
From Idea to Product – Casting Technology and Component Development at the Fraunhofer IFAM

ROADSHOW 2012 – LIGHTWEIGHT TECHNOLOGY

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Agenda

- Fraunhofer-Gesellschaft & Fraunhofer IFAM at a glance
- Casting Technology
- Component Development
- Our Offer

The Fraunhofer-Gesellschaft at a glance

Fraunhofer-Gesellschaft

- founded in 1949
- 60 Fraunhofer-Institutes
- 40 locations in Germany
- 20.000 employees
- 1.8 bn. € total research budget
 - more than 1.5 bn. € contract research
 - 2/3 research for industrial partners
 - 1/3 government funding



Fraunhofer IFAM

- founded in 1969
- two locations
 - Bremen
 - Dresden
- Research groups in Stade and Oldenburg
- 535 employees (2012)
- 40.4 m. € total budget (2011)
- departments
 - Shaping and functional materials
 - Adhesive bonding and surfaces

The department of Casting Technology and Component Development

casting technology

- castings with complex geometries
- function integrated castings
(*Embedded sensors / RFID transponder*)
- material and process development
(*especially for die casting, lost foam-technology, investment casting*)
- numerical simulation, component analytics



component development

- full electric drive train / wheel hub motors
- development of ECUs / power electronics
- functional safety
- productions technologies for electrical machines, casting production of coils and housings using
- vehicle concepts, especially for electric mobility

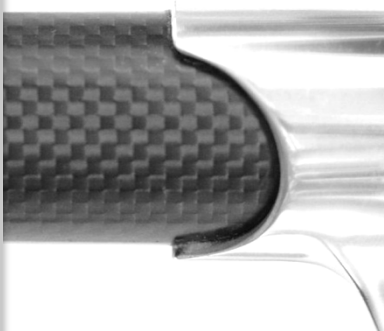


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Current research subjects in casting technologies

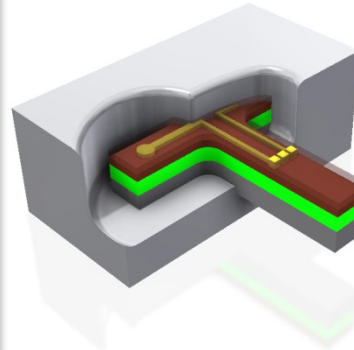
CFRP-aluminium
hybrid casting



embedding of RFID
transponder for
part identification



embedding of sensors
for condition monitoring



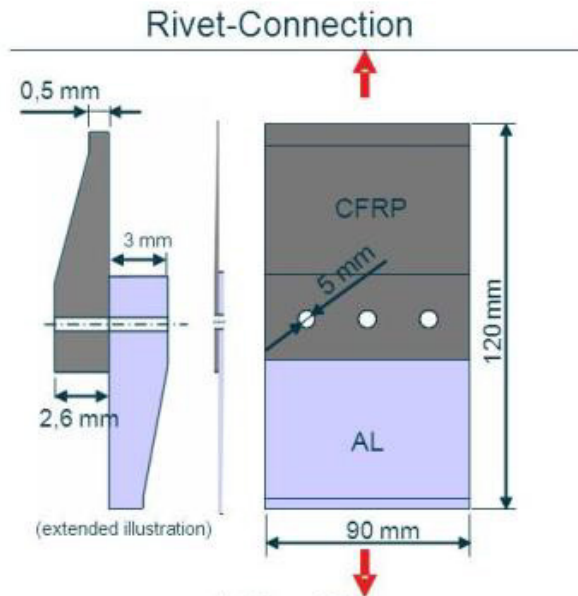
new cast parts
for electric mobility
applications



CFRP-aluminium hybrid casting

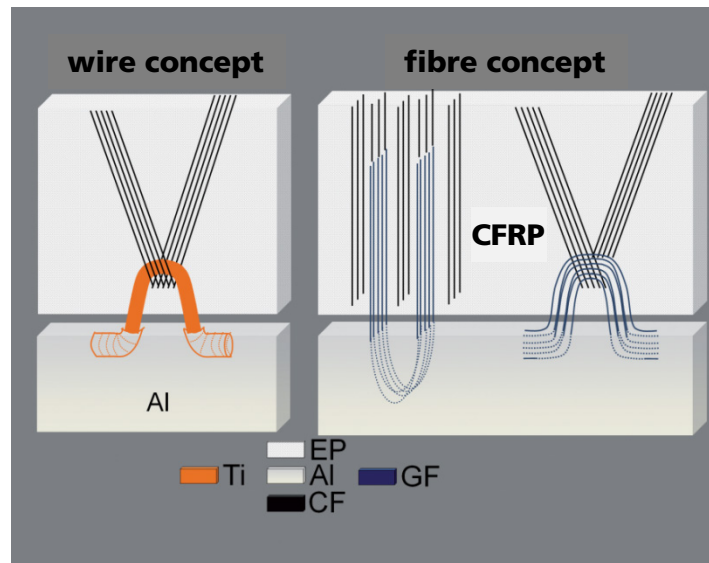
■ motivation and objectives

- trend in modern lightweight materials is increasingly towards multi-material design
- realization of lean, heavy duty and reliable transition structures for CFRP-Al-mixed connections in integral design (e.g. cast nodes)

