



Data Article

Data from vibration measurement in a bucket wheel excavator operator's cabin with the aim of vibrations damping



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ABSTRACT

In the paper the authors present the procedure of measuring vibration and obtained data accruing in a bucket wheel excavator's operator cabin. Details of the selection and location of the measuring points are firstly given. In the following part, the example of for the bucket wheel excavator SchRs 1200, will be presented. This machine is in use at one of Poland's open cast mines. The operating conditions are briefly characterized in the descriptions of the measurement series. The measuring equipment is also presented. The recorded data are presented in two ways. The first of the presents time waveforms for each measuring channel. The second one presents Fast Fourier Transform (FFT) spectrums after filtering the measured signals. The obtained data is used to develop a vibrations control algorithm.

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Specifications Table

Subject	Mechanical Engineering
Specific subject area	Measurements of vibrations of operator cabins in the mining and material handling equipment
Type of data	Table Image Chart Graph Figure
How data were acquired	Raw data were acquired by the data acquisition system (Siemens Scadas) during the operation of the bucket wheel excavator. Measurement data was analysed in Wolfram Mathematica and TestExpress software.
Data format	Raw Analysed Filtered
Parameters for data collection	Data was collected in normal operating conditions of the tested machine
Description of data collection	Data was collected in 10 different measurement series using test equipment. The measurement time for each series varied depending on the operating conditions.
Data source location	Region: Europe, County: Poland Open pit mine in Lower Silesia region
Data accessibility	http://dx.doi.org/10.17632/htddgv2p3b.1
Related research article	W. Rafajłowicz, J. Więckowski, P. Moczko, E. Rafajłowicz, Iterative learning from suppressing vibrations in construction machinery using magnetorheological dampers. Automation in Construction. 2020, vol. 119, art. 103,326, s. 1–10. DOI: https://doi.org/10.1016/j.autcon.2020.103326

Value of the Data

- The data show the working conditions of the bucket wheel excavator operator during operation.
- The data will be helpful for researchers involved in the dynamics of large scale mining and material handling equipment
- They can be used as guidelines for testing similar machines
- They can be used to test control algorithms for vibration control systems.

1. Data Description

The locations of measuring points for the SchRs 1200 bucket wheel excavator are shown in Fig. 1. The measured accelerations are aimed at identifying the vibration source, which is a bucket wheel (points 1,2) and the dynamic responses of the vibrations, which are the operator cabin and its boom (points 3 to 6). [1,2]. Table 1 describes the direction of measured accelerations, in accordance with the direction of the coordinate system shown in Fig. 1. Mainly the Z direction of acceleration was measured, due to the nature of the excavator's operation, where most of the excitation forces are vertically oriented. Table 2 describes the conditions for each of the recorded measurement series. Figs. 2 to 12 show the frequency spectra (FFT) after filtering the signal. Figs. 13 to 17 present time waveforms respectively. The waveforms are presented for

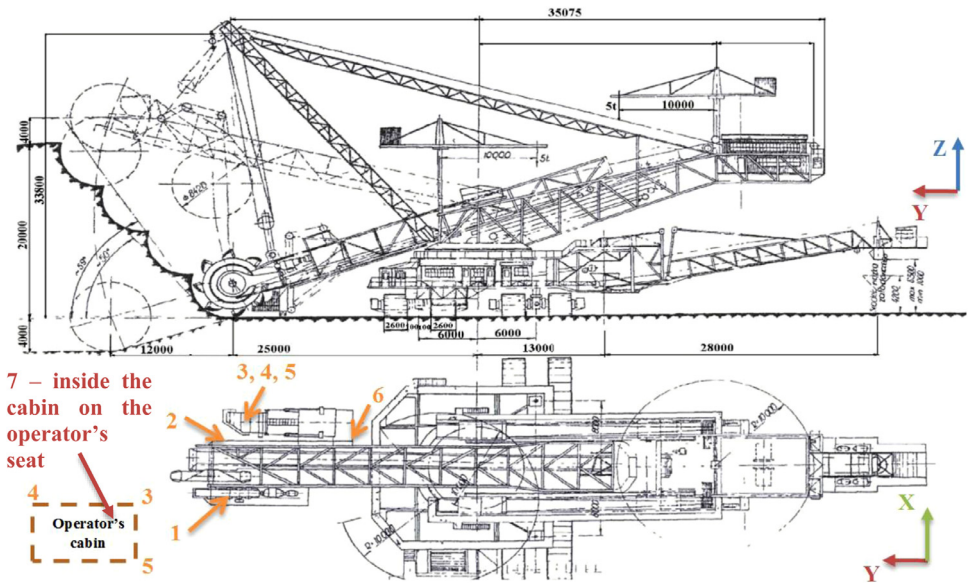


Fig. 1. Locations of measuring points on the superstructure.

Table 1

List of acceleration directions together with measuring channels.

