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IMPACT TESTS OF MICROMILLING TOOL MOUNTED IN MICROMILLING MACHINE SPINDLE

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Abstract:
Method of performing impact test of tool mounted in micromilling machine spindle is presented. Due to very small tool dimensions performing impact test in classical way is impossible. Accelerometer cannot be used for impulse response measurement. For measurement of tool displacement laser vibrometer is used. Frequency response function was measured in two directions in seven points of micromilling tool. Additionally frequency response function in three points of machine spindle is measured. Resonant frequencies and their amplitude for points on tool and on machine spindle are compared. Results of performed impact tests are shown. Conclusions arising from performed impact tests are presented.

Key words: *micromilling, impact test, frequency response function, micromilling tool*

INTRODUCTION

Frequency response function of tool mounted in milling machine spindle measured on the tool tip gives the possibility of process dynamic analysis. It can be used eg. for process stability lobes evaluation [1].

Common method used in macro scale of estimating frequency response function of tool mounted in machine spindle is impact test performed on tool tip. In most cases tool displacement is measured with accelerometer attached to tool tip. Due to very small micromilling tool dimensions performing impact test on tool tip can be difficult. Excitation of tool tip with micro impact hammer is impossible. Usage of accelerometer for tool displacement measurement is also unreasonable.

There are some known methods of estimating frequency response function on milling and micromilling tool tip [2, 3, 4, 5, 6, 7, 8]. Usually these methods uses complex mathematical models and are based on synthesis of experimental and analytical data [2, 3 ,4, 5, 6, 7, 8]. The main disadvantage of these methods is difficult experimental verification of calculated transfer function.

In the paper is proposed tool displacement measurement with laser vibrometer. Laser vibrometry do not requires attachment of accelerometer which ads extra mass to the measured object. Laser vibrometry also provides velocity signal that requires one integration in case to get displacement signal. Acceleration signal requires double integration to obtain displacement signal.

Proposed method can be used for verification of frequency response function obtained from analytical methods. From described method can be obtained frequency response function from point on tool and tool tip. Due to large impulse force hammer dimensions and very small tool tip dimensions frequency response function from tool tip to tool tip cannot be obtained directly.

EXPERIMENT SETUP

Experiment was performed on prototype three-axial micromilling machine SNTM-CM-ZUT-1 (Fig. 1a) which was build in Mechatronics Centre of West Pomeranian University of Technology.

LSM SCADAS III data acquisition device was used for signal registration. Impulse force hammer *PCB 086E80* was used for tool excitation. Tool displacement was measured with *Polytec PSV-400* Scanning Vibrometer. *LMS Test Lab* software was used for signal processing and frequency response function evaluation.

Impact tests were performed in two directions. (*X* and *Y*). For measurement of tool displacement in *Y* direction there was used additional mirror from *Renishaw* interferometer. Tool response was measured in points 1-7 (Fig. 1b), spindle response was measured in points A-C. Excitation from impulse force hammer was applied in point 5 of micromilling tool. For performed tests micromilling tool *Kyocera 2FESM005-010-04* was used. Tool tip diameter was 0.5 mm.

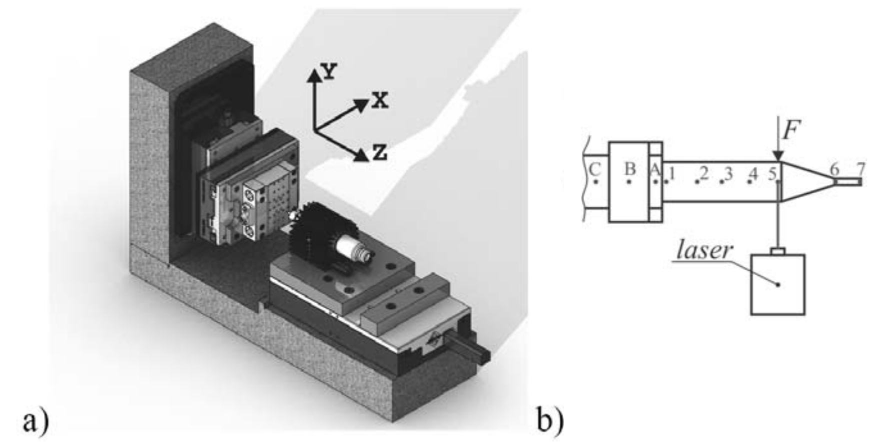

Fig. 1. a) schematic view of micromilling machine, b) 1-7 points of tool displacement measurement, A-C, points of spindle displacement measuremen

