Matej URBANSKÝ[1], Peter KAŠŠAY[2], Michal PUŠKÁR[3]

Supervisor: Jaroslav HOMIŠIN[4]

PNEUMATYCZNE SPRZĘGŁO ELASTYCZNE STYCZNE Z SZEREGOWO ROZMIESZCZONYMI ELEMENTAMI ELASTYCZNYMI

Streszczenie: W artykule jest przedstawiono nowo opracowane pneumatyczne sprzęgło elastyczne styczne z szeregowo rozmieszczonymi elementami elastycznymi. Jego konstrukcja koncentruje się na tworzeniu wysoce elastycznego sprzęgła, co oznacza elastyczne sprzęgło o bardzo niskiej względnej sztywności skrętnej. Sprzęgło jest chronione wzorem użytkowym.

Słowa kluczowe: pneumatyczne sprzęgło elastyczne, sprężyny pneumatyczne, patent

TANGENTIAL PNEUMATIC FLEXIBLE SHAFT COUPLING WITH SERIAL ARRANGED FLEXIBLE ELEMENTS

Summary: The paper presents a newly developed Tangential pneumatic flexible shaft coupling with serial arranged flexible elements. Its design is focused on creating the high-flexible coupling, which means flexible coupling with very low value of relative torsional stiffness. The coupling is protected by means of a utility model.

Keywords: pneumatic flexible shaft coupling, air-springs, patent

1. Introduction

Nowadays, flexible shaft couplings are the most utilized machine parts for the flexible transmission of load torque in machines with rotary power transmission, mainly in

[1] Technical University of Košice; Faculty of Mechanical Engineering, Department of Machine Design and Transport Engineering; Matej.Urbansky@tuke.sk
[2] Technical University of Košice; Faculty of Mechanical Engineering, Department of Machine Design and Transport Engineering; Peter.Kassay@tuke.sk
[3] Technical University of Košice; Faculty of Mechanical Engineering, Department of Machine Design and Transport Engineering; Michal.Puskar@tuke.sk
[4] prof. Ing., CSc.; Technical University of Košice; Faculty of Mechanical Engineering; Department of Machine Design and Transport Engineering; Jaroslav.Homisin@tuke.sk

order to avoid dangerous torsional vibration in the systems. Therefore, a flexible coupling with suitable dynamic properties, particularly dynamic torsional stiffness, has to be carefully chosen for each specific application, e.g. [2-5, 7-9, 11].
Flexible elements of flexible shaft couplings are made of various materials, mainly of rubber, plastic and metal. During the operation of mechanical systems, it comes particularly to the fatigue and ageing of rubber and plastic flexible elements and to the ageing and wearing down of the metal flexible elements of applied flexible coupling, e.g. [1, 9]. Consequently, the applied flexible coupling loses its original dynamic properties and thus the ability to carry out its important functions in a torsionally oscillating mechanical system (TOMS), mainly the tuning of a mechanical system in terms of torsional dynamics. The disadvantages of the mentioned flexible elements can be eliminated using pneumatic flexible elements (air springs, e.g. [6, 10]). The flexible transmission of torque is ensured by compressed gaseous medium, which do not suffer from fatigue or ageing. The main advantage of pneumatic flexible shaft couplings (for example Fig. 1) is the possibility to change their torsional stiffness which depends on the gaseous medium pressure value in its pneumatic flexible elements. This makes it possible to suitably adapt the dynamic torsional stiffness of a pneumatic coupling to the actual operating mode of a mechanical system.

