DOI: https://doi.org/10.53052/9788366249974.15

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WPŁYW DEZAKTYWACJI CYLINDRA NA GŁOŚNOŚĆ NAPĘDU MECHANICZNEGO PRZY ZASTOSOWANIU PNEUMATYCZNEGO SPRZĘGŁA PODATNEGO

Streszczenie: Własności napędów mechanicznych mogą być zmieniane za pomocą podatnych sprzęgieł pneumatycznych. Takie sprzęgła odpowiednio zmieniają własności dynamiczne układów mechanicznych, co ma korzystny wpływ na drgania oraz głośność tychże układów. Drgania oraz zbyt duża głośność mają negatywny wpływ na pracowników obsługi, operatorów oraz środowisko.

Słowa kluczowe: napęd mechaniczny, głośność, podatne sprzęgło pneumatyczne

THE EFFECT OF COMPRESSOR CYLINDER DEACTIVATION ON THE NOISINESS OF THE MECHANICAL DRIVE WITH A PNEUMATIC FLEXIBLE COUPLING

Summary: The properties of mechanical drives can be changed with pneumatic flexible couplings. They subsequently change its dynamic properties, which affect vibrations and noisiness that negatively affect the operators and environment.

Keywords: mechanical drive, noisiness, pneumatic flexible coupling

1. Introduction

In technical practice, every machine in a factory produces noise, which above a certain level can be harmful for the operators. In recent years, efforts have been made to reduce the level of this dangerously high noise level. Each level of machine

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noise and vibrations in mechanical drives can be controlled by changing the stiffness of the drive members. To ensure proper tuning of vibrating mechanical drive, the application of the pneumatic flexible coupling is suitable solution for the mechanical drive´s tuning.
Changing the pressure of the gaseous medium in the pneumatic flexible coupling affects its stiffness and dumping properties. Torsional stiffness k is allowed to be a dynamic property that significantly affects the mechanical drive. Our examined mechanical drive operates in the range of operating speed of electromotor. Into the mechanical system, a three-cylinder compressor is included and it is use as a producer of torsional vibration. During our experimental measurements, we will monitor the change in noisiness when deactivating one cylinder of compressor, as a part of the mechanical drive. The deactivation of the compressor cylinder is simulated by decommissioning of the one cylinder which causes a significant change in torsional vibration. The aim of the article is to demonstrate the suitability of using a pneumatic flexible coupling as a tuner of a mechanical drive to reduce its noisiness during deactivation of the cylinder in compressor.

2. Designed mechanical drive

To provide experimental measurements, the mechanical drive with compressor was assembled in our department laboratory conditions. The examined mechanical drive (Fig. 1) consists of a tree-cylinder compressor (4), which is driven via pneumatic flexible coupling (3) by a three phase asynchronous electric motor (1) which drives a two-speed gearbox (2). Individual positions of parts of the mechanical system correspond to the indications in Fig. 1.

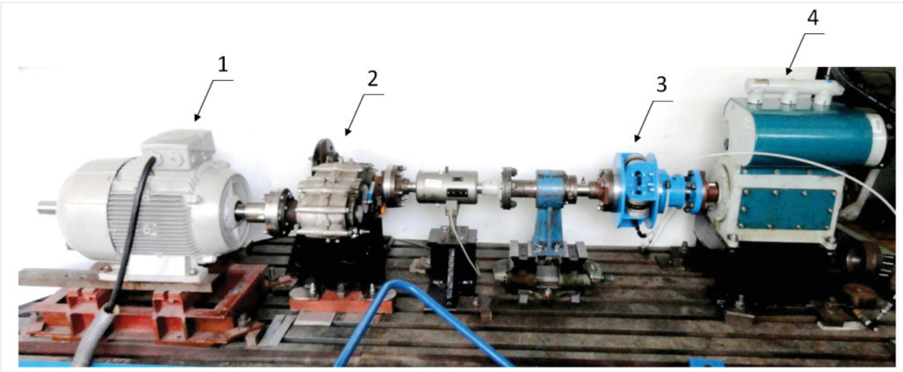

Figure 1. Experimental mechanical drive

3. Experimental noise measurement

3.1. Location of the measurement

During the noise measurement of the mechanical system, a sound level meter was used, the location of which is drawn in Figure 2. The height of the sound level meter from the floor is 1.5 m, which simulates the average height of a machine operator.

