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(Lightweight Forging)

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Phase I Passenger Car, 2013 – 2014

Full screen display with CTRL+L

next

Lightweight Forging ...

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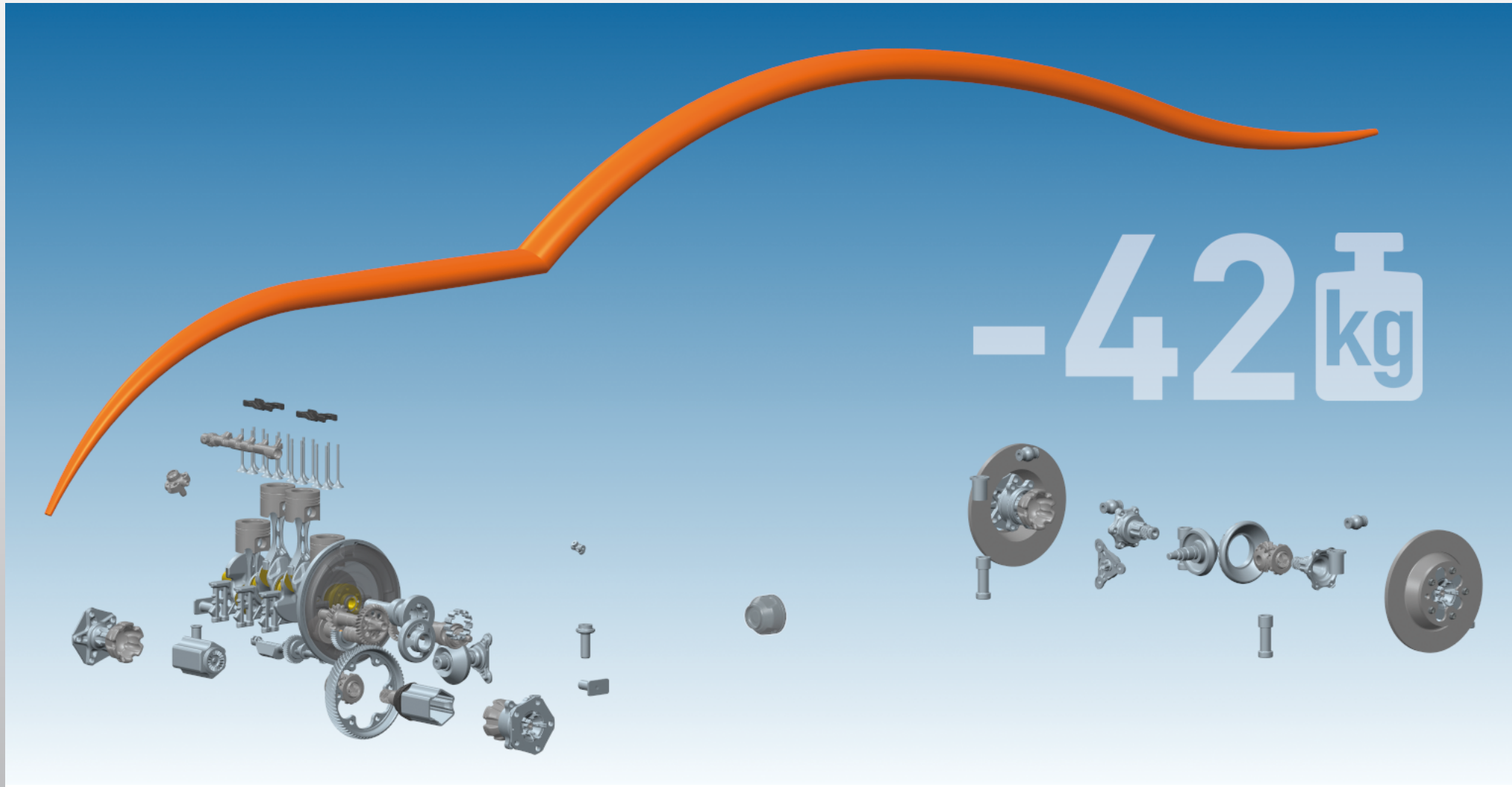
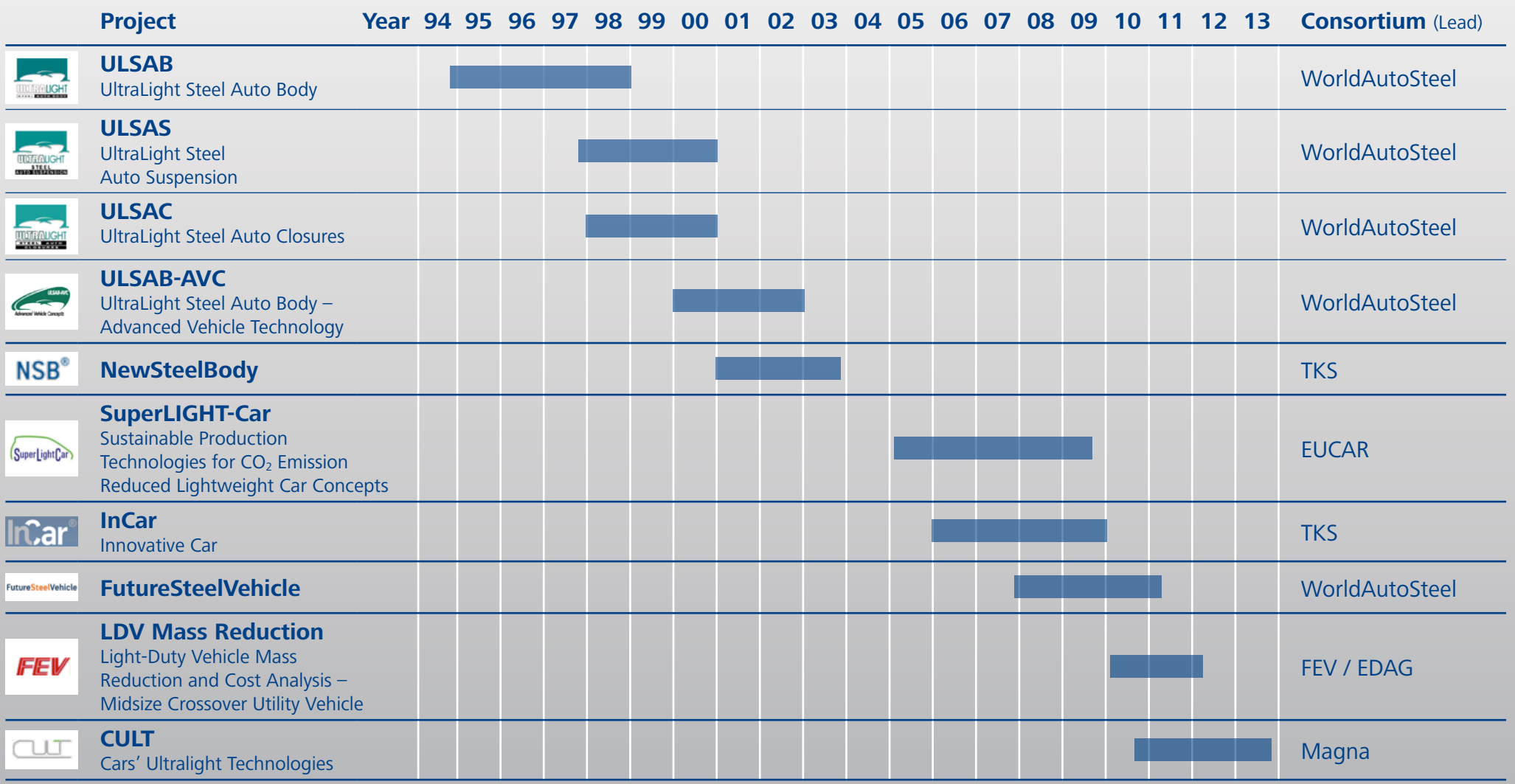


