Project

In order to improve our society’s mobility, as environmentally 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.

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.

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)

Fig. 1: Double rotating electric motor structural design
Targeted vehicle reach and CO₂-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 CO₂/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).

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

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

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