12th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2008, Istanbul, Turkey, 26-30 August, 2008

EXPERIMENTAL MODELLING IN FUNCTION OF OPTIMISING VIBROISOLATION

Davorka Šaravanja, Alija Cigić
Faculty of Mechanical Engineering and Computing
Matice hrvatske bb, Mostar
Bosnia & Herzegovina

Darko Petković
Faculty of Mechanical Engineering
Fakultetska 1, Zenica
Bosnia & Herzegovina

ABSTRACT
This paper was dedicated to research of vibration phenomenon systems, their discovering and tracking by using spectral-correlation methods for processing measured data along with specific methods in analyses of vibration structure processes, while principles of vibroacustical diagnostics i.e. recognition of spectral images was used for optimising vibroisolation procedures. Experimental modelling was conducted using defined exchange of technical condition parameters to simulate the most important defects. Sources of vibrations were determined and identified, therefore, the functional correlation was established along with accompanying defects as the consequence of vibroactive behaviour of particular elements in mechanical system, and all this with the aim to use gathered information more efficiently within the system to discover and track vibrations before their functional realisation still during designing phase and manufacturing phase of products, structures or structural groups which belong to particular assembly.
Keywords: vibroacustical diagnostics, defects of mechanical systems, modelling, vibroisolation

1. INTRODUCTION
During last several decades, experimental methods of research were being used intensively to simulate behaviour of machines and structures on particularly constructed models of various sizes. Having in mind the presence and application of more advanced and demanding structures, especially application of the new technologies and materials the above mentioned method was widely used, but with every respect to the binding principles.
Modelling is the most employable research method for machine running and structural applicability, not only because of its ability to test the applied calculation method but to be used as individual method for experimental testing of machines and structures.[1]

2. ANALYSES OF POTENTIAL VIBRATION SOURCES AS THE PART OF AN EXPERIMENTAL RESEARCH
In elaborated experimental model used to simulate the actual vibration sources, the origins of vibrations are determined and identified and functional relation with its defects was established as consequence of vibroactive behaviour of specific vibration sources.
The idea which had pointed to research in this paper was the question why does such information could not be used and efficiently installed into the system of discovering and tracking vibrations before their actual functional realisation, i.e. to install them during designing and manufacturing phase of making the product, structure or a group of structures belonging to particular assembly. During such

undertaking it should not be forgotten that vibrations as phenomenon can appear as well as the result of failures made through all the phases of product's existence, particularly during manufacturing phase and phase of assembly. [2]

After elaborated experimental model, whose elements present the possible vibration sources, every source of vibration is being defined with its position and location, meaning that the centre of the mass of its activity was defined and nature frequency was defined for each vibration source, or in other words dynamic force was defined at the particular location. One of the most important tasks in this procedure is determining the dynamic force and its locations due to its formation at a pre-defined positions, which will become bearers of vibration isolation elements, i.e. bearers of vibroisolators disposition.[3]

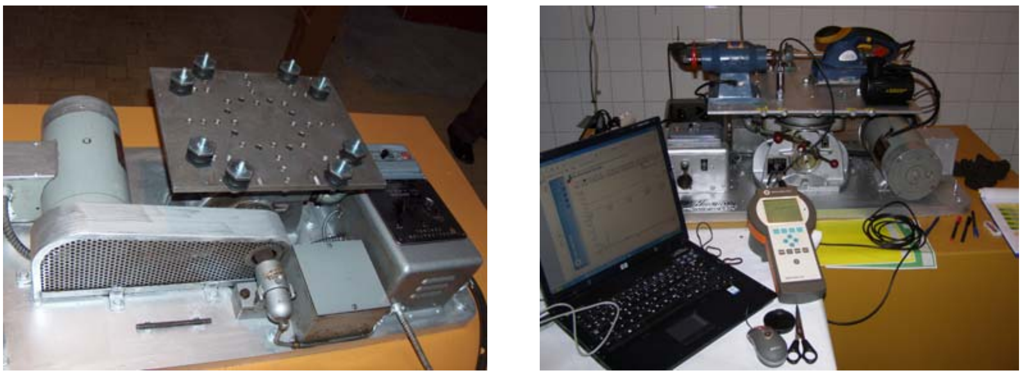
Considering that the experimental model represents the sum of several elements, which simulate particular vibrations sources with possible defects (imbalanced rotor, bent shaft, defect on bearing or roller bearings, defects on actuating element i.e. motor, defects during coupling montage, transmission defects, pulley or reducing gear), it is essential to recognize the most important defects for each of these vibration sources. Therefore, if a defect is caused by imbalance it can be dynamic, static or imbalance at the overhang; if it is on a motor it can be off-centre rotor, defects at stator, bent rod, cracked rod, defects in power supply from the network; if it is a defect of a binding kind it can be parallel, angle or combined misalignment, etc.[4]

