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ANALYSIS OF STEEL STRUCTURE VIBRATIONS OF THE BUCKET WHEEL EXCAVATOR SCHRS 1320

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Abstract: *In case of bucket wheel excavators (BWE) the digging forces are dominant sources of vibrations. The influence of digging forces on steel structures of upper part of BWE depends on position of terrace. Structural configuration of BWE is different while cutting terrace on the ground level or higher level. It causes changes of stiffness of steel structure and changes of natural frequencies of BWE. More over location of the resultant of digging forces changes too. Huge measurement of vibrations of the steel structure of upper part of BWE SchRs 1320 was made during operation. The paper deals with the influence of changes in locations of the bucket wheel boom to vibrations of the steel structure of upper part of BWE SchRs 1320.*

Keywords: ***Bucket wheel excavator, Natural frequency, Vibrations, Accelerometer, Fourier transform, Frequency, Amplitude, Measuring, Time-frequency transform.***

1. Introduction

Machines for surface mining such as bucket wheel excavators (BWE) are heavily dynamically loaded during operating. Their steel structures and steel components are continually loaded dependently on geological situations during surface mining, requirements of plans of mining i.e. maximum usage of machine. The material from which the machines or their components are made is damaged by fatigue. The fatigue damage can cause failure of the machines or of some of their significant components, see e.g. (Bošnjak et al., 2010; Savković et al., 2011).

It is of a great importance to the operator of mining machines to their machines were in use as long as possible, they would also like to avoid machines failures which are connected with enormous economical loss and in the worst cases with losses of human lives. Their aim is also to avoid ecological losses. Dominant factors that influence life time of structures can be studied by methods of uncertainty and sensitivity analysis see e.g. (Kala 2009; Melcher et al., 2009). We can expect some influence of higher order interaction effects of input factors on carrying capacity (Kala, 2010). Results of these studies provide data, which are significant to decision-making about control services see, e.g. (Kala et al., 2010). In general priority should be given to controls and consequently to predictions of residual life times of significant components of structures (Kala 2008) as well as whole structures see e.g. (Vujic et al., 2010).

In case of bucket wheel excavators the digging forces are the dominant source of vibrations. It is desirable to investigate the influence of digging forces on steel structure of BWE and on any significant components. Progress of digging forces depends on geological profile of block. Occurrences of stone bands have undesirable influence on steel structure vibrations and depreciation of machine. It is possible to predict this occurrence and to optimize the working process. Another aspect that has significant influence on dynamical response of steel structure of BWE is their structural setting. BWEs are machines that change the structural setting during their working process. They change locations of bucket wheel boom what is of influence on situations of terraces in working block as well as on location of the resultant of the digging forces.

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2. Measuring of vibrations of bucket wheel excavator SchRs 1320

On the BWE SchRs 1320 vibrations of upper part of steel structure were continuously measured. Measuring was made during one mining cycle of the whole block, which was mined by terrace cutting method. The block was 20.5 m high and was divided into four terraces. The first terrace was 7.2 m high, the second was 4.9 m high, the third was 5.2 m high, and the last, the forth, was 3.2 m high. These dimensions were computed from the record of locations of the bucket wheel boom, which were measured for operator with other data; details about measuring are described in (Fries at al., 2010). The whole measured signal was divided into individual benches in terrace and directions of slewing of vibrations were differentiated, too. For evaluation of measuring FFT analysis with combination of time-frequency (wavelet) method were used, which gave us useful information about changes of frequencies in time. Figs. 2 - 17 show obtained results. On Fig. 1 and others we can see changes of some frequency peaks that are dependent on geometrical changes of mined benches and of some geological anomaly, too. Fig. 4 and subsequent others show results of FTT analysis, these results are more convenient for description of peaks values, however information on time dependence is lost. On figures below are data that were measured by accelerometer A_06z, which was situated in right bearing of bucket wheel shaft, see scheme on Fig. 1, for details of other measured places see (Fries et al., 2010; Gottvald, 2010).