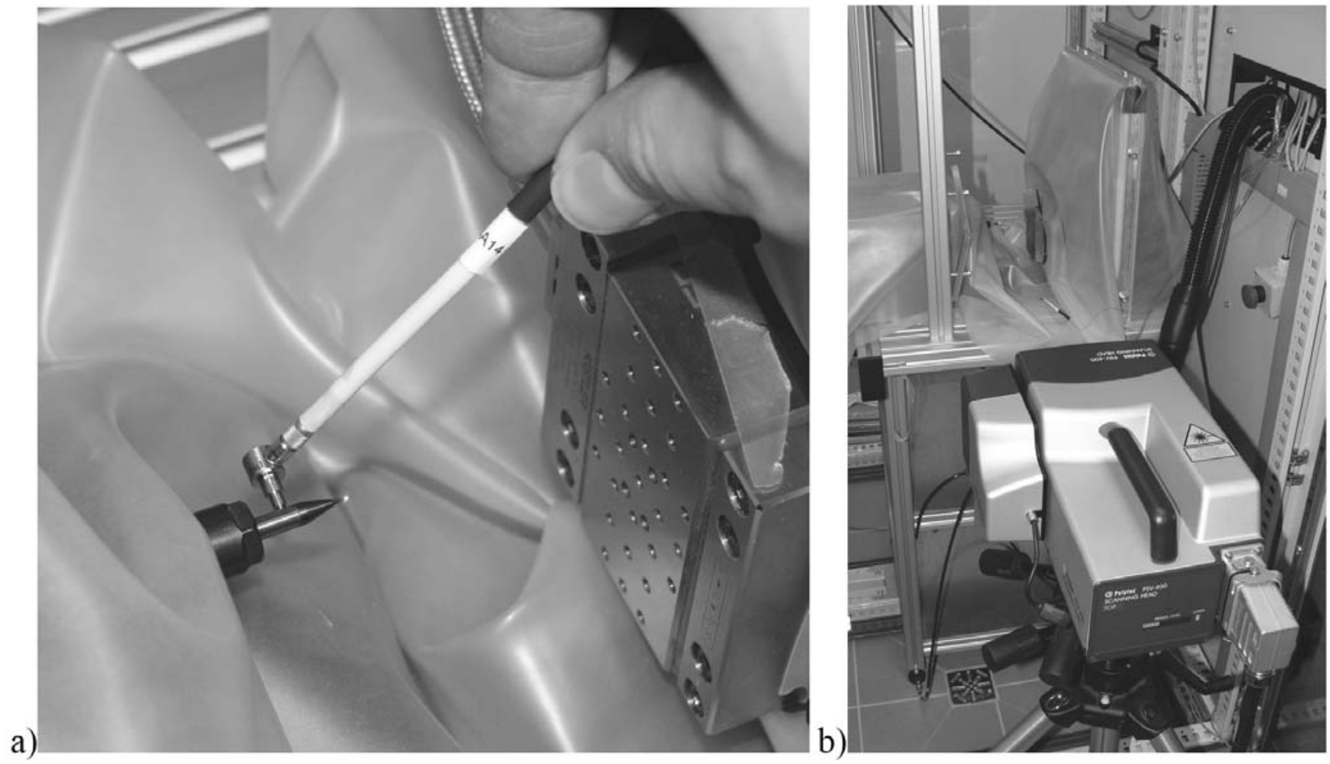

Fig. 2. Impact test of tool: a) impact hammer and tool, b) micromilling machine and laser vibrometer

EXPERIMENT RESULTS

Comparison of frequency response function for points 1, 5 and 7 in *X* (horizontal) direction is shown on fig 3. There can be seen three main resonant frequencies at 2100 Hz, 2700 Hz and 11 kHz. Resonant frequencies for measurement points 1, 5 and 7 on tool in X direction are the same. Only their amplitude differs. On the tool tip (measurement point 7) highest amplitude has third resonant frequency (11 kHz) and first resonant frequency (2100 Hz). First two resonant frequencies (2100 Hz and 2700 Hz) have the similar amplitude for points 1 and 5. Third resonant frequency (11 kHz) has higher amplitude in point 5 than in point 1.

