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Robert GREGA[1], Jaroslav HOMIŠIN[2], Jozef KRAJŇAK[3], Matej URBANSKÝ[4]

ANALYSIS OF THE IMPACT OF FLEXIBLE COUPLINGS ON GEARBOX VIBRATIONS

Summary. Dangerous vibrations of mechanical systems' components are causes of failures and reduction in service life, as well lead to negative effects on the environment and the health of operators. In order to reduce these unwanted vibrations, it is necessary to pay attention to the proper design of components in mechanical systems. The aim of this article is based on the experimental measurements and demonstration of the effects of different types of flexible couplings on the size of vibration in a gearbox that forms part of a mechanical system.

Keywords: flexible couplings, vibrations, gearbox, mechanical system

1. INTRODUCTION

In mechanical systems, in which gear mechanisms are classified, unwanted vibrations can be observed, for example, as a consequence of improperly designed, manufactured, assembled

[1] Faculty of Mechanical Engineering, Technical University of Košice, 9 Letná 9 Street, 042 00 Košice, Slovakia. E-mail: robert.grega@tuke.sk.
[2] Faculty of Mechanical Engineering, Technical University of Košice, 9 Letná Street, 042 00 Košice, Slovakia. E-mail: jaroslav.homisin@tuke.sk.
[3] Faculty of Mechanical Engineering, Technical University of Košice, 9 Letná Street, 042 00 Košice, Slovakia. E-mail: jozef.krajnak@tuke.sk.
[4] Faculty of Mechanical Engineering, Technical University of Košice, 9 Letná Street, 042 00 Košice, Slovakia. E-mail: matej.urbansky@tuke.sk.

and operated mechanical systems [1], [2], [3]. The main issue regarding the reduction of vibrations concerns an intense flow of information throughout the process of designing, manufacturing, installing, operating and diagnosing mechanical systems. Responsibility for a low level of vibrations cannot be delegated to a single designer, but should be owned by a team of professionals. The fulfilment of all targets to minimize vibrations is in the interests of those involved at the technical, legislative and subjective level. It is very important to properly associate the aforementioned fields of interest with the cost, durability and environmental impact of the measures taken [10], [11], [12].

Knowledge of the basic sources of excitation of vibration is one of the prerequisites for enabling a reduction in vibrations within mechanical systems. It should be remembered that, in addition to the known vibration exciters in vibration spectra, random vibrations may occur that we cannot prejudge in advance. Such random vibrations, however, could be an important source of information about the technical condition of the mechanical system concerned [6], [7], [8], [9].

Torsional vibrations represent a specific type of vibration, which are caused by the rotating components. By assembling machinery that produces torsional vibrations into a mechanical system, torsional vibrations follow the direction of energy flow and in turn become vibration exciters to other parts of the system. In many cases, serious failures are behind the cause of sources other than torsional vibrations. It is very important to pay attention to machines that produce torsional vibrations in order to minimize the impact of torsional vibrations within a mechanical system. A very appropriate solution for vibration reduction in mechanical systems is properly designed flexible shaft coupling. With properly designed flexible coupling can help mechanical systems achieve a minimum level of vibrations by appropriately tuning the revolutions produced by all members of the system. In our case, the interest is directed to a gearbox, which forms part of the examined mechanical system. Based on experimental measurements, we prove the effect of different types of flexible couplings on the size of gearbox vibration. In turn, we demonstrate the importance of appropriately tuning the mechanical system using flexible coupling [4], [5].

2. EXPERIMENT DESCRIPTION

The experiment, which aimed to demonstrate the impact of the flexible couplings on the size of gearbox vibrations, was realized using the mechanical systems shown in Fig. 1. The aforementioned mechanical system consisted of a torsional oscillation exciter, which was a three-cylinder compressor. The compressor was driven by an electromotor with the possibility of variable speed control. The examined gearbox was included in the mechanical system between the compressor and the electromotor. It was an auxiliary gearbox with the gear ratio i=1, as used in automotive drive. The mechanical systems included other components necessary for diagnosing the mechanical system.