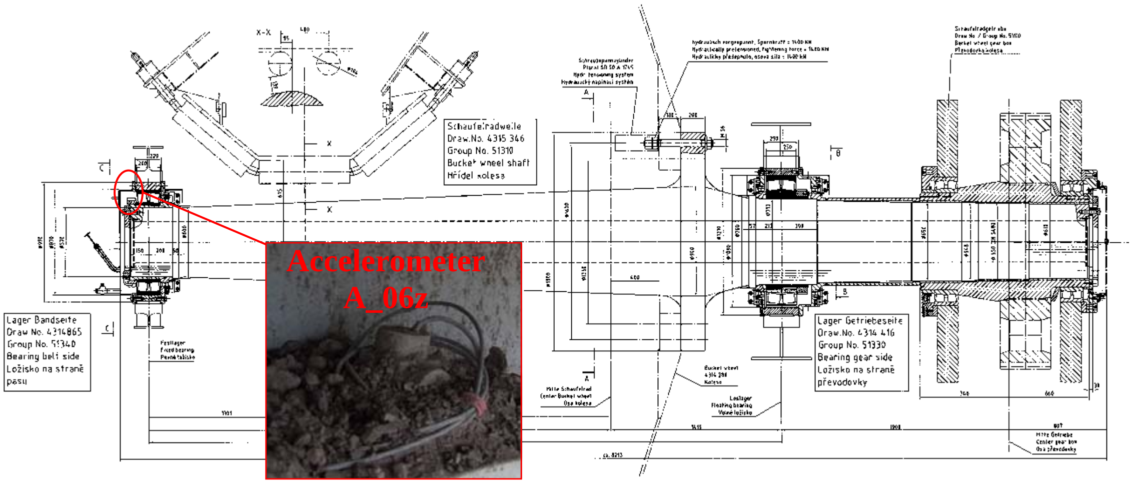

Fig. 1: Scheme of bucket wheel shaft with accelerometer A_06z.

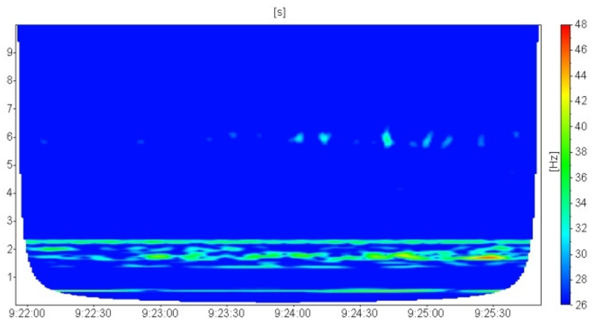

Fig. 2: 1st terrace – slewing to the left (1st bench).

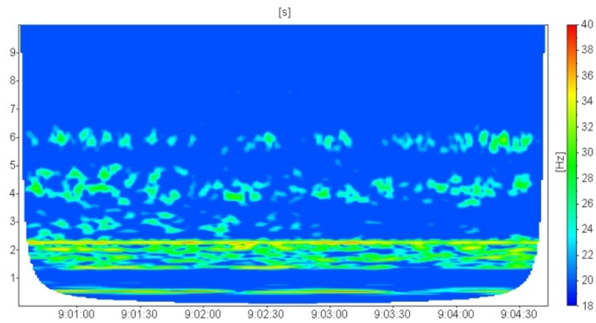

Fig. 3: 1st terrace – slewing to the right (2nd bench).

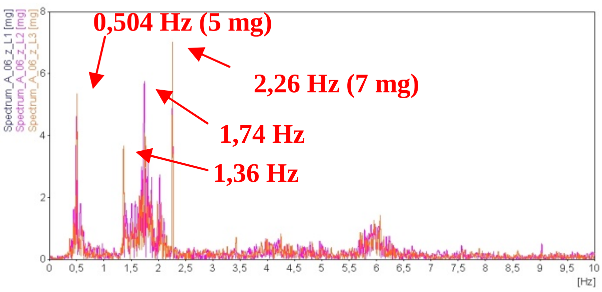

Fig. 4: Frequency spectrum – 1st terrace, slewing to the left.

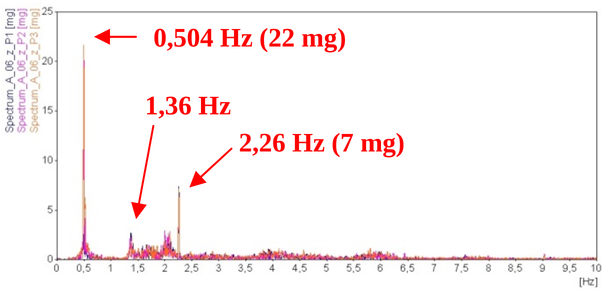

Fig. 5: Frequency spectrum – 1st terrace, slewing to the right.

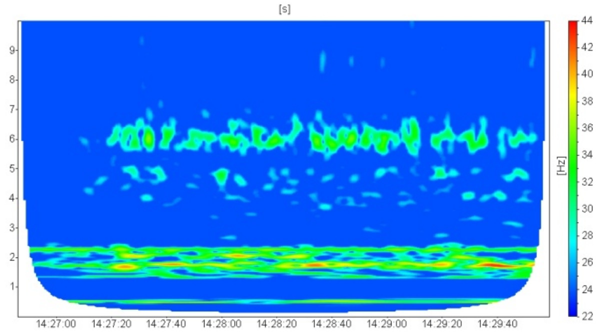

Fig. 6: 2^{nd} terrace, slewing to the left (1^{st} bench).

