Verification of Machine Tools for the Purpose of Remanufacturing

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Abstract: *The analysis of technological equipment before remanufacturing through modal analysis involves the determination of the frequencies and vibration modes of their mechanical components. Based on this analysis, information obtained is about the dynamic behavior of the analyzed structure. The decision to remanufacture a machine tools also takes into account the issues related to the dynamic behavior of its structure.*

Keywords: *machine tools, remanufacturing, modal analysis*

1. INTRODUCTION

The study presented in this paper refers to the analysis of the opportunity to remanufacture a FUS 32 milling machine and its transformation into a CNC (Computer Numerical Control) machine tool.

The purpose of the experimental research is to determine the maximum speed supported by the structural elements of the studied machine tool (figure 1). For the modal analysis of the dynamic behavior of the machines, mobile equipment can be used for data acquisition.

Fig. 1. Milling machine FUS 32.

There are many production companies of performance equipments. (Bruel&Kjaer, Oros etc.) [8]

The equipment used for data acquisition is shown in the following figures, the VIBROPORT 41 system, from Bruel & Kjaer (figure 2), accelerometer and impact hammer (figure 3).

Fig.2. Vibroport 41 [8].

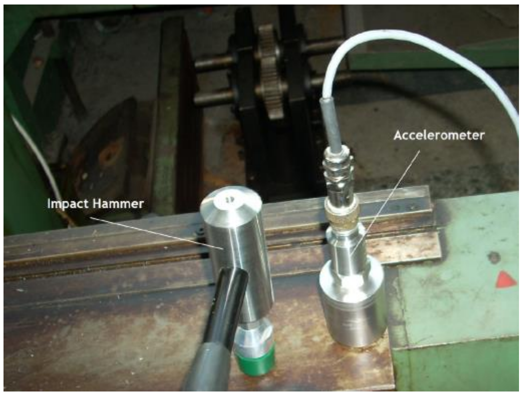

Fig. 3. Accelerometer and Impact hammer [7,8].

This equipment can be used for diagnostics in the case of predictive maintenance of technological equipment, aggregates, vehicles etc. [7].

The analysis module allows the display, in the form of a diagram, of some measurements stored in the determined database in a period of time [5,6].

The technical characteristics of the FUS 32 milling machines, which are of interest for the current evaluation are [3]:

- revolution range ....20....1600 rpm.
- feed rate ………………5...400 mm/min.
- weight of the machine .... 1650 kg.

Using the equipment presented above, measurements were performed to identify the own vibration modes of the main components of the studied milling machine.

2.THE MEANS OF CARRYING OUT THE MEASURING

The machine tools can be checked dynamically by performing one of the two analyzes.

- determination of the global vibration level of the technological equipment in working order and on the site in the production space.
- determination of the vibration level of the elastic structure of the machine tool or of some parts of them.

The first situation seeks to determine the amplitudes and frequencies of vibrations which exist at the technological equipment, as the size of the exciting forces remains unknown. In case the level of vibrations exceeds the admissible limits, the excitatory factors are determined and the excitations are reduced or removed. In this case the measuring is carried out by separate and simultanious coupling of the subassemblies of the equipment assembly. The other measuring category is carried out by superposing the action of an impulse or of a harmonic or aleatory constant force, having known values, to some component parts or to the whole elastic assembly of the machine tool [1].

In this paper we presented the determination
method of a milling machine own vibration mode, by
experimental means.

To be remanufactured, most machines can be in one of the following situations:

- decommissioned after the expiry of the normal service life.
- physically or morally worn out.
- not used because the owner of the machine has changed his manufacturing range.

The parameters of the new machine are established by its manufacturer or by the entity that has activity in this field. The remanufactured machine can return to the old owner or enter the remanufacturer's commercial circuit.

Vibration analysis is performed with the equipment in malfunction. We choose this way of working so that the measurement results are not compromised by the vibrations generated by the connections between the structural elements, the way of fixing in the foundation, the electric drive systems etc.

Accelerometer attachment points and excitation application are shown in Figures 4, 5, 6 and 7 [3].

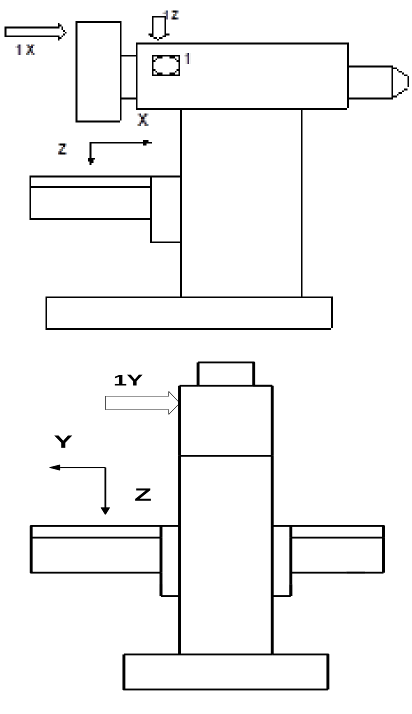

Fig. 4. Measuring no. 1.