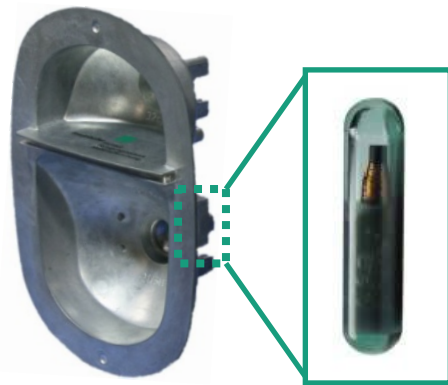


CFRP-aluminium hybrid casting

- advantages
 - lightweight construction / small space design
 - corrosion-resistant join patch
 - fibre adjusted design



Embedding of RFID transponder for part identification

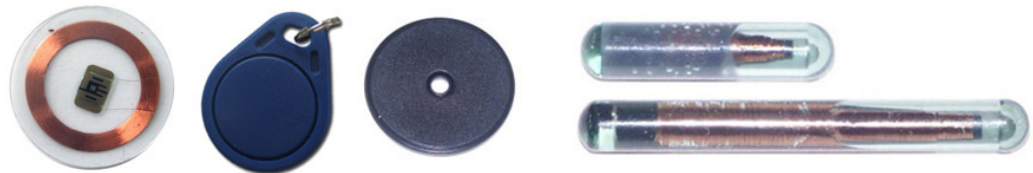


■ advantages of RFID transponder compared to alternative ident-technologies

- part identification via radio transmission
- no intervisibility required
- penetration of non-metallic materials
- complete automation of data acquisition

■ additional advantage

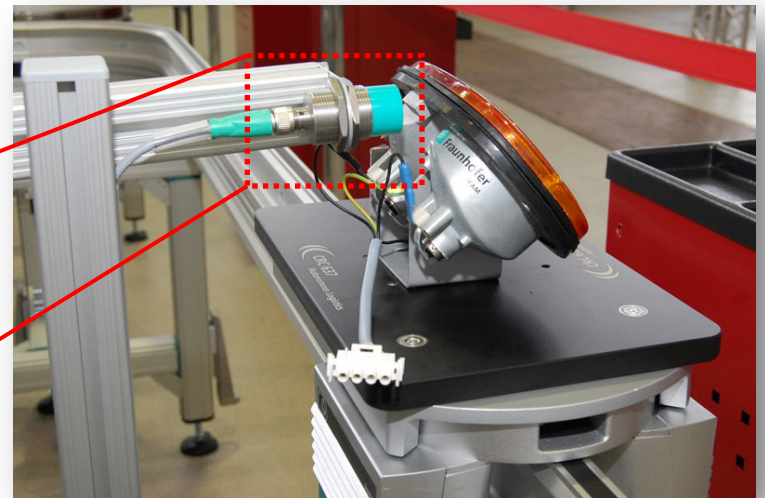
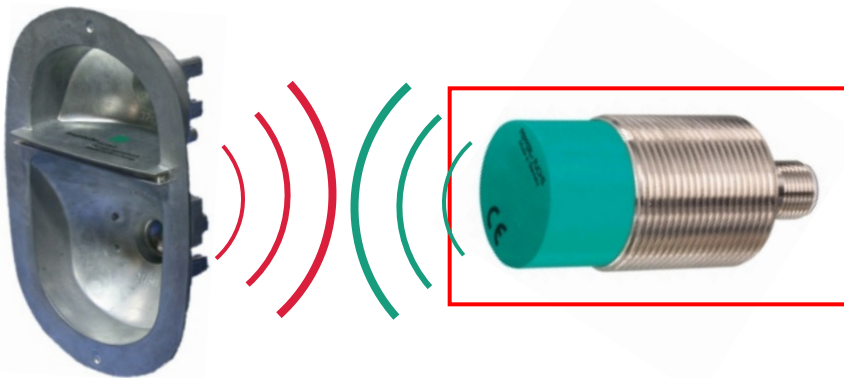
- tamper-proof, electronic “genuineness certificate”
→ protection against product piracy