Measuring point	Measuring channel	Direction
1	1	Y
	2	Z
2	3	Z
	4	Y
3	5	Z
	6	Z
4	6	Z
5	7	Z
6	8	Z
7	9	X
	10	Y
	11	Z

Table 2

Description of the measurement series.

Number of measurement series	Description
4	Accelerometers in the cabin, superstructure movement to the left
5	Accelerometers in the cabin, superstructure movement to the right
6	Accelerometers in the cabin, superstructure movement to the left
7	Accelerometers in the cabin, superstructure movement to the right
8	Accelerometers in the cabin, superstructure movement to the right
9	Accelerometers on the cab frame, superstructure movement to the right.
10	Accelerometers on the cab frame, superstructure movement to the left.
11	Accelerometers on the cab frame, superstructure movement to the right.
12	Accelerometers on the cab frame, superstructure movement to the left.
13	Revers driving of the bucket wheel excavator

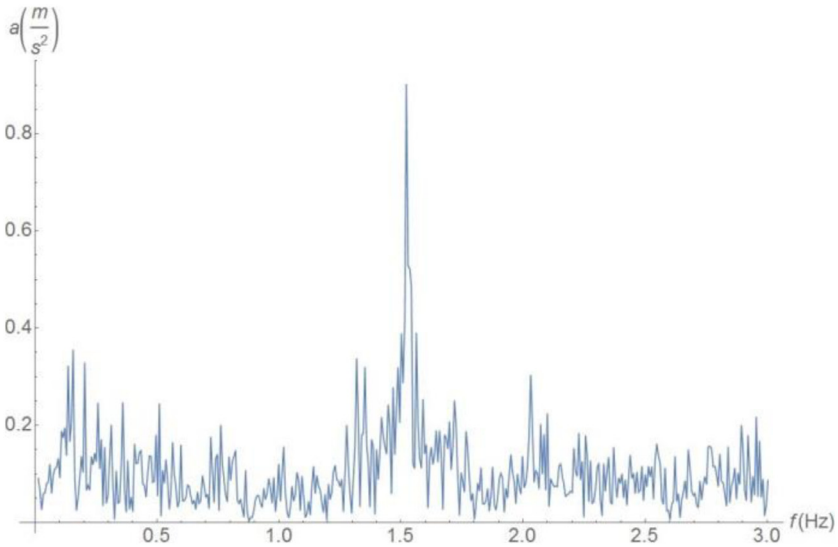


Fig. 2. FFT from channel 1 of the series no. 4.

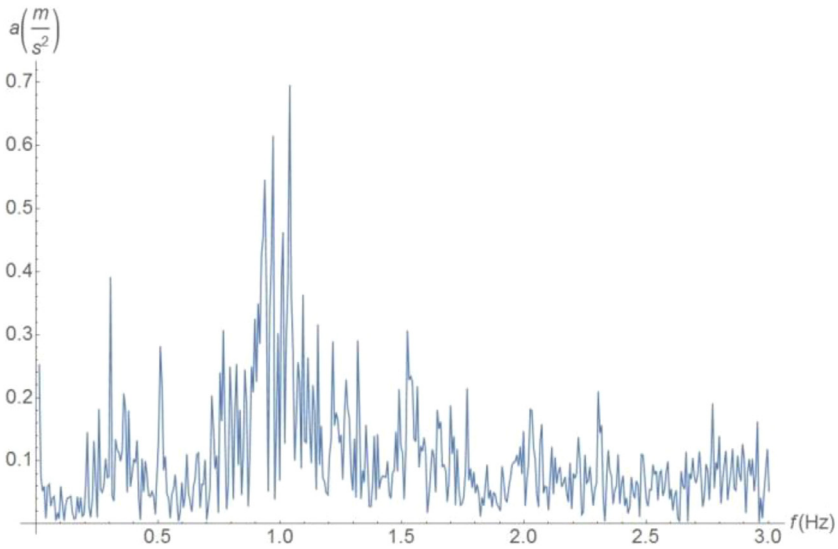


Fig. 3. FFT from channel 2 of the series no. 4.

different time periods to demonstrate the occurrence of quasi-periodic excitation, during operation of the bucket wheel excavator. The data in pictures 13 to 18 have been filtered by a 20 Hz low-pass filter. List of data files listed below:

- Raw data – file: KWK1200M_04.xls
- Data for Fig. 2– file: data_fft_fig2.csv
- Data for Fig. 3– file: data_fft_fig3.csv
- Data for Fig. 4– file: data_fft_fig4.csv
- Data for Fig. 5– file: data_fft_fig5.csv