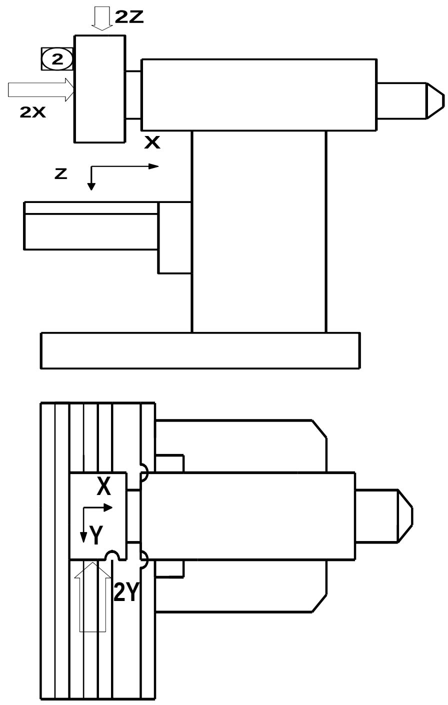

Fig. 5. Measuring no. 2.

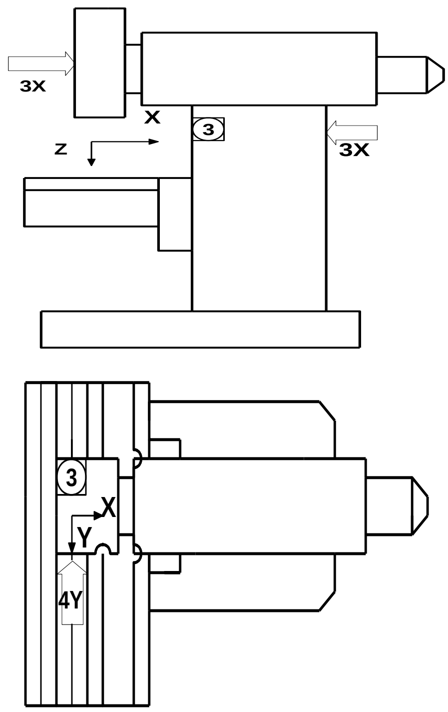

Fig. 6. Measuring no. 3.

The machine tool analyzed is in the condition that it will be when it enters the remanufacturing process. The measurement process was started with the machine tool in the state it was in at that moment, without prior preparation.

To determine the points of application of the excitation with the impact hammer we took into account some considerations:

- all components of the machine tool are included in the analysis.
- the most sensitive areas from a dynamic point of view were identified.
- the measurements were performed at a temperature of 20^o C.

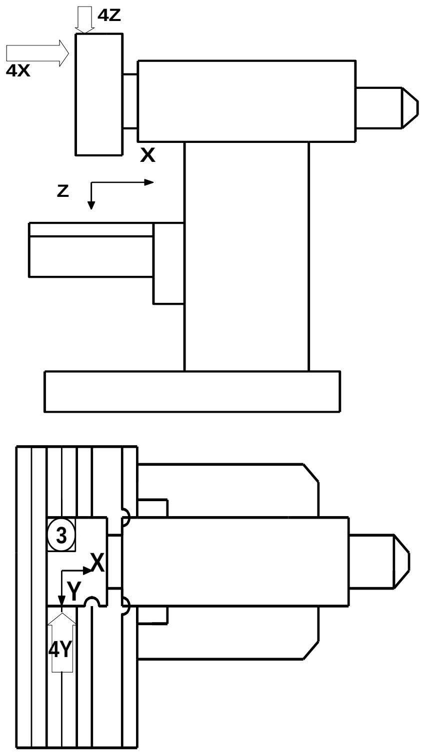

Fig. 7. Measuring no. 4.

Accelerometer attachment points and excitation application are shown in Figures 4, 5, 6 and 7 [3].

Table 1. shows the measurement points, where the accelerometer was marked with *acc* and the impact hammer was marked with *ci*.

3. INTERPRETATION OF THE RESULTS

The frequency responses (figure 8) were obtained based on the information stored in the Vibroport 41 system which was processed with a vibration analysis program.

Based on these results, the own frequencies of the equipment can be determined and then the maximum speeds so as to avoid the resonance phenomenon [2].
The determined maximum speeds are shown in Table 2.

From the information presented in table 2 it can beestablish that the FUS 32 milling machine will be able to operate at a maximum speed of 6600 rpm.

In the speed range there are values at which the FUS 32 milling machine can be affected by resonance (3000 rpm, 5400 rpm). If the milling machine is equipped with a CNC, these values will be removed from the program.

Table 1. Centralization of positions for the accelerometer and the impact hammer [3].

