# Special Back-to-back Test Rig for Passenger Car Gearboxes

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**Summary**

The aim of this contribution is to present special back-to-back test rig which enables to test whole passenger car gearbox. Commonly are provided endurance tests only at single pair of gearwheels. In our case the gear set is tested directly in original gearbox under conditions very close to reality. Furthermore is the gearbox screwed together with engine cast and placed into the test rig frame using original rubber silentblocks. There will be described two pretensioning mechanisms, comparison between them and partial efficiencies in the closed loop. For evaluation of gearbox efficiency, the magnitude of power losses will be evaluated for different revolutions, load levels and shifted speeds.

## 1 Introduction

Nowadays there are many possibilities of software analysis of powertrain parts. Finally each designed part which is important for the operation of the whole assembly has to be tested under loading conditions as in reality. The same holds true for gearboxes and gear sets in cars. In our laboratories of CTU in Prague there is a special test bench for testing of passenger car gearboxes.

## 2 Endurance tests

In case of gearwheels the most important test is an endurance test when gear sets are loaded and tested under defined loading conditions. These tests are very time demanding - hundreds of hours. For so long tests it is very convenient to save energy. This can be achieved by using of so called "back-to-back" rig. This testing principle was invented by prof. Niemann and uses power circulation in pretended circuit which consists of tested and technological gear set. The loading torque is applied by torsional displacement of both sides of the friction clutch. In this loaded position is then the friction clutch connected (fixed). To run the test after pretension of the circuit is then needed the power only for running this already pretended circuit which means only to overrule passive resistances in the circuit. This already described principle is commonly applied only at gear sets in simple robust housing and shafts to be sure that the weakest part of the circuit will be the tested gear set.

## 3 Description of the test rig

In our case there was the aim to achieve loading conditions as real as possible. From this reason there are used instead of simple gear sets whole gearboxes. This assures real mesh conditions considering real deflections of shafts, real lubrication, etc. To achieve more realistic conditions are these gearboxes screwed with the engine blocks and placed in the test rig frame using original rubber mounts. Both assemblies are connected using joint shafts. Parameters of the test bench are listed in tab.1 and the overall view is in figure 1.

| | |
|---|---|
| Maximal electromotor power | 22 kW |
| Maximal rotations on the input shaft of the gearbox | 4200 rpm |
| Maximal torque on the input shaft of the gearbox | 220 Nm |
| Torque limit on the input shaft for the 1st speed | 100 Nm |