The flexible couplings, which were used during measurements, were included in sequence between the gearbox and the compressor. Four types of coupling (shown in Fig. 2 to Fig. 5 inclusive) were examined: pneumatic flexible coupling, Hardy coupling, Periflex coupling and claw coupling.

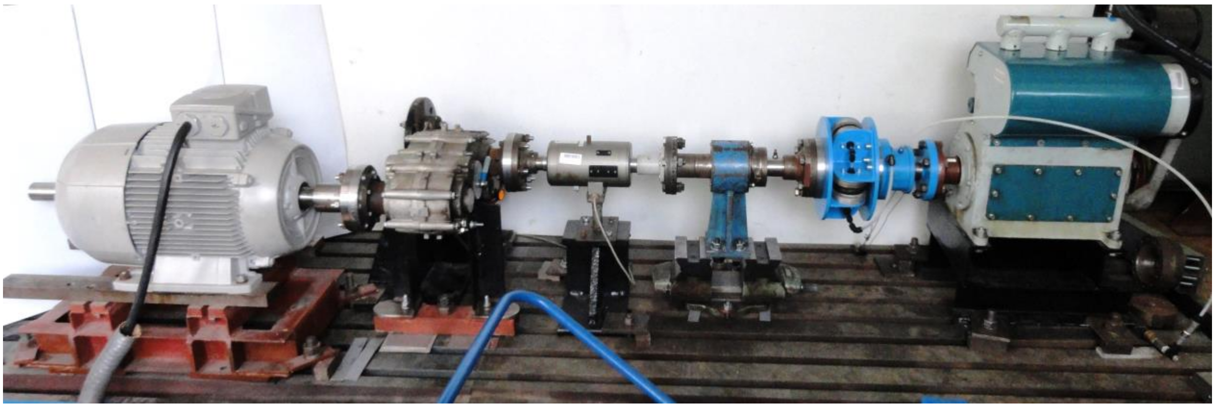

Fig. 1 Scheme of the mechanical system

Fig. 2 Pneumatic flexible coupling

Fig. 3 Hardy coupling

Fig. 4 Periflex coupling

Fig. 5 Claw coupling

3. EXPERIMENTAL MEASUREMENT RESULTS

The experiments were carried out in an operating mode with a rotation speed between 200 min^{-1} and 1,000 min^{-1}. In this operating mode, the values of vibrations on the gearbox were obtained. The measured value of the monitored vibrations, which is known as RMS, is regarded as an effective value of vibration speed. In the case of using pneumatic flexible coupling to measure vibration values, air pressure between 100 kPa and 700 kPa, in terms of pneumatic elements of coupling, were applied. In Fig. 6 to Fig. 9 inclusive, diagrams have been constructed based on the measurements of RMS on the gearbox. As can be seen from the courses of RMS, the maximum value of the vibration in each case is at a speed between 500 min^{-1} and 800 min^{-1}. This maximum value of RMS corresponds to the speed value when the mechanical system starts to resonate from the main exciter's harmonic component in the compressor.

