AN APPARATUS FOR MEASUREMENT OF INCLINATION OF GEARS ON NEEDLE BEARINGS

Václav MOSLER[1], Jiří HAVLÍK[2], Jan PAVLÍK[3], Ivo KŘISTEK[4]

[1] *VŠB – Technical University of Ostrava, Czech Rebuplic*
[2] *VŠB – Technical University of Ostrava, Czech Rebuplic*
[3] *VŠB – Technical University of Ostrava, Czech Rebuplic*
[4] *VŠB – Technical University of Ostrava, Czech Rebuplic*

Abstract
The objective of the apparatus is to measure inclination of a gear on a needle bearing relative to the load and rotational speed. Furthermore, bearing clearance is to be optimised in terms of its noise and vibrations.

Key words: inclination of a gear, noise, vibration
.
INTRODUCTION

Transmission of personal vehicles with stepped changes of the gear ratio using the gears, transmissions are consist of drive shaft and driven shaft on witch are fitted gears in permanent contact. On one shaft is gear rigidly mounted, on the other is gear mounted on needle bearings, torque transmission between the gear and shaft is reached by synchronizer. Gears witch are not used for transfer torque, they are rotate freely on needle bearing. Currently are used on all forward speed gears, gears with witch helical cogs in transmission of personal vehicle. A diagram depicting a two-shaft transmission of a personal vehicle is provided in Figure 1.

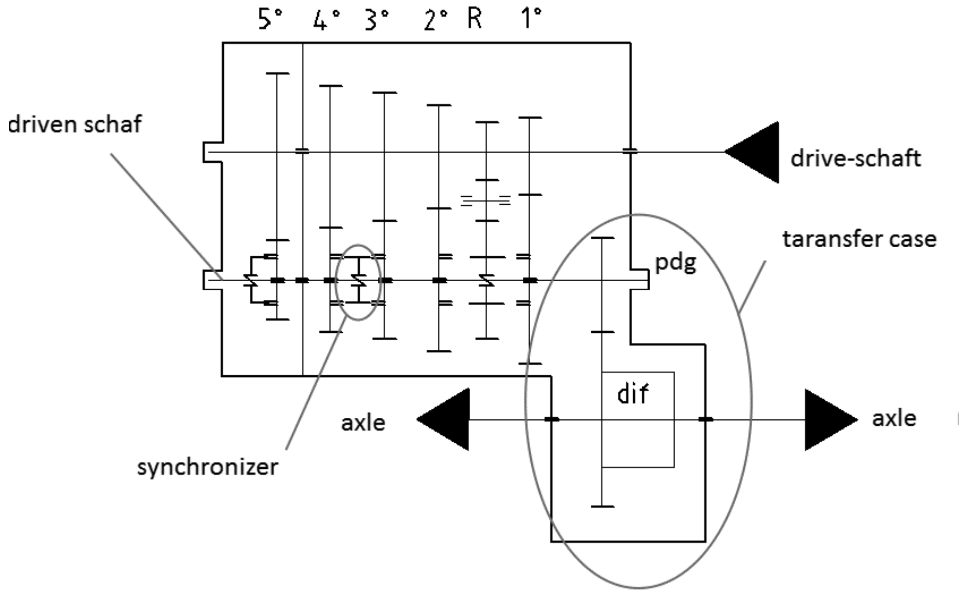

Fig. 1 A diagram of a two-shaft transmission

Transmission of torque between a gear and a shaft is realized by a synchronizer. Effects of force are transmitted from the gear to the shaft by a needle bearing. As an result of manufacturing of needle bearing, shafts and hubs arise radial clearance between the components. By using of helical cogs it can be assumed due to the effect of axial force from the gears, that the bearing is inclined towards the shaft because of the radial clearance, described in (Fujimura, Beppu, Hibi, Murakami, & Yokoi, 1987). Size of the inclination cannot be accurately computed, as it is affected by deformation of the needles as well, therefore it needs to establish experimental measurements. This phenomenon can be classified as a deviation of a gear transmission. It can be assumed, that the deviation will have an effect on vibrations and noise, described in (Jolivet, Mezghani, El Mansori, Vargiolu, & Zahouani, 2017; Moravec, Dejl, Něměek, Folta, & Havlík, 2009). The objective of this work is design a test device to verify the above phenomenon

MATERIALS AND METHODS

Testing apparatus can be placed to an open or a closed trial circuit, described in (Moravec, et al., 2009). The differences between the circuits are considered to be widely-known, thus they will not be further analysed. From the above listed requirements it can be determined that a trial circuit with open energy flow (depicted in Fig. 2) is most suitable for application of the apparatus.

