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

Supervisor: Jaroslav HOMIŠIN[4]

PNEUMATYCZNE SPRZĘGŁO ELASTYCZNE BĘBNOWE STOSOWANE W PRZEMYŚLE MOTORYZACYJNYM

Streszczenie: W pracy przedstawiono nowy typ sprzęgła pneumatycznego opracowany przez autorów artykułu, cechujący się wysoką elastycznością, a w rezultacie dużym kątem skrętu, a także dobrymi własnościami tłumiącymi. Tego rodzaju sprzęgła znajdują zastosowanie w budowie samochodów jako element dwumasowych kół zamachowych.

Słowa kluczowe: pneumatyczne sprzęgło elastyczne, wysoce elastyczne sprzęgło, wzór użytkowy, przemysł samochodowy

DRUM PNEUMATIC FLEXIBLE SHAFT COUPLING APPLICABLE IN THE AUTOMOTIVE INDUSTRY

Summary: The paper presents a newly developed Drum pneumatic flexible shaft coupling, which is applicable in the automotive industry as a dual-mass flywheel. 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, high-flexible coupling, utility model, automotive industry

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 order to avoid dangerous torsional vibration in the systems. Therefore, a flexible

[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

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, for example air springs, e.g. [6, 10]. The flexible transmission of torque is ensured by compressed gaseous medium, which does 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.

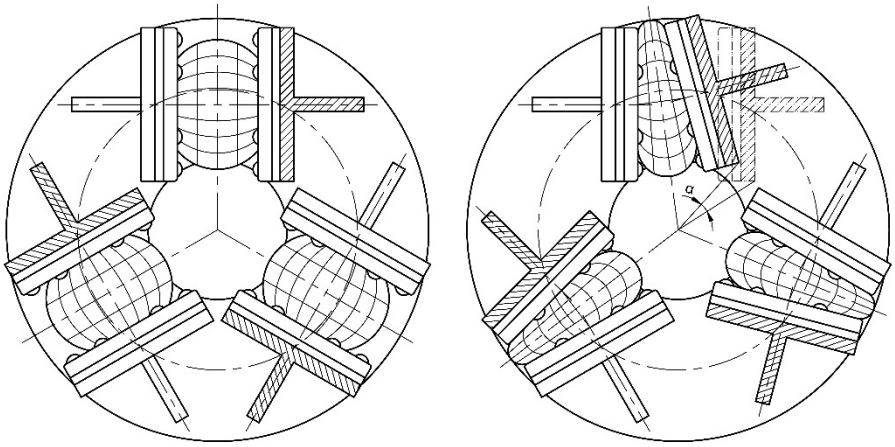


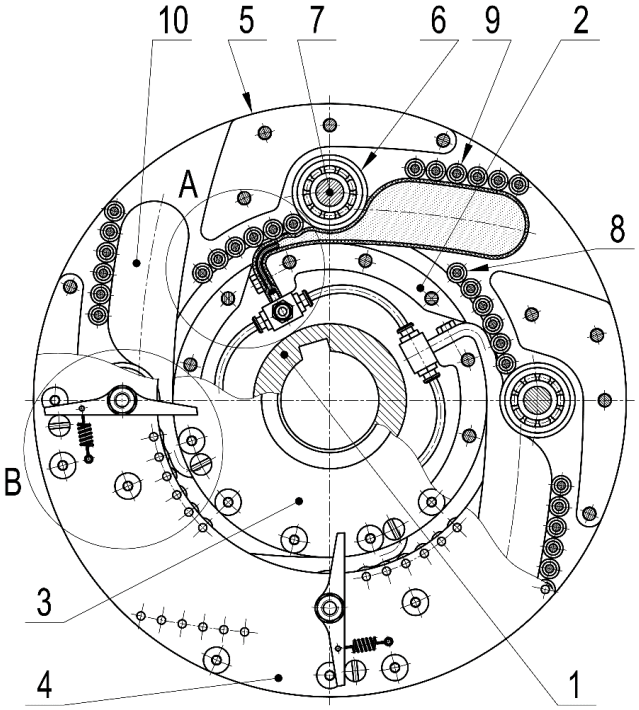
Figure 1. A tangential pneumatic flexible shaft coupling, a) in basic position, b) in fully loaded state (at maximum twist angle α)

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 drum pneumatic tuner was designed. The aim of this article is to introduce this new pneumatic tuner,

protected by means of utility model [5], namely the Drum pneumatic flexible shaft coupling. 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 drum pneumatic flexible shaft coupling (Fig. 2, Fig. 3) is made up of a driving part – a driving drum and a driven part. Between the driving and driven part, a compression space of the coupling is situated. The driving drum is made up of a driving flange (1), segments (2) and a support disc (3). The driven part is made up of a driven disc body (5), a support disc (4), deformational rollers (6) which are rotatably mounted on pins (7), rotatably mounted small rollers (8) and rotatably mounted guiding small rollers (9).



