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BADANIE ZMIAN TEMPERATURY POWIETRZA W ELEMENCIE PODATNYM W ZALEŻNOŚCI OD LICZBY OTWORÓW ŁĄCZĄCYCH W TRAKCIE SPRĘŻANIA TEGO ELEMENTU

Streszczenie: Na naszym wydziale, badania sprzęgieł podatnych są prowadzone od wielu lat. W tych sprzęgłach, stosujemy elementy podatne, które mogą być przełączane/mocowane z zastosowaniem różnych liczb otworów łączących. W tym artykule, opisano badania zmian temperatury powietrza wewnątrz elementu podatnego w zależności od liczby otworów łączących, które służą do przyłączania tego typu elementów. Element elastyczny jest sprężany przy specyficznym ciśnieniu oraz prędkości. Zestawiono wyniki badań.

Słowa kluczowe: ciśnienie, sprężanie, element pneumatyczny, sprzęgło wału, otwory łączące

INVESTIGATION OF AIR TEMPERATURE CHANGE IN THE FLEXIBLE ELEMENT DEPENDING ON CONNECTING HOLES NUMBER DURING COMPRESSING OF THIS ELEMENT

Summary: At our department, we have been researching flexible couplings for many years. In these couplings, we use flexible elements that can be connected with a different number of connecting holes. This article examines the changes in air temperature inside the flexible element depending on the number of connecting holes by which these elements are connected. The elastic element is compressed at a specific pressure and speed.

Keywords: pressure, compression, pneumatic element, shaft coupling, connecting holes

1. Introduction

Various mechanical devices consisting of driving and driving devices are used in various administrative facilities as well as in other industries. the composition of these devices is called a mechanical system in mechanical engineering. It is an

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important part of this system shaft coupling. Such a barrel has many functions, but in addition to connecting the driving machine with, it also ensures the ideal operation of the device and protects individual parts against any of them when there are various vibrations in such mechanical devices. According to several authors, the best way to control dangerous torsional oscillations is to use a suitably selected shaft coupling. [1, 2, 4, 5, 8, 13, 14].

At our workplace, we deal with the issue of flexible pneumatic couplings and transient torque. In these couplings, we commonly use pneumatic spring elements, which we compress and expand during operation. This process ensures the transmission of torque. [6, 7, 10, 11, 15, 16].

These flexible couplings can work at different pressures and different speeds. By changing the pressure of the elastic elements inserted in the pneumatic couplings, we can change the characteristics of this coupling and this allows us to tune the frictional oscillating system, adjust its parameters according to the operating characteristics so that in the operating mode of the system there is no dangerous resonance and at most the entire system. equipment or operator injury. By reducing vibrations and oscillations, we also reduce the noise of the entire mechanical system and thereby increase safety. Currently, attention is paid to the development and research of pneumatic flexible members, which are made of a rubber-cord jacket filled with a gaseous medium. [9, 22]. These elastic elements are dynamically stressed. However, it should be remembered that the load is not transmitted by the rubber but by the gas medium, the pneumatic coupling is filled. [12 , 17, 18, 19, 20 , 21].
The main goal of this article is to investigate the temperature of the air that we compress inside the elastic element when it is compressed. The article examines a pair of these elements, which can be connected by a different number of connecting holes. We will perform the measurements at different speeds and different pressures in the flexible element.

2. Pneumatic flexible elements

Flexible pneumatic elements can be different. Pneumatic elements are used in various pneumatic devices. There are various manufacturers of flexible elements in the world. Different sizes and different numbers of bellows are also produced. Most are made of single-wave, two-wave and three-wave elements. For our measurements, we will use more frequently used elements, which are single-wave units.

Figure 1. A pair of flexible elements connected by a connecting flange

Figure 2. Connecting flange with 6 holes

We used two such elements to ensure proper stressing of the elastic elements. We connect these elements together with a connecting flange through a hole in which there are 6 holes. We press the elements on the measuring device designed at the found workplace. We can change the number of connecting holes and thus we can perform different measurements under different conditions. We will perform measurements at pressures of 200kPa and 500kPa.