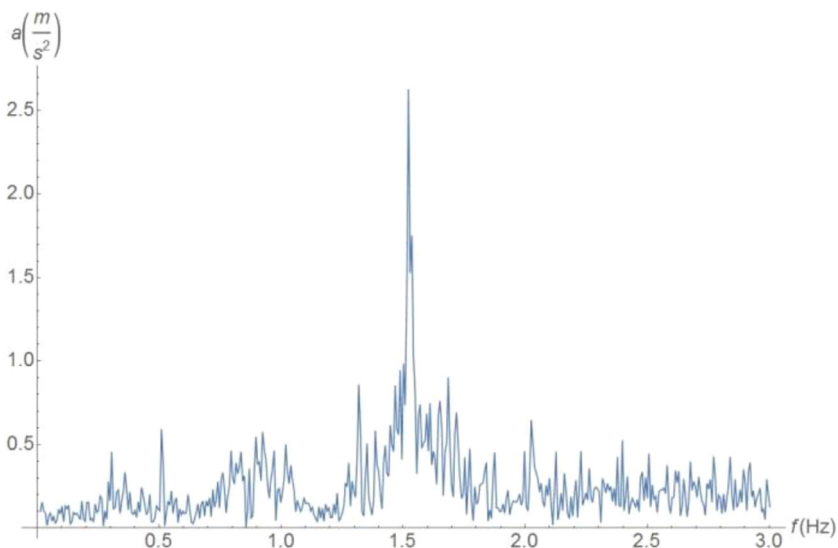


Fig. 4. FFT from channel 3 of series no. 4.

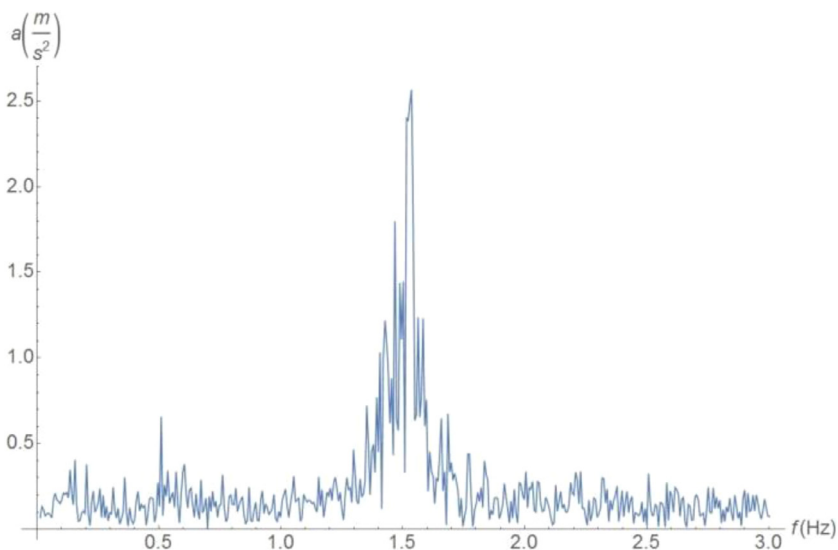


Fig. 5. FFT from channel 4 of series no. 4.

Data for Fig. 6– file: data_fft_fig6.csv

Data for Fig. 7– file: data_fft_fig7.csv

Data for Fig. 8– file: data_fft_fig8.csv

Data for Fig. 9– file: data_fft_fig9.csv

Data for Fig. 10– file: data_fft_fig10.csv

Data for Fig. 11– file: data_fft_fig11.csv

Data for Fig. 12– file: data_fft_fig12.csv

Data for Fig. 13– file: data_time_fig13.txt

Data for Fig. 14– file: data_time_fig14.txt

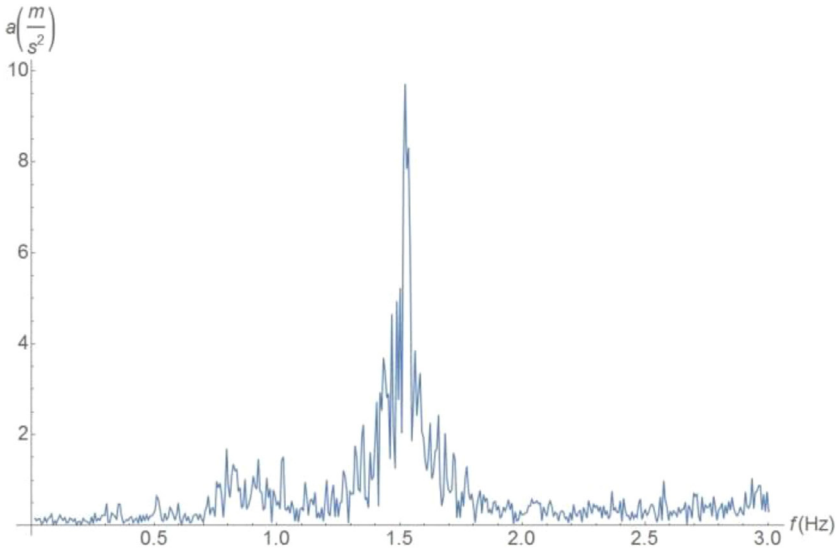


Fig. 6. FFT from channel 5 of series no. 4.