... in the powertrain and chassis of a car

Context Analysis

Systematic overview of previous automotive lightweight design projects ...



... Focus to date on sheet metal forming and car body

Automotive Lightweight Design with Forging

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- Projects to date have focused exclusively on the car body and on lightweight design solutions based on sheet metal
- An area which has seldom been considered so far is the lightweight design potential in the powertrain and chassis
- In **The Lightweight Forging Initiative**, the steel manufacture and forging industries present lightweight design concepts relating to design, material and production engineering
- Unique cooperation between manufacturers and component suppliers in the entire process chain for wire and bar products
- Demonstrating solutions, the success of which may be measured with respect to lightweight design, cost and implementation potential
- Lightweight design proposals of the supplier relating to material or production engineering are particularly effective if they flow into the early phase of part design

Clear reduction in energy consumption and CO_2 emissions possible through NEW lightweight design solutions with innovative, forged steel components

Project Motivation

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Reversal of the weight spiral through lightweight design in the powertrain and chassis

Increasing demands placed on ...

Safety	Comfort	Driving performance	Space	Variability	Quality

Weight Increase

Weight Reduction

Vehicle Manufacturers:

- Integrated vehicle concepts
- Focus on **car body**
- **Top-Down** approach

Suppliers:

- Component and production know-how
- Focus on **powertrain and chassis**
- **Bottom-Up** approach

24 Partners form The Lightweight Forging Initiative

A.+E. KELLER KALTUMFORMTECHNIK AEK

TEKFOR An Amtek Group Company

BGH

BROCH ADLER Umformtechnik

CDP BHARAT FORGE KALYANI

DEUTSCHE EDELSTAHLWERKE Providing special steel solutions

EZM EDELSTAHLZIEHEREI MARK

Georgsmarienhütte GmbH · seit 1856 · Edelstahl

Hammerwerk Fridingen

HEW

Hirschvogel Automotive Group

KAMAX

LSW Lech-Stahlwerke

metaldyne

metallumform Member of HAY | GROUP

MacLean-Fogg COMPONENT SOLUTIONS Presswerk Krefeld

PROFIL Verbindungstechnik

saarstahl

SEISSENSCHMIDT

sona Driving Tomorrow

SAH Stahlwerk Annahütte

SWISS STEEL Providing special steel solutions

SCHONDELMAIER PRESSWERK

voestalpine EINEN SCHRITT VORAUS.

