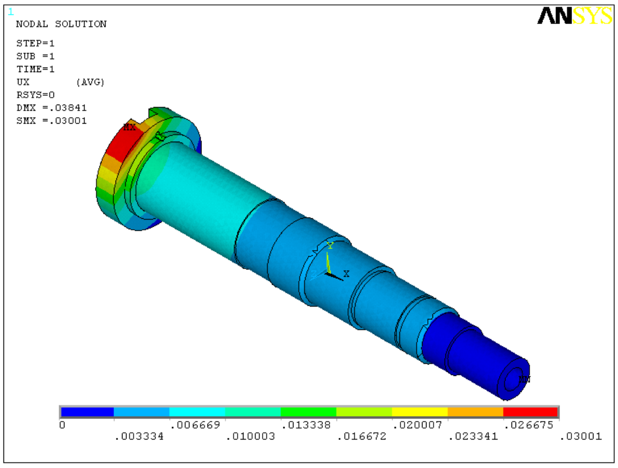


Fig. 4. Displacement of the structure, the model „b”, in the direction of the X axis (rad).

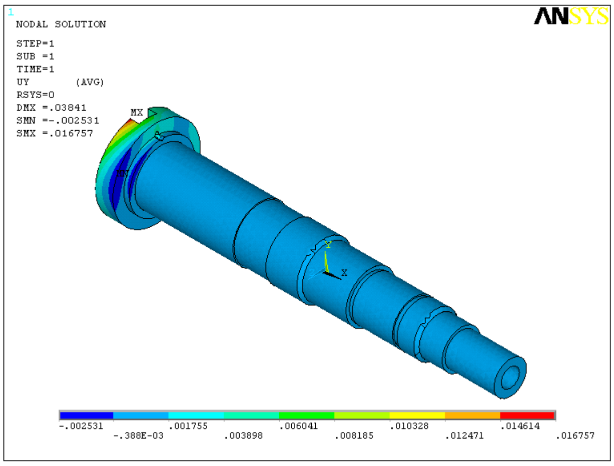


Fig. 5. Displacement of the structure, the model „b”, in the direction of the Y axis (rad).

The analysis noted that for the model „a”, as a result of the load with M_t - torque equivalent, results are insignificant values of angular displacements structure X and Y axes directions are nulls while the Z axis direction maximum angular displacement is DMX = 0.016 (rad).

For the model „b” (Fig. 4, Fig. 5, Fig. 6 and Fig. 7), as a result of the load of the forces in the type of surface generation, angular displacement of the structure has the same value in all three directions of axes X, Y and Z (DMX = 0.038 (rad)).

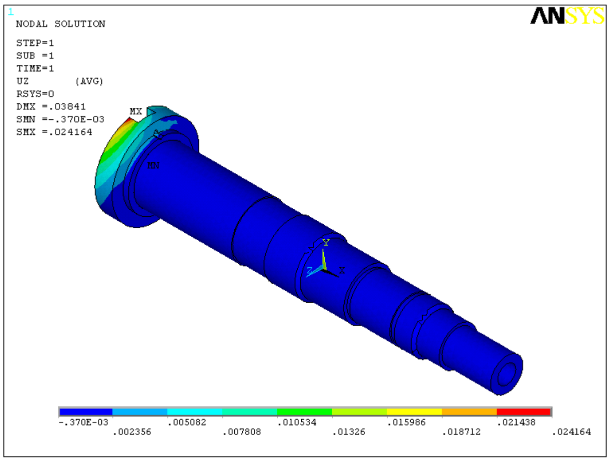


Fig. 6. Displacement of the structure, the “model b”, in the direction of the Z axis (rad).

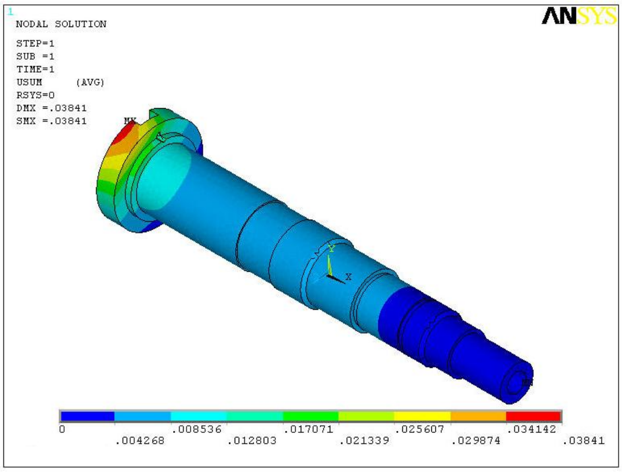


Fig. 7. The amount of displacement (mm) “model b”.