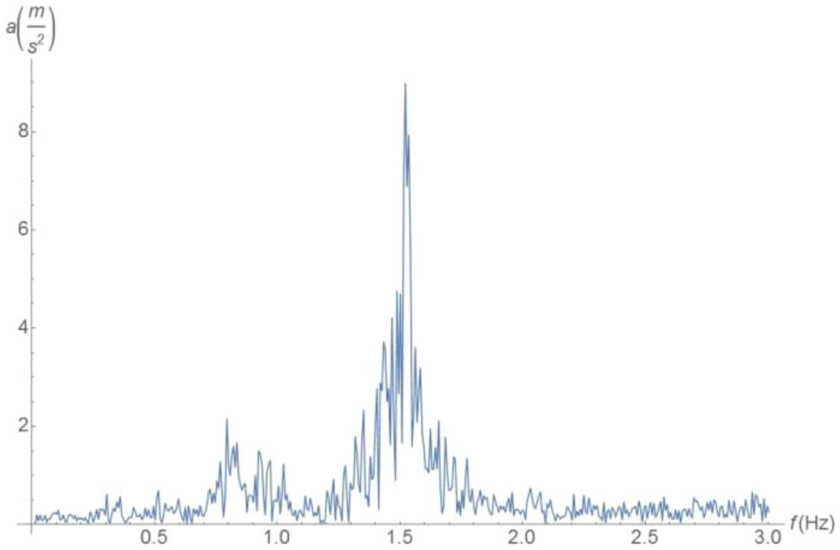


Fig. 7. FFT from channel 6 of series no. 4.

Data for Fig. 15- file: data_time_fig15.txt

Data for Fig. 16- file: data_time_fig16.txt

Data for Fig. 17- file: data_time_fig17.txt

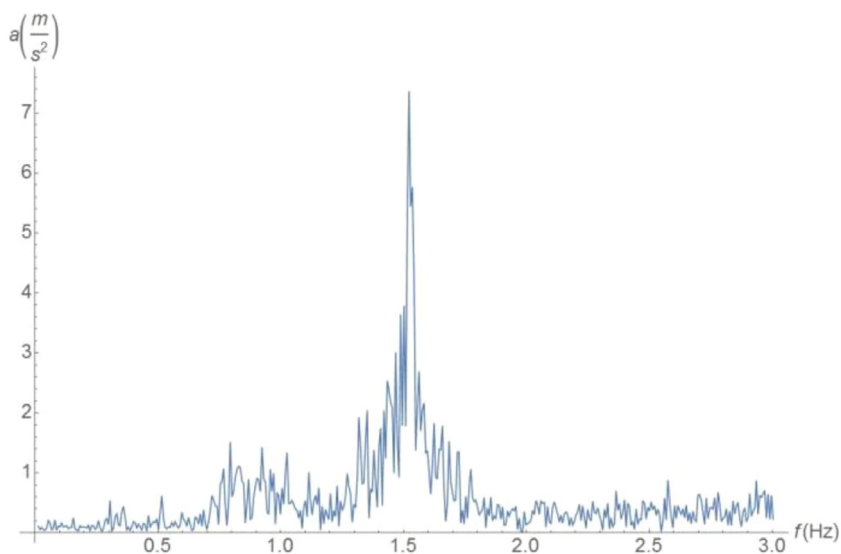


Fig. 8. FFT from channel 7 of series no. 4.

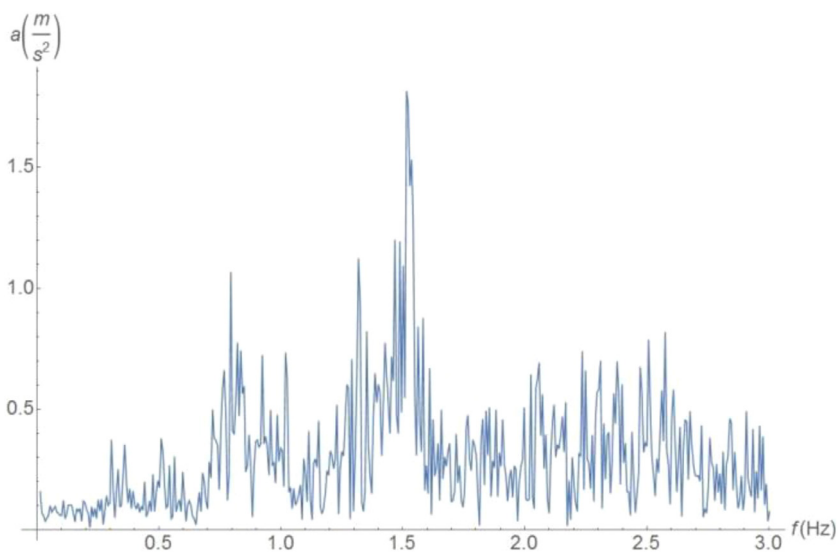


Fig. 9. FFT from channel 8 of series no. 4.