Position number	Accelerometer	Impact Hammer
1	1Yacc	1Yci
	1Yacc	1Zci
	1Yacc	1Xci
2	2Xacc	2Xci
	2Xacc	2Yci
	2Xacc	2Zci
3	3Yacc	3Xci
	3Yacc	3Xci
	3Yacc	3Yci
4	4Zacc	4Zci
	4Zacc	4Xci
	4Zacc	4Yci

Table 2. Results of measuring

Item	Pozition *acc* and *ci*	Own frequency [Hz}	Maximum revolution [rpm]	Notes
1	1Yacc-1Yci	250	15000	It does not comprise to the domain
	1Yacc-1Zci	150	9000	
	1Yacc-1Xci	50	3000	It is to be eliminated by CNC
2.	2Xacc- 2Xci	100	6000	
	2Xacc- 2Yci	50	3000	It is to be eliminated by CNC
	2Xacc- 2Zci	110	6600	
3.	3Yacc- 3Xci	50	3000	It is to be eliminated by CNC
	3Yacc- 3Xci	50	3000	It is to be eliminated by CNC
	3Yacc- 3Yci	115	6900	
4.	4Zacc- 4Zci	90	5400	It is to be eliminated by CNC
	4Zacc- 4Xci	200	12000	It does not comprise to the domain
	4Zacc- 4Yci	210	12600	It does not comprise to the domain

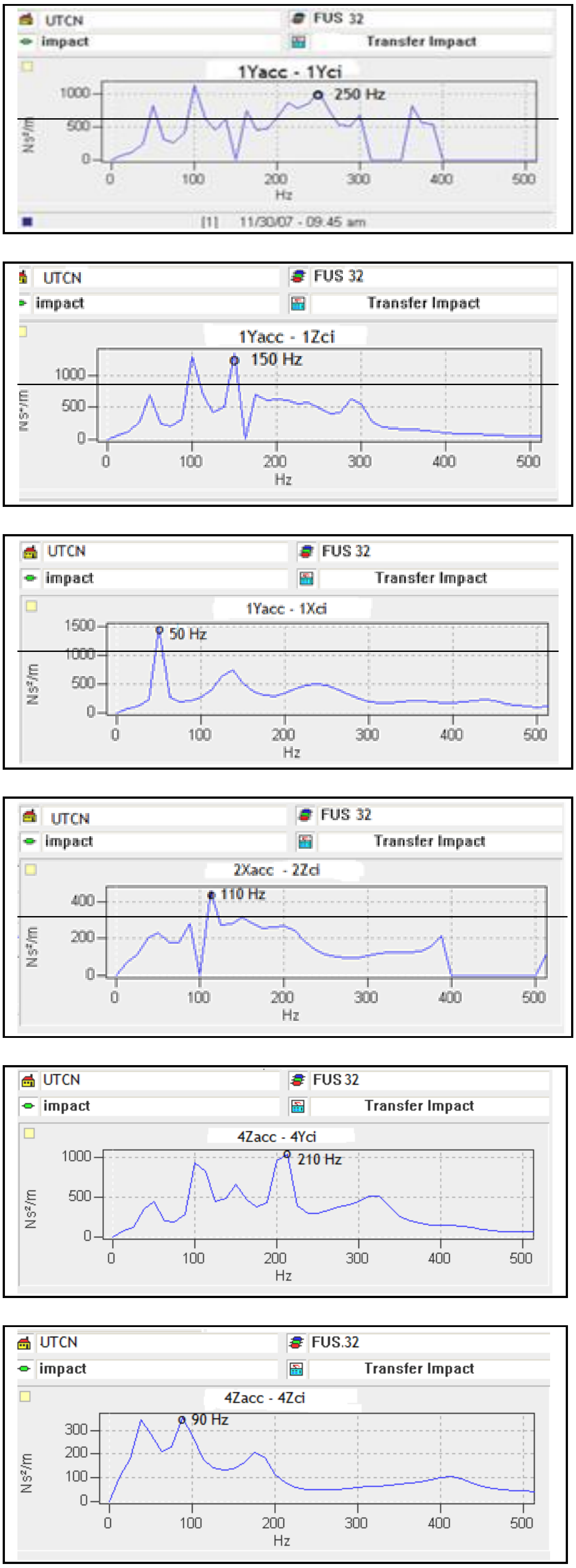

Fig.8. Frequency response at different excitations.

4. CONCLUSIONS

The paper presented the method of determining, experimentally, for the FUS 32 milling machine, its own vibration mode.

The situations resulting from the analysis that lead to the limitation of the rotation speed of the main shaft, will be reanalyzed after the design of the structure for remanufacturing.

The own modes which lead to the limitation of the main spindle rotation will be re-assessed after re-designing the structure for the remanufacturing option.

For a series of own frequencies of the assessed structure, the risk of resonance does not appear anymore, as these are off the domain of the work frequencies.

Natural frequencies and vibration modes are very important parameters for the design phase because they provide information about the dynamic behavior of the analyzed technology equipment structures.

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