Tab. 1: Parameters of the test rig

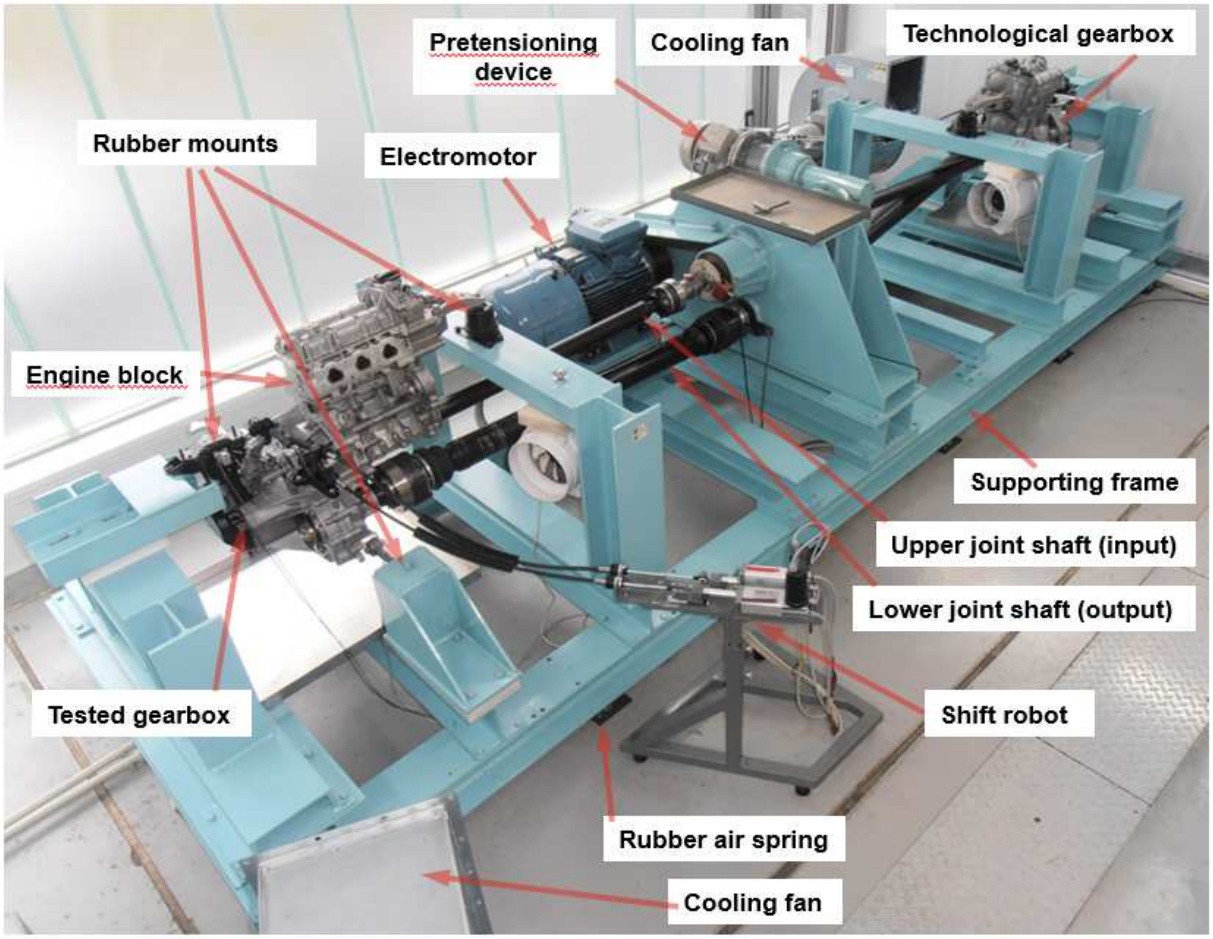


Fig. 1: Test rig for passenger car gearboxes at CTU in Prague - overall view.

Supporting frame of the test rig is then placed at air springs because of damping of vibrations going into the laboratory building. In the scheme of this test rig (see fig.2) there are visible two places for torque measurement and pretensioning mechanism (PM) at the input shaft at the technological half of the test rig. Because the torque is measured at two points (M1, M2), it is possible to determine efficiency between them.

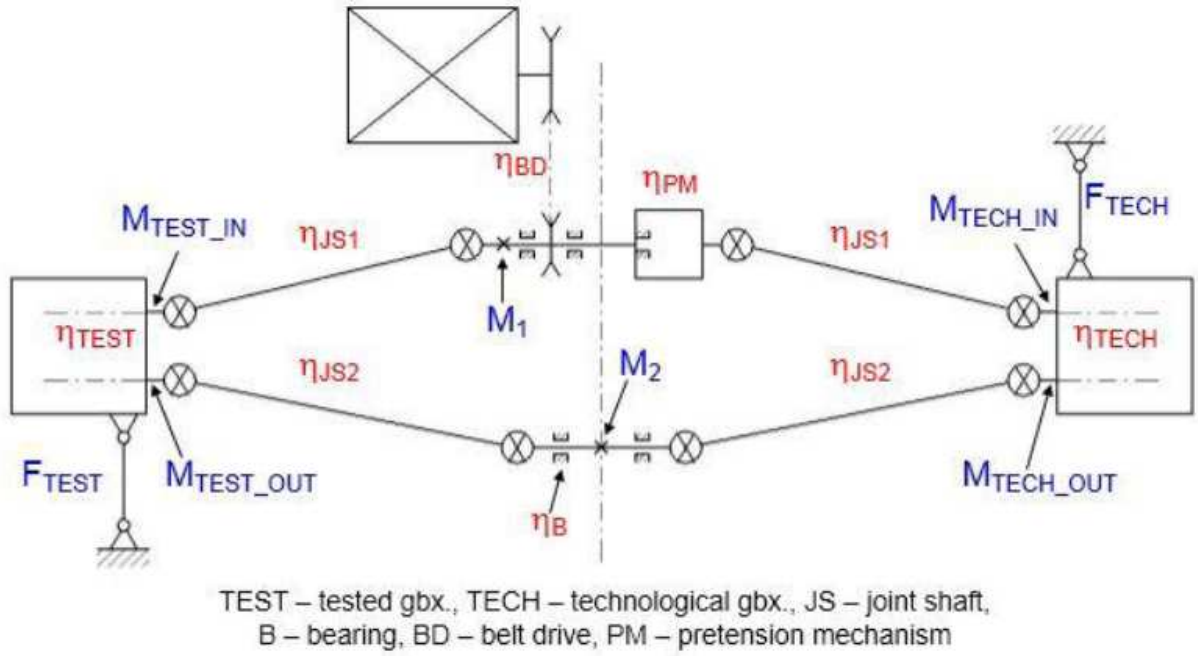


Fig. 2: Functional scheme of the test rig at CTU in Prague.