Embedding of RFID transponder for part identification



- advantages of cast embedded RFID
 - resistant to dirt, industrial terms and environmental conditions
 - no loss of information due to mechanical damage
 - surface treatment feasible (e.g. varnishing, blasting)
 - full traceability of cast parts



Embedding of RFID transponder for part identification

CASTronics - RFID

Elektronisches Datenblatt

Fraunhofer IFAM

Produkt

Produktvariante

Bimnsset "rot-orange"

Bimnsset Blende

Produktinformationen

Seriennummer: 145 107 100 121

Gieß-Datum: 13.08.2008

Gieß-Zeit: 11

Gieß Schicht: Früh

Legierung: ZL0400

Qualitätsprüfungsdatum: 19.08.2008

Kunde: VesTec GmbH

Verbindung

IP: 172.28.20.21

Port: 10000

Verbinden

1

EF - Enhanced buffer

Senden

Produktionsstatus

☒ Gießen ☒ Anguss entfernen

☒ Entgraten ☒ Fräsen

☒ Bohren ☒ Strahlen

☒ Polieren

Montagestatus

☒ Elektronik ☐ Dichtung

☒ Bimnsset ☐ Blende

Schreiben

Daten speichern

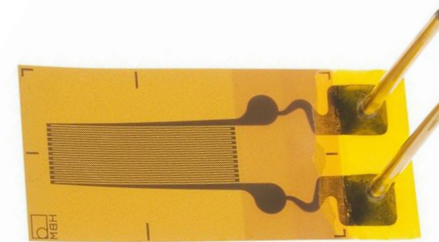
Daten schicken

Bild

145 107 100 121

Embedding of sensors for condition monitoring

- widespread implementation of embedding in castings failed so far
 - appropriate sensor systems
 - joining techniques
- strain gauges
 - well established and cost effective
 - but only applicable on the surface
 - protection layer required against damage
 - no condition monitoring in the component
- piezo-electric sensors
 - feasibility of embedding in casting was demonstrated
 - piezo-ceramic material is restricted to 200 – 300 °C
 - only dynamic loads measureable, not static loads



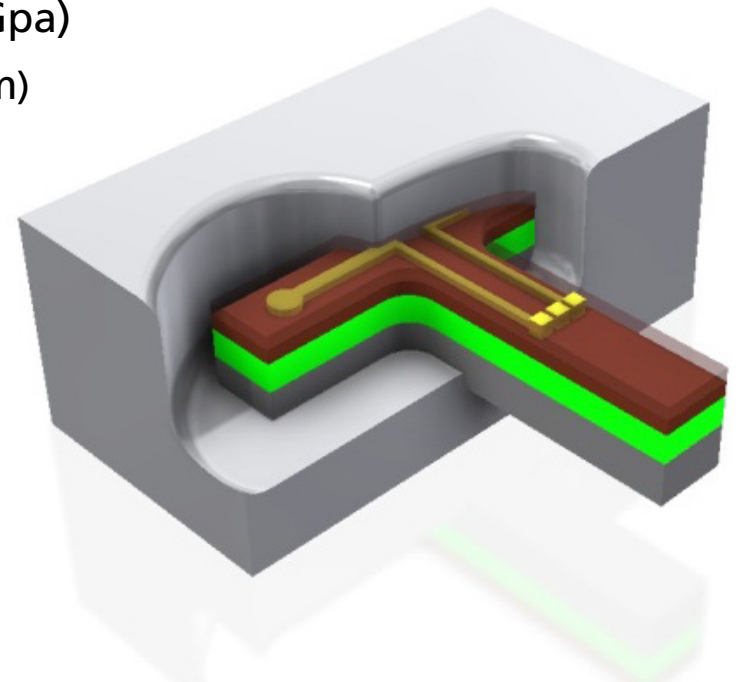
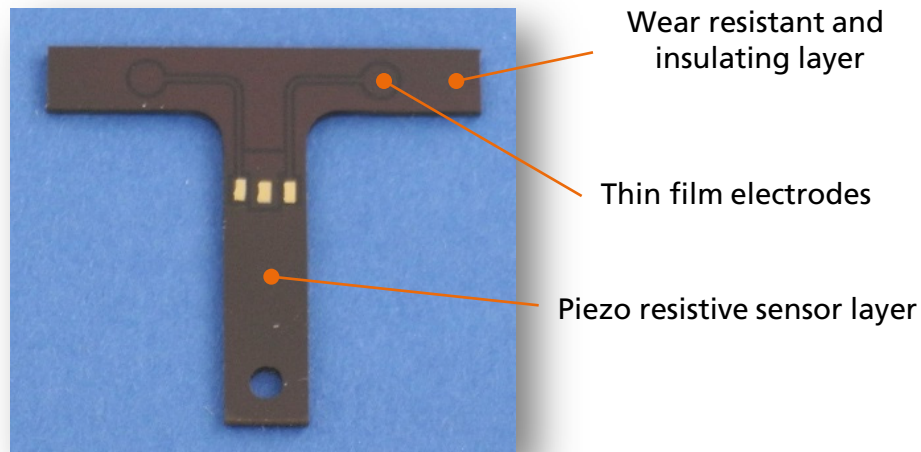
Strain gauge
Image: HBM