[5] Urbanský Matej. 2018. *Drum pneumatic flexible shaft coupling*. Utility model No. SK 8246 Y1. Banská Bystrica: ÚPV SR. 8 p. Patent application form No. 72-2017.

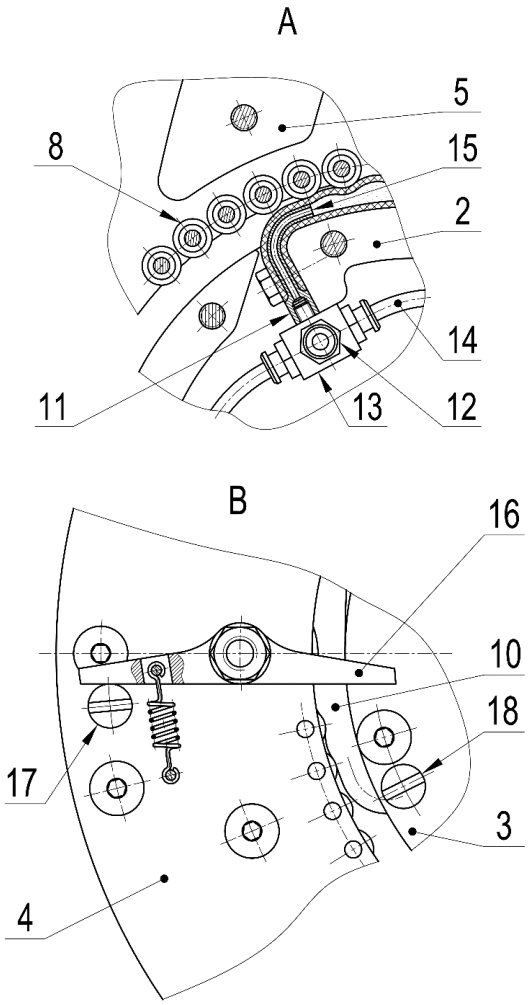
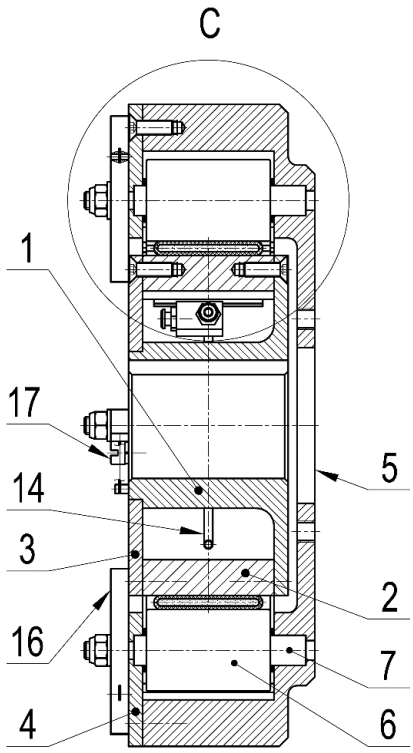


Figure 2. The drum pneumatic flexible shaft coupling in partially loaded state – main view with details

Flexible torque transmission from the driving drum to the driven part of the coupling is ensured by the compression space of the coupling, which is created by flexible hollow bodies (10), which are, together with shaped rigid bodies (11), fastened to the segments (2) of the driving drum. Each shaped rigid body (11) is undismountably joined with a flexible hollow body (10). The compression space of the coupling can be filled with gaseous medium through a valve (12), which is part of one of distributing bodies (13). By the distributing bodies (13) and connecting hoses (14), the mutual interconnection of the flexible hollow bodies (10) is ensured. The distributing bodies (13) are fastened to the shaped rigid bodies (11). Intake ducts (15) are created in the shaped rigid bodies (11).

If the flexible hollow bodies (10) of the unloaded shaft coupling are filled through the valve (12), distributing bodies (13), connecting hoses (14) and intake ducts (15) with gaseous medium (which suitable overpressure value was set in advance), sprung levers (16), which are rotatably mounted on pins (7), lean on stoppers (17) and (18). So the driving drum acquire its basic position towards the driven part of the coupling. Under load by torque, it comes to an angular deflection between the driving drum and driven part of the coupling (Fig.2) and consequently to a deformation of the hollow bodies (10) – pneumatic flexible elements of the pneumatic coupling, caused by deformational rollers (6). The deformed pneumatic flexible elements (10) are wrapped around the driving drum. The gaseous medium compression in the pneumatic flexible elements (10) is proportional to the load, so the load torque can be transmitted flexibly in mechanical systems.