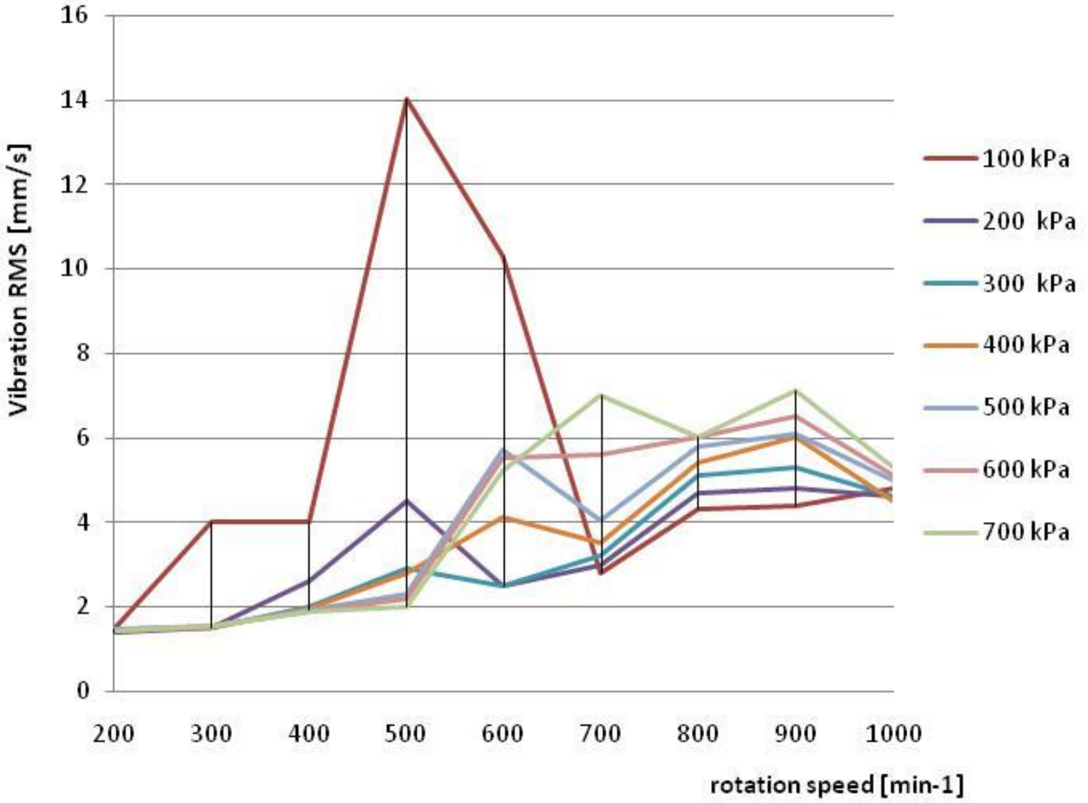

Fig. 6 Measured value of pneumatic flexible coupling

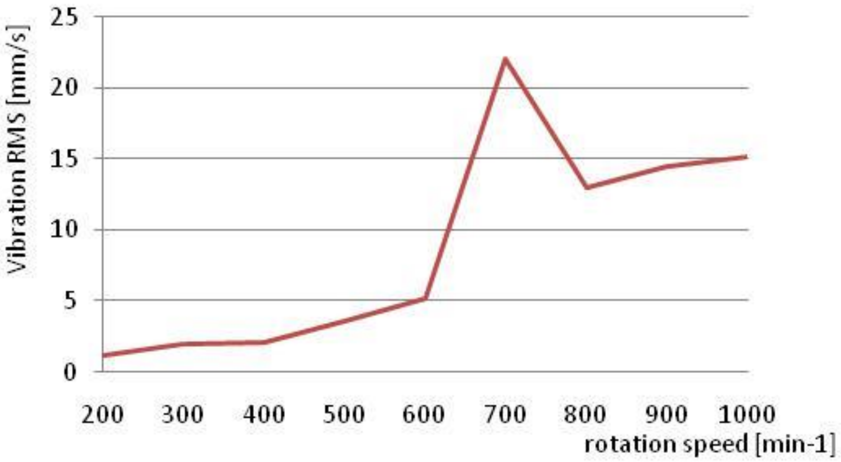

Fig. 7 Measured value of Hardy coupling

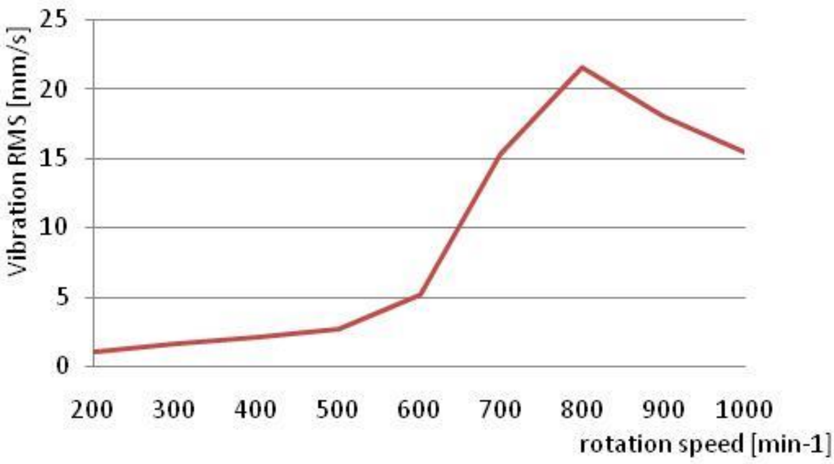

Fig. 8 Measured value of Periflex coupling

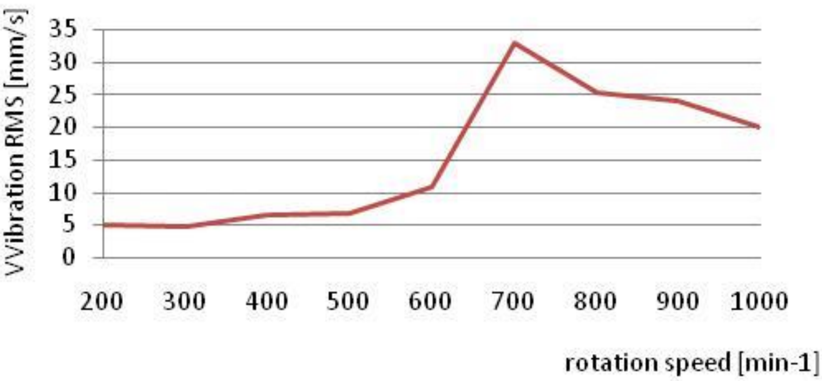

Fig. 9 Measured value of claw coupling

4. CONCLUSION

Following the mutual comparison of the individual values of vibrations obtained from the measurements, we can state that, in the current case regarding all operating speeds of the mechanical system, the lowest vibration levels in a gearbox are achieved using pneumatic flexible couplings with a pressure of 300 kPa in their pneumatic flexible elements.

Fig. 10 presents all RMS courses of each of the used couplings. The RMS course, which uses pneumatic flexible coupling, represents the line with a value of air pressure equal to 300 kPa. As stated in this figure, we can observe that the size of vibration involving pneumatic flexible coupling equates to less than 700% in comparison with other couplings, especially in the area of resonance of the mechanical system. The aforementioned target detections, therefore, represent sufficient grounds to present our proposals for an appropriate coupling design for any mechanical system. In particular, the suitability of selected flexible coupling can significantly protect individual parts of the mechanical system and thus increase their durability, as well as reduce their failure rate.

