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ASPECTS ON THE ANALYSIS WITH THE FINITE ELEMENTS METHOD OF THE MACHINE TOOLS STRUCTURES REGARDING REMANUFACTURING

ANALÝZA TÝKAJÍCÍ SE OPRAVY OBRÁBĚCÍHO STROJE S VYUŽITÍM METODY KONEČNÝCH PRVKŮ

Abstract

The finite element method is a numerical method used for solving the complex issues of engineering.

The method comprises of discretion the continuous environment through assemble of finite elements, which interact between them in a finite number of nodes. The interacting forces of the nodes of the model characterize the actions of the interior forces or stresses that are applied upon the contours of the neighbouring elements.

Abstrakt

Metoda konečných prvků je numerická metoda používaná pro řešení komplexních problémů ve strojírenství. Tato metoda se skládá z průběžného prostředí shromážděných konečných prvků, které se vzájemně mezi sebou mění v konečný počet uzlů. V interakci sil uzlů v modelu charakterizují činnosti vnitřních sil a zdůrazňují, že jsou uplatňovány na kontury sousedních prvků.

INTRODUCTION

The finite elements method comprises of replacing the real structure (continuous) with an ideal structure (not continuous), divided or discrete into smaller subsets named ***finite elements***.

The continuous advance in computers technology paved the way for simulating the different components in exploitation mode, thus concurring to the decreasing or even totally eliminating the necessary costs of the prototypes making and research.

The finite element method is a numerical method used for solving the complex issues of engineering. This method was applied for the first time more than 50 years ago and it was continuously developed, so today it is considered to be one of the best methods of efficiently solving a large variety of practical issues.

1 WORK STAGES

The method comprises of discreting the continuous environment through assemble of finite elements, which interact between them in a finite number of nodes. The interacting forces of the nodes of the model characterize the actions of the interior forces or stresses that are applied upon the contours of the neighboring elements. So, calculating of a strength element which is considered as a

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continuous environment with an infinite number of connections has been reduced to calculating of a system with a finite number of connections or degrees of freedom.

Discreting the structures can be carried out with linear, plane or spatial finite elements.

The structures analysis imposes using two systems of reference [4].

- One system which is associated to the structure – named **global system** – in which the position is defined and its movements are determined;
- One system which is associated to each element – named **local system**.

One of the known coordinate systems: Cartesian, cylindrical or spherical, can be chosen as systems of reference.

Finite elements of square linear type, stressed within the local plane (q, k), with two degrees of freedom on every node were used, in order to discrete the analyzed structure. The approximation function of movements (u,v) is as it follows [5]:

$$\begin{Bmatrix} u \\ v \end{Bmatrix} = \begin{bmatrix} N_1 & 0 & N_2 & 0 & N_3 & 0 & N_4 & 0 \\ O & N_1 & 0 & N_2 & 0 & N_3 & 0 & N_4 \end{bmatrix} \cdot \begin{Bmatrix} u_1 \\ v_1 \\ u_2 \\ v_2 \\ u_3 \\ v_3 \\ u_4 \\ v_4 \end{Bmatrix} \tag{1.1}$$

The interpolation functions used in the calculus have the following form [5]:

$$N_1 = \frac{(1-k)(1-q)}{4} \text{ for node D;} \quad N_2 = \frac{(1+k)[1-q]}{4} \text{ for node C;}$$

$$N_3 = \frac{(1+k)(1+q)}{4} \text{ for node B;} \quad N_4 = \frac{(1-k)(1+q)}{4} \text{ for node A .} \tag{1.2}$$

It is known that: $N_1 + N_2 + N_3 + N_4 = 1$

The geometry of the structure of the FUS 25 milling machine was carried out using a CAD program; afterwards it was discreted using square type finite elements. The model presented in Fig.1 is prepared for the finite elements analysis, after imposing the conditions of stress and support.

The vibration modes of structures can be vibration modes for rigid bodies and vibration modes for elastic bodies. All structures can have the six vibration modes of the rigid solid: three translations and three rotations.