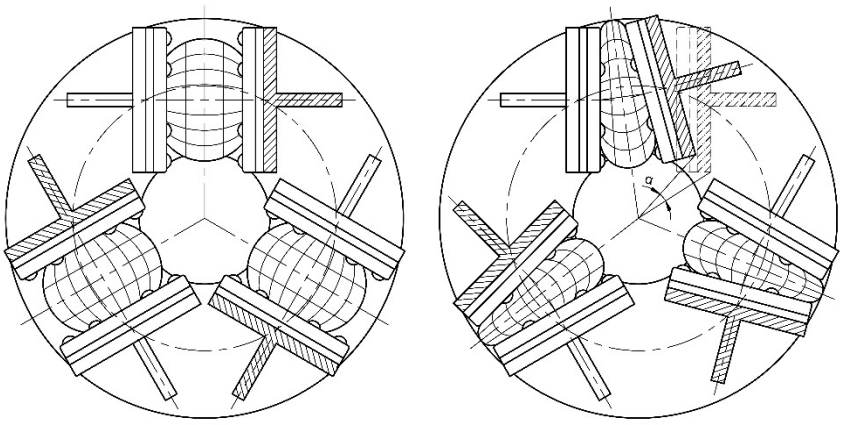

Figure 1. A tangential pneumatic flexible shaft coupling, a) in basic position, b) in fully loaded state (at maximum twist angle α)

At our department, we deal with development, research and application of pneumatic flexible shaft couplings into mechanical systems. We focus mainly on continuous tuning of mechanical systems during their operation in terms of torsional dynamics using pneumatic flexible shaft couplings as active torsional vibration tuners. For the continuous tuning, we use electronic control systems, developed by us. Our extensive research in the field of pneumatic torsional vibration tuners and torsional dynamics also leads to improvements of our pneumatic tuners and control systems, e.g. [2-5]. In order to improve the tuners in terms of better utilization of their pneumatic flexible elements and achieving specific operational properties, a new pneumatic tuner with tangential arrangement of its pneumatic flexible elements was designed. The aim

of this article is to introduce this new pneumatic tuner, protected by means of utility model [5], namely the Tangential pneumatic flexible shaft coupling with serial arranged flexible elements.
Due to the reason that mentioned pneumatic tuner is not manufactured yet, this article deals mainly with principles and expected advantages of the tuner.

2. Proposed flexible shaft coupling

Proposed tangential pneumatic flexible shaft coupling with serial arranged flexible elements (Fig. 2) contains a driving flange (1) and a driven flange (2). Between the flanges, the compression space of the coupling is situated. The compression space of the coupling is comprised of pneumatic flexible elements (3), (4), (5), which are arranged in a circle so that they are connected and create a "flexible chain". The flanges of the pneumatic flexible elements (3) are fixed to rigid parts (6) of the driving flange and to support bodies (7). The flanges of the pneumatic flexible elements (4) are fixed only to the support bodies (7). The flanges of the pneumatic flexible elements (5) are fixed to rigid parts (8) of the driven flange and to the support bodies (7). The support bodies are fastened to rotatable floating bodies (9) by pins (10). The rotatable floating bodies are rotatably mounted on a pin (11). The pin (11) is coaxially embodied in the driven flange (2). Mutual interconnections of the pneumatic flexible elements (3), (4), (5) are done by ducts (14), which are created in the support bodies (7). The compression space of the coupling can be filled with gaseous medium through valves (12) and valve ducts (13).

If there is overpressure of the gaseous medium in the pneumatic flexible elements (compared to the atmospheric pressure) then the rigid parts (6) of the driving flange and the rigid parts (8) of the driven flange are in contact and so the unloaded coupling is in basic position (Fig. 2). Under load by torque, it comes to an angular deflection between the driving and driven hub and consequently to a deformation of the pneumatic flexible elements of the pneumatic coupling. The angular twist causes the gaseous medium compression and so the load torque can be transmitted flexibly in mechanical systems (Fig. 3). The shape of the support bodies (Position 7 in Fig. 2) can be adjusted so that the bearing surfaces of the pneumatic flexible elements flanges are parallel at the maximum twist angle α of the coupling (Fig. 3), in order to maximize the effective area of the compression space of the coupling and so increase the maximum load torque of the coupling.

The function of the support bodies (7) in connection with rotatable floating bodies (9) (Fig. 2) is to ensure the stability of the "flexible chain" of pneumatic flexible elements in the radial and axial direction (referred to the axis of rotation of the coupling) when the coupling is twisted. This is how much higher values of the maximum twist angle

[5] Urbanský Matej. 2018. *Tangential pneumatic flexible shaft coupling with serial arranged flexible elements*. Utility model No. SK 8183 Y1. Banská Bystrica: ÚPV SR. 8 p. Patent application form No. 73-2017.

α of the coupling (Fig. 3) can be achieved (for example, compared to the tangential pneumatic flexible shaft coupling shown in Fig. 1.