Cooperation Partners

DEUTSCHE MASSIVUMFORMUNG

Stahl

Research company conducting the lightweight design potential study as well as the source of graphics

fka

Project Procedure – 1

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Structure of the lightweight design potential study:

Context Analysis

A systematic overview of previous lightweight design potential in the powertrain and chassis is available.

Benchmarking

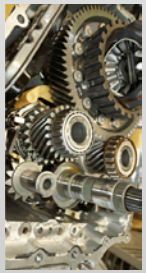
A reference vehicle was systematically disassembled, documented and recorded.

1. Determining the total vehicle weight

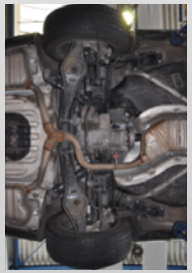
Reference Vehicle:
125 kW / 170 PS
2.0 l Turbo-DI diesel engine
Double-clutch transmission, all-wheel drive
Total mass: 1,740 kg

2. Disassembling the entire vehicle

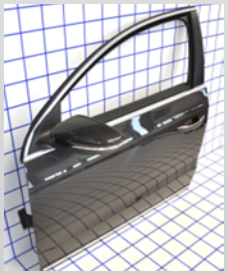
Combustion engine



Trans-mission



Chassis



Door, seat, seat-belt, tow coupling

3. Listing and naming all individual parts

4. Analysis of individual parts

Bauteilcode	Bezeichnung	Gewicht [kg]	x [m...]	y [m...]	z [mm...]	Bauteilwerkstoff
22202010112	Ölablassschraube (Typ 1) Gehäuse Differential	0,0278	16	16	40	Stahl
22202010113	Differentialträger	5,62	143	252	143	Stahl
22202010114	Kegelrollenlager 1 Differentialträger	0,1968	70	19	70	Stahl
22202010115	Lagerschale Kegelrollenlager 1 Differentialträger	0,0941	75	14	75	Stahl
22202010116	Distanzscheibe Lagerschale Kegelrollenlager 1	0,0143	75	2	75	Stahl
22202010117	Radialwellendichtring (Typ 1) Kegelrollenlager 1	0,0292	83	8	83	Stahl/Kunststoff
22202010118	Kegelrollenlager 2 Differentialträger	0,2865	84	20	84	Stahl
22202010119	Lagerschale Kegelrollenlager 2	0,1328	89	14	89	Stahl
22202010120	Distanzscheibe Lagerschale Kegelrollenlager 2	0,0213	89	2	89	Stahl
22202010121	Radialwellendichtring (Typ 1) Kegelrollenlager 2	0,0297	83	8	83	Stahl/Kunststoff

Project Procedure – 2

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Structure of the lightweight design potential study:

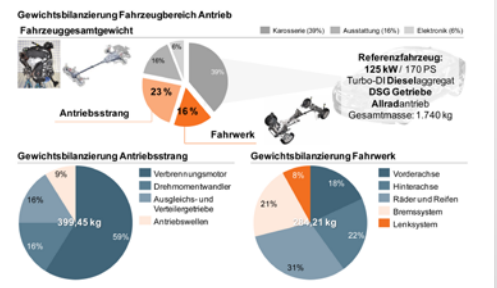
Three hands-on workshops

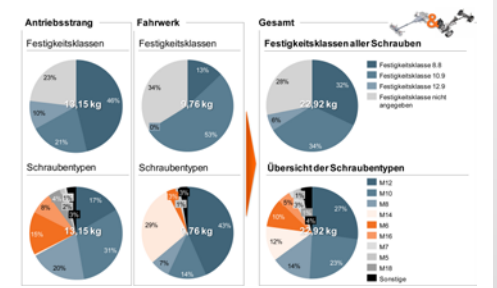
Facilitated workshops on the drive, chassis and other components.

Gathering ideas and deriving lightweight design potential from these

Previously unknown lightweight design potential has been identified on forged components in a car and translated into concrete lightweight design proposals.

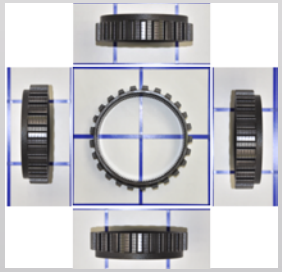
5. Weight of assemblies





6. Photo documentation

- ISO views
- Detailed views
- Installation position, where necessary
- Digital removal of manufacturer logo



7. Database implementation with proposals for lightweight design potential

Workshop Overview

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Three workshops with a total of **65 experts** from **30 companies** and **research institutions**

Analysis of approx. **3,500 parts** from the **powertrain**, **chassis** and **other** selected **components**

Formulation of **399 lightweight design ideas**, which may be subdivided into different lightweight categories

Main documentation in the **benchmarking database**

In total, a feasible lightweight design potential of 42 kg has been identified for the areas under consideration

Evaluation of the 399 Ideas

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Material lightweight design / Alternative material use

- Approx. **33 %** of the lightweight design ideas involve alternative material use
- Recommendation: **Additional analysis** of lightweight design potential through material lightweight design as part of an AiF research project (AiF is an alliance of research associations in Germany)