2. Experimental Design, Materials and Methods

The PCB Piezotronics accelerometers model 3741B1210G were used at the measuring points shown in Fig. 1, those are DC response accelerometers. They are included to highly sensitive sensors. With the exception point 7, which was on the operator's seat, the Triaxial ICP Seat Pad Accelerometer from PCB was used. Accelerometers were not placed in the construction joints. Data from the sensors was processed with the use of Siemens LMS Scadas recorder/analyser. The measurement parameters were as follows: sample frequency – 512 Hz, measure time – different in each measure series. According to data provided by the manufacturer, the accuracy

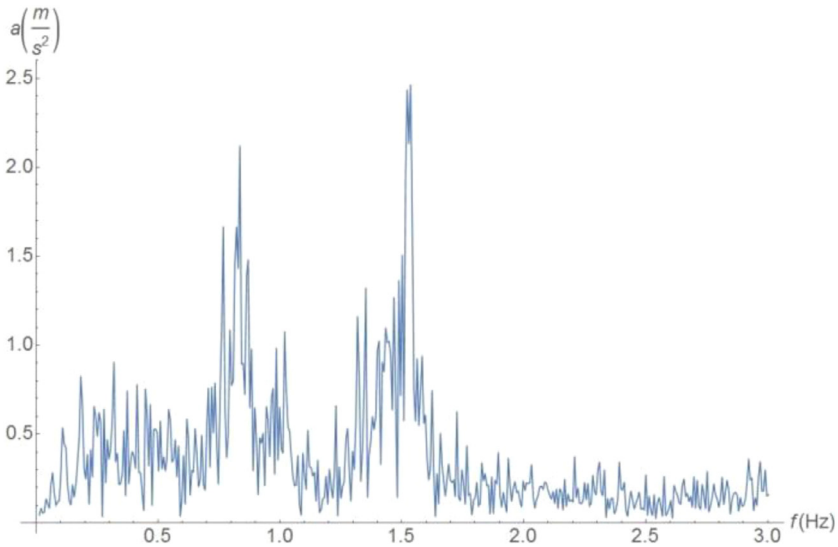


Fig. 10. FFT from channel 9 of series no. 4.

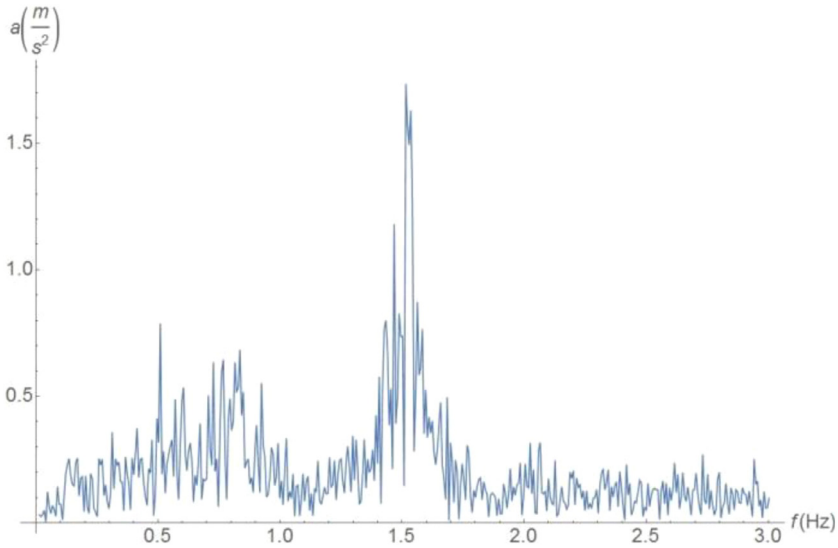


Fig. 11. FFT from channel 10 of series no. 4.

is not worse than 2%, except for very low or very high signals' frequencies. The data analysis conducted by the authors indicates that the precision of observations is between 0.015 m/s^2 and 0.045 m/s^2 , depending on a selected channel (see [Table 3](#)), utilizing a large oversampling (512 Hz). The collected data have been filtered for further FFT operation. The filtering procedure was, a simple moving average (SMA) with the arithmetic mean of 50 samples. The fast Fourier transform was performed from the averaged data. This type of filtering is a typical approach in developing control algorithms 3–6. All the mathematical operations were performed with the use of Wolfram Mathematica software. Time courses were processed in LMS Test Express software. The measured data have been filtered with the use of a 20 Hz low pass filter. The

