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INDUSTRIAL MACHINERY DYNAMIC EFFECTS ON PRODUCTION PROCESS AND HALL STRUCTURES

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Abstract: *In this paper a dynamic characterization and vibration analysis has been used for the detection and identification of the machine processing condition and the effect of the production machinery vibration on building complex structures and production process. For sensitive process machines and structures dynamic response due to production machinery calculation procedures was applied using experimental input data via spectral analysis.*

Keywords: Machine vibration, Ground vibrations, Experimental tests, Vibration monitoring.

1. Introduction

In production hall all machines vibrate and, as the state of the machines worsen their vibration level increase and this causes increasing of the structure vibration level, too. An ideal indicator on this state, especially dynamic behavior is obtained via measuring and by supervising the vibration level produced by a machine (Karabay, 2007). While the increase in machine vibration allows us to detect the defects, the analysis of the machine vibration characteristics makes it possible to identify their reasons and to make a suggestion to eliminate them (Chandiranai & Pothala, 2006; Chen & Tsao, 2006). The analysis in frequency domain is generally carried out when the machine vibratory level is considered to be higher than the acceptable threshold (Newmark, 2011). This kind of vibrations if excessive can damage to nearby buildings and structures and also can negative affect the process in industrial production halls (Risbood, Dixit & Sahasrabudhe 2003; Tounsi & Otho, 1999).

2. Industrial Machinery Vibrations

The industrial production machinery process may cause undesirable vibrations transmitted from machine foundations via ground to production hall structures as well as nearby buildings and environment. The ground vibrations due to man activities recorded at a distance from machine foundations are analyzed assuming them to be a random and statistically stationary functions of the time. This kind of vibrations if excessive can damage to nearby buildings and structures (Dowding, 1996). Vibration which usually also has a negative impact on security and stability of the structures, facilities performance and people should be controlled by experimental analysis and the results compared (spectral picks limit, vibration levels, etc.) with relevant standards prescription values and criteria (Slovak Standard STN EN 1998 – 1/NA/Z1, 2010; Slovak Standard STN 73 0032, 2005. The case study regarding to the analysis of vibrations caused by unfavorable production machinery effects on hall structures and production process in ***Justur a.s. St. Turá*** industrial plant (Benčat, 2011) is describes in the paper.

2.1. Assessment of building vibration due to industrial activities

The assessment of building vibration due to industrial activities caused by production machines is a problem that can be solved through the application of research (Chiou & Liang, 1998; Lalwani, Mehta & Jain, 2008; Qi, He, Li, Zi, & Chen, 2008). This research consists mainly of defining the relationship between intensity vibrations in the ground (the vibration energy quantity) and the distance from the vibration source (Rizzo & Shippy, 2003). The intensity vibrations can appear in different physical quantities, such as the displacement, velocity and acceleration amplitudes, vibration frequency, ground

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motion intensity and energy etc. There are accessible several standards in the field of measurement of vibration regarding the building vibration limits in the European Union, USA, Australia, ISO codes and others. In Slovakia in the field of measuring and assessing of building vibrations due to ground motion the most commonly used standard is Slovak Standard STN EN 1998 – 1/NA/Z1 based on EC8 and Slovak Standard STN 73 0032, (in Slovak).

2.2. Machine effects on building structure and production process experimental analysis

This paper section shortly described study of the unfavorable production machinery effects on industrial building complex structures and also on vibration–sensitive production process in industrial plant of the ***Justur a.s. St. Tura*** (company). The complex of industrial processing buildings is fully described in (Benčat, 2011). The most sensitive part of the industrial processing buildings is the building **M1** fixed for special medical articles production, which is tailored to accurate technological processes. This building is joined with the adjacent processing building **M2** by partition wall. The vibrations caused by production traditional tool machinery effects in building M2 unfavorable affected the sensitive operations processing (CNC lathe MORI SEIKI SL–204) in adjacent building M1 even they have unfavorable effects on M1 structure with vibration velocities amplitude v_{max} > 6.0 mm/s. ***To determine harmful machine vibration sources and to regulate their working regime***, it was need to *perform experimental measurements and monitoring of the machines – related vibrations and compare to the low–vibration fabrication machines criteria or relevant Standards.*

Experimental procedure and devices. The industrial processing buildings dynamic response (M1) due to traditional tool machinery in building M2 were measured in relevant structure points by accelerometers BK – 8306. The output signals from the accelerometers were preamplified and recorded on portable PC equipped with A/D converters of the software packages NI and DISYS, (Fig. 1). The experimental analysis has been carried out in the Laboratory of the Department of Structural Mechanics, CEF, University of Žilina (Benčat, 2011). The machines and structure vibrations frequencies were obtained using spectral analysis of the recorded response dynamic components, which are considered as ergodic and stationary. Spectral analysis (power spectra, PSD) was performed via National Instrument software package NI LabVIEW.

