Article citation info:
Krajňák J., Homišin J., Grega R., Urbanský M. The analysis of the impact of vibrations on noisiness of the mechanical system. Diagnostyka. 2016;17(3):21-26

DIAGNOSTYKA, 2016, Vol. 17, No. 3

ISSN 1641-6414
e-ISSN 2449-5220

THE ANALYSIS OF THE IMPACT OF VIBRATIONS ON NOISINESS OF THE MECHANICAL SYSTEM

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Summary

The article describes the mechanical system developed at our department. It examines shaft couplings and their impact of torsional oscillation and vibrations on noisiness of the mechanical system. The noisiness of the mechanical system is compared with the vibrations measured in a given mechanical system. The article also presents the apparatus used for measurements. Every device is described in detail and highlights its use in practice. These devices were used for measurements in the laboratory and the results of the measurements are shown in the graphs. From the results, we can evaluate that vibration and noisiness are closely related. A detailed evaluation of the changes of individual values using a variety of shaft couplings is summarized at the end of the article.

Key words: flexible shaft coupling, mechanical system, noisiness, gearbox, electric motor

1. INTRODUCTION

At the Department of Machine Design, Transport and Logistic at the Faculty of Mechanical Engineering, there is a long term research relating to the development of the pneumatic flexible couplings and also taking control of dangerous torsion vibrations in the mechanical systems by an application of those couplings [1, 2, 3]. According to many authors [5, 15, 16], the most appropriate solution to take control of dangerous torsion vibrations is the application of adequate flexible pneumatic coupling into the mechanical system. By taking control of these dangerous torsion vibrations we can greatly reduce or eliminate negative impacts on the environment (namely vibration or noise level) and at the same time protect the individual parts of machinery from the mechanical damage [1, 3, 10].

Measurement of the noisiness and vibrations of the mechanical systems as technological units is an essential part of the analysis of vibrodiagnostic and acoustic effects. The evaluation of such systems can be carried out by several ways and requirements. Monitoring of the mechanical systems is also being made in terms of the dynamic action of the forces. Vibrations of the mechanical systems can induce a resonance in other parts and components and it can become a strong source of mechanical vibrations and noisiness. In terms of torsion vibrations, the system can work in the area under the resonance, in a resonance area or area over the resonance. The article will evaluate the impact of various couplings on the resonance arose in the mechanical system. Also it compares the noisiness and vibration and state whether they are connected [6, 12].

2. CHARACTERISTIC OF THE MECHANICAL SYSTEM

The mechanical system, which we used for the measurement, is placed in the laboratory of our department [13, 14].

The assembled mechanical system (Fig.1) consists of electric motor 1 (Siemens 1LE10011DB234AF4-Z, 11 kW, 1470 min^{-1}), shaft coupling 2, gearbox 3 (through a gearbox with gear ratio 1:1), torque sensor 4, compressor 5 (3-cylinder piston compressor ORLIK 3JSK-75), bearing housing 6 and examined shaft coupling 7 [3]. In spot number 8, we have placed an instrument for the measuring of noisiness of the mechanical systems.

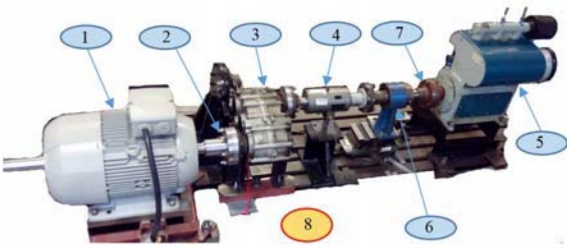

Fig. 1. The assembled mechanical system

On the designed and assembled mechanical systems, we carry out several measurements. In this system, the components such as electric motor, gearbox and compressor were unchanged. During the measurements, we changed the shaft couplings at position 7 and after that; we used an analyzer to measure a noise level. This analyzer was placed at the position 8. The microphone was situated at a distance of 30 mm from the device.