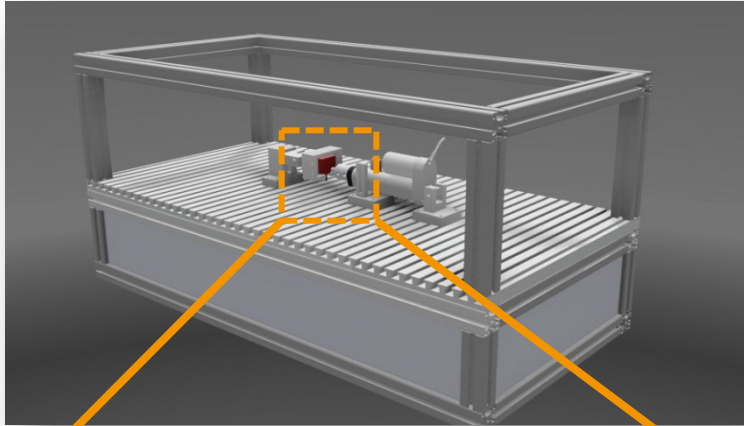
Casted pedal crank with embedded piezo sensors
Image: Fraunhofer IFAM

Embedding of sensors for condition monitoring

- characterization of the DiaForce® sensor
 - thin film sensor – based on piezoresistive hydrocarbon layers
 - developed and manufactured at Fraunhofer IST
 - changes electrical resistance under mechanical load
 - high tribological resistance (hardness ~ 24 Gpa)
 - extremely thin film sensory coating (9-10 µm)

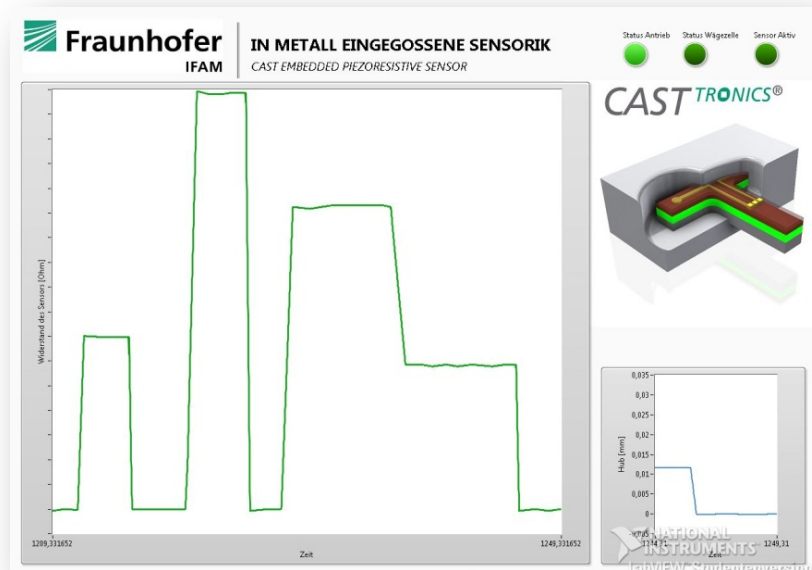
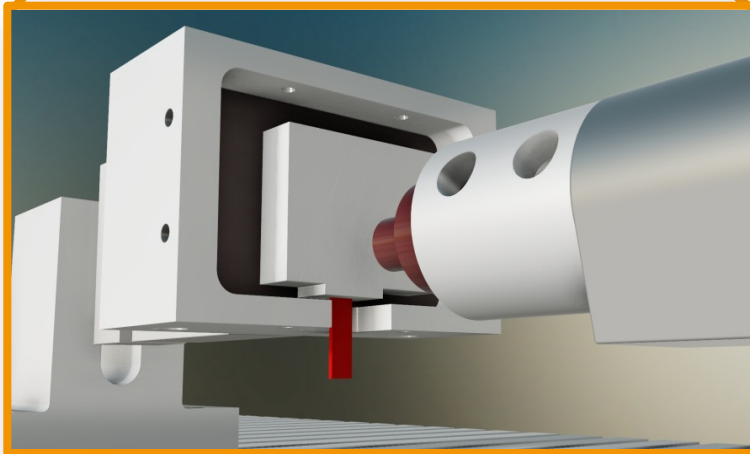