## 4 Pretensioning mechanisms

### 4.1 Friction clutch

For tests with constant torque (one-load level) it is convenient to use as the pretensioning mechanism (PM) hand managed worm gear set and friction clutch. After setting desired load is the clutch engaged and the worm is removed from the worm wheel. Power loss of this PM consists only from two bearings, so it can be in comparison with all other losses in the circuit neglected. See fig. 3.

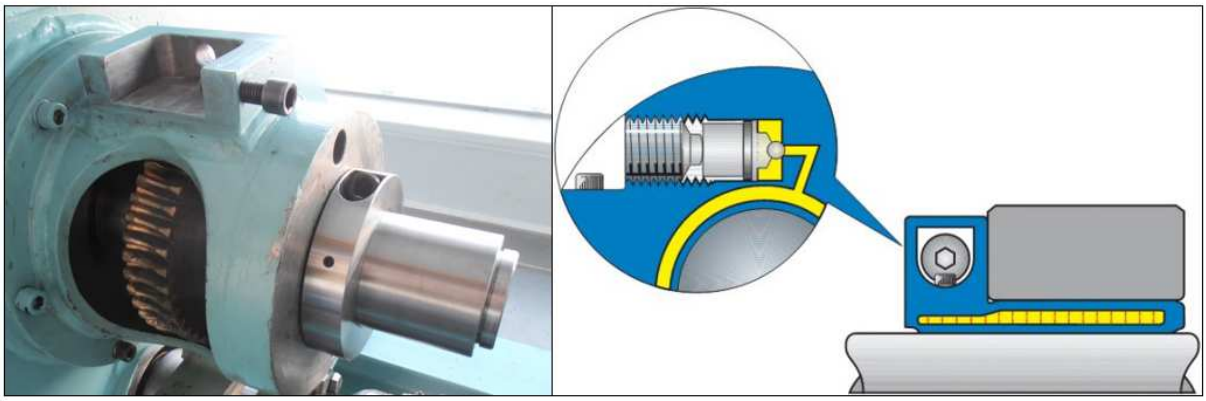

Fig. 3: Appearance and principle of the friction clutch as pretensioning mechanism.

### 4.2 Planetary torque unit

It is very convenient to run two tests parallel because there is a need of changing shifted speed after certain interval because of local overheating. From this reason is this test rig equipped with two electromechanical shift robots. But for shifting it is

necessary to decrease torque and thereafter to set the torque again. For this purpose is used planetary torque unit (PTU), see figure 4. This PM consists of two identical planetary gear sets with common spider. One crown is fixed, second one is rotary - managed by worm gear set. This PTU has two degrees of freedom and enables to change pretension in the circuit while rotating. So it can be used for more-load tests (emulating of loading spectrum). For unmanned operation with shifting is this PTU necessary.