After determining and describing each defect which could be the cause of vibrations, in accordance to the measurement results based on selected parameters of a mechanical system and other adequate device parameters for vibration examining, the regular order of defects was established, classified by its negative effect and its frequency. This is very important for determining the impact coefficients of defects and how will they effect the intensity of dynamic force with the aim the optimise vibroisolation.[5]

2.1. Description of mechanical model for experimental research

This experiment was conducted at The Laboratory for vibration and noise at The Faculty of Mechanical engineering and Computer science, University of Mostar, on the mechanical model especially made for vibroisolation research of particular system elements, as well as on the more complex system whose model represents the simulation of a typical industrial drive. The simulation of system's specific parameters variation under working conditions was conducted, all of this was enabled by using the gear for a vibration research, meaning that changes of movement amplitudes and changes of the waking frequencies of vibration platform inside the frequency range was undertaken, matching the needs of experimental modelling. This procedure provided environment to create conditions for the simulation, so called passive and active vibroisolation.[6,7,8,9]

Defining various matrix of vibroisolation systems (SVI-4, SVI-6 and SVI-8) with the possibility of determining the schedule of the load on each isolator, corrected defect coefficient, was presented on the mechanical model by positioning the vibroisolators in defined combination between the vibration platform working board and the supplementary board which has layout of model elements of a typical industrial drive. (Fig.1).[10]



Fifure 1. a) Model 25-VP-T; b) The experimental model with the equipment for the measurement and the analyses

2.2. Equipment for waking and measurement of vibrations

2.2.1. Waking equipment

For waking of forced vertical vibration of the system-model, the vibro-platform Model 25-VP-T was used (Fig.1a). The basic characteristics of the platform are presented in the Tab.1. [11]

Table 1. Specification of the vibro-platform Model 25-VP-T

Specification of the equipment for vibration waking (Model 25-VP-T):	
Platform movement	*Vertical*
Platform area	*304,8 mm x 381 mm*
Platform bearing	*11,25 kg (na 10 g)*
Number of holes on the platform	*40*
Diameter of holes on the platform	*(7 mm-8 mm)*
Total displacement	*0-3,81 mm (0-0.150")*
Maximum capacity (acceleration)	*≈ 23 g*
Frequency (manual adjustment)	*5 - 100 Hz*
Frequency (autom. adjustment)	*5 - 100 Hz*
Dimensions of the instrument base	*533,4 mm x 1016 mm*
Height of the instrument	*330,2 mm*
Weight of the instrument	*139,5 kg*
Motor	*Dynamic varying actuating speed, input value 380 volts, 50 periods, 3 phases, AC.*

2.2.2. Instrument for measurement and analysis of vibrations

For experimental researches on models and measurement of vibration response, the vibration measuring instrument type VIBROTEST 60 was used, and for suitable frequency area the matching sender type AC 065 (AS06X/07X) was applied. The optimal PC software package for VIBROTEST 60 is XMS software (Extended Monitoring Software). Modular structure of XMS enables the overall display of the machine's structure, but also the display of particular parts or groups, which can be chosen by individual demands. It is important to emphasize the possibility of forming files in the basic module, which relates to data-collector and data-analyser, i.e. two interface modules: Analysis Module and Diagnosis Module. (Fig.1b). [12,13]

