National Conference with International Participation

ENGINEERING MECHANICS 2008

Svratka, Czech Republic, May 12 – 15, 2008

DYNAMIC ANALYSIS OF THE *THREONIN* PRODUCTION PROCESS EFFECTS ON PROCESSING BUILDING STRUCTURE

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Summary: *The paper deals with the dynamics analysis results of the steel structure subjected to dynamic loading in the Fermas a.s. – Threonin processing building complex at Slovenská Ľupča. FE model was used for full and empty technological tanks in the numerical analysis (natural frequencies and natural modes). Real dynamic response of the steel structure was verified by the experimental testing. The conclusions based on analytical and experimental testing results showed the structure investigation is abele to resist actual dynamic loads and it is in compliance with the relevant Slovak standard criteria. For structural dynamic stiffness conservation, in the case of the new machines adding for the production increasing, there were the technological criteria defined, too.*

1 Introduction

Theoretical and experimental investigation of a industrial building steel structure in the *Fermas a.s. – Threonin* processing building complex at *Slovenská Ľupča* are described in this paper. Full–scale tests were conducted. To measure the dynamic response of the steel structure subjected to dynamic response of the steel structure subjected to dynamic loading inducted by operating machines equipment. In the theoretical study, vibration modes were determined by means of a three–dimensional finite element model (FEM) of the processing building steel structure and the information obtained from the experimental tests provided a detailed assessment and validation of the model formulation and accuracy. The conclusions based on analytical and experimental testing results proved adequate dynamic stiffness and operating ability of the investigated structure.

2 Processing building structure

The processing building used for *THR 3* productions *Threonin* is tailored to machine and technological function. Load bearing structure in object *SO 01* creates steel space frame with 6,0 x 6,0 m blocks. The operation floors are in the following levels: ± 0,00 + 5,40 + 10,20 m and + 15,00 m. The bearing frame is composed by the beams and columns system with steal cross–sections mainly "I" profile shape. There are the monolithic foundation concrete blocks

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used for the structure support. Object *SO 02* is situated near the investigated object SO 01 and it is dilated. External cladding is made of the steel prefabricated panels *Hoesch LL60*. The planar dimensions of the whole object *SO 01* are 24 x 30 m and its height is 21m.

Fig. 1 View of tested *SO 01*

4 Finite element consulting and experimental analysis results

An analytical model of the structure vibration was created as an FE model in computing system *IDA Nexis* version *3.50.08* which respects all data assumed in project documentation and design calculation. The FEM involvers 9210 degrees of freedom and used large number of finite elements for the steel structure so that a regular distribution of masses was obtained.

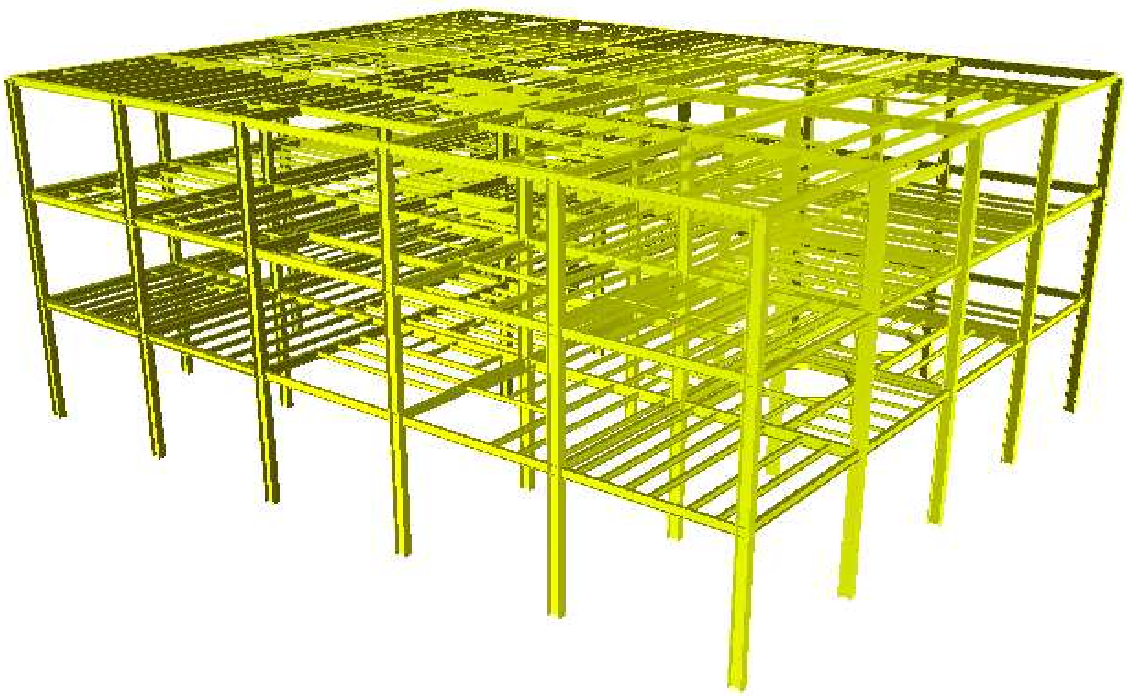

Fig. 2 Layout of the *FE* model

The first 50 natural frequencies and modes of natural vibration were calculated for this model. Analytical results were performed for two versions of the mass values. In the first and second version FE–model involved full and empty tanks.