The compression speed depends on the speed of the electric motor. The speed of the electric motor will be 200, 400, 600 and 800 min^{-1}. The flexible pneumatic elements and the connecting flange can be seen in fig. 1 and fig.2.

This flange consists of 6 drilled holes that we can close. We can connect flexible elements with a different number of holes. This solution has one drawback. The disadvantage of this solution is that we have to disassemble and reassemble the measuring device every time the number of connecting holes is changed. Cannot be processed at runtime. The diameter of the holes is 2.5 mm and they are drilled on a circle with a pitch of 40 mm. We will measure the air temperature inside the flexible element. When measuring, we use flexible pneumatic elements with a diameter of 120 mm and a neutral height of 75 mm, as shown in fig.

The working pressure is limited by the maximum working pressure, which is 800 kPa. The normal operating temperature is in the range of -40 °C to 70 °C. For special cases, the manufacturer can provide another material working in the temperature range of -20 °C to 115 °C.

3. Test device for temperature measuring

Test rig is precisely described and shown in fig. 3. It consists of electric motor (1) which drives the crank mechanism (2) through the belt transmission (3). The flexible pneumatic elements (4) are fixed in the fixed frame (5), which are connected by means of a connecting flange (6).

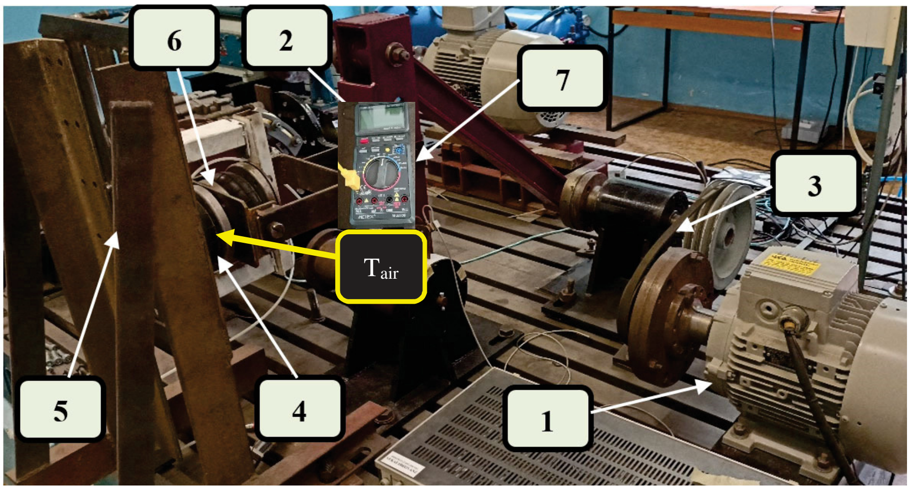

Figure 3. Test device for measuring the temperature of 2 interconnected flexible pneumatic elements

We use the SM 160L DC electric motor (1) with an output of 16 kW with an additional thyristor speed controller of the IRO type with a possibility of a continuous speed change from 0 – 2000 min-1. For sensing of air temperature inside the flexible member Tair we used two digital multimeter M-3870D METEX (7) with temperature probe ETP–003, and measurement range −50 °C to +250 °C. Temperature probes were set up in three measured locations. The following temperatures were measured. The place where the air temperature inside the flexible element is measured is shown in Figure 3 with a yellow arrow.

3. Measurement results

Contributions of the investigation of the air inside the flexible element, we proved that the value of the Reynolds number is very high. That is why we consider air flow to be turbulent. When examining the air flow inside the flexible element, we proved that the value of the Reynolds number is very high. A value greater than 2300. We consider the air flow to be turbulent. [3] The mathematical expression of temperature is very complicated, so I will only document the results using measured values.

After carrying out several measurements, we can conclude that the air temperature changes over a period of 25 to 30 minutes. After 30 minutes, the values are constant and no longer change.

We can see it in Figure 4 when we performed the measurement at a pressure of 200 kPa and a speed of 800 min^{-1}. The temperature started to rise from the ambient temperature of 24 °C to 46 °C. It reached its final temperature after 25 minutes, and after this time the value was already constant.