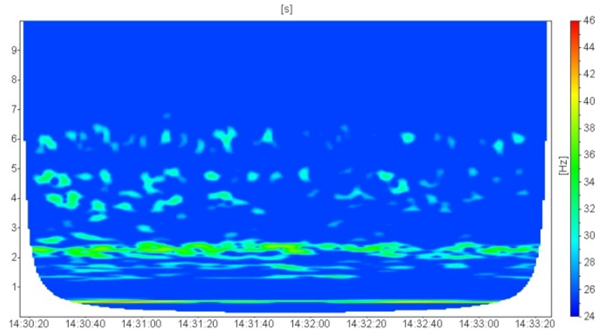

Fig. 7: 2^{nd} terrace, slewing to the right (2^{nd} bench).

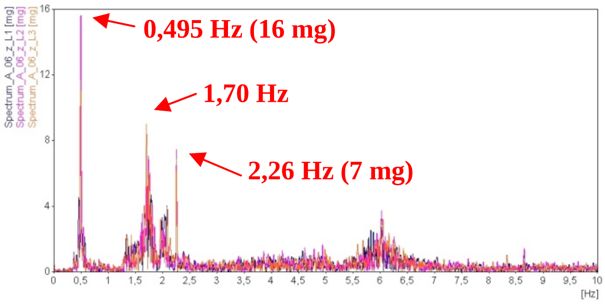

Fig. 8: Frequency spectrum – 2^{nd} terrace, slewing to the left.

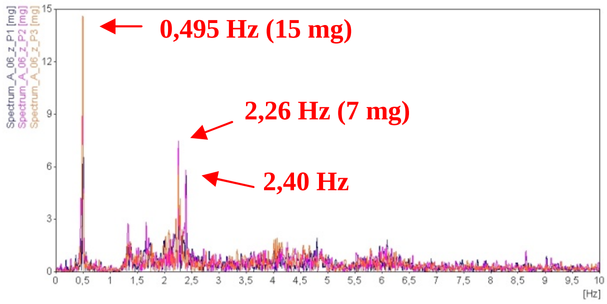

Fig. 9: Frequency spectrum – 2^{nd} terrace, slewing to the right.

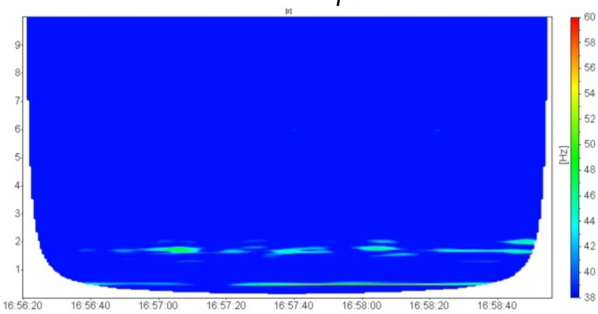

Fig. 10: 3^{rd} terrace, slewing to the left (1^{st} bench.)

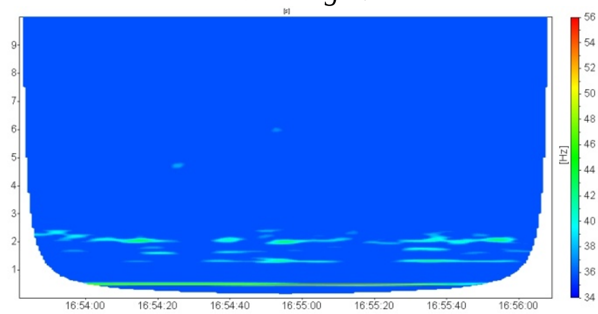

Fig. 11: 3^{rd} terrace, slewing to the right (2^{nd} bench).

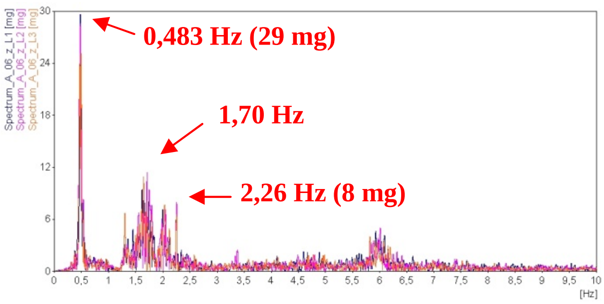

Fig. 12: Frequency spectrum – 3^{rd} terrace, slewing to the left.

