„Function-integrated Lightweight Design Structures for Next Generation Ground Vehicles“

09-10.10.2014, IEA Workshop

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DLR - German Aerospace Center

DLR's mission:

- exploration of the Earth and the solar system
- research aimed at protecting the environment
- development of environmentally-friendly technologies to promote mobility, communication and security.

7,700 employees are working at 32 research institutes and facilities in 9 locations and 7 branch offices.
DLR - German Aerospace Center

Institute of Vehicle Concepts:

- 72 employee

- Vehicle systems and technology assessment
- Vehicle energy concepts
- Alternative energy conversion
- Lightweight and hybrid construction

Source: DLR
Evolution of Megacities

- We are reaching the limits of oil extraction
- Climate change is taking place
- Growing population, concentrated in megacities

Vehicle Concepts

- Lower energy consumption
- Reduced CO₂ emissions by using CNG
- Reduce NOx emissions by using CNG
- Zero-Emission in urban areas
- Alternative and renewable energy sources
- …
Alternative drive technologies offer many new opportunities for the creation of synergies and the integration of various functions leading to new components and lightweight structures.
DLR – Konzept Fahrwerk, Antrieb, Speicher Technologie - ConFAST

(I) DLR-LEICHT
Lightweight Energy-efficient Integrative Chassis with Hub-motor Technology

(II) DLR-”Wabentank”
Free-Shapeable-Modular High Pressure Storage
(I) LEICHT
Concept Introduction

- **Wheel guidance mechanism:**
  - Linear guidance for absorption of forces in 2 dimensions and bending moments in 3 dimensions
  - Camber and castor angle stability

- **Housing of drive:**
  - Transmission of forces and cooling functions
  - Attachment to wheel guidance mechanism

According to: Höfer, Wiesebrock, et. al. – Stuttgart Symposium 2014
(I) LEICHT
Demonstration of Functions

- Current Design:
  - Integration of functions
  - Concept lightweight design
  - Shape optimisation

- Future Design:
  - Lightweight material
  - Topology optimisation
(I) LEICHT

Competitive Advantages

Concept with centrally-positioned-drive

Source: Mitsubishi i-MiEV

Concept with drive positioned close-to-the-wheels

Source: ZF eTB

Concept with wheel-hub-motor

Source: Fraunhofer Frecc0

DLR – „LEICHT“

Goal

...combining the advantages of centrally-positioned drive and hub-motor concepts

According to: Höfer, Wiesbrock, et. al. – Stuttgart Symposium 2014
(I) LEICHT
Competitive Advantages

Package proportions
Based on the best available data in [Vol %]

Unsprung mass proportions
Based on the best available data in [kg %]

Benchmark 1
Benchmark 2
Benchmark 3
DLR "LEICHT"

According to: Höfer, et. al. – SAE World Congress & Exhibition 2014
(I) LEICHT
Simulation Results

- **Full vehicle simulation:**
  - Double lane change while cornering
  - Excellent behaviour of innovative suspension confirmed
  - Torque vectoring to improve stability and performance
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(II) DLR-"Wabentank"
Free-Shapeable-Modular High Pressure Storage

(I) DLR-LEICHT
Lightweight Energy-efficient Integrative Chassis with Hub-motor Technology
(II) DLR-"Wabentank"
Free-Shapeable-Modular High Pressure Storage

- **Motivation:**
  - Reduction of emissions
  - CNG / H$_2$ as alternative fuels

- **State of the Art:**
  - Stored in cylindrical vessels
  - Range approx. 400km
  - A need to improve range

- **To Do:**
  - Increase the available volume
  - Increase the design variability
(II) DLR-”Wabentank”
Wide range of packaging variations as enabler

- **State of the Art:**
  Innovation through
  → **lightweight material**

<table>
<thead>
<tr>
<th></th>
<th>CNG 1</th>
<th>CNG 2</th>
<th>CNG 3</th>
<th>CNG 4</th>
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<tr>
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<td>metallic</td>
<td>metallic</td>
<td>Non metallic</td>
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<tr>
<td>Winding</td>
<td>-</td>
<td>Hoop wrapped</td>
<td>Fully wrapped</td>
<td>Fully wrapped</td>
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</tbody>
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- **Basic Concept – DLR Patent**
  Innovation through
  → **design**

- **Variability in the use of the available space**
(II) New Production Approach Type 3
Modular and Fully Scalable High Pressure Storage

According to: Schierle, Friedrich – FKFS-8. Tagung Gasfahrzeuge 2013
(II) New Production Approach Type 3
Modular and Fully Scalable High Pressure Storage
(II) DLR-”Wabentank”

Potentials

- By changing the winding composition it is possible to integrate different loading capacities to the component

- DLR-Patent is able to be incorporated at any stage and position in the vehicle development process

- Increasing volume
- Increasing range of CNG-vehicles
- Increasing customer benefits
- Lowering weight
(I) LEICHT Potentials

- **Combines the advantages** of wheel hub motor and center drive
- **Complete solution** for the powertrain and chassis
- **Protection** of the drive against impact, abuse, acceleration
- High degree of **modularisation**
  - Power, torque
  - Hybridisation
  - Front wheel application

- **Decresation mass**
- **Increasing volume**
- **Increasing range of EV**
- **Increasing vehicle applications**
Outlook

- Function-integrated Lightweight Design Structures for Next Generation Ground Vehicles →
  - Improved lightweight solutions (new materials and combination of materials)
  - New function integrated solutions (mechanical, thermal, electric, …)
  - Solutions applicable in different series

- DLR Institute of Vehicle Concepts:
  - (I) „LEICHT“: Prototyping for functional demonstration
  - (II) „DLR Wabentank“: Validation of concept
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