Fig. 2 Open circuit

RESULTS AND DISCUSSION

Fig. 3 depicts a trial stand used for placing of the testing apparatus. This stand is powered by a 30kW engine (1), which is connected to a frequency converter with ability of revolution control up to 3,000 RPM. The measuring apparatus (5) is bolted to the console (4), which is capable of axial shifting in the axis of the engine. The measuring apparatus and the engine are connected by a constant velocity shaft (4). Load of the circuit is delivered by the disc brake (7). This is placed on a tower, which is movable to a limited extent in translational fashion in the direction perpendicular to the engine's axis. Regulation of the braking moment is conducted by rotation of the handle of the braking cylinder (6). The measuring apparatus and the disc brake are connected by a constant velocity shaft. There are sensors of torque and rotational speed already placed on this shaft, therefore their selection is not considered in this work. A sensor of vibrations is to be placed magnetically, externally to the trial box of the transmission. Measuring of noise is to be conducted by an externally placed sound meter.

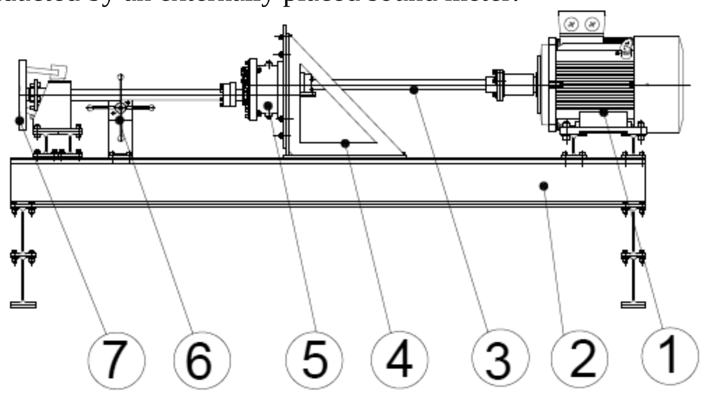

Fig. 3 Trial stand

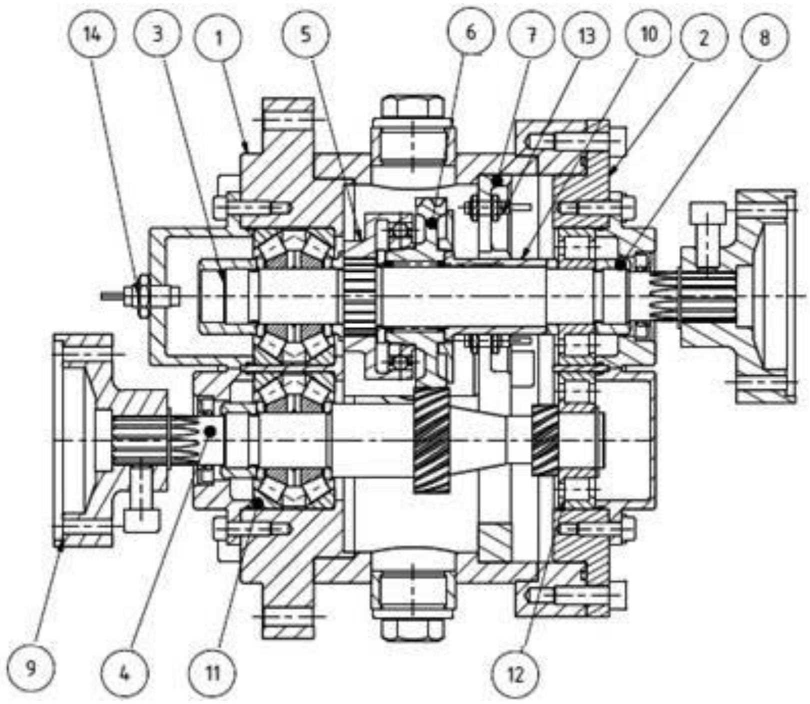

Fig. 4 Measuring apparatus

Fig. 4 depicts a trial testing apparatus. Box of the transmission (1) is welded to a thick-walled seamless pipe and sheet-metal rings of sufficient width. There are tapered roller bearings placed in the box (11). This bearings are axially conductive from both sides. There is a lid bolted to the box (2), in which axially-loose roller bearings ale placed (12). These bearings are fixed to the shaft by a nut. (8). The construction is created for simplifying of the assembly. The selected construction from thick-walled profile is significantly rigid, which ensures imperviousness of the result of the rigidity of the box. Arrangement in Fig.4 corresponds to measurement for A^{nd} gear ratio. The drive shaft is in this case a modified shaft from a transmission, which is due to the fact that the pinion of the A^{nd} gear is manufactured on the shaft (4). For the rest of the gear ratios, there will be a separately manufactured shaft, onto which a corresponding gear is to be pressed. On the drive shaft (3), a body of a clutch with small spheres will be installed (5).This clutch serves as a substitute for a synchromesh for transmitting of torque from a gear (6) to the shaft. Synchromesh prevents the maximum possible tilt of the gear. This clutch type was developed for the specific case of use. The gear is to be changed together