Assuming that the analyzed structure is positioned on elastic elements, then the displacement is approximated with a rigid solid mode.

Fig.2 shows the conditions of fastening and stress for the analysis of the structure behavior to static stress (the force F_2 = 2598 N has its application point on the case of the main shaft, and the force that actions on the machine table has the value of F = 2000 N).

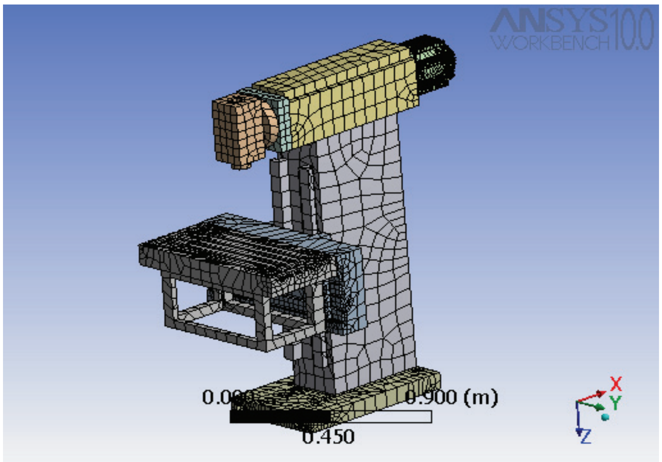

Fig.1 The discreted geometric model

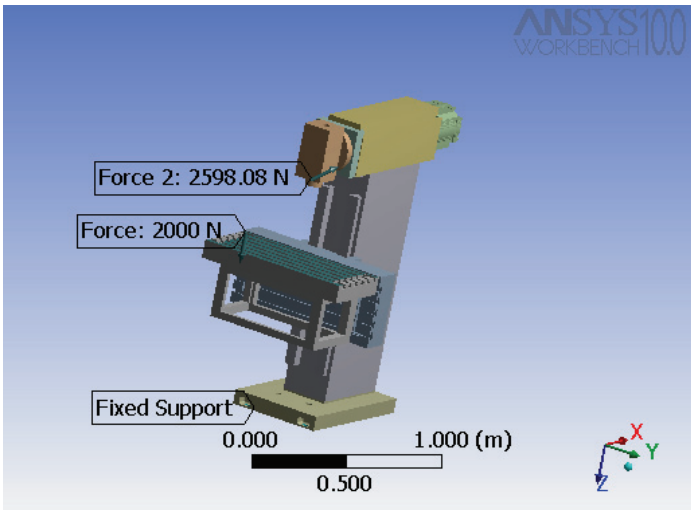

Fig. 2 Mode of fastening and stress

The structure is freed from bonds, in the finite elements modal analyses. The first six own frequencies, relative to the six degrees of freedom of the structure (three translations and three rotations) are not taken into account. The structure analysis begins from the 7^{th} own frequency. The first own frequencies obtained by theoretic analysis are low. For example, the frequency of 4.6 Hz, according to Fig.3, is a false frequency that can be corrected by stiffening the table support, as from the analysis it is found that the table support can be broken at this frequency.

The 112.3 Hz own vibration, - Fig.4 – leads the machine tool to a resonance state that contributes to displacements of the machine structure elements, severely affecting the processing accuracy. A rotation of the machine body and table around the Z axis but in contrary directions is noted in Fig.4, leading to the modification of the position of the tool against the processed part. The own mode presented in Fig.5 at the frequency of 140,84 Hz marks out a bending of the machine body and table within the X-Z plane, catastrophically affecting the tool-part position.

