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# Design and Implementation of Testing Stand for Gearboxes of Railway Vehicles

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**Abstract.** Published paper summarizes development of unique testing stand for experimental testing of railway vehicle gearboxes under dynamic impact and torque load. There is presented a description of design of main parts. Paper also previews the process of implementation and first run-in tests including figures from tuning process and a picture of final design.

## Introduction

Long term testing of gearboxes in real world conditions is not always easy and cost effective to perform during development. One way how to deal with this problem is developing a testing facility within a company that allows to simulate real world conditions and opens new possibilities of understanding behaviour of gearboxes and its parts under dynamic loading.

Development and implementation of such testing stand is presented in this paper. Stand was built in the company Wikov MGI a.s., Czech Republic and was developed in cooperation with Department of Designing and Machine Components, Faculty of Mechanical Engineering of CTU in Prague.

## Design Review

**Electrical Loop.** System for dynamic loading of gearboxes compounds of two main parts. First part is loading the gearbox with torque [2]. The other one is unit for simulation of loads by track irregularities – impacts.

There are several ways of simulating torque load of gearboxes. Some of them are described in [1]. For design of presented test stand was chosen a concept of closed electro-mechanical loop due to its advantages described further.

Concept is based on combination of electrical and mechanical power transfer in closed loop [1]. It consists of main driving motor with power 1,4MW, tested gearbox and breaking electric generator that makes torque loading with maximal value about 22kNm. In concept of closed loop the energy that is generated in breaking motor is then returned into driving motor through frequency converters. That makes this concept energy efficient, because only energy that is necessary for covering energy dissipation in mechanical part of stand is taken from electric distribution network. Control of whole system is ensured by frequency converters that

allows to control the rotations of driving motor and/or loading torque of generator on the output.

In case of presented test stand, electrical loop is also accompanied with acceleration gearbox that provides desired rotation speed on the input shaft of tested gearbox. Safety components such as break that is designed to break down the system in less than 20 seconds and safety clutch which enables disconnection of driving motor from the rest of system in case of sudden torque overload are located in front of the acceleration gearbox.

**Parallel Structure for Dynamic Loading.** As it was described above, developed test stand is equipped with unique system for simulation of track irregularities [3] that dynamically load the gearbox and considerably affects its fatigue properties.

System allows simulation of loading in three axes. Main frame of system consists of six hydraulic heavy duty servo-cylinders that creates a parallel hexapod structure.

Tested gearbox is according to a Fig. 1 clamped to its output shaft in two bearing houses that simulates the axle of railway vehicle. To catch torque effects, gearbox has a hanger with silent blocks that is connected to a vehicle's frame. Therefore the stand is also equipped with solid frame so the gearbox has very similar conditions of mounting as it has in vehicle.

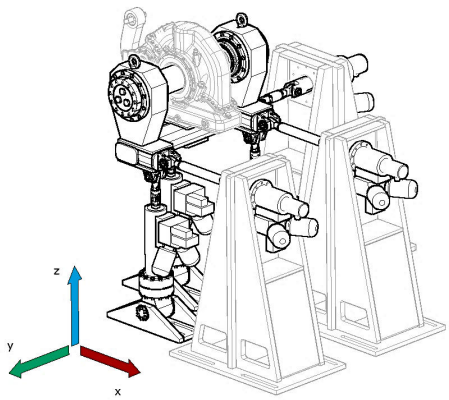


Fig. 1. Hexapod structure.

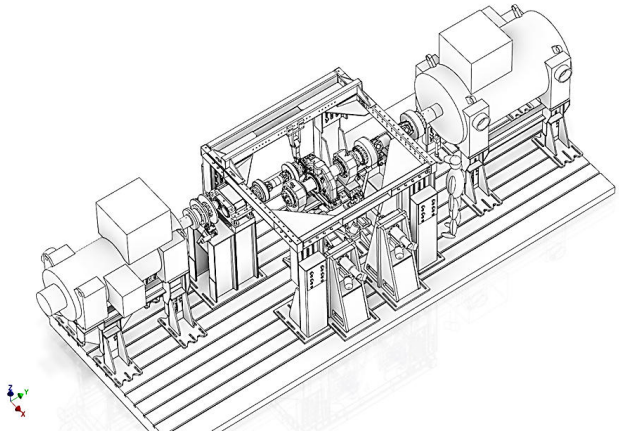

Fig. 2. Testing stand – concept.

