VCR Technology for Increasing the Efficiency of Internal Combustion Engines

TLB
Technologie-Lizenz-Büro
der Baden-Württembergischen Hochschulen GmbH

An extensively developed technology for reciprocating engines, consisting of several novel solutions for reliable technical implementation.

- Efficiency increase in combustion engines through variable compression resulting in lower consumption, lower CO2 emissions
- Less complexity than previous VCR systems
- Weight savings and more compact design compared to similar systems
- Cost effective production using conventional manufacturing processes
- Avoidance of knocking combustion with fuels with high ignition propensity, e.g., hydrogen

Fields of applications

The application of VCR technology is possible in all reciprocating engines, even when using CO_2-neutral fuels (e-fuels, hydrogen). The system is particularly well suited for use in large machines, e.g., trucks, mobile machines or locomotives.

Contact

Dipl.-Ing. Erick Pérez-Borroto Ferrer
TLB GmbH
Ettlinger Straße 25
76137 Karlsruhe | Germany
Phone +49 721-79004-0
perez@tlb.de | www.tlb.de

Development Status

TRL 7 - Test of a system prototype in real operation

Patent Situation

DE 10 2017 100 024 A1 granted
DE 10 2017 102 313 A1 granted
DE 10 2017 122 869 A1 granted
DE 10 2018 120 002 B3 granted
DE 10 2018 132 718 A1 granted
DE 10 2019 101 269 B3 granted
DE 10 2020 112 990 B3 granted
DE 10 2020 119 755.1 granted

Reference ID

20/018TLB

Service

Technologie-Lizenz-Büro GmbH has been entrusted with exploiting this technology and assisting companies in obtaining licenses.

Background

The goal of reducing CO2 emissions by 55 percent until 2030 is Germany's contribution to the Paris climate agreement. Mobility plays a major role in this; ever stricter CO2 limits for new cars demand appropriate technology. Entirely new, but also revitalized technologies are on the rise; electromobility is just one variant. Even proven powertrain technologies such as the internal combustion engine can be made significantly more environmentally friendly through optimization. The idea of variable compression (abbreviated VCR as in "variable compression ratio") to increase efficiency is about as old as the internal combustion engine itself. However, since the thermodynamic benefits of the solutions proposed so far have not been able to justify the necessary effort, only one engine (in 2019) with variable compression has made it into series production to date. New, more efficient components for VCR systems are being designed at Heilbronn University of Applied Sciences. In the future, hydrogen or e-fuels could also be considered as fuels for combustion engines. Particularly in the case of hydrogen combustion, the adjustability of the compression is of great advantage in order to counteract the higher susceptibility to knocking.

Problem

With VCR technology, there are several key issues that need to be addressed to qualify the system for use in production engines. These include the fluid connection of the adjusting mechanism, the actuation, the mass of the connecting rod and, above all, the manufacturing and assembly costs of the components.

Solution

At Heilbronn University of Applied Sciences, many years of research and development work have resulted in the design of a fully comprehensive VCR system that has proven itself in test applications in various vehicles. This includes several novel solutions, which are briefly described below:

- **VCR eccentric lever:** a lightweight, low-cost eccentric lever composite in which the eccentric is only partially enclosed by the lever.
- **VCR locking system:** A mechanical, simply designed and very robust locking mechanism for variable length connecting rods.
- **Electromagnetic actuation system:** This electromagnetically actuated switching valve enables two-point control of the length of the VCR connecting rod by means of a high switching speed.
- **Oil transfer:** A new slip ring design enables safe permanent fluid connection between the crankshaft and connecting rod.
- **VCR central valve:** A central valve integrated into the crankshaft that completely decouples the hydraulic shifting system of the VCR connecting rods from the ambient fluid pressure in the engine.
- **Centrifugally compensated shift valve:** A centrifugally compensated pilot valve on the crankshaft that eliminates the speed-dependent pressure components of the control oil.

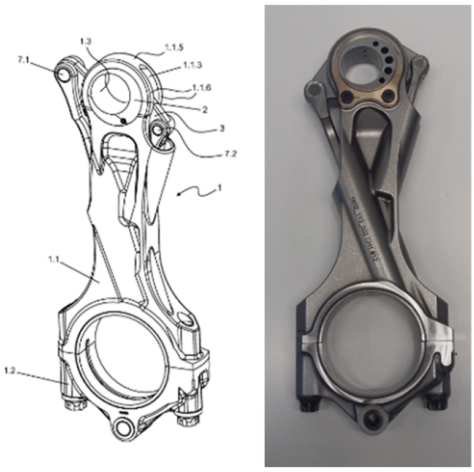

Fig. 1: Drawing from patent specification (left) and prototype of the VCR-Pleuel (right) [Prof. Dr.-Ing. K.Wittek, Faculty of Mechanics and Electronics; HS Heilbronn].

Fig. 2: Prototypes of the VCR-Pleuel (bottom) in the engine laboratory of Heilbronn University of Applied Sciences with the associated pistons (top) for use in a test vehicle. [Prof. Dr.-Ing. K.Wittek, Faculty of Mechanics and Electronics; HS Heilbronn].

Literature and links

1. K. Wittek, F. Geiger, M.G. Justino Vaz, Characterization of the system behaviour of a variable compression ratio (VCR) connecting rod with eccentrically piston pin suspension and hydraulic moment support, Energy Convers. Manag. 213 (2020). https://doi.org/10.1016/j.enconman.2020.112814.
2. K. Wittek, F. Geiger, Betriebsverhalten längenvariabler Pleuelstangen, MTZ - Mot. Zeitschrift. 81 (2020) 74–79. https://doi.org/10.1007-/s35146-020-0253-5.
3. K. Wittek, F. Geiger, Operating Characteristics of Variable Length Connecting Rods, MTZ Worldw. 81 (2020) 66–71. https://doi.org/10.1007-/s38313-020-0253-3.
4. K. Wittek, F. Geiger, Innovative Betätigungskonzepte für längenvariable Pleuelstangen, MTZ - Mot. Zeitschrift. 81 (2020) 80–84. https://doi.org/10.1007-/s35146-020-0317-6.
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6. K. Wittek, F. Geiger, J. Andert, M. Martins, V. Cogo, T. Lanzanova, Experimental investigation of a variable compression ratio system applied to a gasoline passenger car engine, Energy Convers. Manag. 183 (2019) 753–763. https://doi.org/10.1016/j.enconman.2019.01.037.