Embedding of sensors for condition monitoring



■ advantages

- measuring of dynamic loads
- measuring of static loads / deformation
- no thermal insulation needed

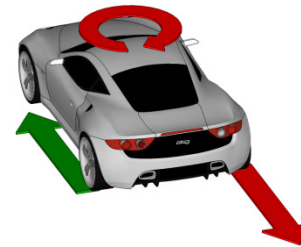
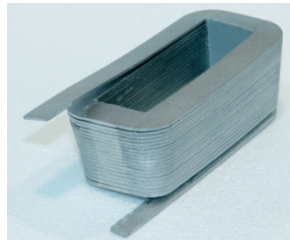


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Department Component Development

FROM THE DEVELOPMENT TO THE SAVE APPLICATION IN VEHICLE



DEVELOPMENT

- electromagnetic design / simulation of electric machines
- vehicle control, inverter, software development, controller
- construction of electric drive
- recent vehicle concepts of electro mobility

PRODUCTION

- casting production of coils
- manufacturing of complex components for electric machines using casting technology
- assembly of prototypical electric drive
- component manufacturing drive chain / chassis

TESTING

- functional safety of control units
- performance test of electric machines
- fault tolerance of electric drive
- testing of complete vehicle

APPLICATION

- vehicle integration of components
- configuration of test bench and demonstrator vehicle
- Major structuring of further education electro mobility



DEVELOPMENT

Fraunhofer Wheel Hub Drive - Drive Concept

- permanent magnet synchronous machine with outer rotor
- power electronics (IGBTs) with dc-link capacitor and control unit placed inside the stator case
- case integrated fluid cooling for stator windings and power electronics
- increased fault tolerance by changes in the converter-drive topology
- CAN-Bus connection to vehicle control unit

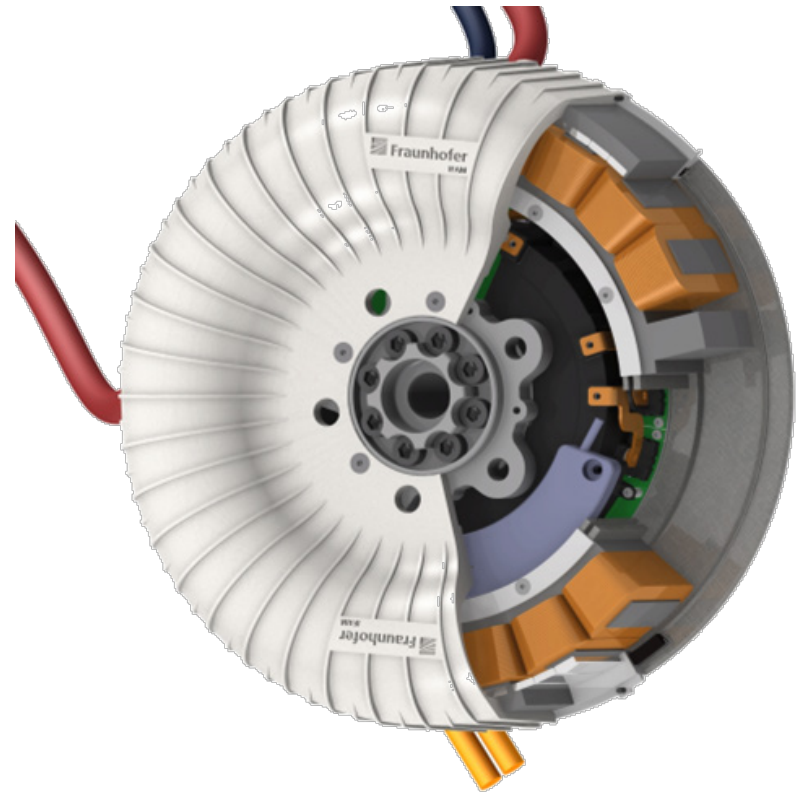
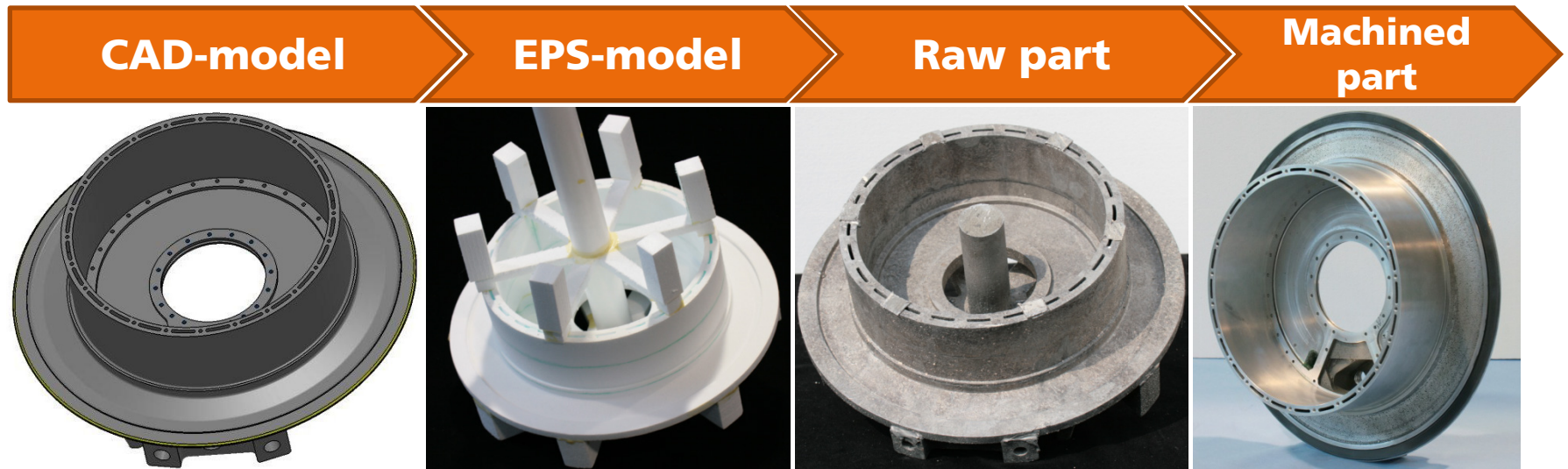