3. MEASURING AND ANALYSES RESULTS ON SELECTED MODEL

Experimental researches on this model are related to measurements of vibration sensors at the supplementary board, vibrating platform but as well at the mounted elements of mechanical system at the marked positions, when the waking was started by simulated defects on the elements of the mechanical system (for example eccentricity, belt-drive problems, impulse during motor running at certain number of turns, defects on roller bearings, misalignment shaft, impulse during shaft rotation at certain number of turns) while vibrating platform is being still. The measurements are being conducted on the model EXM for the each of the three vibroisolators systems (SVI8, SVI6, SVI4).

Table 2. Results of the measured vibration answers on measuring locations EXM-SVI8

Measuring position		***Amplitude displacement 0,025 mm=0,001"***			
		Frequency (Hz)			
		5	***15***	***30***	***45***
M1H2-8	***Vibration velocity (mm/s)***	*0,234*	*0,764*	*23,658*	*40,674*
	FFT spectrum	*M1H2-85Hz*	*M1H2-815Hz*	*M1H2-830Hz*	*M1H2-845Hz*
M1V2-8	***Vibration velocity (mm/s)***	*6,471*	*22,568*	*55,987*	*233,94*
	FFT spectrum	*M1V2-85Hz*	*M1V2-815Hz*	*M1V2-830Hz*	*M1V2-845Hz*
M2H2-8	***Vibration velocity (mm/s)***	*0,345*	*0,890*	*21,871*	*35,876*
	FFT spectrum	*M2H2-85Hz*	*M2H2-815Hz*	*M2H2-830Hz*	*M2H2-845Hz*
M2V2-8	***Vibration velocity (mm/s)***	*6,582*	*21,827*	*58,701*	*214,89*
	FFT spectrum	*M2V2-85Hz*	*M2V2-815Hz*	*M2V2-830Hz*	*M2V2-845Hz*
L1H2-8	***Vibration velocity (mm/s)***	*0,452*	*0,659*	*22,98*	*34,981*
	FFT spectrum	*L1H2-85Hz*	*L1H2-815Hz*	*L1H2-830Hz*	*L1H2-845Hz*
L1V2-8	***Vibration velocity (mm/s)***	*6,565*	*23,125*	*79,174*	*221,8*
	FFT spectrum	*L1V2-85Hz*	*L1V2-815Hz*	*L1V2-830Hz*	*L1V2-845Hz*
L2H2-8	***Vibration velocity (mm/s)***	*0,671*	*0,821*	*24,876*	*40,76*
	FFT spectrum	*L2H2-85Hz*	*L2H2-815Hz*	*L2H2-830Hz*	*L2H2-845Hz*
L2V2-8	***Vibration velocity (mm/s)***	*6,566*	*21,844*	*66,188*	*231,78*
	FFT spectrum	*L2V2-85Hz*	*L2V2-815Hz*	*L2V2-830Hz*	*L2V2-845Hz*
L3H2-8	***Vibration velocity (mm/s)***	*0,542*	*0,921*	*30,87*	*65,89*
	FFT spectrum	*L3H2-85Hz*	*L3H2-815Hz*	*L3H2-830Hz*	*L3H2-845Hz*
L3V2-8	***Vibration velocity (mm/s)***	*6,642*	*20943*	*63,408*	*213,8*
	FFT spectrum	*L3V2-85Hz*	*L3V2-815Hz*	*L3V2-830Hz*	*L3V2-845Hz*