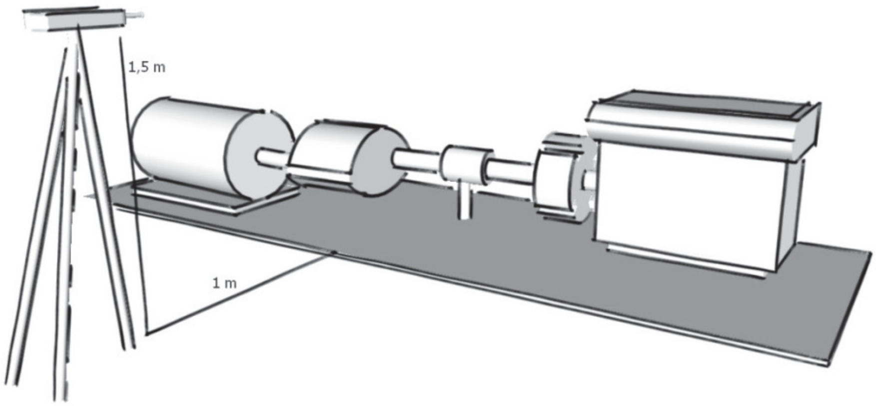

Figure 2. Location of sound level meter during measurement

3.2 Method of the measurement

In order to obtain the results on noisiness of the mechanical system, several experiments in our laboratory of measurements and tuning of torsional vibration were conducted. The recorded change in the noise of the mechanical system was achieved by changing the pressure of the gaseous medium in the pneumatic flexible coupling (Fig.3), which was in the interval from 200-600 kPa. At the same time, the speed of the electric motor was continuously changed in the range of 400-800 rpm.

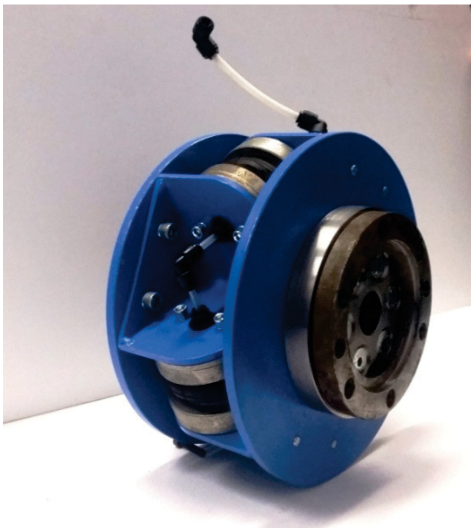

Figure 3. Pneumatic flexible coupling used during measurements

3.3 Quantity and unit of the measurement

After consideration, as a measuring quantity was chosen A-weighted equivalent sound pressure level L_{aeq} in dB, that values were obtained from sound-level meter during the measurements.

3.4 Measuring apparatus

The following devices were used to measure a noise:

- handheld sound level meter analyzer Brüel&Kjær Type 2250,
- Microphone Type 4189, nominal sensitivity 50 mV/Pa,
- Tripod carrying sound level meter.