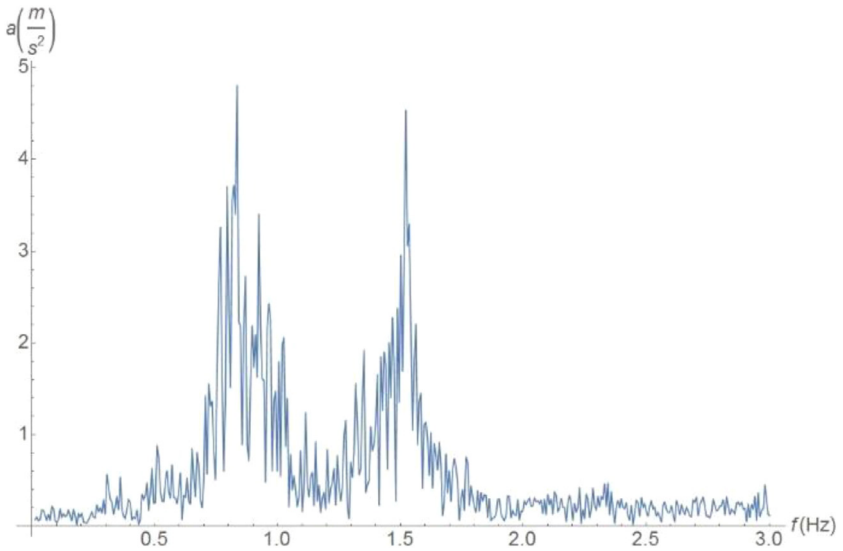


Fig. 12. FFT from channel 11 of series no. 4.

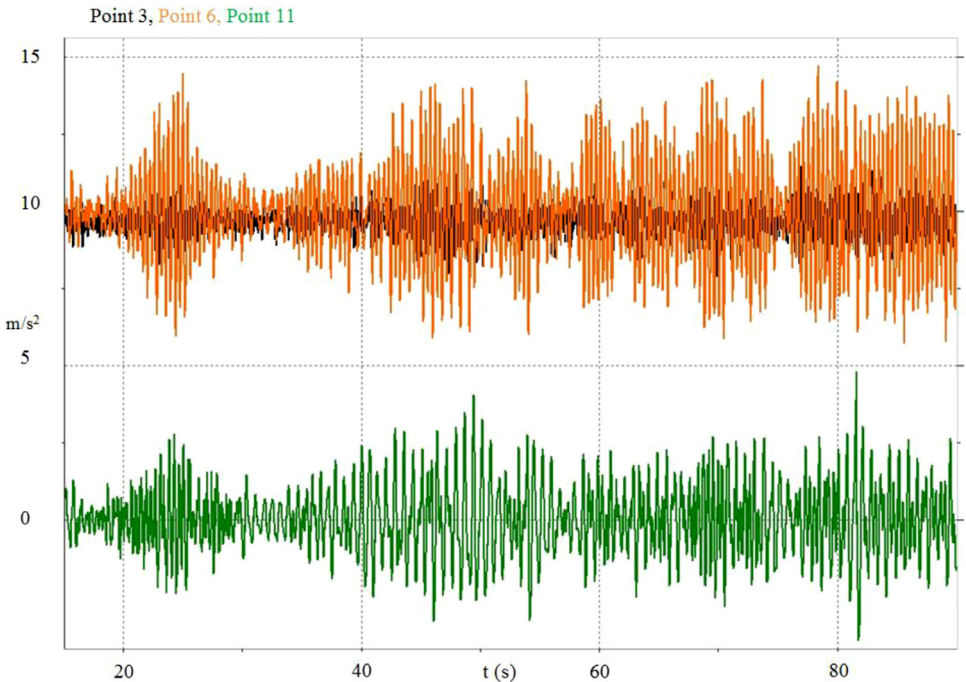


Fig. 13. Acceleration waveform vs time in the time interval [10–86s] - points 3, 5 and 11 - measurement series no. 4.

obtained data were analysed at different time intervals (see Figs. 13–17). The purpose of the analysis was to check the correlation between the excitation source, which is the digging force acting on the bucket wheel (point 3) and the operator’s cabin (point 6). This was checked by FFT analyses of the referenced points and the assumption was confirmed. The excitation force in the tested bucket wheel excavator acts with a frequency of about 1.5 Hz. This frequency depends