Fig.: sectional view of the wheel hub motor

PRODUCTION

Design and construction of complex casting parts

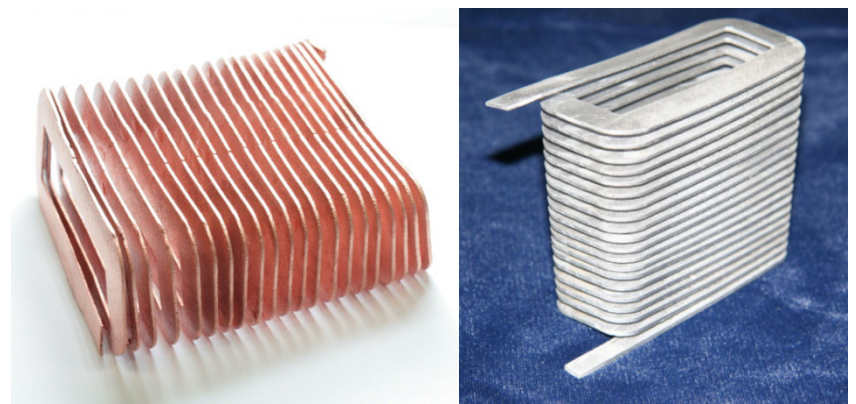
- Production of complex casting parts for electrical machines using Lost Foam casting (e.g. integrated fluid cooling system)
- Great freedom of design (e.g. undercuts, wide range of variants)
- Cost-efficient production of models due to low tool wear
- Milling of EPS-models for rapid production of functioning prototypes
- Inherent flexibility due to segmentation of the model



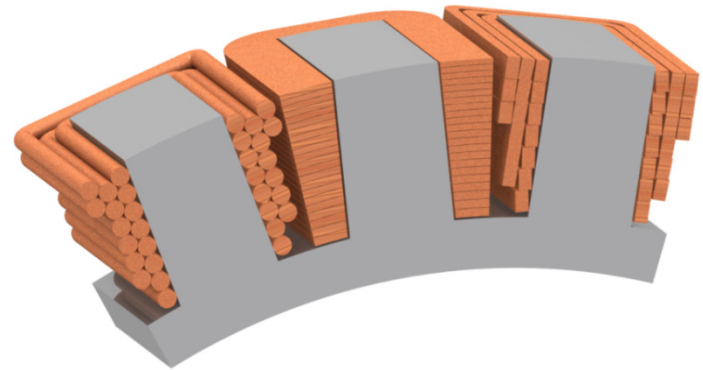
PRODUCTION

Casting of coils for electric machines

- Idea: Coils are produced using a casting process
 - Exact reproduction of design geometry
 - Possibility to vary the cross-sectional geometry along the entire length of the conductor
- Flat conductor alignment with variable width and height
- Slot filling factor up to 90%
- Minimised skin effect
- Positive model of the coil is stretched to allow the casting process and insulation
- Compression of the coil after the casting process



