DESIGN OF TEST RIG FOR BEVEL GEARS

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Abstract
The article describes the design of test rig for testing of bevel gears with different materials, parameters and way of lubrications. Further are described in detail elements of electrically closed loop and their properties.

Key words: *test rig; bevel gear; design; torque moment; gear-mash; gearbox; strain gauge.*

INTRODUCTION

Experimental testing of gearing (gears) can be done in several ways, e.g. by pulsating or operating (running) (*Petr & Dynybyl, 2014*). This article describes operating testing of bevel gears with perpendicular axis. Running tests on bevel gear set are cumulative test processes in which large number of manufacturing-dependent deviations are captured simultaneously. Pinions and wheels can be tested in pairs or compared to appropriate master gears. In most cases, bevel gears are pair-tested and the grading applies to the gear set.
Many running test methods have been developed in the past. Subjective methods include noise tests made by a tester and visual contact pattern testing. Objective methods are single-flank (*ISO 17485:2006, 2006*) and double-flank tests or the structure-borne noise test (*Klingelnberg, 2016*).

MATERIALS AND METHODS

Conceptual Scheme of Test Rig With Electrically Closed Loop

The article's goal is to give a detail description of each part of electrically closed loop that can be used for testing of gearboxes for rail vehicles. Electrically closed loop has been chosen as the best concept of the test rig for the testing of gearboxes (*Petr, Dynybyl &Češpíro, 2012*). The basic concepts are shown in the Fig. 1.

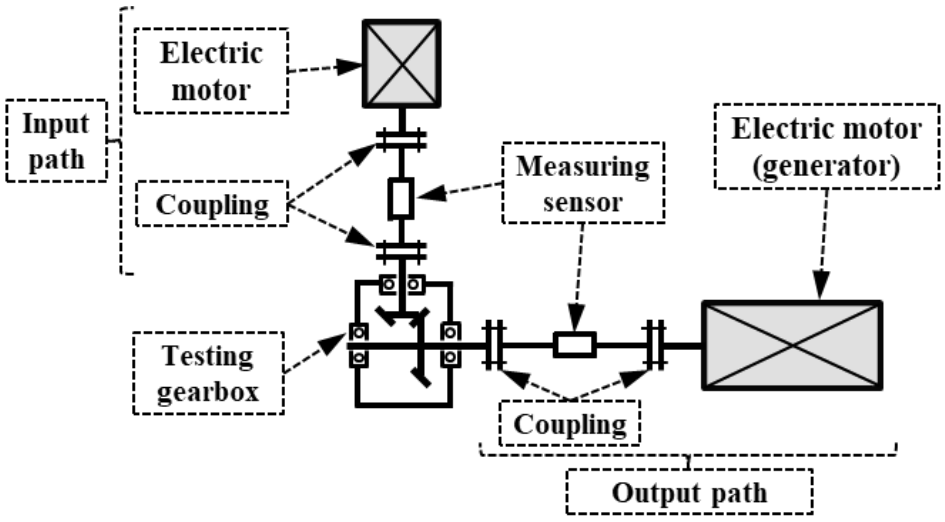

Fig. 1 Conceptual scheme of electrically close loop for testing of bevel gear.

Fig. 1 shows main components in the loop are two electro motors (on the input and on the output of gearbox), tested gearbox, servo insert coupling with collet clamp (KBE2) and designed measuring sensor for measuring of torque moments.

Design of Gearbox and Gear Parameters

Testing device (see Fig. 2) is designed for testing of bevel gears with module 3 or 3.5 mm, for maximum input torque moment 13.2 Nmm and for maximum speed 2 900 RPM.

