Design of Machines and Structures, Vol. 10, No. 2 (2020), pp. 59–64.
https://doi.org/10.32972/dms.2020.015

ANALYSIS OF DMU40 MACHINE CENTRE BY VIBRATION MEASUREMENT

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Abstract: This article is part of a longer research-analytical work, because it outlines the results and conclusions of the study according to the main topic of the research and the applied method. The central theme of the research is the dynamic stiffness of machine tools and the various methods for their determination. Following analytical analysis the machine tool natural frequencies were determined using a finite element software (ANSYS Workbench R19.1), which we now approach from a practical point of view, that is determined in the workshop by measurements. The results obtained are compared for each of the three methods.

Keywords: *DMU40, accelerometer sensor, measurement procedure, vibration measurement, natural frequency*

1. INTRODUCTION

The determination of the natural frequencies of different machines and equipment is important in several aspects, because this will allow the error to be detected in time and can assist in the repair or redesign of the equipment under investigation. It can also clarify the diagnosis made during the vibration test. Based on machine vibration, you can get a comprehensive picture of the machine state and consequently the current state of each machine part.

In the field of vibration diagnostics, three test methods are typically used: bearing vibration test, resonance test and motion-animation test.

The modal analysis analytically derived by the finite element method and executed by the software can be used in practice to describe the vibrations of flexible bodies and related properties [1] [2]. A flexible body can also be considered mechanically known if it is possible to predetermine the motion of the flexible body, even if it is excited at any point by a force function.

Calculations of the natural frequencies can be done by analytically (using the finite element method – modal analysis) [3], but this testing is very complicated and has a much higher chance of error and hence of error. We also used software to determine the individual natural frequencies, oscillations and resonance curves for the machine tool under examination.

Here the focus is on building the 3D model, because for various reasons it is not possible to create a machine tool model in such detail as in reality, various simplifications will result in inaccurate calculations [4] [5]. This is why experimental testing is needed to compare the results of previous calculations and measurements and to further refine certain elements of the 3D assembly as well as the vibration model itself.

2. MAIN FEATURES AND PROCEDURE OF MEASUREMENT

The purpose of the measurement is to investigate the dynamic stiffness of a 5-axis CNC machine centre at the department's workshop. Examination of the behaviour of a tool that is unbalanced during the measurement in the environment of natural frequencies which was previously defined by analytical and software as a function of speed.

Measuring instruments:

- acceleration sensor: Kistler 8632C50,
- teflon-insulated connection wiring,
- charging amplifier: Kistler 5134,
- measuring amplifier: HBM Spider 8,
- display device: laptop,
- evaluation software: HBM Catman 4.0

Measurement of vibration acceleration at unspecified tool at predetermined measuring point(s) near the spindle of the tested machine (CNC machine centre) by rotating the spindle at different revolutions, around the natural frequencies determined by previous calculations or software FEM analyses.

2.1. Preparation of the measurement, assembly of the measurement circuit

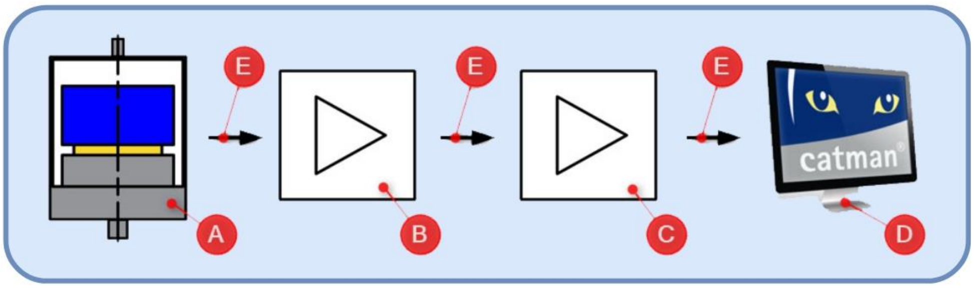

Figure 1
Outline of measurement set-up

Where the devices in *Figure 1* are: A) a vibration accelerometer; B) charge amplifier; C) measuring amplifier; D) an evaluation tool; E) wiring.

2.2. Determining the measuring point, fixing the sensor at the selected point

The machine cover makes it very difficult to place the accelerometer sensor. In the study, we focused primarily on the y-slide and within it the spindle environment. Since the excitation was not a pulse hammer, but the effect of unbalanced tool vibrations was investigated, it was advisable to place the measuring point as close to the spindle as possible.

2.3. Adding excitation to the system

After turning on the CNC machine centre, we set pre-determined speeds for the spindle speed. A diameter 40 mm cutting tool was installed in the spindle to hold four inserts, but to ensure unbalance, only one cutting insert was installed in the tool. After adjusting each speed, the sensor measured data (vibration acceleration values) were saved from Catman 4.0 in Excel format, so the measured data was further evaluated using Excel and Maple software.

2.4. Perform the measurement

Figure 2 depicts the measurement installation by displaying the accelerometer used for vibration testing.

Figure 2

Vibration acceleration sensor at the measuring point and unbalanced tool

2.5. Evaluation of results

From the measurement results, that is the response of the machine tool, the characteristic frequency values of the machine at each speed can be read out using the frequency spectrum *(Figure 3, Figure 4, Figure 5)*. Knowing these results, they become comparable with previously obtained analytical results and with data calculated by the finite element software.

The final conclusion can then be drawn to determine the extent to which the calculated and measured results differ from each other and to adjust the vibration model and the 3D assembly drawing of the machine tool accordingly.