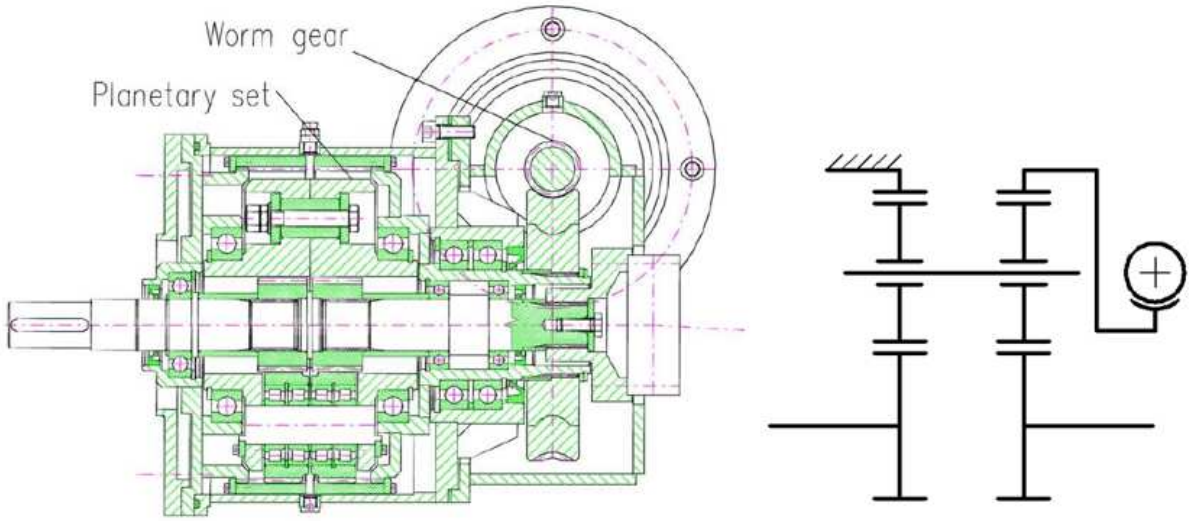


Fig. 4: Cross section and scheme of the planetary torque unit.

## 5 Comparison of pretensioning mechanisms

During the test is known from the frequency convertor power consumption of the whole test rig. Because the power is measured at input and output shaft, we can determine partial efficiencies of all parts of the circuit. Efficiencies of joint shafts by certain angle are given from their manufacturer. So we can determine the efficiency

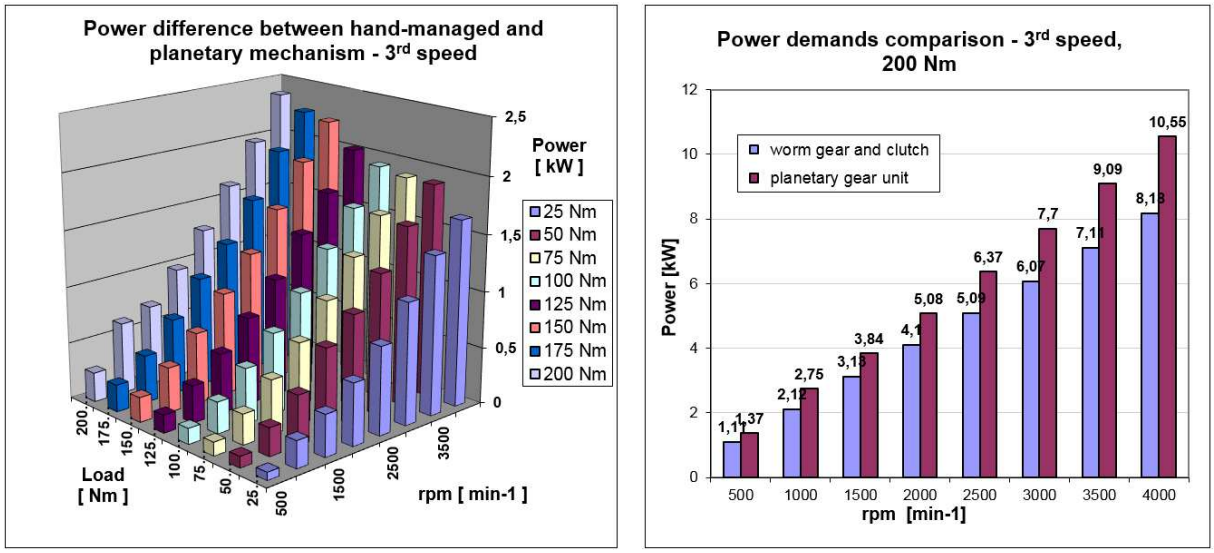


Fig. 5: Power demands at third speed with both pretensioning mechanisms

of both gearboxes. If we compare power demands of the test rig under same loading conditions with both PMs, we'll find out that there is a difference between them. This difference happens only in PM because the rest of the rig is unchanged. If we neglect losses in bearings in PM with friction clutch, then this different is exactly power loss in planetary torque unit. Example of this comparison is shown in the figure 5.

## 6 Conclusion

This above described back-to-back test rig is really unique. Loading conditions are really very close to reality because of original placing of gearwheels, housing and mounting points of the whole assembly with the engine cast to the main frame. Also data acquired from this test bench are really valuable. Next advantage is that there are always tested two identical gear sets which are loaded in same direction. Only the technological one rotates in opposite direction. Disadvantages of this test rig are torque limitations given by joint shafts and housing which do not allow overloading and shortening of endurance tests. Despite these limitations in practice usually happens that the most loaded bearings must be changed during the test.

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