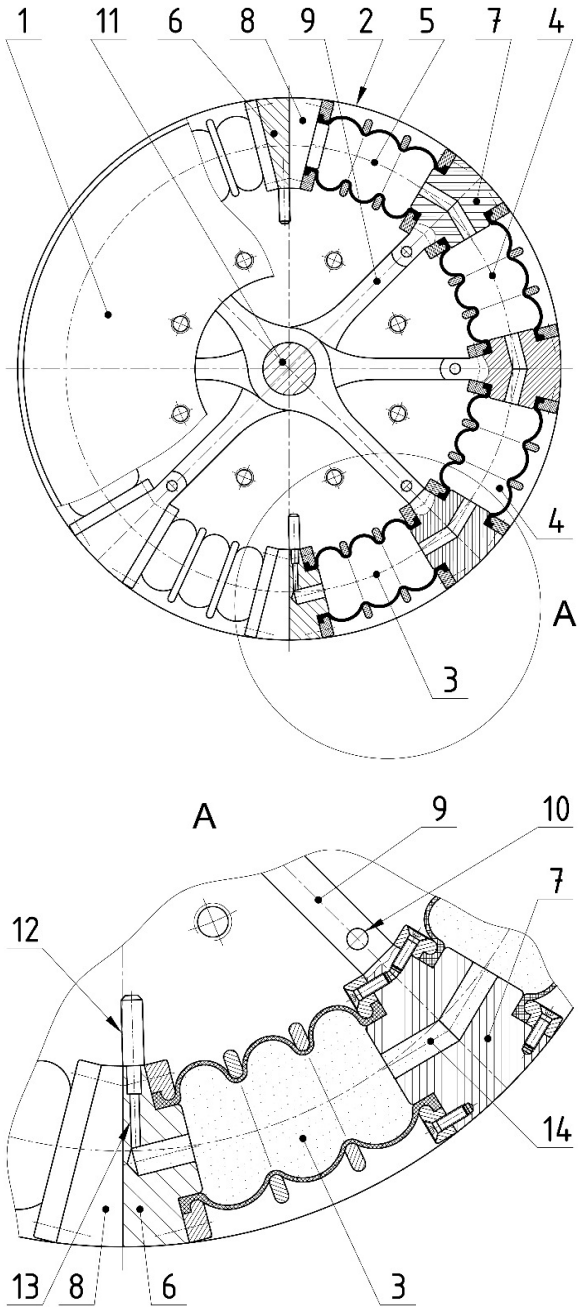

Figure 2. The tangential pneumatic flexible shaft coupling with serial arranged flexible elements in unloaded state

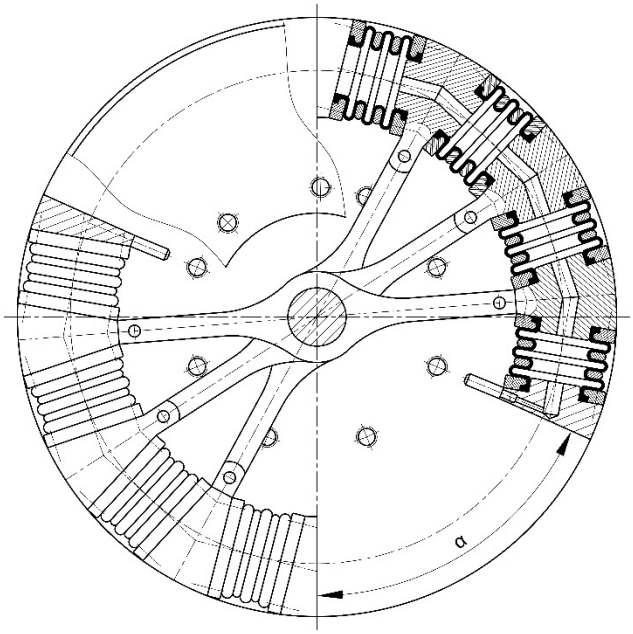

Figure 3. The tangential pneumatic flexible shaft coupling with serial arranged flexible elements in fully loaded state (at maximum twist angle α)