The theoretical frequency obtained by modal FEM analysis were validate by experimental data acquisition (fig.6) with a Schenk Vibroport 41 and the reiceiver (the accelerometer) (fig.7) [8] from the National Research Centre for Performances of Technological Systems – Optimum (*http://sun.cfic.pub.ro*)

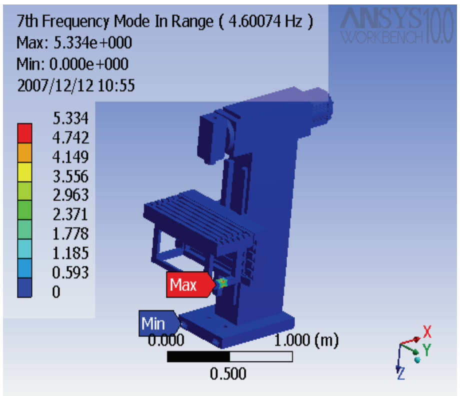

Fig.3 Movements of the structure by f = 4,6 Hz

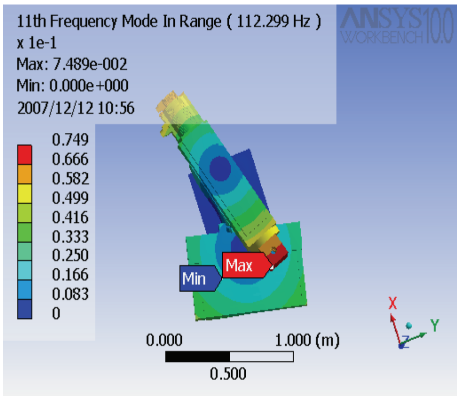

Fig.4 Movements of the structure by f = 112

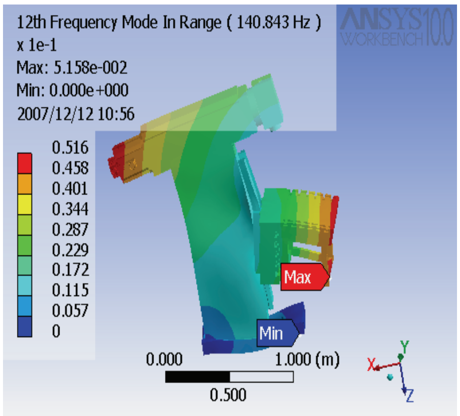

Fig .5 Movements of the structure by f = 140Hz.

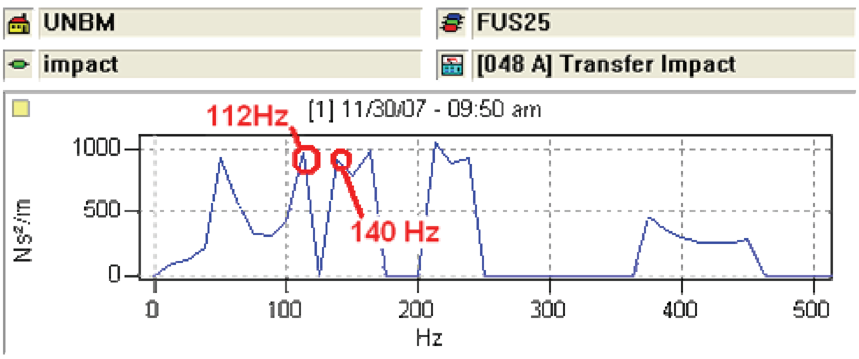

Fig.6 Transfer function experimental data acquisition

Fig.7 Vibroport 41 and the position of the accelerometer

The resonance danger does not appear anymore from the 112 Hz own frequency of the analyzed structure, as the subsequent frequencies are off the domain of the work frequencies.

In the view of this analyses, it can be asserted that the own frequency that imposes the maximum value of the remanufactured machine speed is 112 Hz.

Thus the maximum speed will be **6700** rev/ min.

2 CONCLUSIONS

In order to set up a methodology of assessing the dynamic performances of the remanufactured machine tools, previously from commencing their remanufacturing, we chose a milling machine for the theoretic research, as the milling process is a procedure of generating the surfaces, which is highly generating forced vibrations. The dynamic aspects met by the milling machines can be considered as covering for most of the machine tools.

The results of the research should contribute to obtain a valid analytical model that is to characterize the future dynamic behavior of the remanufactured technologic equipment, and which is to offer information that are less evident in the design stage of remanufacturing.

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