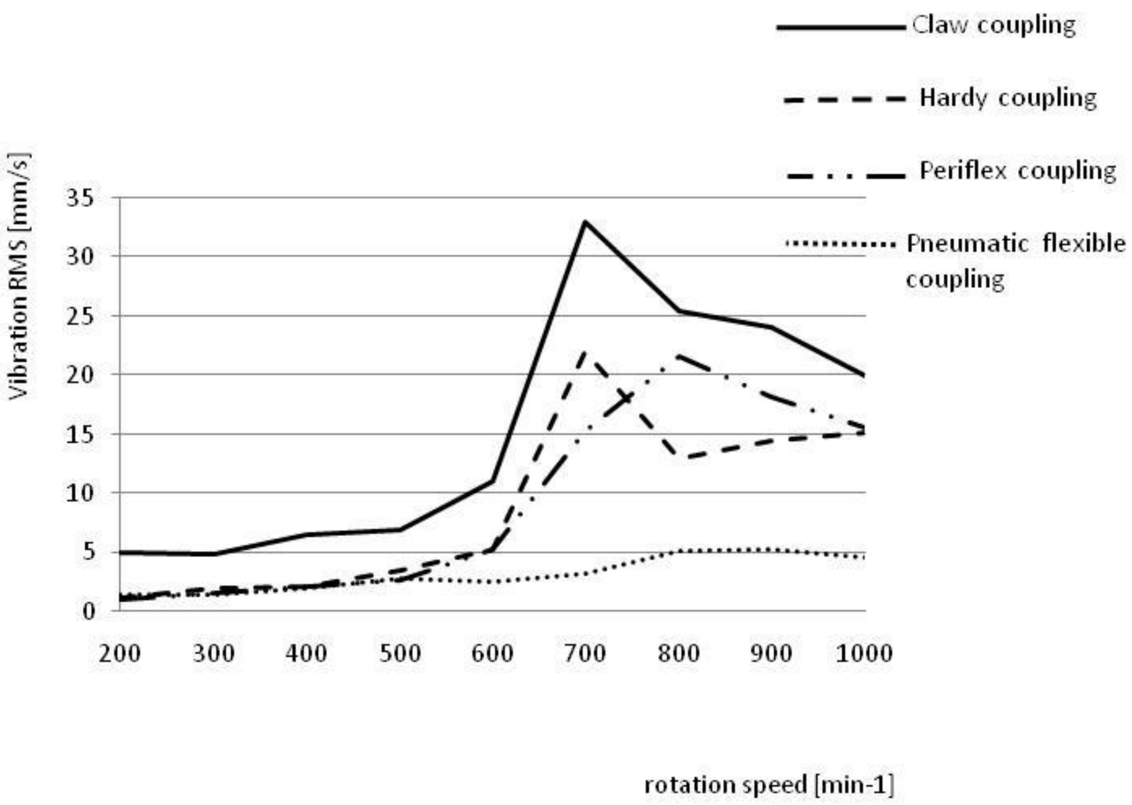

Fig. 10 Measured value of all used couplings

References

1. Grega R. et al. 2015 „The chances for reduction of vibrations in mechanical system with low-emission ships combustion engines”. *International Journal of Maritime Engineering* 157 (A4): 235-240. ISSN: 1479-8751.
2. Baran P., R. Grega. 2015. „Comparison of dynamic properties of dual mass flywheel”. *Diagnostyka* 16(1): 29-33. ISSN: 1641-6414.
3. Medvecká-Beňová S., M. Mantič, R. Grega. 2014. „The stress analysis in dangerous section of gear teeth”. *Applied Mechanics and Materials* 611: 279-283. ISSN: 1660-9336.
4. Homišin J. 2013. „New ways of controlling dangerous torsional vibration in mechanical systems”. *Transactions on Electrical Engineering* 2(3): 70-76. ISSN: 1805-3386.
5. Homišin J., P. Kaššay, P. Čopan. 2014. „Possibility of torsional vibration extremal control”. *Diagnostyka* 15(2): 7-12. ISSN: 1641-6414.
6. Vaško M., B. Leitner, M. Sága. 2010. „Computational fatigue damage prediction of the lorry frames under random excitation”. *Communications* 12(4): 62–67. ISSN: 1335-4205.

7. Sága M., P. Kopas, M. Vaško. 2010. „Some computational aspects of vehicle shell frames optimization subjected to fatigue life*". Communications* 12(4): 73-79. ISSN: 1335-4205.
8. Konieczny Ł., R. Burdzik, J. Warczek, P. Czech, G. Wojnar, J. Młyńczak. 2015. „Determination of the effect of tire stiffness on wheel accelerations by the forced vibration test method". *Journal of Vibroengineering* 17(8): 4469-4477. ISSN: 1392-8716.
9. Dekys V., A. Sapietova, O. Stevka. 2013. „Understanding of the dynamical properties of machines based on the interpretation of spectral measurement and FRF". In *51st International Scientific Conference* on *"Experimental Stress analysis"*: 106-112. Litomerice, Czech Republic. 11-13 June 2013.
10. Jakubovičová L., P. Zavadinka, J. Jakubovič. 2016. „Transport duty cycle measurement of hybrid drive unit for mixing drum". *Advances in Intelligent Systems and Computing* 393: 219-224. Berlin: Springer Verlag. ISSN: 21945357.
11. Wojnar G., P. Czech, P. Folęga. 2014. „Problem with diagnosing local faults of gearboxes on the basis of vibration signal". *Transactions of the Universities of Košice* 2: 95-100. ISSN: 1335-2334.
12. Czech P., G. Wojnar, J. Warczek. 2014. „Diagnosing of car engine fuel injectors damage using bi-spectral analysis and radial basis function." *Logistyka* 3: 1,181-1,187. ISSN: 1231-5478.

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