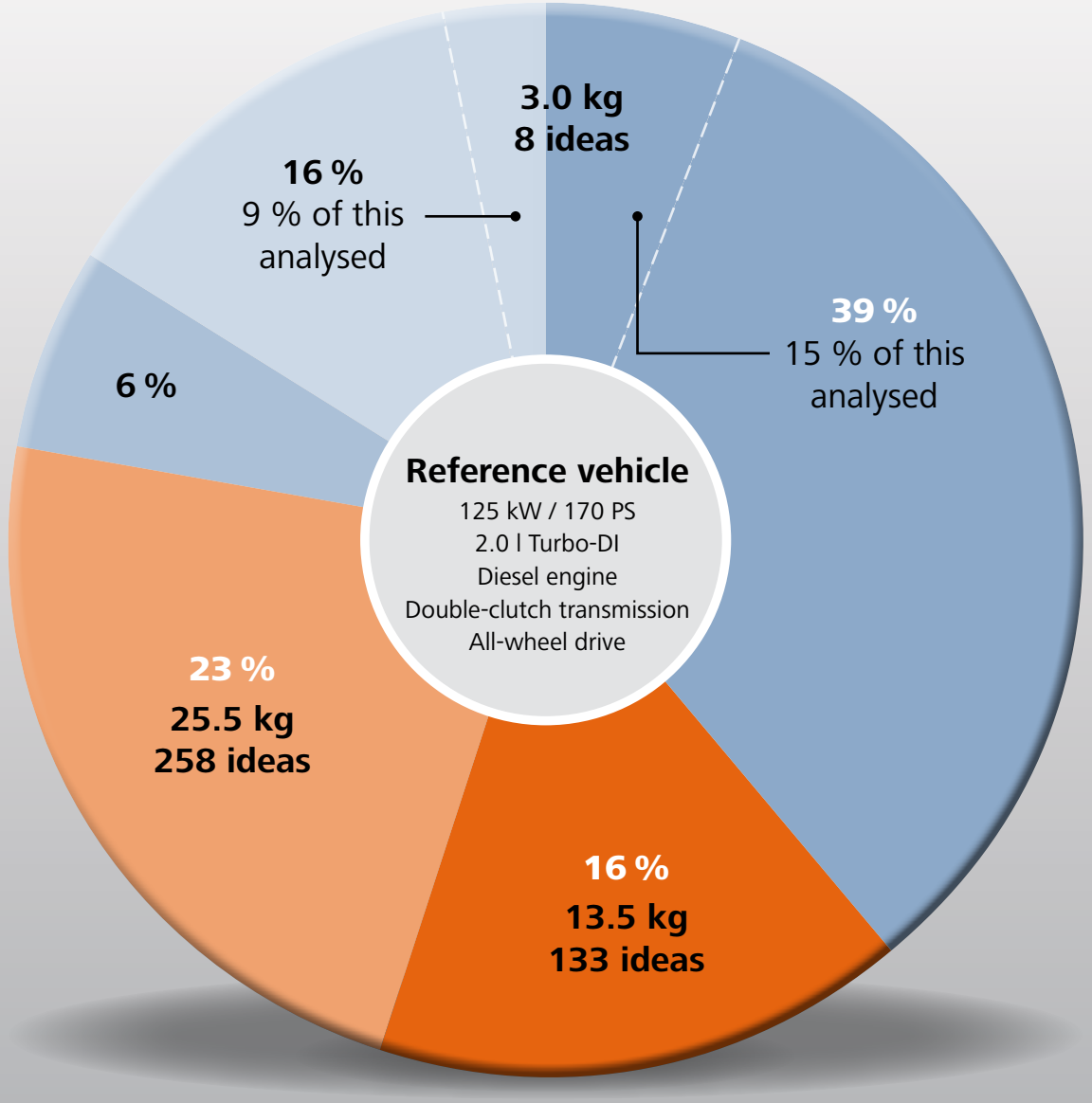
Lightweight structures and lightweight manufacturing

- Approx. **75 %** of the lightweight ideas involve adapted structural designs and are based on the use of forging suitable for large serial production
- Recommendation: **Intensive communication** of the results with customers for establishing the lightweight ideas in serial production

Conceptual lightweight design

- Approx. **6 %** of the lightweight design ideas involve innovative concepts
- Recommendation: **Intensive communication** and additional analysis of the technical feasibility of particularly innovative concepts