System of loading is designed to simulate dynamic effects of excitation on a gearbox by track irregularities. According to this assumption were designed the parameters of system.

Hydraulic cylinders are dimensioned to draw motion acceleration of gearbox in the moment of impact up to 15g. This value was derived from the measurements of acceleration performed on various tracks. It is possible to reach even higher values, but it depends on actual mass of tested gearbox. Connection of cylinders to the structure and the ground is with spherical joints that are necessary for implementation of such parallel structure. Their design was described in [3].

Bearing housing that substitute wheels compounds of preloaded tapered roller bearings with respect to dynamic load that they have to withstand. They are mounted to supporting structure with six bolts each, so they can be easily dismounted and a gearbox can be changed. Lubrication of bearings is with plastic grease but in case of higher loads to prevent damage of bearings due to high temperature, housing is prepared for connection to hydraulic lubrication loop.

Supporting frames were designed to be stiff with respect to loading frequencies and mass. Their design was therefore supported with checking FEM calculations where natural frequencies of each frame were extracted, compared to loading and other dominant expected frequencies in system and performed structure optimization if needed.

## Implementation and Testing

Presented concept was implemented in company Wikov MGI a.s. as new testing facility. Final design of supporting structures was changed by specialists from Wikov MGI a. s. due to additional specific requests and cost reduction.

Implementation requested careful testing of each part of stand and finally tests of whole system. There was tested just parallel structure at the beginning. First tests were focused on control of motion and tuning of control software. There were also tested software safety mechanisms that shut down and stabilize stand in case of failure that could be detected from motion and acceleration sensors by crossing set limits.

One part of tuning the software was definition of shape and strength of simulated impacts. Their size and frequency had to be set not to destabilize the structure of stand but to have similar effect on the mechanisms of gearbox like impacts in real world conditions.

Example of time record of acceleration from one of the cylinders is presented on Fig. 3. There is visible one strong impact with acceleration nearly 10g and several others with acceleration between 2g and 4g. Presented record comes from tuning phase of stand implementation. Development and tuning of control software was realized by specialists from suppliers of hydraulic cylinders.

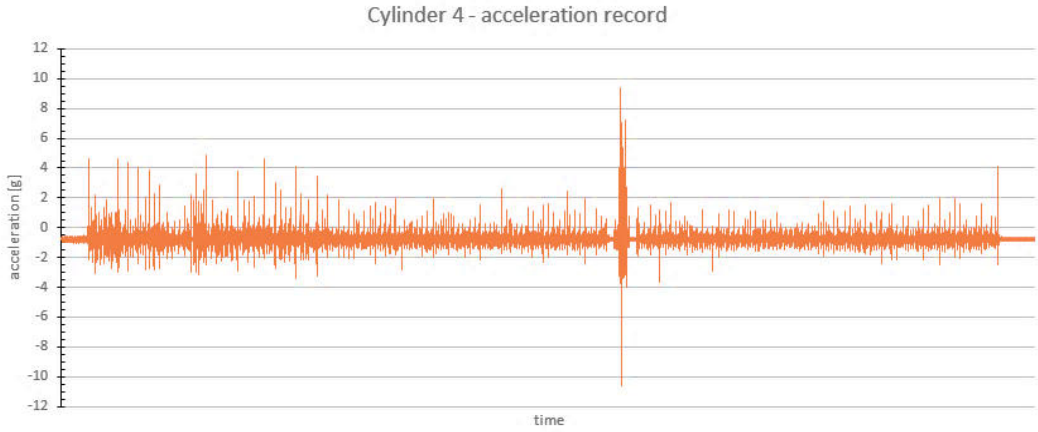


Fig. 3. Acceleration record from cylinder 4.