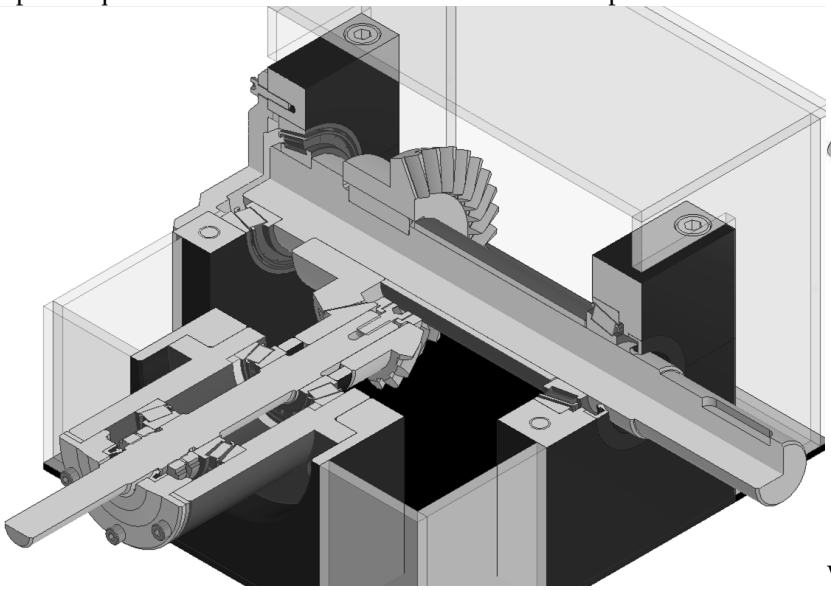

Fig. 2 3D model of gearbox for testing of bevel gears.

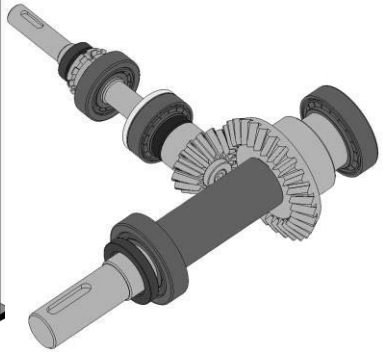

Fig. 3 3D model of gear set with shaft, bearings, selling and axial locking.

Fig. 3 shows gear set with shaft, bearings, selling and axial locking. For different gear ratio are necessary to used different distance tube, but position of bearings are still same.

Table 1 shows parameter of gear set for testing. Each gear set have been different gear ratio (1:2; 1:2.5; 1:3) or module (3 or 3.5).

Tab. 1 Parameter of gears for testing.

Parameters	Gear ratio			
	1:2	1:2	1:2,5	1:3
Module [mm]	3	3.5	3	3
Pitch diameter of the pinion [mm]	37.40	43.33	40.02	38.36
Pitch diameter of the gear (wheel) [mm]	74.79	86.66	100.04	115.08
Radial (Axial) force on the pinion [N]	229.33	197.92	222.49	237.14
Radial (Axial) force on the gear (wheel) [N]	114.67	98.96	89.00	79.05
Tangential force [N]	704.46	607.97	658.37	686.79

Measuring Sensor

For measure of torque moments was used frequency converter and has been designed measuring sensor (see Fig. 4). The sensor is composed of tube with two strain gauges (1-XY21-3/120), servo insert coupling with collet clamp (KBE2) for connection and rings for transmitting values on computer.

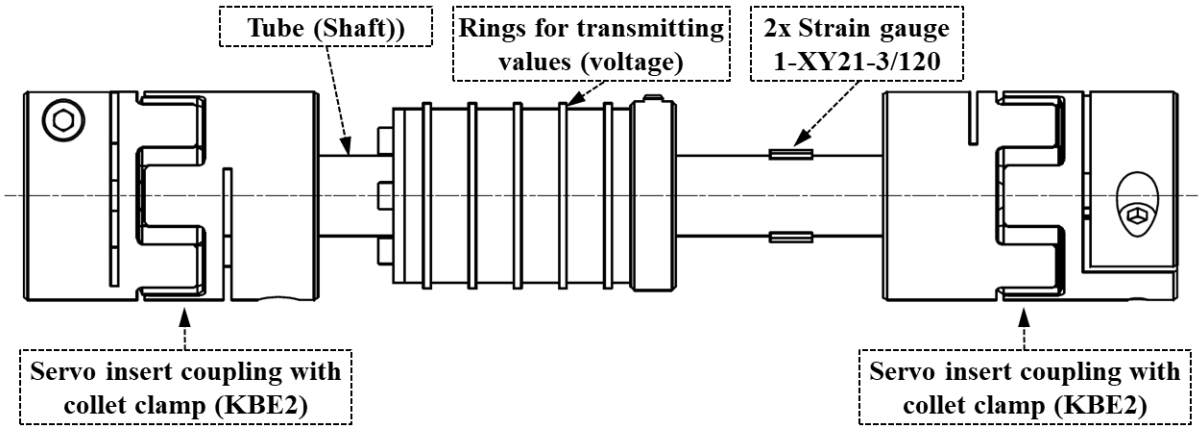

Fig. 4 3D model of measuring sensor with couplings.
Second type of measuring sensor will be designed with two semiconductor strain gauges.