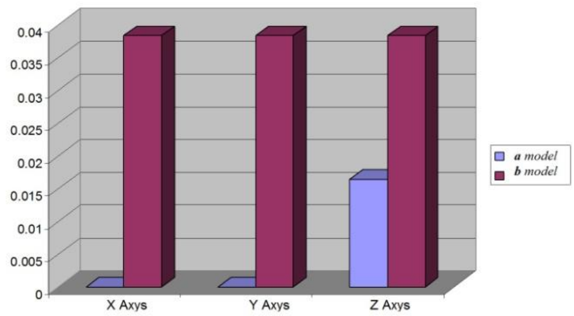


Fig. 8. The values of the angular displacements of the structure in the directions of axes X, Y, and Z (rad).

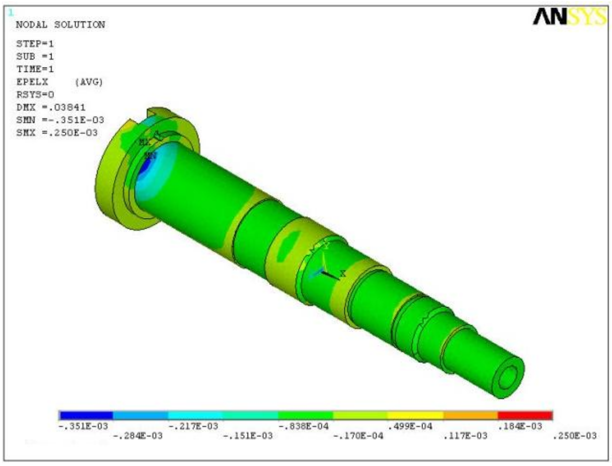


Fig. 9. Specific deformations of the structure for "model b", the direction of the axis X (μm).

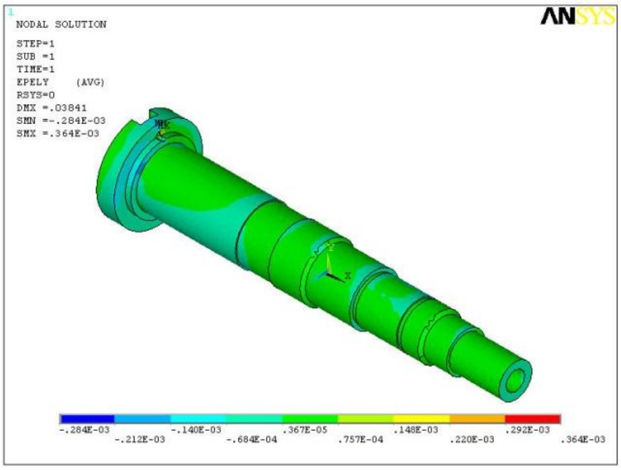


Fig. 10. Specific deformations of the structure for "model b", the direction of the axis Y (μm).

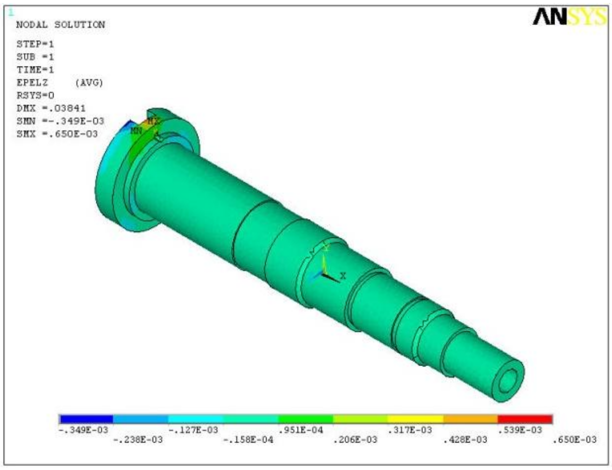


Fig. 11. Specific deformations of the structure for "model b", the direction of the axis Z (μm).

IV. CONCLUSION

According to the graphic representation of Fig. 8, notes that the angular displacement of the structure Z axis direction increases with 2.32 for the "model b" vs. "model a".

In terms of specific strains of the structure reveals that they do not influence the accuracy of processing (Fig. 9, Fig. 10 and Fig. 11).

Based on the results obtained in static analysis shaft used as a case study it can be said that under the reuse system, it can be used in machine tools with extended working speeds of the spindle structure is stable in terms static. In a forthcoming paper we will try to adapt this technology to horizontal drilling and milling CNC machining with a high-speed cutting. The fabrication cell information system contains several information flows as well many connections which are established between various components.

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