3.5 Results of the measurement

The aim of the measurement was to identify the impact of deactivation of one cylinder in compressor and subsequently its noisiness during this deactivation. Mechanical drive worked in range of operating speed 200 – 600 rpm. The experimental measurements were carried out at individual pressures in the pneumatic flexible coupling in order to observe changes in the noise of the mechanical drive during the deactivation of one compressor cylinder. The measured L_{Aeq} values are shown in the graph in Figure 4. The green columns indicate the drive noise at a pressure of 200 kPa, which is equal to the torsional stiffness of the pneumatic flexible coupling k_{p200}. The yellow columns are the noise values at a pressure of 400 kPa, which is equal to the torsional stiffness of the pneumatic flexible coupling k_{p400}, and the red columns indicate the pressure in the pneumatic flexible coupling of 600 kPa, which is equal to the torsional stiffness of the pneumatic flexible coupling k_{p600}. As can be seen from the graphs, the higher revolutions of the electric motor are, the higher noise levels were measured. However, at a pressure of 200 kPa, the noise of the mechanical drive decreased with increasing revolutions. It is very interesting to note the fact that by increasing the speed from 400 to 600 rpm, the noise value increased by an average of 9 dB at pressures of 400 and 600 kPa, while the noise value at 200 kPa pressure, on the contrary, decreased by 7 dB.

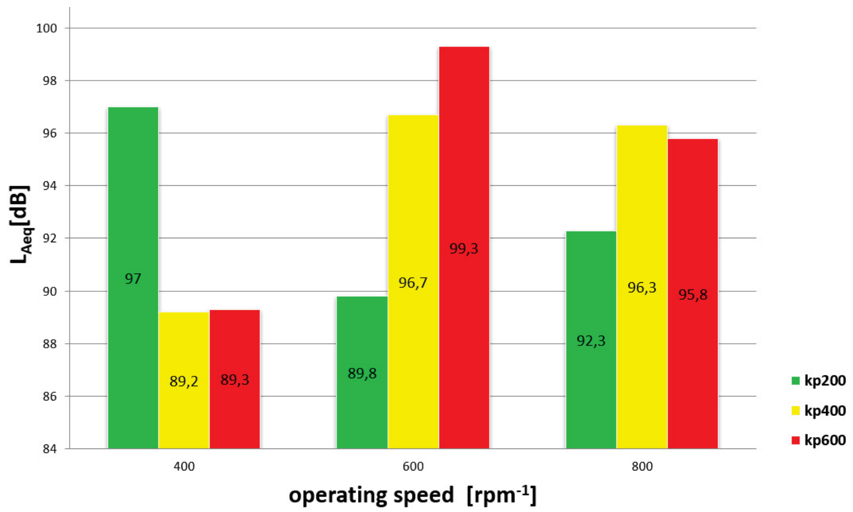

Figure 4 Measured noisiness of the mechanical drive with compressor cylinder deactivation

In the following graph shown in Fig. 5, we have added a noise limit of 93 dB to the graph of measured noise values of mechanical drive. This limit was determined by the average of the noise values that were measured during the full operation of compressor; it means without deactivation its cylinders.