Conclusion

The tangential pneumatic flexible shaft coupling with serial arranged flexible elements can be applied in systems of mechanical drives. It allows flexible torque transmission and thanks to the ability to change its torsional stiffness, ensure the tuning of these systems at various operating conditions.
The design of the tangential pneumatic flexible shaft coupling with serial arranged flexible elements is focused on creating the high-flexible coupling. The current trend in the field of flexible shaft couplings, the most noticeable in automotive industry, is just the development and utilization of high-flexible couplings as dual mass flywheels. Because gaseous media throughout its lifetime is not subject to ageing, resulting that pneumatic couplings do not lose their initial positive dynamic properties, it seems to be very advantageous to develop flexible couplings with the advantages of both pneumatic and high-flexible couplings.

Acknowledgement. This article was written within the framework of grant projects:
APVV-16-0259: „*Research and development of combustion technology based on controlled homogenous charge compression ignition in order to reduce nitrogen oxide emissions of motor vehicles*";
KEGA 041TUKE-4/2017: „*Implementation of new technologies specified for solving questions concerning the emissions of vehicles and their transformation in educational processes in order to improve the quality of education*";

VEGA 1/0473/17: „*Research and development of technology for homogeneous charge self-ignition using compression in order to increase engine efficiency and to reduce vehicle emissions*".

REFERENCES

1. GURSKÝ P.: Influence of working cycles identification on characteristics of flexible couplings and their comparison. PhD thesis, Košice, Slovakia: Technical University of Košice 2011.
2. HOMIŠIN J.: Characteristics of pneumatic tuners of torsional oscillation as a result of patent activity. Acta Mechanica et Automatica 10(2016)4: 316-323. ISSN 1898-4088. DOI: 10.1515/ama-2016-0050.
3. HOMIŠIN J.: Contribution and perspectives of new flexible shaft coupling types – pneumatic couplings. Scientific Journal of Silesian University of Technology. Series Transport. 99(2018), 65-77, ISSN 0209-3324. DOI: *https://doi.org/10.20858/sjsutst.2018.99.6*.
4. HOMIŠIN J.: Dostrajanie ukadów mechanicznych drgajacych skretnie przy pomocy sprzegie pneumatycznych. [In Polish: Tuning methods of torsional oscillating mechanical systems by pneumatic couplings]. Bielsko-Biała: ATH 2008. ISBN 978-83-60714-55-3.
5. HOMIŠIN J.: Nové typy pružných hriadeľových spojok: Vývoj-Výskum-Aplikácia. [In Slovak: New Types of Flexible Shaft Couplings: Development-Research-Application]. Košice: Vienala 2002. ISBN 80-7099-834-2.
6. IMI. „Compact air bellows". Accessed: 30.09.2019. Available at: *https://www.imi-precision.com/uk/en/list/actuators/air-bellows*
7. KURYTNIK I., BOHDAN B., HOMIŠIN J.: Reducing vibration and torsional oscillations in mechanical system. Przeglad Elektrotechniczny 86(2010)8, 214-216. ISSN 0033-2097.
8. LIPTAI P., MORAVEC M., LUMNITZER E., GERGEĽOVÁ M.: Proposal of the sound insulating measures for a vibrational sorter and verification of the measured effectiveness. Advances in Science and Technology-Research Journal 11(2017)3, 196-203. ISSN 2299-8624. DOI: 10.12913/22998624/76068.
9. MALÁKOVÁ S., HOMIŠIN J.: Defining of material characteristics for flexible element in pneumatic flexible coupling. In Projektowanie, badania i eksploatacja Tom 1, edited by Jacek Rysiński, 277-282. Poland: Wydawnictwo Naukowe Akademii Techniczno-Humanistycznej w Bielsku-Białej 2018. ISBN 978-83-65182-93-7.
10. RUBEN A.: Air Springs". Accessed: 30.09.2019. Available at: *https://www.rubena.eu/underwood/download/files/rubena_vlnovce_trelleborg_2019.pdf*
11. STURM M., LUBOMÍR P.: Determination of a Vibrating Bowl Feeder Dynamic Model and Mechanical Parameters. Acta Mechanica et Automatica 11(2017)3, 243-246. ISSN 1898-4088. DOI: 10.1515/ama-2017-0038.