The other part of stand implementation was running and control of both motors without simulated impacts. There was tested wide spectrum of loading. From running at high speed to high torque. Example of such test cycle is presented at Fig. 4.

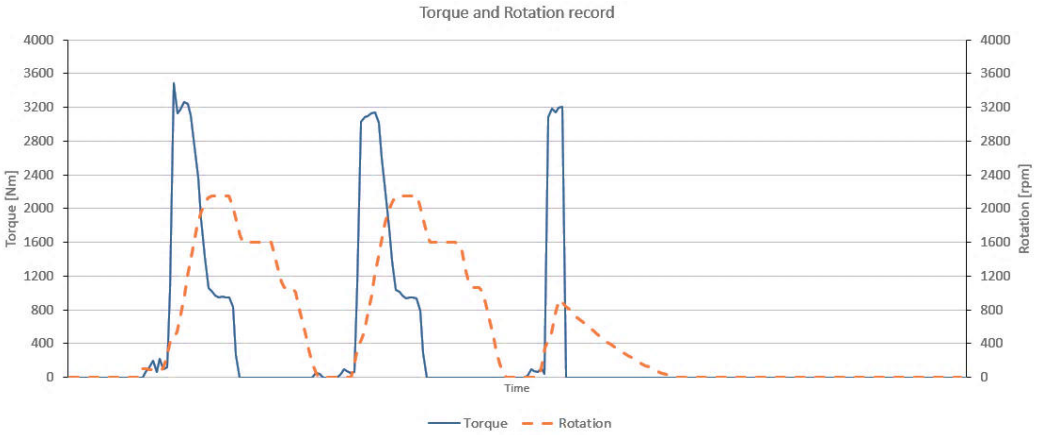


Fig. 4. Rotation and Torque record example.

Final assembly of testing stand is shown at Fig. 5.

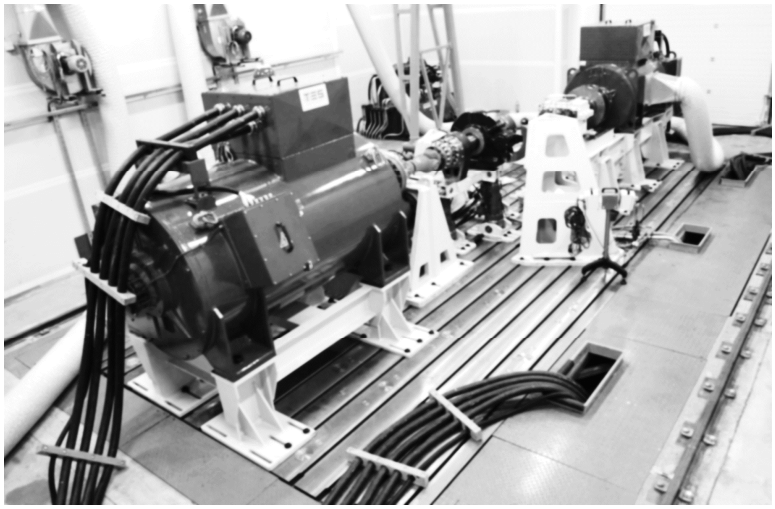

Fig. 5. Final design at testing facility in Wikov MGI a.s.

In the middle of picture there is apparent clamped tested gearbox. Gearbox has mounted several sensors that watch values of vibration and temperature. These values are recorded and it is observed their trend in time. To evaluate damage of teeth inside gearbox, after certain number of test cycles there is performed a visual control, when all teeth are photoed and their state is then analysed with respect to vibration measurement.

There is expected that the testing stand should improve the knowledge of behaviour and fatigue of gearbox as assembly, where are minimum factors neglected. It should also push the company ahead its competitors and improve the trust of its customers. First evaluated results of long time testing are expected by the end of summer 2014.

## Conclusions

Presented article summarizes development of test stand for gearboxes of railway vehicles. Implementation was done during year 2013 in Wikov MGI a.s., Hronov, CZ.

Test stand helps the company to improve the know-how about behaviour of Gearboxes and opens new possibilities in testing.

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