Tab. 1 Natural frequencies of the steel structure

Fermasas.	Natural frequencies f[Hz]									
FEM1*	0.390	0.496	0.680	0.714	0.864	0.995	1.149	1.172	1.237	1.261
FEM2*	1.640	2.093	2.842	2.932	3.639	4.113	4.645	4.976	4.995	5.327
Experiment	1.51	-	-	-	-	-	-	-	-	5,46

*FEM1-full tanks FEM2-empty tanks

The set of accelerometers (*BK 8306)* was used for measurement of global and local vibrations in the most representing sections and points of *SO – 01* structure (Benčat et al., 2003). For recording both analogue and digital methods were used including A/D converters, filters, portable computer (PC/DX4), on/off line evaluation and reasonable data acquisition, (Benčat et al., 2003).

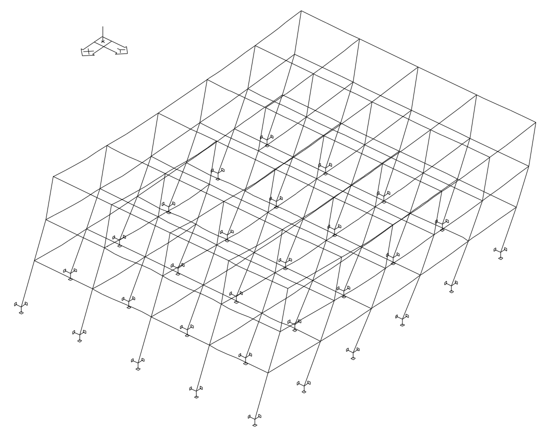

Fig.3. Natural mode $f_{(1)}$ = 0.397 Hz (Main console vibration of the system direction y)

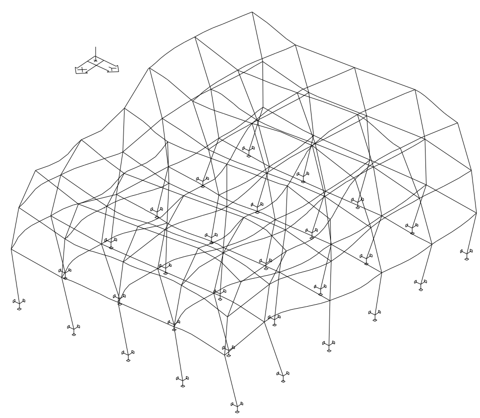

Fig.4. Natural mode $f_{(10)}$ = 1.261 Hz (Main local diffracted vibration of the cell substructure)

The recorded signals (Fig. 5) were evaluated in *Laboratory the Department of Structural Mechanics (CEF – University of Žilina)* or preferably in situ , using amplitude, frequency and amplitude–phase analysis, by method of spectral and correlation analysis using two channel frequency analyzer connected via *GPIB* with relevant software *(DISYS, DAS 16…)*. The main experimental natural frequencies of tested structure are in Table 1. Final experimental results involved also power spectra $G_v(f)$, (Bendat & Piersol, 1980) measured at relevant points and results of time history amplitude analysis as a maxima vibration velocity at measured points.

Positions of structure measured points and mentioned results are described in (Benčat et al., 2003).