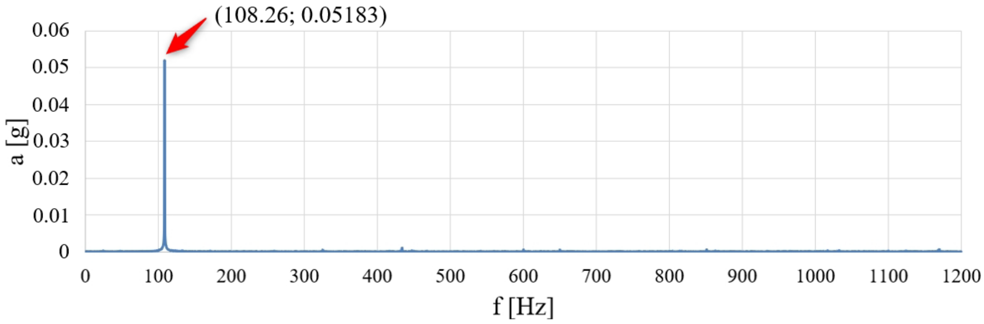

Figure 3
Frequency spectrum 1

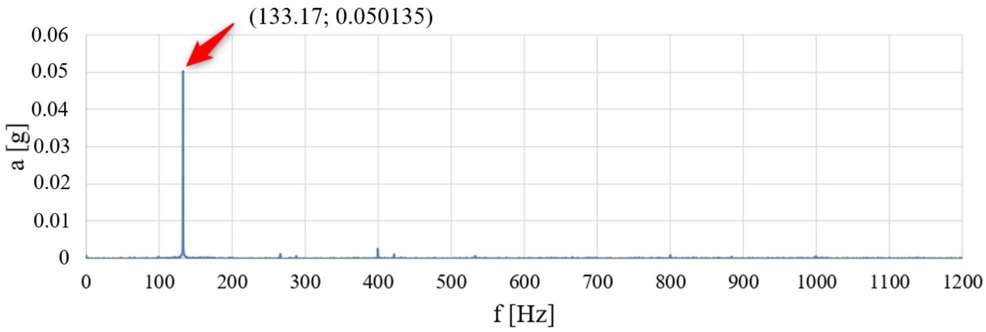

Figure 4
Frequency spectrum 2

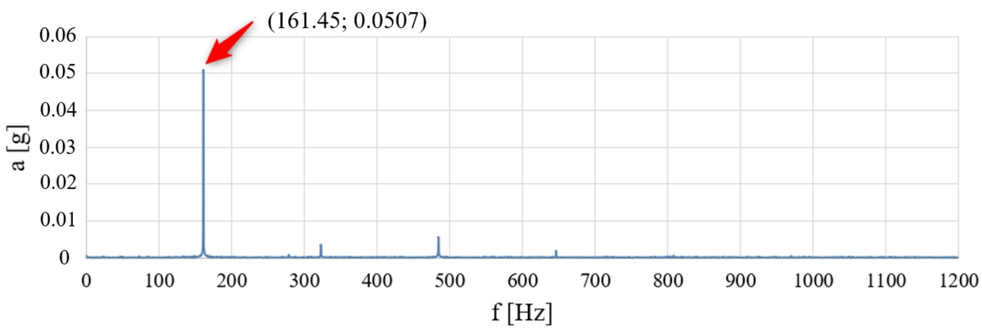

Figure 5
Frequency spectrum 3

The data obtained gives a visual picture, when the sample is transformed by Fourier-transformation and a frequency spectrum is plotted from them. The diagrams thus converted are illustrated in *Figure 3*, *Figure 4* and *Figure 5* above. Based on the above it can be concluded that the measured structure has its natural frequency at the following frequency locations:

1. 108,26 Hz
2. 133,17 Hz
3. 161,45 Hz

3. SUMMARY

In this paper we have presented another possible method for determining the dynamic stiffness (natural frequencies) of a machine centre. Testing with CAE (Computer Aided Engineering) software enables fast and accurate computation, if we have a right 3D model and the material quality of each element which information necessary to run the simulation. In terms of results, the previously analytically calculated natural frequency values approximate the software-calculated data. The results of the methods are summarized in *Table 1* below.

4. CONCLUSION

In order to achieve more accurate manufacturing and better surface quality, care should be taken to avoid operating the machine centre at and above its natural frequencies as defined during manufacturing.

Table 1

Comparing the natural frequencies computed analytically, numerically and experimentally

Natural frequency	Analytically	Ansys R19.1	Measurement
f_1	107,39 Hz	108,12 Hz	108,26 Hz
f_2	134,22 Hz	132,89 Hz	133,17 Hz
f_3	160,04 Hz	159,29 Hz	161,45 Hz
f_4	221,20 Hz	228,89 Hz	–
f_5	316,51 Hz	325,71 Hz	–
f_6	378,71 Hz	377,26 Hz	–
f_7	540,51 Hz	538,13 Hz	–
f_8	659,27 Hz	664,41 Hz	–

ACKNOWLEDGEMENT

The described article/presentation/study was carried out as part of the EFOP-3.6.1-16-2016-00011 *Younger and Renewing University – Innovative Knowledge City – institutional development of the University of Miskolc aiming at intelligent specialisation* project implemented in the framework of the Szechenyi 2020 program. The realization of this project is supported by the European Union, co-financed by the European Social Fund.

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