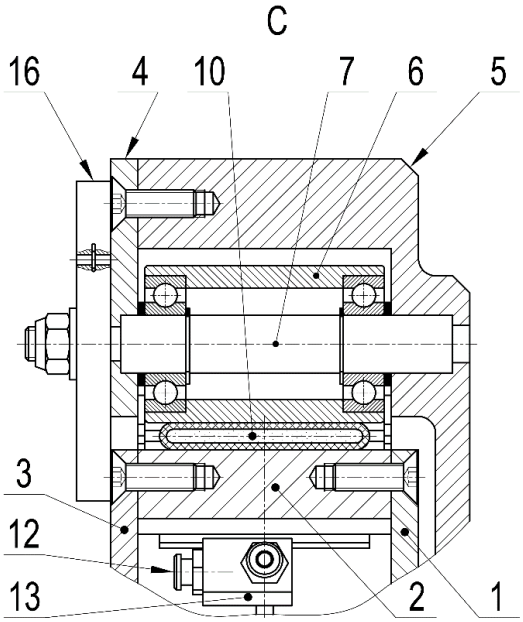


Figure 3. The drum pneumatic flexible shaft coupling in partially loaded state – side view with detail

The rotatably mounted small rollers (8) ensure that the deformed pneumatic flexible elements (10) stay in the deformed shape (Fig.4) when the coupling is twisted. Rotatably mounted guiding small rollers (9) guide the pneumatic flexible elements (10) during rotation of the coupling, when the centrifugal force acts on the elements.

The coupling transmits a load torque flexibly in one direction only. The sprung levers (16) block the twisting of the coupling in opposite direction. Because an over-twisting of the coupling is enabled at an overload, given coupling acts also as safety-coupling in mechanical systems.

In Fig.4 we can see that the design of the coupling allows that much higher values of the maximum twist angle α of the coupling can be achieved (for example, compared to the tangential pneumatic flexible shaft coupling shown in Fig. 1), which is one of prerequisites for creating a high-flexible coupling.

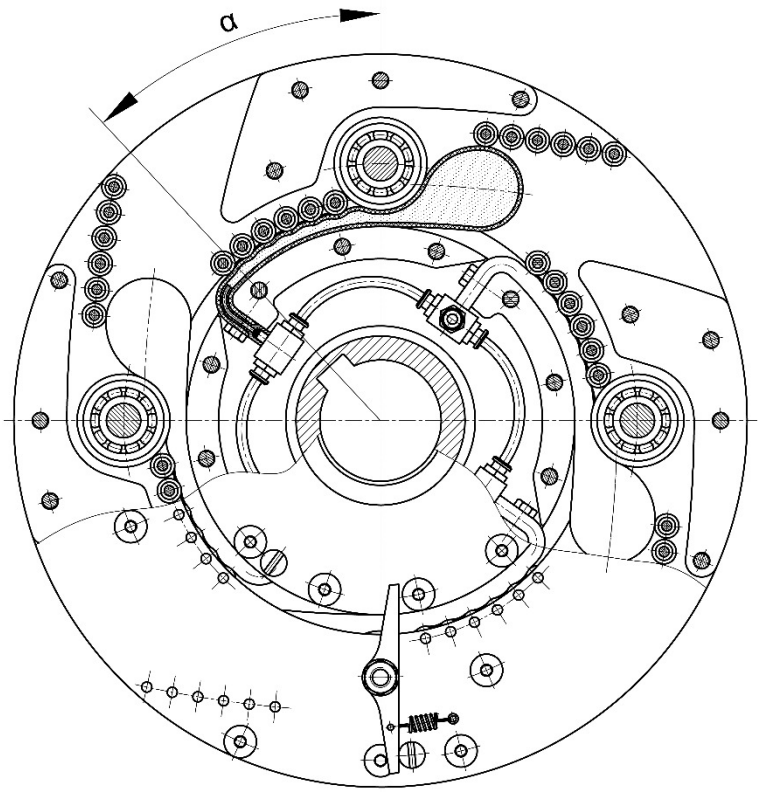


Figure 4. The drum pneumatic flexible shaft coupling in fully loaded state (at maximum twist angle α)

3. Conclusions

The drum pneumatic flexible shaft coupling 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 drum pneumatic flexible shaft coupling 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 work was supported by the Slovak Research and Development Agency under the Contract no. APVV-19-0328.
This paper was written within the framework of grant project: VEGA 1/0528/20: „*Solution of new elements for mechanical system tuning*".

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(2011)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]. 2008 Bielsko-Biała: ATH. 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]. 2002 Košice: Vienala. 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., BOROWIK 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. RUBENA. „Air Springs". Accessed: 30.09.2019. Available at: *https://www.rubena.eu/underwood/download/files/rubena_vlnovce_trelleborg_2019.pdf*
11. STURM M., PEŠÍK L.: 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.