2.1 Vibration of mechanical drive systems and their characteristics

Machine or machinery is part of the process of converting inputs to outputs. Part of this energy transformation can causes a vibration of individual parts. As a consequence of this fact, the noise of the mechanical system is emitted.

Vibration is a term which expresses movement. Movement is the deflection and its derivative - the speed and acceleration. In practice, therefore, describe the phenomenon of various variables that have a clear link between them.

Vibration can be defined as the mechanical movement of the area, which has a deflection for a time course, the median value is zero. Then the vibrating movement is taking place around the equilibrium position. From the timing of the periodic vibration, we can also determine the frequency of vibration. Periodic nature of the vibrations can be expected in cases where the processes are repeated in regular intervals [9, 10, 11].

2.2 Vibration monitoring and Diagnostics of the Developed mechanical systems

The principal objective of the vibration monitoring of rotating parts of machinery is to provide information considering the operational and technical condition of equipment. Vibration diagnostics determines a technical condition of machines.

Vibrodiagnostics is one of the methods where a decomposition of the assembly is not needed [7, 8]. Surveyed are mainly mechanical conditions, such as imbalance, not-alignment, mechanical release, bent shaft, resonance, and so forth.

Monitoring generally is used to obtain baseline data in order to provide a complete overview on the state of the address. They are comparable to and approved by the survey methods of collecting and evaluating data [17, 18].

Monitoring is a continuous on-line real-time measurement of certain values, whether physical, mechanical, apparatus used for such measurements.

Fig. 2. Vibration monitoring system ADASH 3600

Optimization based on monitoring allows continuous monitoring of operational status of all machines. The failure in system will be informed in advance (Fig. 2).

The main benefit of long-term monitoring of power drive throughout the period of service, is obtaining accurate information on the effects of vibration and negative torsion vibration transmitted to the system [12].

The main difference with the classical method used so far is the evaluation of values in real time. This means that any value coming from the system is analyzed and when they fulfill the conditions laid down, together with previous local extremes, is assessed and then provided the necessary adjustments in optimizing power. Based on the changes can be immediately converted value of vibration and torsion vibration in the system and assess their impact on the system [4, 6, 11].

3. THE MEASURING APPARATUS

To measure noisiness of the mechanical system, we used sound-level analyzer type 2250. This device is the innovative, 4th generation, hand-held analyzer from Brüel & Kjær (Fig. 3). The design philosophy is based on extensive research which concluded that the instrument should be easy and safe to use, while at the same time incorporating clever features. Type 2250 can host a number of software modules, including frequency analysis, logging (profiling) and recording of the measured signal. Device was used during a measurement continuously. Its operation was easy and quickly. The measured results are shown in Figure 6 and Figure 8.

Type 2250 has generous hardware and software specifications creating an extremely flexible example, from the traditional uses in assessing environmental and workplace noise to industrial quality control and development. Type 2250 is a technological platform for realizing measurement applications in a compact and robust hand-held instrument. Measured values of noise varied between 82 dB to 112 dB. The accuracy of the device was sufficient in this range.

Fig. 3. Sound-level analyser type 2250

The vibrations of the system are measured only manually by the analyser Adash 4101, seen on the fig.4. The performance of the analyser is determined by the firmware stored in the memory of your instrument.

The firmware is solved on a modular basis, thus allowing the user to specify in the order the requested characteristics of the selected analyser and to determine the optimal ratio of performance - price. In the instruments of 4100 series there are two main types of measured data – static and dynamic. Static data are represented by a single value (real or complex). An example is the result of wideband vibration values measurement (for instance, ISO 2372) or measurement of RPM. Dynamic data are represented by an array of measured values. An example is the result of spectrum or time signal measurement.

It enables real time amplitude and phase measurement at machine speed frequency. The beep labels every new measurement. By measuring, we find the point and direction where vibrations at the machine speed frequency are the strongest.