Fig. 1: Set of accelerometers with amplifiers and measuring PC in acquisition configuration to measure floor and mounts vibrations of the CNC lathe MORI SEIKI SL–204 (BK4).

The building structure dynamic response (BSDR) and the machines dynamic response (MDS) assessment procedure. The main purpose of the dynamic tests in the building M1 was to determine the structure vibrations level and machines vibrations level (in common processing regime and in out of operation regime) due to machinery effects working in building M2 and to compare to the limiting value recommended by machines producer (CNC lathe MORI SEIKI SL–204) prescription vibration level or standard level. In this case machine producer prescription was not available. To reach dynamic analysis target (BSDR, MDS) it was reason to carry out 2 series of experimental measurements and 14 days continual monitoring of the dynamic response of the CNC and M1 building structure at selected representative points (Benčat, 2011). During the first series of tests and 14 days monitoring in the both halls (M1, M2) there were performed normal machines production progress of work and during those processes there were measured in selected points vibration level amplitude values v_{max} (mm/s) and *max* v_{rms} (mm/s) with results summarized in Fig. 2.

As the measured vibration level values for the structure fundament (BK3) and the most sensitive production equipment CNC lathe Mori Seiki, SL – 204 (BK5) had higher values than the standard upper limits of the vibration level (machine producer prescription vibration level was not available) it was necessary to perform the machines working regime adjusting in the hall M2 to obtain the required allowable vibration velocity.

After the machines working regime adjusting in hall M2 there were performed the second series of the tests in the same points and procedures as during the first series of the tests. The summarized measured vibration velocity values with their upper standard limits are plotted in Fig. 2. As an example of the machines induced vibrations analysis results in frequency domain (PSD) and time domain (velocities amplitude time history – $v(t)$) of the structure fundament (BK3) and the most sensitive production equipment CNC lathe Mori Seiky, SL – 204 (BK5) are plotted on Fig. 3.

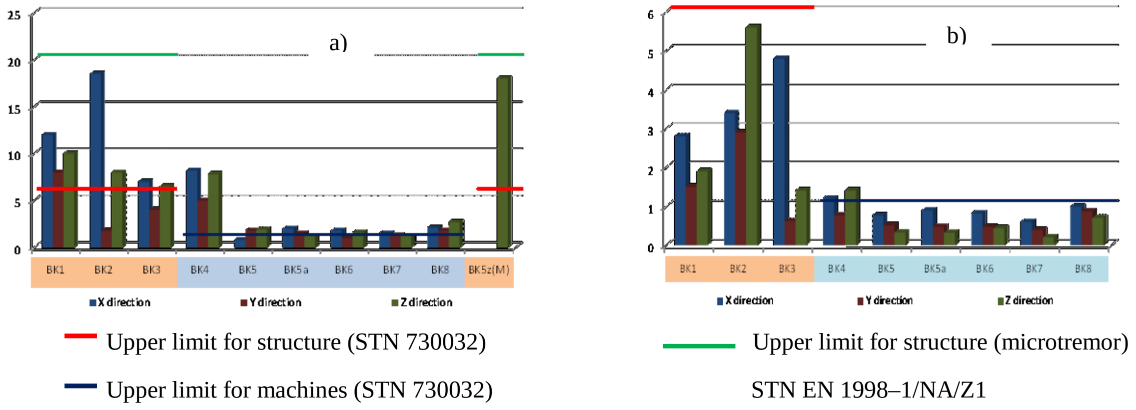

Fig. 2: Amplitude of extreme velocities values v_{max} (mm/s) of the tests:
a) 1th series and monitoring; b) 2nd series.