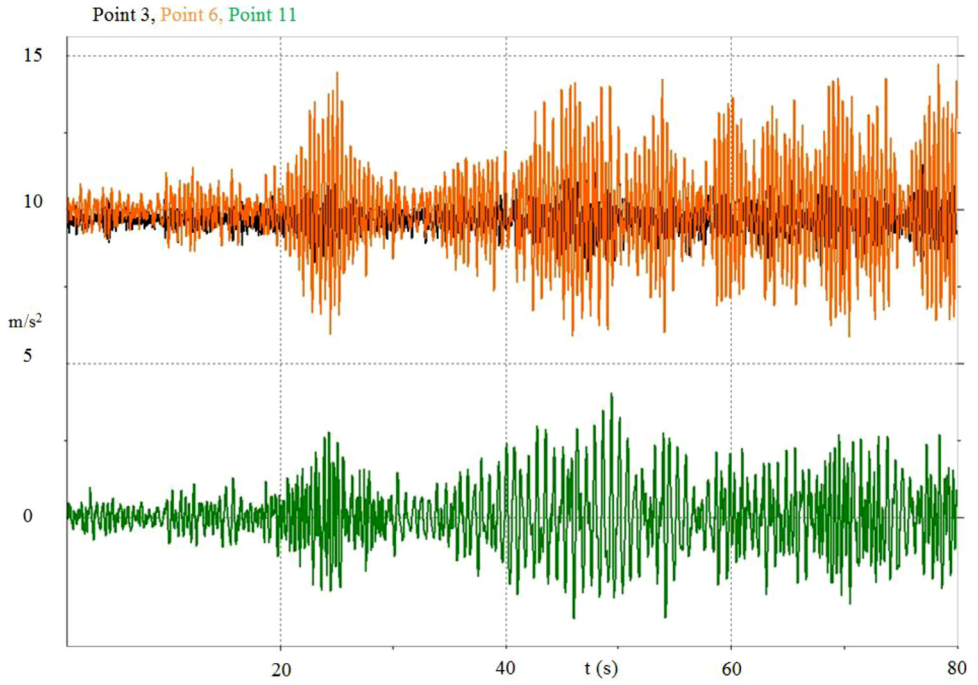


Fig. 14. Acceleration waveform vs time in the time interval [0–80 s] - points 3, 5 and 11 - measurement series no. 4.

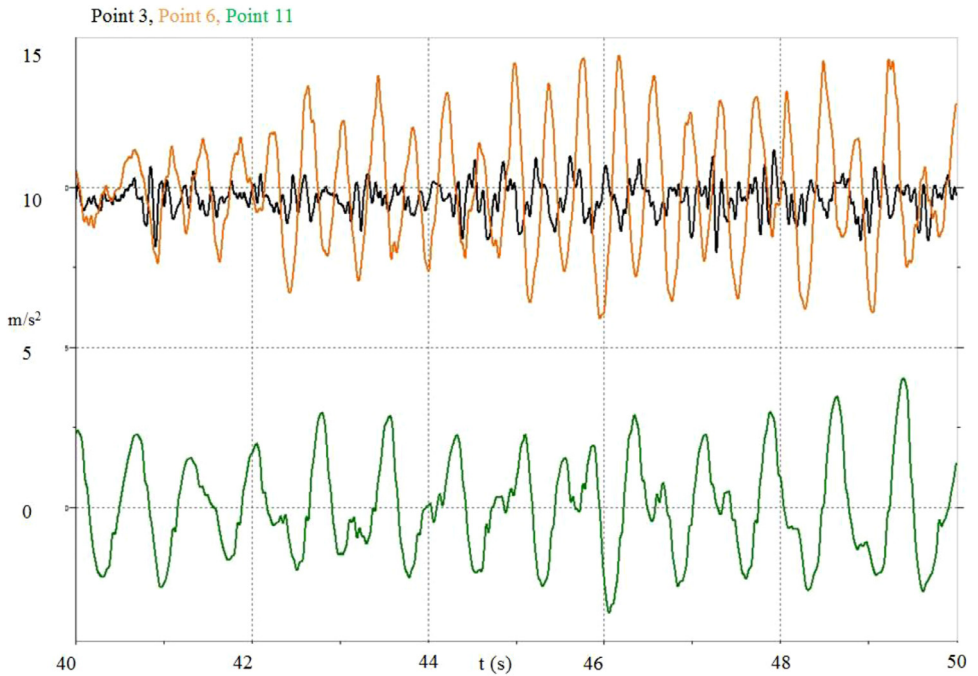


Fig. 15. Acceleration waveform vs time in the time interval [40–50 s] - points 3, 5 and 11 - measurement series no. 4.