Fig. 4. Vibration analyzer Adash 4101

4. THE RESULT OF THE MEASURING

In the assembled mechanical system, at first we used the pneumatic shaft coupling developed at our department. We carried out a set of several measurements. The pressure in the coupling (type 4-1/70-T-C), we tried to maintain a constant 100 kPa. The rotation speed was changed in the range from 200 up to 1000 min^{-1}. After changing a pressure and the rotation speed, the mechanical system acquires a stable state; after that we start noisiness measurements by using a sound-level analyzer Type 2250.

On the Fig. 5 we can follow that the highest value of vibration 14 m/s the mechanical system achieves at a rotational speed of 500 min^{-1}. The value of vibration in the speed range from 200 to 400min^{-1} it achieves only small values of 4 m/s. Then it begins to rise on the maximum value at the rotational speed of 500 min^{-1}. From rotational speed 600min^{-1} it begins gradually decline to 4m/s that the mechanical system maintained up to the maximum measured speed 100min^{-1}. If we look at the noisiness so we can see that the value also increased progressively and at a rotational speed of 500min^{-1} and also achieved a substantial increase in noisiness up to 90,6dB.

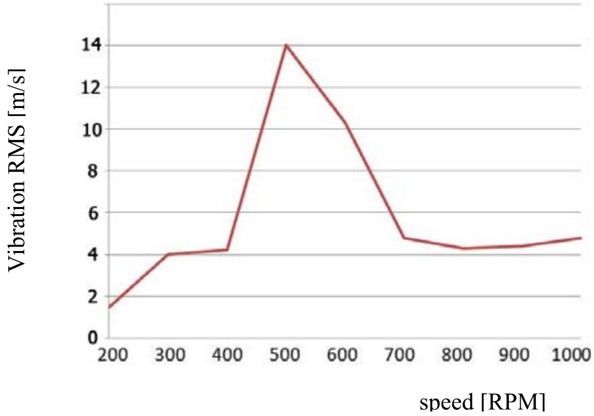

Fig. 5. Dependence of the speed on the vibration values of mechanical system using pneumatic coupling pressurized on the pressure value 100 kPa

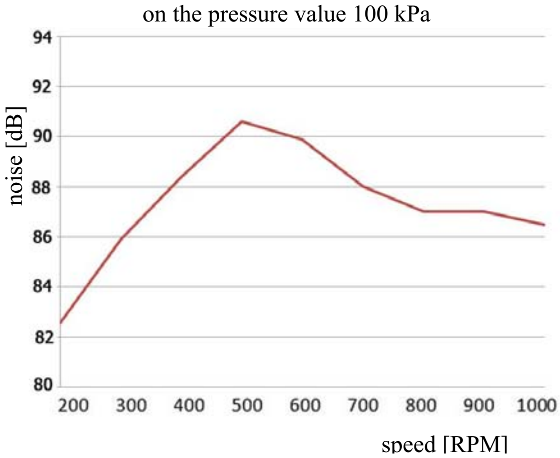

Fig. 6. Dependence of the speed on the noise level of the mechanical system using pneumatic coupling pressurized on the pressure value 100 kPa

In fig. 7 and fig. 8, the influence of using of Hardy coupling GJ9 in the mechanical system is shown.

On the fig.7 we see the dependence of the vibrations on rotation speed. During that measuring, in the mechanical systems we have used Hardy (JUBOFLEX GJ9) shaft coupling, which has different properties than pneumatic shaft coupling. Using this coupling, we can say that the value of the vibration gradually increased with increasing rotation speed. It reaches a maximum value of vibration at rotation speed 700min^{-1}. This value moves to the edge of 22 m/s with increasing rotation speed, the vibration value decreased to value of 15 m//s. Vibration values are higher compared to using pneumatic shaft coupling. The vibrations' increasing is mainly due to the fact that in comparison with the pneumatic coupling, other couplings are not so flexible.

