For electric drives: Designing load-optimised and resource-efficient high-speed gearboxes

About this project

Light4Speed

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Markets:

Material: Steel

This project is funded by the Technology Transfer Programme Leichtbau (TTP LB) of the Federal Ministry of Economics and Energy.

Technology Transfer Program Leichtbau

Context

The transition to electromobility is also changing the demands on the drivetrain - and therefore on transmission technology. Although electric vehicles require fewer mechanical components than conventional drives, efficiency and lightweight construction are taking centre stage for the remaining components in particular. Less weight means lower energy consumption, improved range and reduced CO# emissions during operation.

Electric motors have to deliver high torque at low speeds and are often large and heavy as a result. High-speed concepts open up opportunities here: Smaller, lighter motors achieve the same power at significantly higher speeds - provided the gearbox can reduce this efficiently. This is where modern high-speed transmissions come in.

However, as speeds increase, so do the centrifugal forces in the gear - particularly in the area of the tooth root. Current calculation standards do not adequately reflect these stresses. This makes an optimised, weight-reduced design more difficult. At the same time, lightweight construction is a key to reducing CO# emissions over the entire vehicle life cycle - by using less material and consuming less energy during operation. Against this backdrop, new, standardised approaches are needed for gears in the high-speed range and new methods for increasing the load-bearing capacity of gears in electric drives. This is where the Light4Speed project comes in.

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Purpose

The project team is developing new methods for designing gears for high-speed gearboxes in a weight- and load-optimised manner. The aim is to master the growing centrifugal forces at speeds of up to 50,000 revolutions per minute both in terms of design and calculation - and thus enable lighter, resource-saving drive solutions.

The focus is on the tooth root, which is particularly stressed by the superposition of centrifugal forces and the torque required for power transmission. The researchers are pursuing an integrated approach: they are combining lightweight design, material and manufacturing to increase load-bearing capacity and are analysing the influence of centrifugal forces on stress and damage behaviour.

This is not just about new design guidelines. The team will also develop a simplified calculation approach that can be integrated into standards such as ISO 6336 in the future. In addition, reliable test methods are to be developed with which the influence of centrifugal forces can be efficiently evaluated.

This will create a sound basis for the development of innovative transmissions in electromobility. At the same time, the project is making a concrete contribution to reducing CO# emissions - for example by saving material by increasing the load-bearing capacity of the gears used in electric transmissions.

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Procedure

The researchers are investigating how centrifugal forces at very high speeds affect the service life and failure behaviour of gears. To do this, they use experimental test benches and numerical methods such as the finite element method (FEM). This breaks down the component into many elements and thus shows how loads are distributed in the material. The data obtained is used to develop new design models.

At the same time, the researchers are trialling various lightweight construction strategies. In moulded lightweight construction, they specifically design the gear structure - for example with cavities, ribs or bionically inspired shapes - in order to achieve a high load-bearing capacity with minimal use of material. Material lightweight construction uses specially adapted materials and heat treatments to change the structure and residual stresses in the tooth root so that cracks develop more slowly or do not form in the first place. Lightweight manufacturing relies on processes such as optimised shot peening or targeted quenching under preload in order to introduce additional residual compressive stresses.

The project partners test all concepts under realistic conditions, including the so-called "ultra-high cycle fatigue" range, with extremely high load cycles. Finally, they systematically compare the concepts and develop recommendations for industrial practice. The aim is to provide practical and standardised technologies for transmissions in the field of e-mobility.

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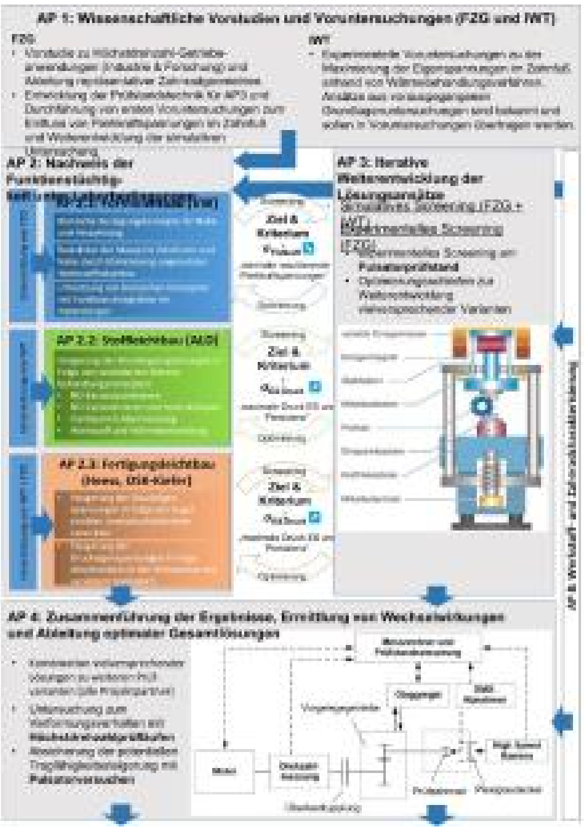

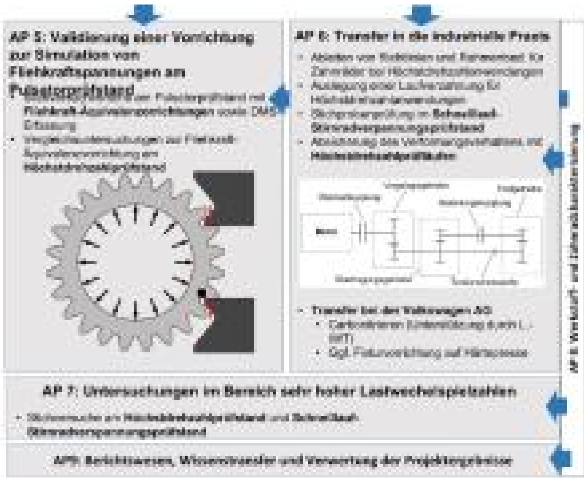

Funding duration:

Funding sign:	03LB3014	**Funding amount:**	EUR 1.3 million

Final report

Further websites foerderportal.bund.de/foekat/jsp/SucheAction.do?actionMode=view&fkz=03LB3014A - Light4Speed in the federal funding catalogue

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English (EN){{ Projektpartner }}

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Lightweighting classification	Realisation
Offer	
Products Parts and components, Tools and moulds	✓
Services & consulting Testing and trials, Engineering, Standardisation, Simulation, Technology transfer	✓
Field of technology	
Design & layout Lightweight manufacturing, Lightweight design, Lightweight material construction	✓
Functional integration Material functionalisation	✓
Measuring and testing technology Component and part analysis, Materials analysis	✓
Modelling and simulation Loads & stress, Life-cycle analysis, Optimisation, Materials	✓
Plant construction & automation Others (Drive technology)	✓
Recycling technologies	

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Lightweighting classification

	Realisation
Manufacturing process	
Additive manufacturing	
Coating (surface engineering)	
Fibre composite technology	
Forming	
Joining	
Material property alteration Mechanical treatment, Thermochemical treatment, Thermomechanical treatment, Heat treatment	✓
Primary forming	
Processing and separating	
Textile technology	
Material	
Biogenic materials	
Cellular materials (foam materials)	
Composites	
Fibres	
Functional materials	
Metals Steel	✓
Plastics	
Structural ceramics	
(Technical) textiles	