Casted coils (copper / aluminium)

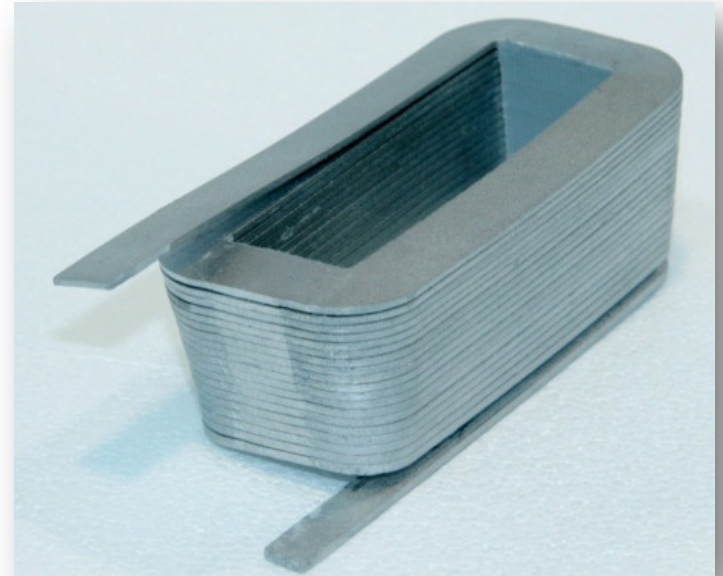


**Sectional view of different conductor types:
circular (left), rectangular (right) and
casted (middle)**

PRODUCTION

Advantages of casted coils

- Considerable increase in slot filling factor allows for significant increase in torque density and efficiency
- Production process of coils offers great potential for cost reduction through automation
- Weight reduction of electrical machines by reducing the height of slots and teeth
- Improved thermal properties through reduced air entrapment, reduced insulation layers and improved thermal conduction between coil and tooth
- Coils become a design element in the motor development process
- Minimised skin effect through flat conductor arrangement
- Exchanging copper for aluminium as coil material while maintaining the existing motor geometry leads to significant weight and cost reduction





TESTING

Safety Issues

- asymmetrical torque at the wheels leads to yawing moment
- reliable safety concept to assure safe vehicle state:
 - reduction of braking torque in case of electrical failures
 - current control with high torque accuracy
 - control unit has to meet requirements of standards like ISO26262
 - with PMSM, active short circuit to avoid high voltage in the dc link in case of failure

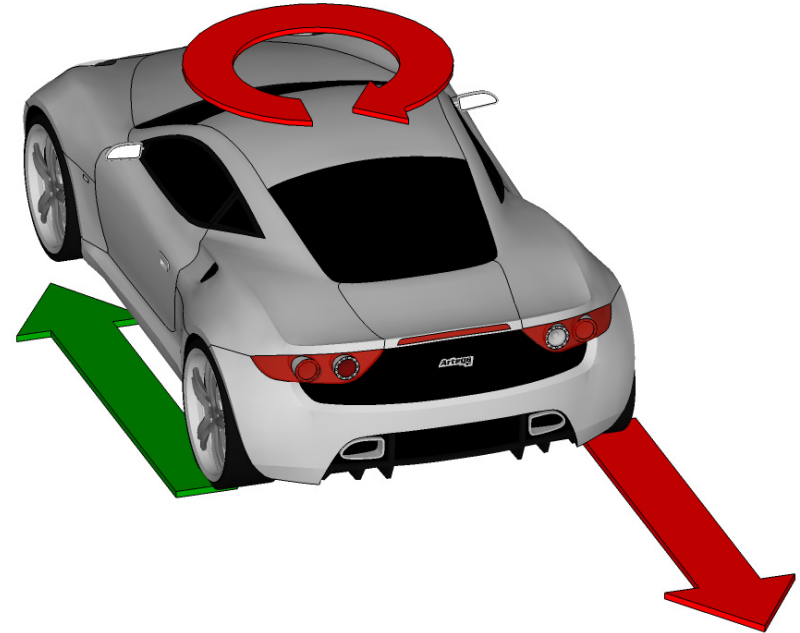
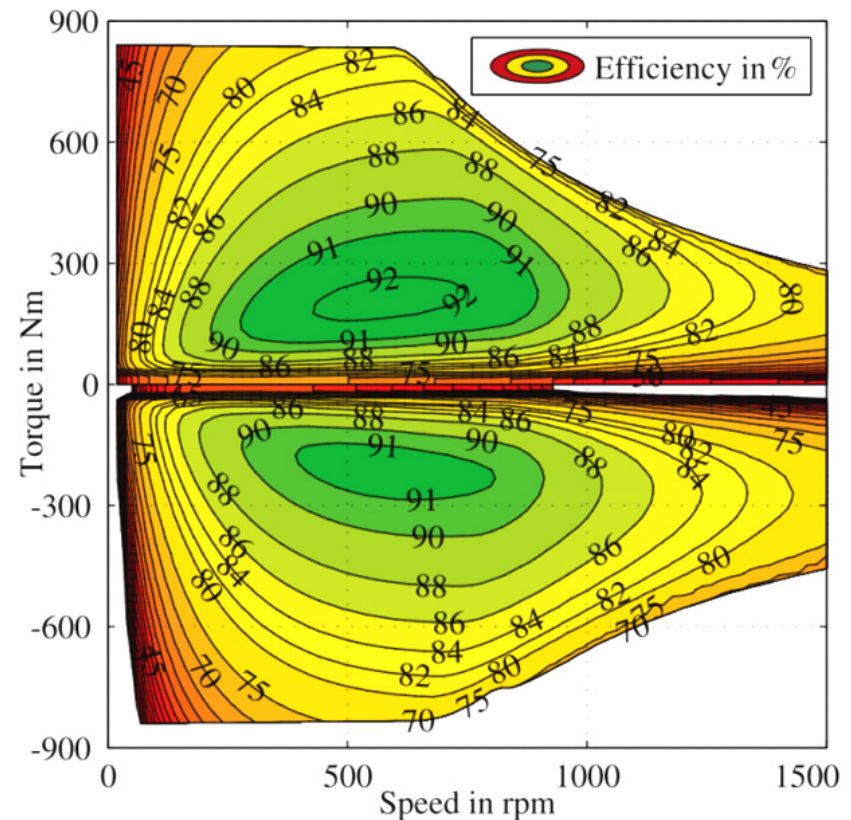


