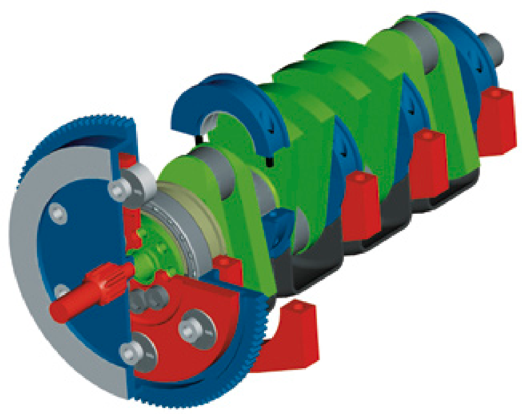
Further Development of FEV's Fully Variable VCR System



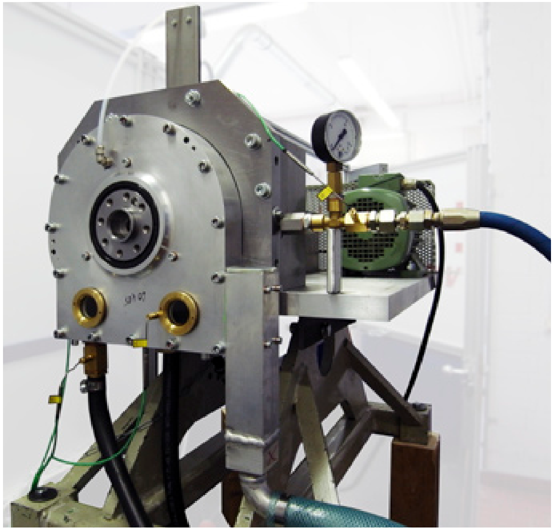


Fig. 6: Precision friction test rig for PKG optimization

The realization of **v**ariable **c**ompression **r**atio (VCR) in combustion engines, using an eccentrically-supported crankshaft, has been the basis of VCR technology development at FEV for the past 10 years. This VCR principle has been applied to various engine architectures and has been successfully tested on the test bench as well as in vehicles within several of our development projects.

A special challenge with this VCR system is to bridge the offset between the eccentrically positioned crankshaft and the stationary transmission input shaft. In general, different solutions are available for this purpose. FEV has developed the "**P**arallel**k**urbel**g**etriebe" (parallel crank transmission or PKG), which incorporates a Schmidt coupling that allows shaft misalignment while offering undisturbed power transmission at constant angular velocity. This represents an especially favorable solution with regard to robustness and packaging.

The main focus in the continuing development of the PKG is the reduction of friction losses, long-term durability, and producibility.

During systematic friction optimization, a high precision test rig with a high resolution torque measuring shaft was developed [Fig. 6]. Motored tests have shown that the primary contribution to reducing friction is the result of an "open" PKG design. The use of roller bearings instead of plain bearings offers another benefit by providing a relatively small friction advantage. FEV was able to reduce friction losses by more than 50 % compared to previous "closed" design stages with roller bearings, as a result of these changes.

The PKG is exposed to high torque fluctuations during engine operation, as the result of being the connecting element between the crankshaft and flywheel. Through extensive CAE support, specifically multi-body simulations and finite element analyses, the PKG has been strengthened for these applications. The durability of the PKG concept has been proved by a number of fired endurance tests based on earlier design stages. Within these tests, the full engine speed range has been run-through quasi-steady-state, thereby covering all critical operating conditions. No noticeable signs of wear or failure were observed while the tests were being conducted or after completion.

In addition to these functional improvements, the PKG design has also been optimized for manufacturing, with the potential for implementation as a complete preassembly.

The results of this optimization program represent another important milestone towards the productionization of this VCR system.

wittek@fev.de