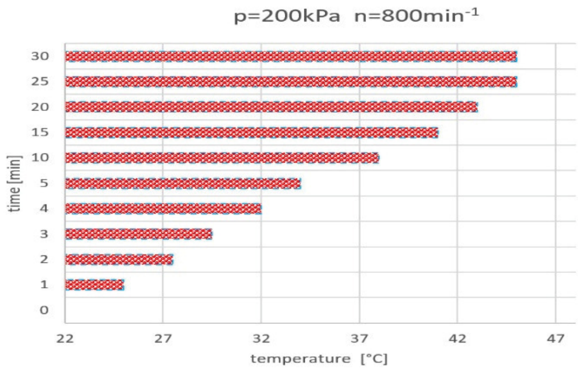

Figure 4. Course of measured air temperatures depending on time, at initial pressure p=200 kPa and speed 800 min^{-1}

By changing the connecting holes on the crank mechanism shown by position 7, fig.3, we can change the size of the oscillation amplitude, which was set to a value of 7.7 mm during our measurements. The ambient temperature at which we performed the measurements is constant, namely T=22°C.
During performing the measurements in our department laboratories, we observed temperature changes in connection of two flexible elements with various number of connecting holes (from 1 to 6).

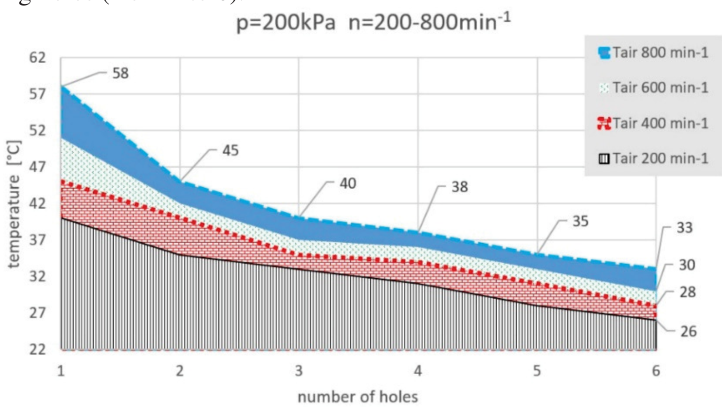

Fig. 5. Course of measured air temperatures in the inner part of the element depending on the number of connecting holes, at initial pressure p=200 kPa and revolutions 200, 400, 600 and 800 min^{-1}

We performed the first measurement at a pressure of 200 kPa. We changed the speed from 200 min^{-1} to 800 min^{-1}. We performed the entire measurement step by step with one connecting hole. We gradually changed the number of connecting holes to 2, 3, 4, 5 and 6. The values of the outside temperature are recorded in fig. 5.

The lowest air temperature is 26°C with the maximum number of connection holes, namely six. With one connection hole, the maximum temperature is 58°C with one hole.

Figure 5 shows that the temperature also increases with increasing revolutions. The air temperature does not reach the critical value of 70°C and therefore there is no risk of damage to the pneumatic element.

In fig. 6 we can see the change in temperature depending on the number of holes in the measurement where the pressure in the elastic element is 500 kPa and the revolutions vary in the range of 200 to 800 min^{-1}. The air temperature inside the flexible elements ranges from 24 to 33°C with six connection holes and reaches a maximum value of 44°C with one hole and the highest speed of 800 min^{-1}.

We can state that the temperature changes depending on the number of connecting holes. The more holes there are in the connecting flange, the lower the temperature of the air in the flexible element, because the air flows faster and cools down faster.

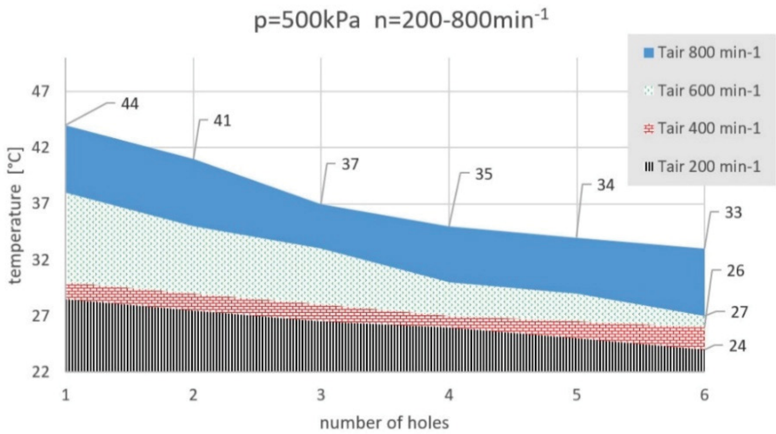

Figure 6. Course of measured air temperatures in the inner part of the element depending on the number of connecting holes, at initial pressure p=500 kPa and revolutions 200, 400, 600 and 800 min^{-1}.