Abb.: yawing moment in all wheel driven electric vehicles

TESTING

Fraunhofer Wheel Hub Drive – Specifications and Efficiency Map

Description	Value
Rated Power	50 kW
Peak Power	72 kW
Rated Torque	700 Nm
Peak Torque	900 Nm
Max. Speed	1500 rpm
Rated DC-Voltage	400 V
Max. Efficiency	93.4 %
Mass (incl. Bearings)	42 kg
Outer diameter	364 mm
Length	105 mm

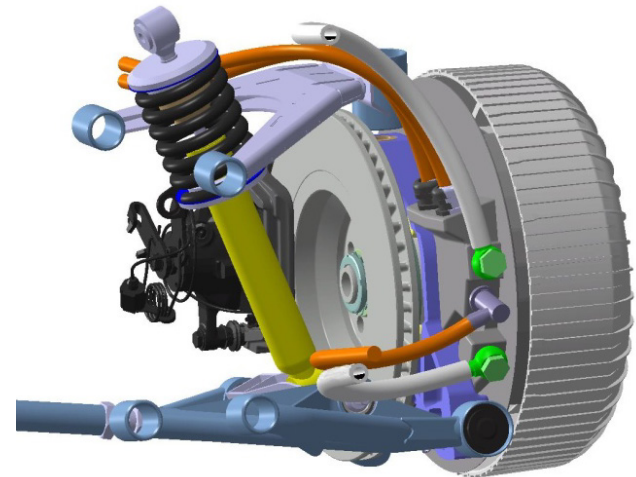


Measured efficiency map

APPLICATION

Vehicle integration and testing - Demonstrator vehicle

- Integration of two wheel hub drives at the rear axle of an electric concept car
- 400 V Lithium-ion battery system with 37.6 kWh
- Complete control over vehicle control unit, independent adjustment of torque distribution possible
- Retention of the original disc brake system at the inner side of wheel carrier
- Reconstructed suspension system



Top: Concept car »Frecc0 2.0« with wheel hub drives

Bot.: Wheel carrier with inner-side disc brake and mounted wheel hub drive

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Our Offer

Casting Technology

- combination and adaption of technology advantages for casting applications
- feasibility studies for casting processes
- prototyping of castings (lost foam or investment casting)
- fault and process analysis for casting processes
- market analysis
- test series up to pre-series engineering
- numerical simulation
- x-ray inspection | computer tomography

Component Development

- development of manufacturing methods for electric drives, especially the production of coils and housings using investment casting, lost foam casting or die casting
- electromagnetic design of electric machines, e.g. numeric field calculation and improvement of torque, efficiency and package
- simulation of system performance of the electric drive and the control concept
- development of electrical drive control units and implementation of safe control algorithms
- testing of electrical drives and assessment of generator and motor operating behavior
- integration and testing of the drive train in the complete vehicle
- technical and strategical consulting

Contact



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