Overview of Car Weight



- Interior
- Electronics
- Car body
- **Chassis**
- **Powertrain**

Focus of analysis: 838 kg
Total weight: 1,740 kg

Portfolio Chart of the Lightweight Design Ideas

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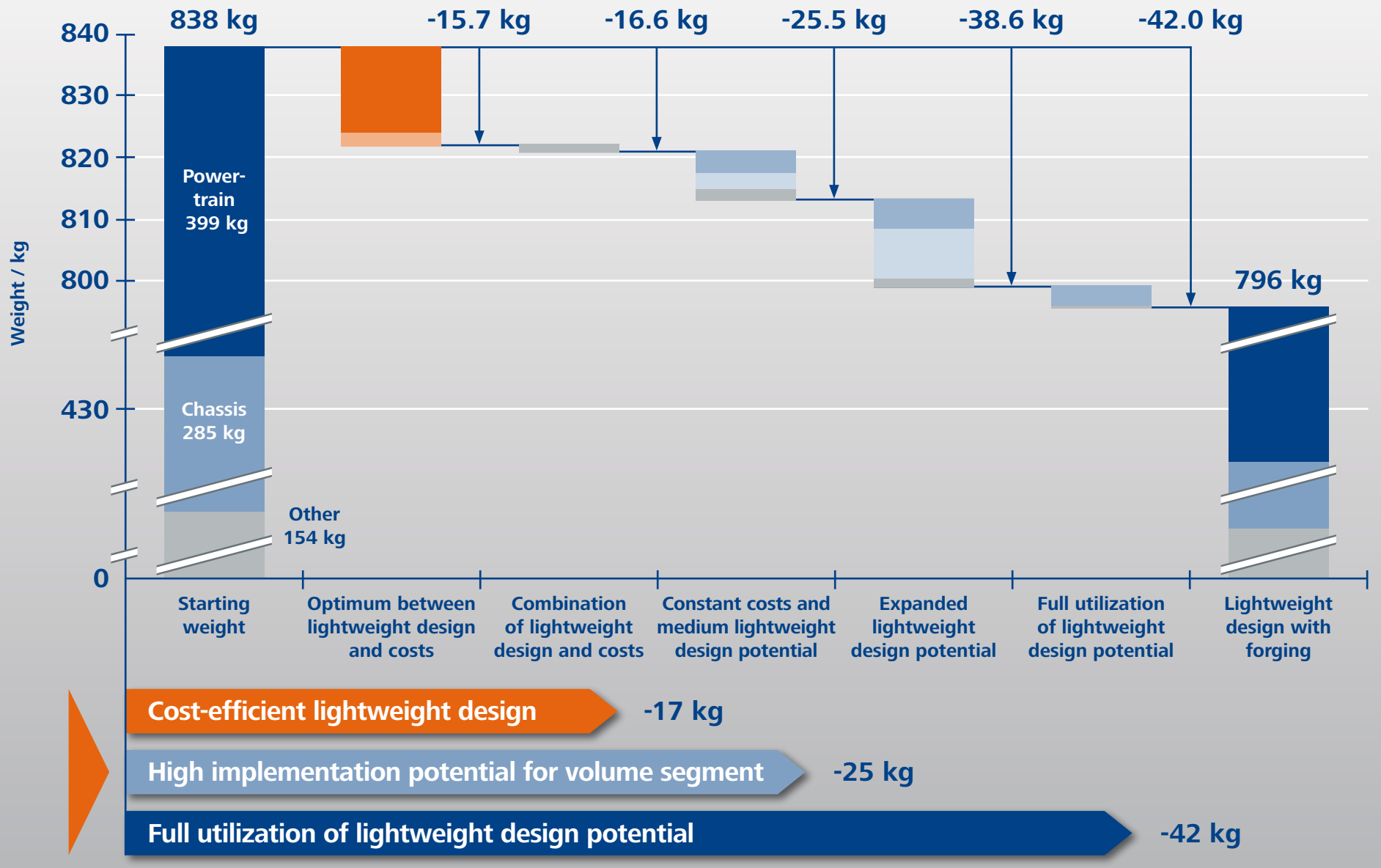