Frequency response functions for points 1, 5, and 7 in *Y* (vertical) direction is shown on figure 4. In this direction can be observed two main resonant frequencies at 2650 Hz and 11 kHz. Highest amplitudes for both first and second resonant frequencies are at point 7.

Difference between frequency response functions obtained for X and Y directions is only in number of resonant frequencies. In X direction there are three resonant frequencies and in Y direction are two resonant frequencies. Both in X and Y directions amplitude in point 7 for last (11 kHz) resonant frequency is much higher than for points 1 and 5. The reason is probably that highest resonant frequency is generates by thin tool tip.

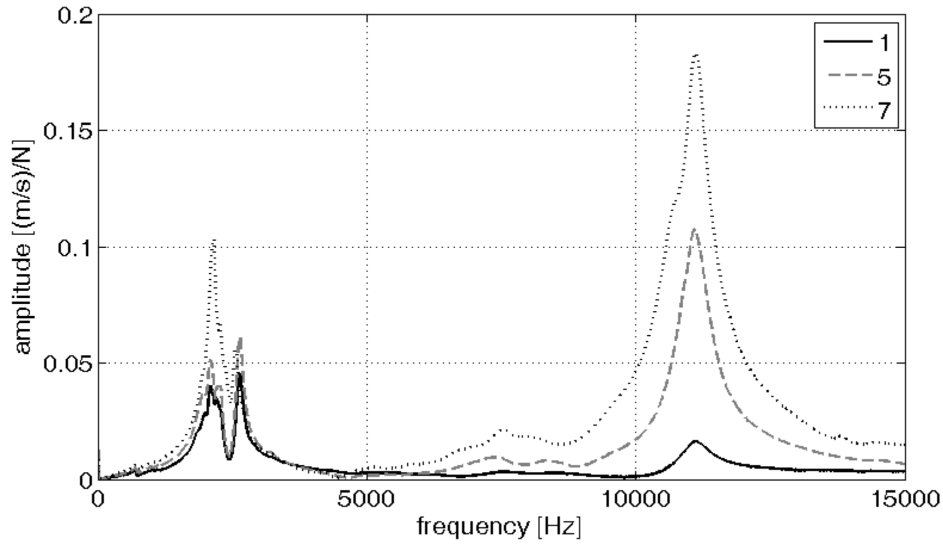

Fig. 3. Transfer function in X direction for points 1, 5 and 7

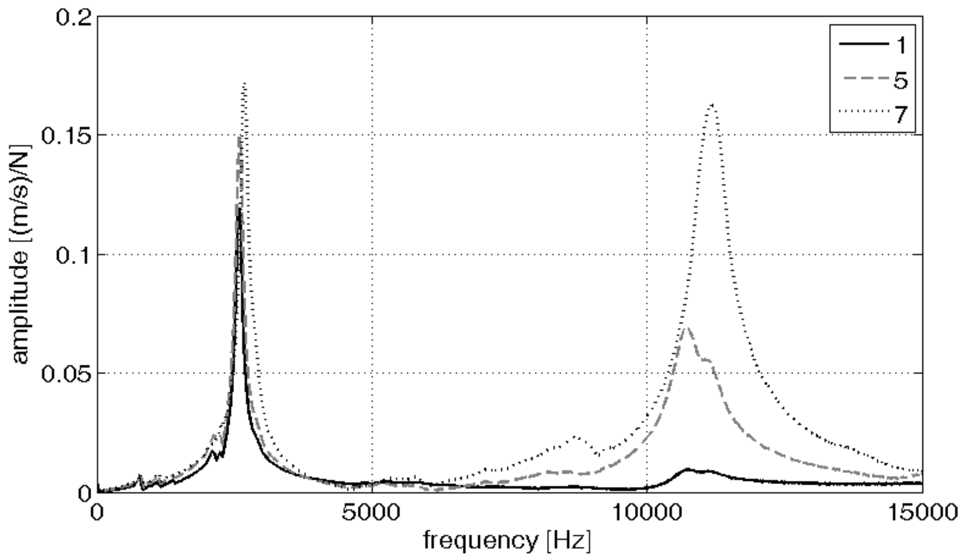

Fig. 4. Transfer function in Y direction for points 1, 5 and 7

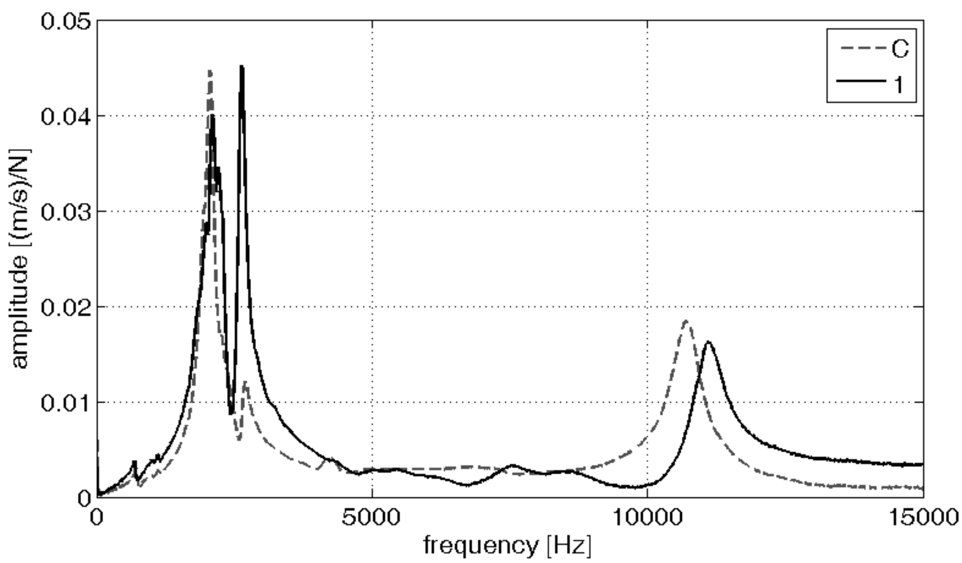

Fig 5. Transfer function for points C and 1 in X direction

Comparison of frequency response function for point 1 of tool, which is closest to the machine spindle and point C of machine spindle is shown on figure 5. Resonant frequencies for these points are different. In point 1 can be seen additional third resonant frequency at 2700 Hz. This frequency do not occurs in point C. Also last resonant frequency is different for point 1 and point C. These differences in resonant frequencies are probably result of spindle-tool connection which is not perfectly stiff and has some damping.

SUMMARY

Performed impact tests show that laser vibrometer can be used for micromilling tool displacement measurement which gives possibility of frequency response function calculation. There is a possibility of displacement measurement of micromilling tool tip of 0.5 mm diameter. Transfer functions from point (5) located on tool to points 1-7 was evaluated. Additionally transfer functions from tool to machine spindle were estimated.

Resonant frequencies both for X and Y direction for different (1, 5, 7) points of tool are the same. Only amplitude for these frequencies is different. Tool is solid part of material with very low damping coefficient which should result in same resonant frequencies for all measurement points.

Measurement point C which in on micromilling machine spindle has different resonant frequencies than frequencies on micromilling tool. Moreover there can be seen (Fig. 5) additional resonant frequency at 2700 Hz that occurs only on micromilling tool and cannot be observed on machine spindle. Probably source of this frequency is spring -mass system that is created by tool chuck stiffness and tool mass. This phenomenon cannot be neglected in tool frequency response function estimation especially when is used synthesis of analytical and experimental results.

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