Project

In order to improve our society´s mobility, as environmental compliant as possible, the Netherlands and the German federal state of North Rhine-Westphalia support the development, demonstration and evaluation of an innovative, efficient, cost-optimized and compact hybrid drive train structure. In this context a research consortium, consisting of two industrial partners from the Netherlands and Germany as well as the Cologne University of Applied Sciences, develops the drive system based on a biaxial electric drivetrain structure with a downsized combustion engine as a range extender.

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The total project volume is around 3.1 Mio €, whereat the federal state NRW provides ca. 1.35 Mio € out of the NRW-EU Ziel2 program. The Dutch project partner receives funding from the European research initiative EUREKA.

Project Partners

Within the project, the North Rhine-Westphalian company Meta Motoren- und Energietechnik GmbH is responsible for the development of a highly efficient combustion engine as a range extender. The double rotating electric motor is engineered by the Dutch partner Centre for Concepts in Mechatronics (CCM).

meta
MOTOREN- UND ENERGIE-TECHNIK

ccm
centre for concepts in mechatronics

Prof. Dr. A. Lohner from the Institute for Automation Engineering at the Cologne University of Applied Sciences is accounted for the simulation based system design, the establishment of an adequate energy management system and the build-up of a first demonstrative vehicle-prototype.

Motivation

The central goal of the current project is to design and build a highly energy-efficient and at the same time economic hybrid-electric all-wheel drivetrain topology for passenger cars. The purpose is to enable entirely electric inner-city operation (plug-in) and non-urban long-distance operation, by the use of an efficient range extender.

Drive Train Topology

As visualized on the cover, the rear axle is driven electrically, while the combustion engine is connected to the differential at the front axle via the double rotating electric motor. The structural design of the double rotating machine can be seen below in Fig. 1.

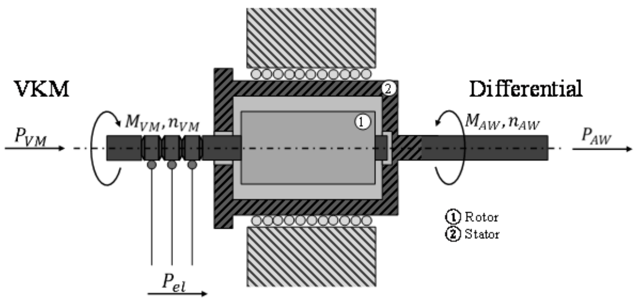

Fig. 1: Double rotating electric motor structural design

Via the double rotating electric motor, the combustion engine and the front axle differential become mechanically disconnected, which allows the combustion engine to be driven in any optional operating point. Therefore the combustion engine´s operating point can be shifted into the range of least specific fuel consumption, maximizing its degree of efficiency and subsequently the overall system efficiency. The dynamic regulation of the desired driving torque is performed by the electric motor at the rear axle. If the combustion engine is switched off, a locally emission-free all-wheel operation is enabled by locking the combustion engine shaft.

Targeted data for the efficiency optimized combustion engine:

- Two-cylinder Otto-engine (1 l cubic capacity)
- 30 – 40 kW; 110 Nm / 3000 RPM
- Minimal fuel consumption: 205 – 215 g/kWh
- 40 % weight reduction compared to a typical four-cylinder engine
- Actual optimal degree of efficiency of 40 %

Targeted data for the double rotating electric motor:

- 20 – 30 kW; 120 Nm (η > 93 %)
- Weight: < 60 kg; Size (volume): < 25 l
- Price: < 800 € (100,000 pcs/a)

Targeted energy storage specifications:

- Tank: Ca. 20 l (30 kg) Otto-fuel (petrol)
- Li/Ion-Battery: 4 – 5 kWh (50 – 60 kg)
- Super-Cap Capacitor: 0.1 – 0.15 kWh (30 – 40 kg)

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Fakultät für Informations-, Medien- und Elektrotechnik

Institut für Automatisierungstechnik
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Targeted vehicle reach and CO_2-Emission:

- Entirely electric drive:
  22 – 28 km (80 % DOD, 0.14 kWh/km)
- Hybrid electric drive with range extender:
  500 – 600 km
- NEDC emissions: Below 60 g CO_2/km

Summary

This new and innovative drive train concept allows a major increase in overall system efficiency in contrast to conventional drive train structures, due to the connection of electric powertrain, double rotating electric motor and combustion engine, optimized for a certain operating point in terms of energy efficiency.

The overall system setup allows highly efficient electric all-wheel operation for short inner city distances. The necessary charging energy for the energy storages during longer drive cycles is provided by the stationary operated range extender. This setup is characterized by a significantly increased degree of efficiency in contrast to conventional engines (Fig. 2).

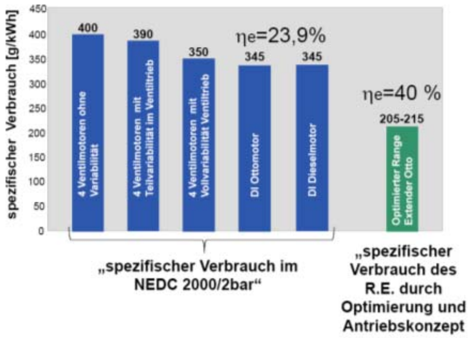

Abb.2: Fuel consumption and degree of efficiency of range extender systems compared to conventional engine types

Project Management

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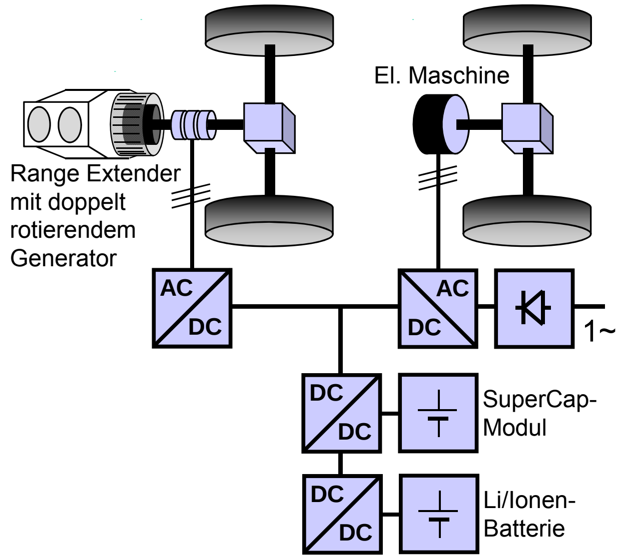

Development, Demonstration, and Evaluation of a Cost-Conscious and -Optimized Drive Combination for Individual Traffic Purposes

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