The comparison of the measured vibration velocities extreme levels (after adjusted machine regime) and standard limits suggests fulfilling standards required criteria $\boldsymbol{v}_{max}$ < 20 mm/s, (STN, 2010) and $\boldsymbol{v}_{max}$ < 6.0 mm/s, (STN, 2005) for hall M1 structure where measured value was $\boldsymbol{v}_{max}$ = 5.8 mm/s and also for sensitive production equipment was fulfilled required standard criterion $\boldsymbol{v}_{max}$ < 1.0 mm/s, (STN, 2005) where measured value on the machine lathe Mori Seiki frame was $\boldsymbol{v}_{max}$ = 0.76 mm/s. According to the results of the structure spectral analysis the structure basic natural frequencies have values $f(n)$ < 10 Hz (Benčat, 2011), it means there were no resonance effects because the exciting machines frequencies are over the 15 Hz, see also Fig. 3.

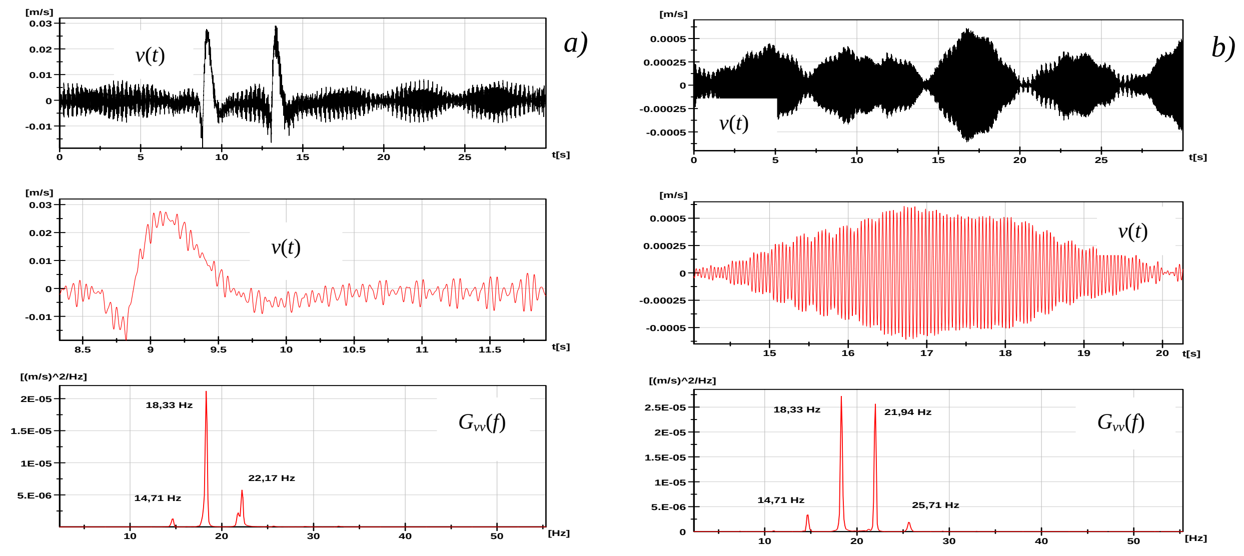

*Fig. 3: Time histories **v(t)** and PSD $\boldsymbol{G_{vv}(f)}$ during: a) Monitoring (BK3); b) 2nd series of tests (BK5).*

3. Conclusions

This paper presents an overview of the analysis of vibrations caused by unfavorable production machinery effects on building structures and production process, too. The results of the theoretical and experimental investigation of vibrations caused by production machinery dynamic effects in hall M2 on the M1 hall structures were analyzed mainly from aspects of the safety of the building structure and the influence of vibrations on production process conditions in production buildings M1 of the industrial plants *Justur a.s. St. Turá.*

Based on the results presented in the paper the following conclusions can be drawn:

i) Since the most sensitive production equipment CNC lathe Mori Seiki in hall M1, during production process had inadmissible vibration level it was necessary to perform in the hall M2 machines working regime adjusting to obtain the required allowable vibration velocity for failure free production process. The machines regime adjusting in adjacent hall M2 caused reducing vibration level of the sensitive production equipment in hall M1 about 52%. The comparison of the measured vibration velocities level and standard limits suggests fulfilling required criteria for sensitive production equipment.

ii) The relevant calculated data values following from experimental spectral and amplitude analysis of the production hall M1 structure dynamic response (spectral picks limit, vibration levels, etc.) were compared with relevant standards prescription values and criteria. From these comparisons it follows that all standards prescription values and criteria regarding building structure after machines regime adjusting in hall M2 were fulfilled, too.

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