RESULTS AND DISCUSSION

Design of Test Rig - Fig. 5 shows model of test rig for testing of bevel gears. The sensor is composed of welded frame from I-profiles, input motor (4 kW, 2 900 RPM), two measuring sensors (input and output run), output motor (7.5 kW, 1 490 RPM) and gearbox. Gearbox was see in Fig. 2, housing was designed as three separate bearing blocks and plates from glass or Plexiglas.
In the gearbox is possible tested different type of lubrication (lubrication by blurring, mist lubrication circulation lubrication, splash lubrication, directly sprayed into gear-mash) (*Petr & Borošˇ, 2016; Petr & Hanousek, 2015*).

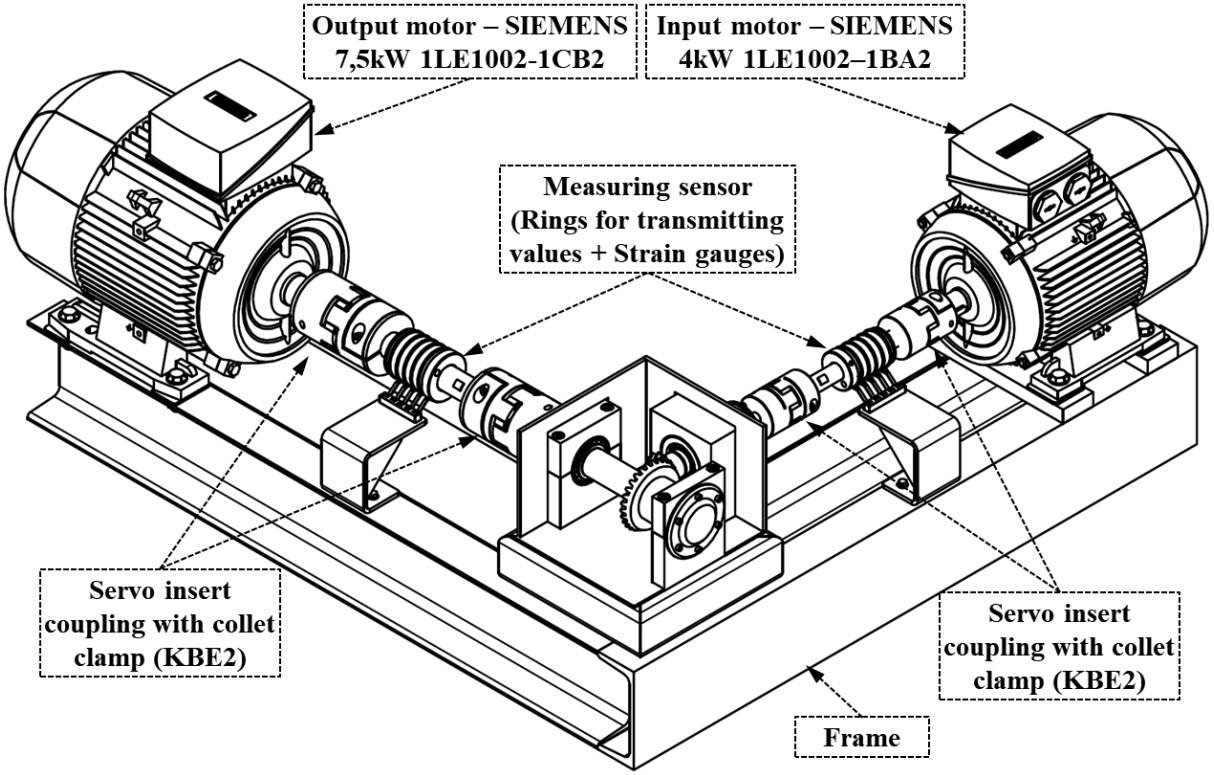

Fig. 5 3D model of test rig for testing of bevel gears.

CONCLUSIONS

The objective of this article was to design a test stand for testing of bevel gear set. All parts were designed for minimum durability 20 000 hours. Some parts were designed by FEM. It was created FEM model, which simulated gear-mash of bevel gears.

It was created FEM model, which can have simulated gear-mash of bevel gears. In the gearbox is possible tested different type of lubrication and different type of materials of bevel gear set. With measuring sensor will be possible measure torque moment and calculate efficiency (maybe).

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