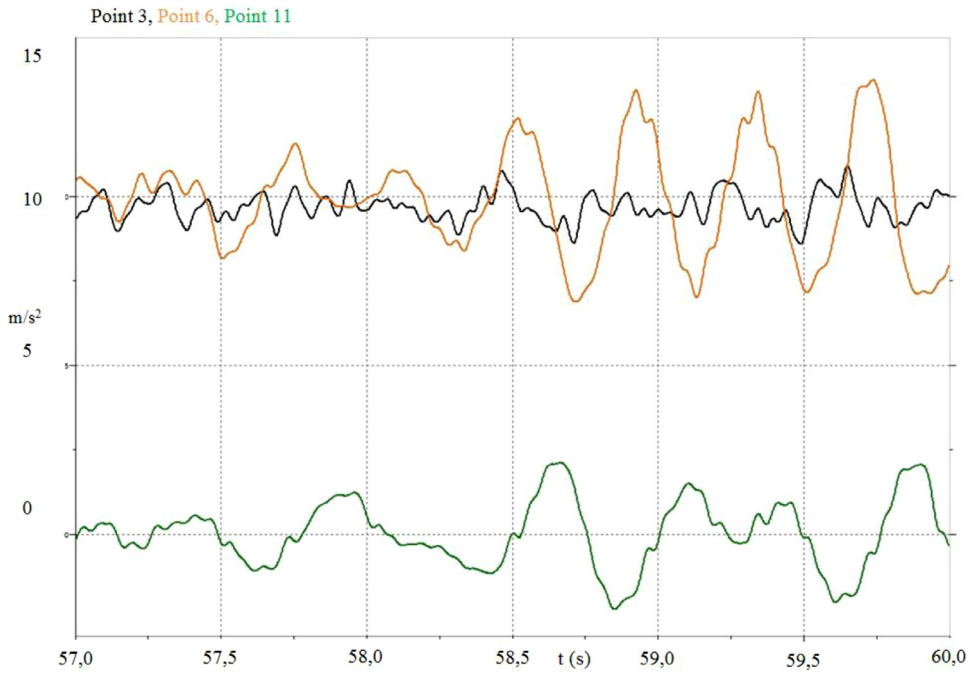


Fig. 16. Acceleration waveform vs time in the time interval [57–60 s] - points 3, 5 and 11 - measurement series no. 4.

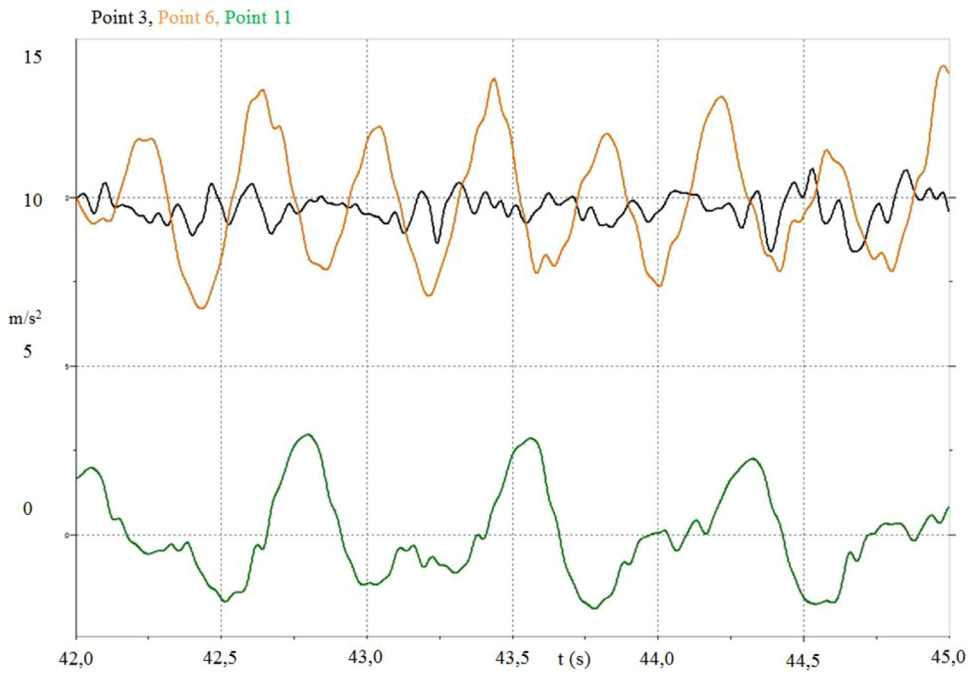


Fig. 17. Acceleration waveform vs time in the time interval [42–45 s] - points 3, 5 and 11 - measurement series no. 4.

Table 3

Precision of observation in each channel.

Channel number	Precision
1	0,0141
2	0,0146
3	0,0303
4	0,0154
5	0,0502
6	0,0453
7	0,0393
8	0,0244
9	0,0227
10	0,0145
11	0,0396

on the bucket wheel's rotation speed and the number of buckets. Vertical accelerations in the operator's seat were also measured (point 11). Fig. 16 and Fig. 17 show an obvious correlation with the accelerations measured in the operator's cabin. The double period for the operator's seat is the effect of additional damping in the seat (the seat has its own vibration damper). The measurements presented in the article were conducted with the aim of developing a control algorithm for the purposes of MR dampers. Details of the algorithm are presented in [7].

CRedit Author Statement

Przemysław Moczko: Conceptualization, Supervision; **Ewaryst Rafajłowicz:** Methodology, Formal analysis; **Wojciech Rafajłowicz:** Software, Data Curation, Visualization; **Jędrzej Więckowski:** Validation, Investigation, Writing – Original Draft, Visualization.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships which have, or could be perceived to have, influenced the work reported in this article.

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