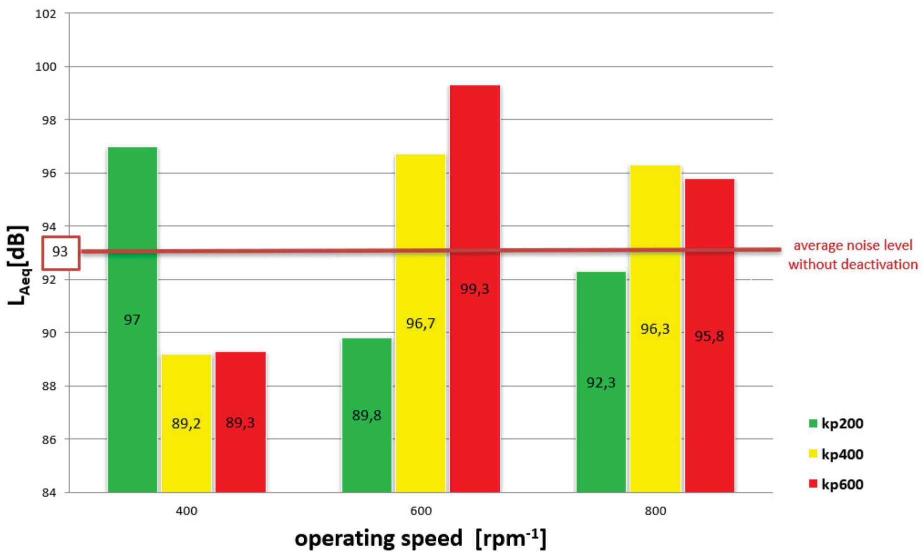

Figure 5. Measured noisiness of the mechanical drive with added average noise level without deactivation

From the above, we wanted to prove the fact that by deactivating one cylinder in the compressor, it is possible to achieve lower noise levels. Concretely, suitable continuous tuning of the drive by changing the pressure in the pneumatic tuner. At lower revolutions, it is appropriate to use a higher pressure in the pneumatic flexible coupling, which means an increase in its stiffness, and conversely, by increasing the revolutions of the drive, it is appropriate to use a lower pressure in the pneumatic flexible coupling.

4. Conclusion

By measured noise values and setting the noise limit, we can confirm that the change in gas pressure in the pneumatic flexible coupling and the deactivation of the cylinder in the compressor cause significant differences in the noise level of the entire mechanical drive. As a result, the environment in which such a mechanical drive is located is less harmful for the operators and the environment. The differences in the values achieved without deactivation of cylinders in the compressor were significant. These values confirm our aim of the article that by deactivating the cylinders and appropriately chosen stiffness of the mechanical drive, lower noise values of around 90 dB can be achieved.

REFERENCES

1. KRAJŇÁK J, GREGA R: Analysis of external temperature in flexible element at various speed levels. Projektowanie, badania i eksploatacja Tom 1. - Bielsko-Biała: Akademia Techniczno-Humanistyczna w Bielsku-Białej (2018) 191-198 ISBN 978-83-65182-93-7.
2. GREGA R. [et al.]: The chances for reduction of vibrations in mechanical system with low-emission ships combustion engines. In: International Journal of Maritime Engineering. Vol. 157, no. A4 (2015), p. 235-240. - ISSN 1479-8751.
3. HOMIŠIN J, KAŠŠAY P, URBANSKÝ M, PUŠKÁR M, GREGA R, KRAJŇÁK J.: Electronic Constant Twist Angle Control System Suitable for Torsional Vibration Tuning of Propulsion Systems. Journal of Marine Science and Engineering. (2020) vol. 8, no 9:721, pp. 1-17.
4. GREGA R, [et al.]: Failure analysis of driveshaft of truck body caused by vibrations. In: Engineering Failure Analysis. Vol. 79. (2017) ISSN 1350-6307.
5. ŽUĽOVÁ L: Identification of the impact of pneumatic flexible coupling on the noise of the mechanical drive: *Diploma thesis*, Košice: TU, 2016.
6. KULKA J, MANTIC M, FEDORKO G, MOLNAR V: Failure analysis of increased rail wear of 200tons foundry crane track, Engineering Failure Analysis 67 1–14. (2016).
7. HOMISIN J, [et al.]: Removal of systematic failure of belt conveyor drive by reducing vibrations. In: Engineering Failure Analysis. 99. (2019), ISSN 1350-6307.
8. HOMISIN J.: Characteristics of pneumatic tuners of torsional oscillation as a result of patent activity, ACTA MECHANICA ET AUTOMATICA 10(2016)4.
9. GREGA R, HOMISIN J, et. al.: The chances for reduction of vibrations in mechanical system with low-emission ships combustion engines. International Journal of Maritime Engineering: Transactions of The Royal Institution of Naval Architects. Vol. 157 (2015).

This paper was written in the framework of Grant Project VEGA: *„1/0528/20 and* **KEGA** *029TUKE-4/2021.*

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