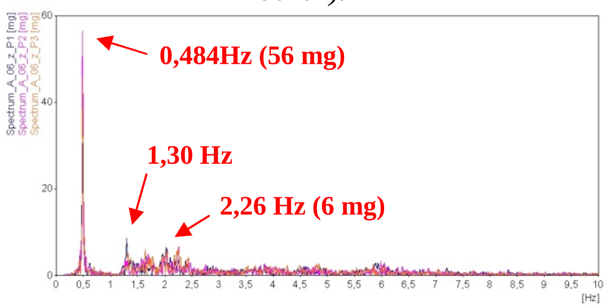

Fig. 13: Frequency spectrum – 3^{rd} terrace, slewing to the right.

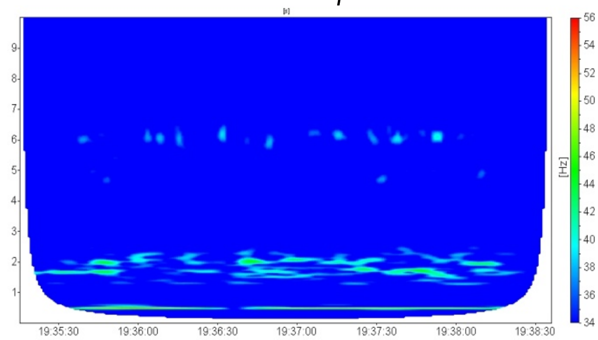

Fig. 14: 4^{th} terrace, slewing to the left (1^{st} bench).

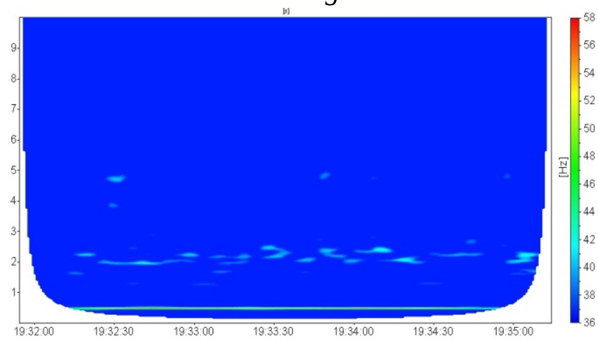

Fig. 15: 4^{th} terrace, slewing to the right (2^{nd} bench).

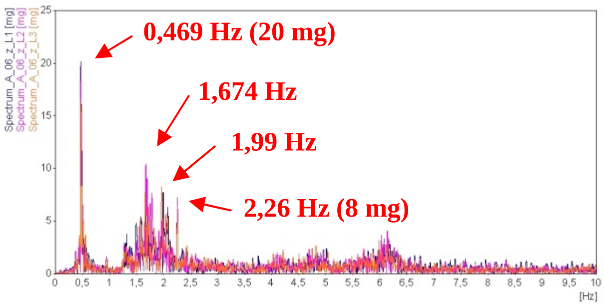

Fig. 16: Frequency spectrum – 4th terrace, slewing to the left.

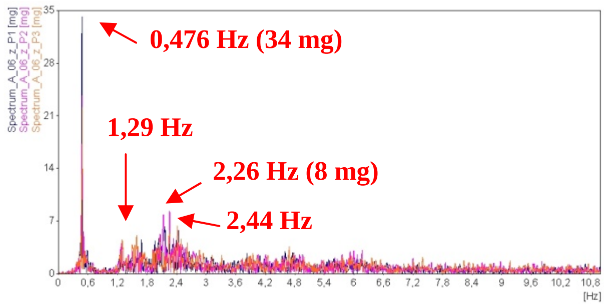

Fig. 17: Frequency spectrum – 4th terrace, slewing to the right.

3. Conclusions

On the basis of evaluation of measuring it could be said that first natural frequency of BWE SchRs 1320 in the first terrace is 0.504 Hz, in the second terrace is 0.495 Hz, in the third terrace is 0.483 Hz, and in the fourth terrace is 0.469 Hz. The values of measured natural frequencies correspond with previous measuring and computing of natural frequencies presented in (Gottvald, 2010). Declining trend of natural frequencies acknowledges simulations presented in (Fries et al., 2010). From frequency spectrums it appears that amplitude has opposite tendency and significantly decreases. This situation corresponds with resonant curves presented in (Fries et al., 2010).

In measured signals frequency 2.26 Hz was inducted. This was rotational frequency of 26 buckets on the wheel during mining. The frequency had constant amplitude c. 8 mg (1 mg = 9.81×10^{-3} m.s^{-2}). Character of these frequency spectra we can see e.g. on Fig. 4 by FTT analysis, and e.g. on Fig. 2 by time-frequency analysis. The calculated spectrums show domination of the first natural frequency of the BWE SchRs 1320 and confirm the previous results of measuring of the natural frequencies of BWE SchRs 1320, see (Gottvald, 2010).

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