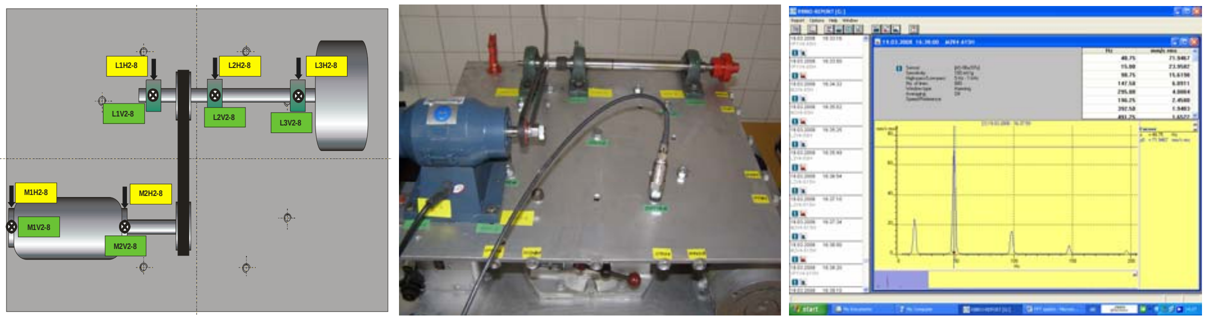


Figure 2. a) Scheme; b) Photography EXM-SVI8; c) FFT spectrum at the specific location

The scheme and the photography of the experimental model was shown on Fig.2a,b, and the measuring results at the measuring locations were presented in Tab.2. Based on the results, the spectral analyses was conducted and presented using the function of VIBRO-REPORT XMS software (Fig.2c).

4. CONCLUSIONS

By choosing one variant of experimental models, by defining priorities and the coefficient of the defect's impact, by selection and by formation of vibroisolators systems it was proven the best way to influence the results of vibration answer of the mechanical system in the function of protection and vibroisolation. Each specific defect with its characteristics, but as well as their interaction dictates the choice of the type of vibration isolators and the true solution is to point to the one optimal in its role. Considering the fact that the experimental researches were based on theoretical explanation of resonant diagrams, which represent the transmission functions dependant to interrelations between waking and personal frequency, but some other characteristics as well, it was proven with this experiment that changes of distribution parameters of mechanical system can influence the transmission, i.e. by changing the elasticity characteristics (stiffness), system's mass or by damping. The procedure of optimising vibration isolations cannot avoid correction of distribution parameters of the mechanical system and achieving equivalent compromise during their correct choice, which will result in reduction of percentage, i.e. the level of transmissibility as the function of displacement/displacement, displacement/force or force/force. For farther research and more detailed results it would be essential to take into consideration more variants influenced by damping, which could become the subject of a longer and more complex research.

5. REFERENCES

[1] R. Vukotić: Testing of structures, Civil engineering faculty, Belgrade, 1984.
[2] M.D. Genkin, A.G. Sokolova: Vibroacustical diagnostics, Mašinostroenie, Moscow, 1987.
[3] C. W. de Silva: Vibration Fundamentals and Practice, Taylor & Francis Group, London-New York, 2006.
[4] Šaravanja, D.: Research of complementary system for discovering and tracking vibrations in function of machine and structures isolation, Doctor's theses, University of Mostar, Mostar 2008.
[5] E. Judina: Protection of noise and vibrations in industry, Mašinostroenie, Moscow, 2001.
[6] Šaravanja, D., Cigić, A. & Petković, D.: Frequency Analysis And Diagnostics Vibration Process On Hydro-Aggregates, Proceedings of the 3rd International Conference ''Business Systems Management UPS 2004, Mostar, 2004.
[7] D. J. Inman: Engineering Vibration, Pearson Prentice Hall, New Jersey, 2007.
[8] J. Den Hartog: Mechanical Vibrations, McGraw-Hill Book Company, 1972.
[9] J. D. Webb: Noise Control in Industry, Holbrook Hall Sudbury Suffolk, 1976.
[10] Šaravanja, D.: Vibration And Noise Monitoring Of Machinery In Function Of The Planned Preventive Maintenance, 7th International Research/Expert Conference ''Trends in the Development of Machinery and Associated Technology'' TMT 2003, Barcelona, Spain, 2003.
[11] All American Tool & MFG. Company: Operating Instructions, Skokie, Illinois, 1982.
[12] Brüel & Kjær, Vibro: VIBROTEST 60 Handbook, 2005.
[13] Brüel & Kjær, Vibro: eXtended Monitoring Software Handbook, 2005.