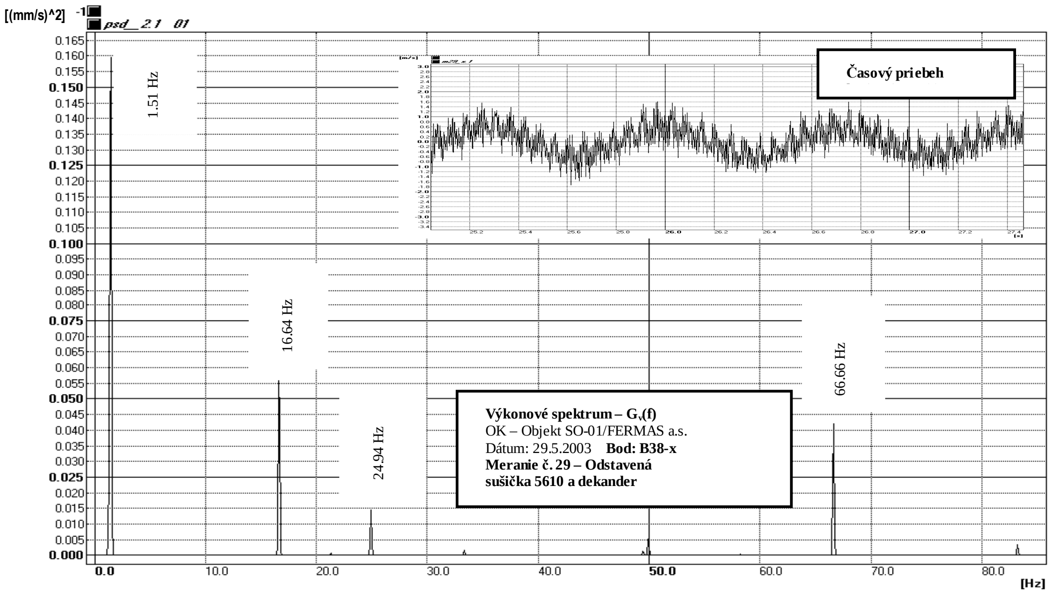

Fig.5 Vibration time history *u(t)* and corresponding power spectrum $G_v(f)$ at point *B38-x*.

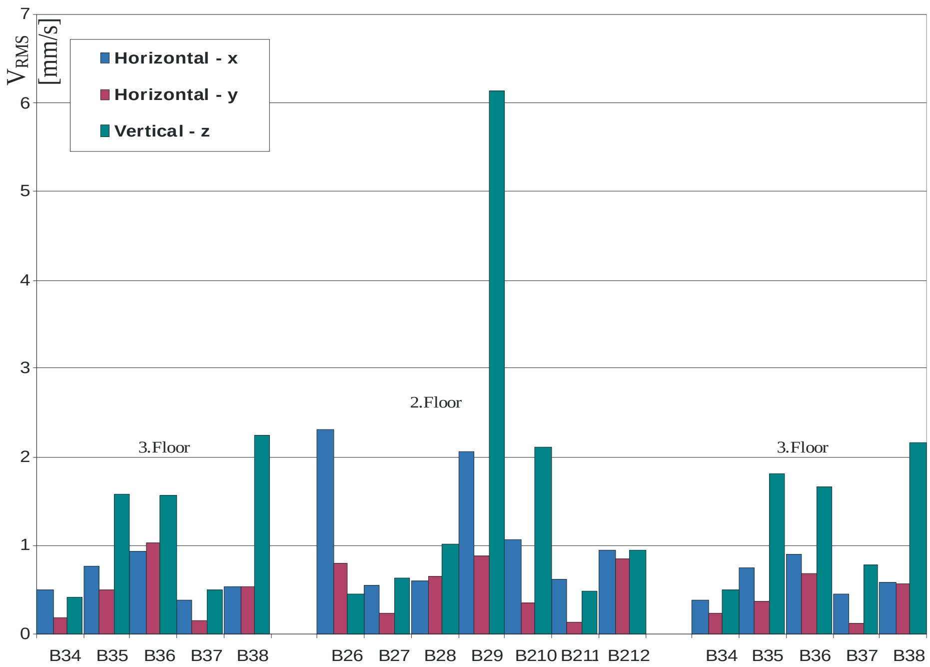

Fig. 6. Maxima vibration velocity at measured points

5 Conclusions

Full – scale dynamic tests were performed on the processing building steel structure *THR 3* using two versions of vibration conditions: with full and empty technological liquid tanks. Natural frequencies resulting from those two types of vibration conditions exhibited good correlation but only limited vibration modes were possible to identify during vibration tests. No experimental evidence was found that would suggest the existence of resonance and non-linear behavior of the structure during the test. The analytical and experimental test results proved adequate dynamic stiffness and operating ability of the investigated structure and enable to define the technological criteria for new technological equipment adding to utilize existing structure capacity.

Acknowledgement

We kindly acknowledge the research project VEGA, Nr. 1/3360/06 *granted by* Scientific Grant Agency of the Slovak Republic Ministry of Education. *We should also like to thank the* Civil Engineering Faculty – University of Žilina *for additional feed in this field research activity.*

References

Benčat J., et al.:*Správa o výsledkoch expertízy stavebného objektu Výroba Threonínu – THR3, Fermas a.s. Slovenská Ľupča.* Report: PČ 20/SvF/2003, Dept. of Structural Mechanics, ŽU

Bendat, J. S. and Piersol, A.G. (1980): *„Engineering Application of Correlation and Spectral* Analysis“. John Willey and Sons, New York, N.Y. 302.

Project documentation, ABB Lummus Chemoprojekt s.r.o., 1995. and *Design calculation*, ABB Lummus Global s.r.o., 1999.

The firm catalogue Brüel – Kjaer (1991 – 2003) D-2850 Naerum, Denmark.

STN 730032 – *„Výpočet stavebných konštrukcií zaťažených dynamickými účinkami strojov“* ÚNMS SR 1993.

NI LabVIEV *Modal Analysis* (LabVIEV MA), Software package National Instrument, USA, 2005.