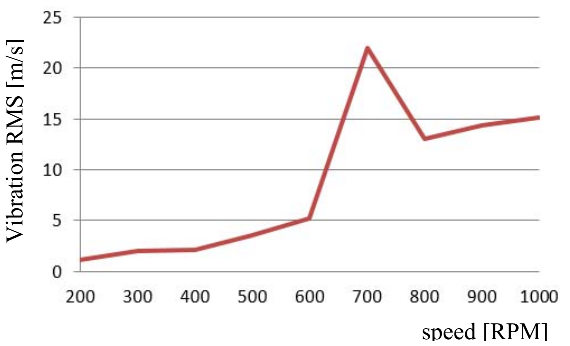

Fig. 7. Dependence of the speed on vibration values of the mechanical systems using shaft couplings Hardy GJ9

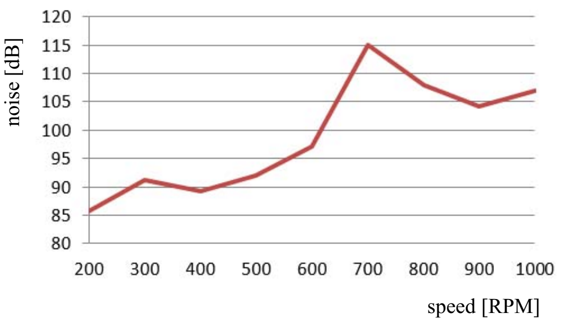

Fig. 8. Dependence of the speed on the noise level in the mechanical system using shaft couplings Hardy GJ9

On the fig. 8 we can monitor the amount of noisiness of the mechanical system measured during using a coupling Hardy. We see that the values of noisiness with comparison to pneumatic coupling are increasing significantly. At rotation speed 200min^{-1}, the value at the limit 85dB are gradually increasing with increasing rotation speed. The maximum noisiness values the mechanical system reached at the rotation speed of 700min^{-1}. Value moves to the limit 115 dB. Further this value decrease to the limit of 105dB. If we compare the values obtain during using the pneumatic coupling with using other couplings, so the difference is about 25dB. This increase is due to the torsional stiffness of the used coupling.

5. SUMMARY

In this article we describe the mechanical Systems (TVMS), which we designed and assembled at our Department. Gradually, in this mechanical system, the one component was changed; the shaft coupling and we realized the measurements where we were changing a rotation speed. In case of the pneumatic flexible shaft coupling, we also changed the pressure in pneumatic elements of coupling to obtain more measurement results and determine how the noise level of the mechanical system will depend on it. During measurements, the measuring sound-level analyzer was used; it has been already described in the article. The results of the measurements can be observed in the fig. 5, 6, 7, 8.

After investigation we can state, that type and properties of the shaft couplings have a significant impact on the noisiness and vibrations of the mechanical system. From those measured values we can also follow that at certain rotation speed it leads to a significant increase of noisiness and also a significant increase in vibration values. This mentioned increases occur especially in the resonance area. Comparing the noisiness and vibrations we found that they related together. During a measurement where the pneumatic shaft coupling was used, an increasing noisiness at rotation speed 500 min^{-1} occurred. Increasing of the vibrations occurred, when we used the same coupling at the same speed. When using the Hardy coupling, an increase in noisiness and vibrations occurred at the rotation speed 700 min^{-1}. The measured values were significantly higher. Increasing values, which were measured with application of Hardy coupling in the mechanical system, were principally due to the fact that the Hardy coupling is not so flexible compared to the pneumatic coupling. In conclusion, we can state that the type and characteristics of the couplings, applied in the mechanical system, have a significant impact on the vibrations and noisiness of the mechanical system. We can further say that the noisiness and vibrations are related together; it means that decreasing of the vibrations caused a decreasing of the noisiness. The value of the vibrations and noisiness significantly increase in the area of resonance.

Acknowledgement: This paper was written in the framework of Grant Project VEGA: „1/0688/12
– Research and application of universal regulation system in order to master the Source of mechanical systems excitation".

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Received 2016-04-12
Accepted 2016-06-12
Available online 2016-09-19

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