4. Conclusion

This paper investigated the air temperature in a flexible element used in flexible pneumatic couplings. The main goal was to find out how the air temperature changes inside two connected elements, when they are placed in a pneumatic coupling and are connected by one or more flexible connecting holes. We designed a measuring device that we made for this purpose and used for our measurements.

During repeated measurements, we found that the measured temperature always stabilizes after 30 minutes. Therefore, we performed all measurements for a maximum of 30 minutes.

We can conclude that the increased number of connecting holes caused a decrease in all temperatures. This is positive information for us. This is because more holes cause the air to flow faster and cause it to cool faster.

We can also state that the highest temperatures were reached at the lowest pressure of 200 kPa, at the maximum temperature of 800 min-1 and one connecting hole. The air temperature inside reached 58°C.
This temperature did not exceed the maximum allowed value of 70°C. At this temperature, rubber elements lose their properties. We can therefore state that pneumatic elements can continue to be used in pneumatic couplings with regard to the reliable and trouble-free operation of the entire device.

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LITERATURA

1. URBANSKÝ M., HOMIŠIN J.: Principle of torsional vibration control on mechanical system at inner accidental event occurrence, In: Projekt interdyscyplinarny projektem 21. wieku. - Bielsko-Biała : Wydawnictwo naukowe ATH, 2017 P. 333-340. - ISBN 978-83-65192-80-7, 2017
2. HOMIŠIN J.: Nové typy pružných hriadeľových spojok: vývoj, výskum, aplikácia. TU, SjF, Košice 2002, ISBN 80-7099-834-2.
3. 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 s. 191-198 - ISBN 978-83-65182-93-7, 2018.
4. CZECH P., WOJNAR G., WARCZEK J.: Diagnosing of car engine fuel injectors damage using bispectral analysis and radial basis function, Logistyka 1181–1187, 2014.
5. URBANSKÝ M., KAŠŠAY P., PUŠKÁR M.: Drum pneumatic flexible shaft coupling applicable in the automotive industry. Projektowanie, badania i eksploatacja 2020. - Bielsko: Wydawnictwo naukowe Akademii techniczno-humanistycznej w Bielsku-Białej s. 363-370. ISBN 978-83-66249-54-7, 2020.
6. JAKUBOVIČOVÁ L., SÁGA M., KOPAS P., HANDRIK M., VAŠKO M.: Some Notes on Analysis of Bending and Torsion Combined Loading, Machine Dynamics Research 34 (3): 97–105. ISSN 2080-9948, 2010.
7. MALÁKOVÁ S., HARACHOVÁ D.,: Konštrukčná optimalizácia prevodovky pre odstránenie prevádzkovej poruchovosti, Technológ. Žilina (Slovensko): Žilinská univerzita v Žiline, 2009 Roč. 11, č. 3, s. 43-48. - ISSN 1337-8996, 2019.
8. GREGA R., KRAJŇÁK J., ŽUĽOVÁ L., FEDORKO G., MOLNÁR V.: Failure analysis of driveshaft of truck body caused by vibrations, In: Engineering Failure Analysis. Vol. 79, p. 208-215. - ISSN 1350-6307, 2017.
9. WOJNAR G., KRAJŇÁK J.: Analysis of defect causes in selected car gearbox, In: 26 Sympozjon Podstaw Konstrukcji Maszyn: Szczyrk, 09.09.-13.09.2013. - Katowice : Politechnika Śląska Wydział Transportu, P. 118. - ISBN 978-83-935232-2-1, 2013.
10. URBANSKÝ M., HOMIŠIN J.: Principle of torsional vibration control on mechanical system at inner accidental event occurrence, In: Projekt interdyscyplinarny projektem 21. wieku. - Bielsko-Biała : Wydawnictwo naukowe ATH, 2017 P. 333-340. - ISBN 978-83-65192-80-7, 2017.