Selected Lightweight Design Potential

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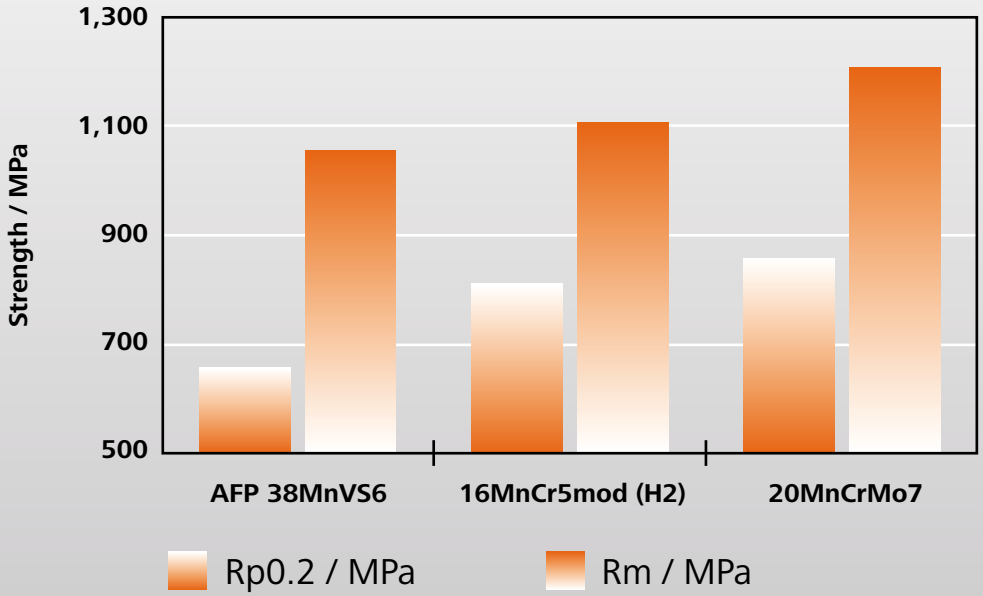
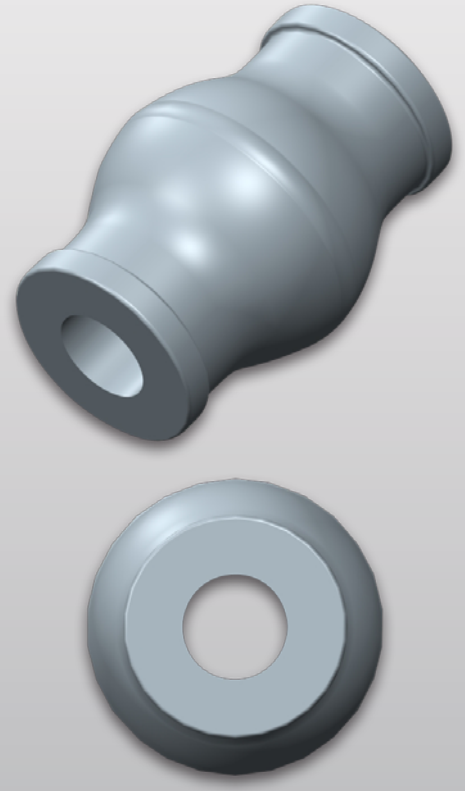
Material Lightweight Design



- Use of bainitic instead of dispersion-hardening steel
- Higher strength at higher toughness level
- **$\Delta m > 10\ \%$**

Chassis bearing



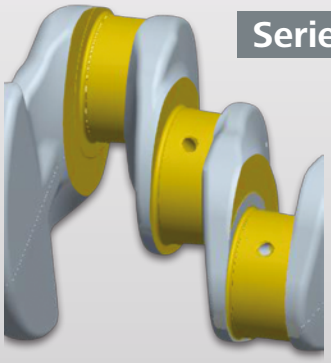
- Material substitution steel → aluminium
- Hollow design

Source: GMH, EZM, Hirschvogel, A+E Keller

Selected Lightweight Design Potential

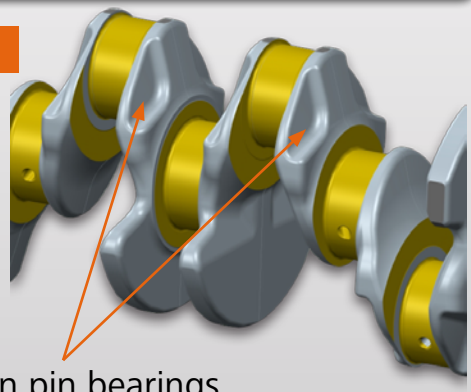
Lightweight Design in the Engine

Crankshaft



Series

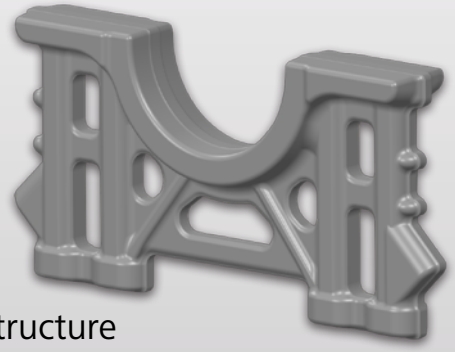
Potential



Δm = 600 g
(4.6 %)

Recesses on pin bearings

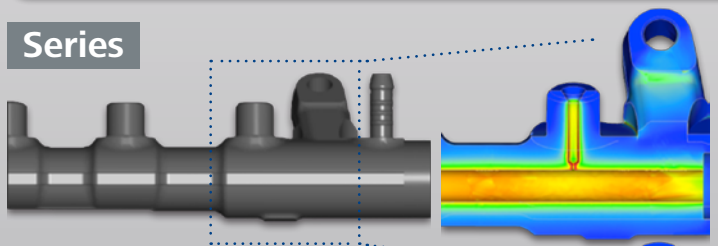
Crankshaft Bearing



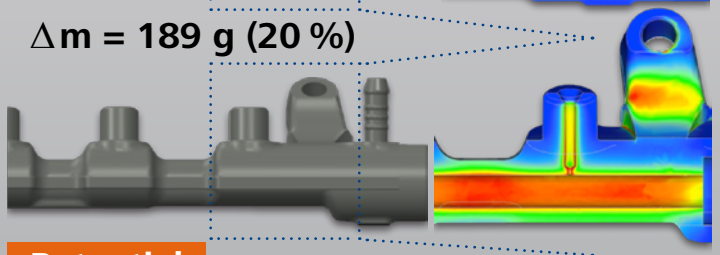
- Switch from cast part to forged part
- Load-optimized structure
- **Δm = approx. 280 g (approx. 25 %)**