with carrier. Carrier is placed on the area of the gear, on which a synchronizer is attached. The tilt of the gear is to be recorded by three sensors based on eddy currents (13). Sensors are attached in the holder of sensors (7). In order to prevent influencing of the results of the measurements by axial oscillations of the drive shaft, a displacement transducer was attached to the face of the shaft (14). The sensor is bolted to the lid of the bearing. There are flanges (9) mounted on both the input and the output shaft by involute splines for connection with joint shafts of the stands. New clutch (Fig. 5) was developed for specific use in the measurement setting. The body of the clutch (1) is mounted on the involute splines of the drive shaft. There are grooves in the body, to which small spheres are placed. The same grooves are in carrier (2) as well, which is attached to the gear (4). The contact between the grooves and the spheres creates positive engagement. Thus, the spheres are free to rotate inside the grooves, which enables loose tilting of the gear. The annulus (5) serves as a sensing area for measurement of inclination.

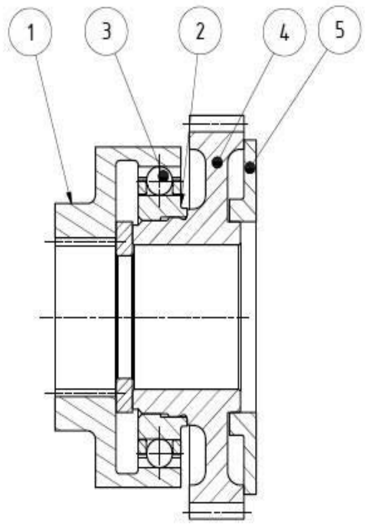

Fig. 5 Clutch with spheres

CONCLUSIONS

Currently, the apparatus is being manufactured and the measurement is being prepared. If it finds that incline of wheel is really happening. The possibility of optimization noise and vibration will research with help of adjustment radial clearance in needle bearing.

ACKNOWLEDGMENT

The trial apparatus was created with the help of the Technology Agency of the Czech Republic as a part of the "Competence Centre for Automotive Industry" project of Josef Božek and a project SP2017./39.

REFERENCES

1. Fujimura, N., Beppu, M., Hibi, K., Murakami, H., & Yokoi, M. (1987). Analysis of the behavior and resonant noise of needle roller bearings used for idler gears in transmission applications. *SAE Technical Papers,* doi:10.4271/871923

2. Jolivet, S., Mezghani, S., El Mansori, M., Vargiolu, R., & Zahouani, H. (2017). Experimental study of the contribution of gear tooth finishing processes to friction noise. *Tribology International, 115*, 70-77. doi:10.1016/j.triboint.2017.05.004

3. Moravec V., M., Dejl, Z., Němček, M., Folta, Z. & Havlík, J. (2014). Spur gearv in transmission car. *Ostrava: MONTANEX a.s, 2009*. ISBN 978-80-7225-304-3.

Corresponding author:

Ing. Václav Mosler, Department machine parts and mechanisms, Faculty of Engineering, Technical University of Ostrava, 17. Listopadu 15/2172, Ostrava – Poruba 708 33, Czech Republic, phone: +420 597 324 313, e-mail: vaclav.mosler@vsb.cz