11. PUŠKÁR M., FABIAN M., KÁDÁROVÁ J. BLIŠŤAN P., KOPAS M.: Autonomous vehicle with internal combustion drive based on the homogeneous charge compression ignition technology, In: International Journal of Advanced Robotic Systems. Vol. 14, no. 5, p. 1-8. - ISSN 1729-8814, 2017.
12. ŠTEININGER J., HRČEK S., KRCHŇAVÝ B.: The design of universal loading device for a grinding machines. In: Procedia Engineering. ISSN 1877-7058. Vol. 192, s. 869-874, 2017.
13. KRAJŇÁK J., HOMIŠIN J., GREGA R., KAŠŠAY P., URBANSKÝ M.: The failures of flexible couplings due to self-heating by torsional vibrations - validation on the heat generation in pneumatic flexible tuner of torsional vibrations, Engineering Failure Analysis. - Amsterdam: Elsevier č. 119, s. 1-13. - ISSN 1350-6307, 2021.
14. JAKUBOVIČOVÁ L., ZAVADINKA P., JAKUBOVIČ J.: Transport duty cycle measurement of hybrid drive unit for mixing drum, Adv. Intell. Syst. Comput. 393, 219–224, 2015.
15. HARACHOVÁ D.: Decomposition of driving systems specified for rehabilitation machines, In: Ad Alta: Journal of Interdisciplinary Research. Vol. 7, no. 2 (2017), p. 271-273. - ISSN 1804-7890, 2017.
16. HOMIŠIN J., KAŠŠAY P., PUŠKÁR M., GREGA R., KRAJŇÁK J., URBANSKÝ M. MORAVIČ M.: Continuous tuning of ship propulsion system by means of pneumatic tuner of torsional oscillation, International Journal of Maritime Engineering: Transactions of The Royal Institution of Naval Architects. Vol. 158, no. Part A3, p. A231-A238. ISSN 1479-8751, 2016.
17. ŽUĽOVÁ L., GREGA R., KRAJŇÁK J., FEDORKO G., MOLNÁR V.,: Optimization of noisiness of mechanical system by using a pneumatic tuner during a failure of piston machine. Engineering Failure Analysis. Vol. 2017, no. 79, p. 845-851. ISSN 1350-6307, 2017.
18. URBANSKÝ M. HOMIŠIN J., KAŠŠAY P., KRAJŇÁK J. : Measurement of air springs volume using indirect method in the design of selected pneumatic devices. In: Acta Mechanica et Automatica. Vol. 12, no. 1 (2018), p. 19-22. ISSN 1898-4088, 2018.
19. CZECH P., WOJNAR G., BURDZIK R., KONIECZNY Ł., WARCZEK, J.: Application of the discrete wavelet transform and probabilistic neural networks in IC engine fault diagnostics. Journal of Vibroengineering 16 (4): 1619-1639. ISSN 1392-8716, 2014.
20. GREGA R., KRAJŇÁK J., HOMIŠIN J., KOPAS M., SÁGA M., JAKUBOVIČOVÁ L.: Znižovanie hlučnosti piestového kompresora pri deaktivácii valca, Technológ. Žilina: Žilinská univerzita v Žiline, 2009 Roč. 11, č. 3, s. 33-38. - ISSN 1337-8996, 2019.
21. FLEGNER P., KAČUR J., DURDÁN M., LACIAK M.: Statistical Process Control Charts Applied to Rock Disintegration Quality Improvement, Applied sciences. - Basel, Multidisciplinary Digital Publishing Institute Roč. 10, č. 23, s. 1-26. ISSN 2076-3417, 2020.
22. ŽUĽOVÁ L., GREGA R.: Experimental measurement of the noise of the mechanical system / Lucia Žuľová, Robert Grega - 2016. In: Inżynier 21. wieku. - Bielsko Biala : Wydawnictwo naukowe ATH, P. 917-921. - ISBN 978-83-65182-51-7, 2016.