Common Rail

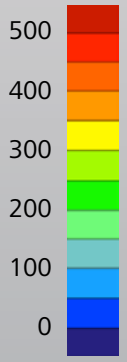
Series



Δm = 189 g (20 %)

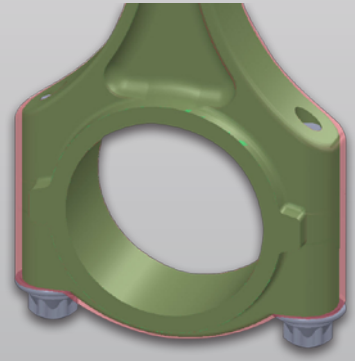


Potential



→ No increase in maximum stress in part

Connecting Rod



- Use of higher strength screws
- M8 → M7
- Reduction of connecting rod thickness / width
- With secondary effects in the entire engine **Δm ~1 kg possible**

Source: CDP BHARAT FORGE, Hammerwerk Fridingen, Kamax, Hirschvogel

Selected Lightweight Design Potential

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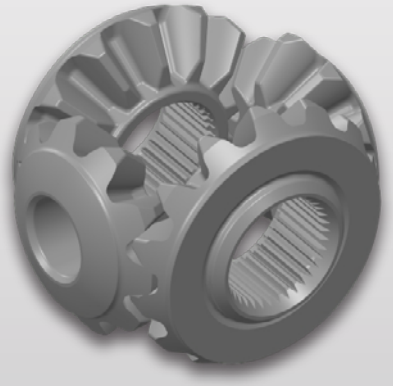
Lightweight Design: Transmission

Differential Pinions



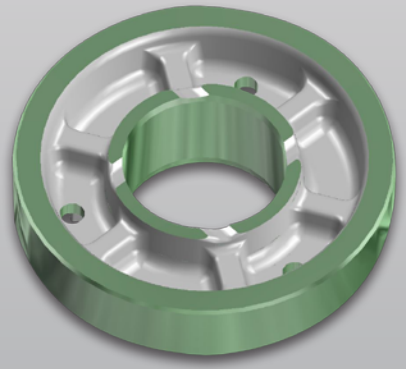
Increased load-bearing capacity through

- further developed gear geometries
- connection of the teeth to the flange

Speed Gear

- Non-rotationally symmetric geometry
- Piercings

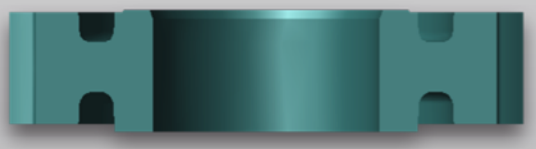
Speed Gear



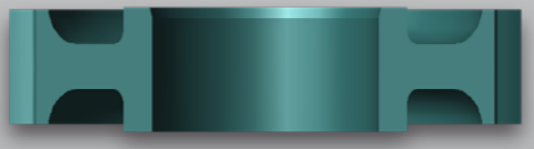
- Stiffening radial arms
- Deep pockets
- Thin wall thicknesses

Speed Gear

Series



Potential



- Reduction in wall thicknesses in areas with low stresses
- **Δm = 172 g (51 %)**

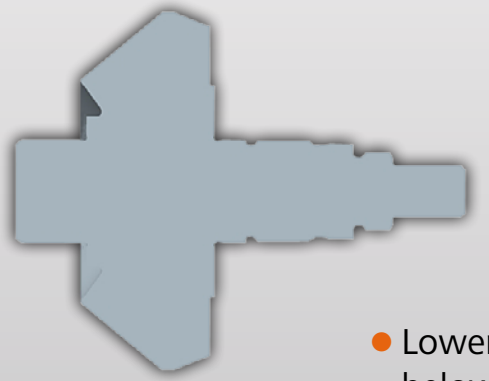
Source: Metaldyne, metallumform, Seissenschmidt, Sona BLW Präzisionsschmiede

Selected Lightweight Design Potential

Lightweight Design: Other Areas of the Powertrain

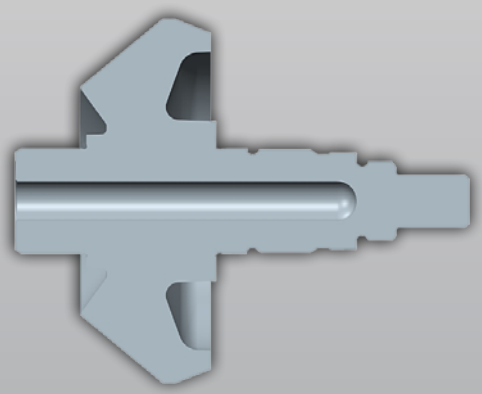
Input Shaft

Series



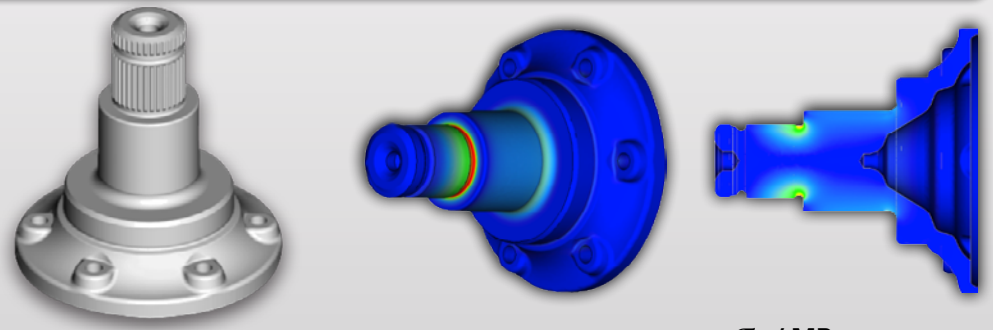
- Lower wall thickness below teeth
- Drilled hollow space
- **Δm = 510 g (approx. 25 %)**

Potential

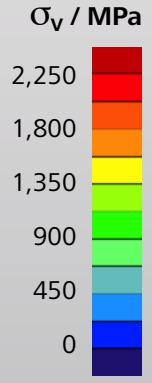


Drive Flange

Series



- Non-rotationally symmetric external geometry
- Pockets forged into part
- Internal contour deeper
- Hardened journal not round
- Constant maximum stress in part
- Torsional stiffness decreases by 14 %
- **Δm = 213 g (21 %)**



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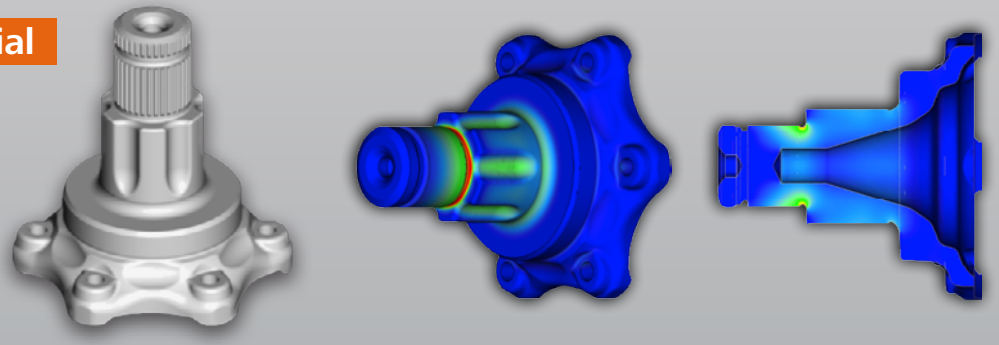
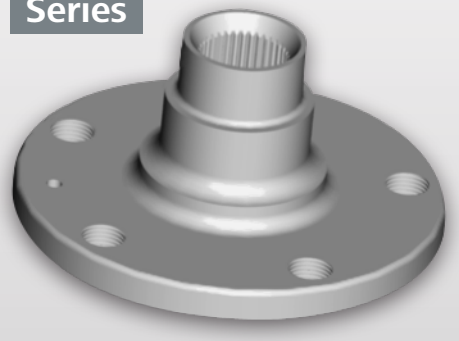


Source: Seissenschmidt, Hirschvogel

Selected Lightweight Design Potential

Lightweight Design: Chassis and Fastening Technology

Series



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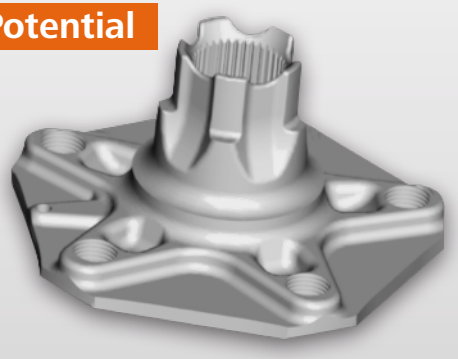
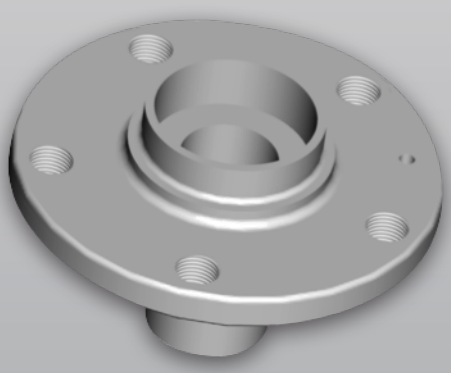


- Non-rotationally symmetric external geometry
- Journal with recesses
- Wheel rim centering via contact surfaces instead of via ring
- Stiffness optimized internal and flange contour
- **Δm = 717 g (67 %)**

Series



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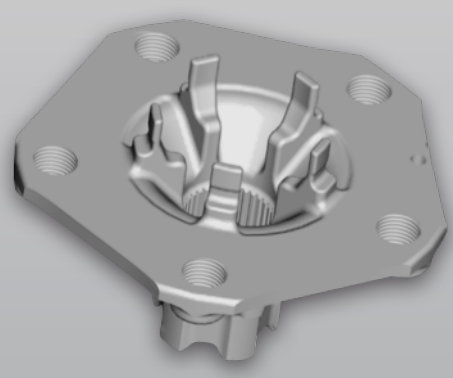

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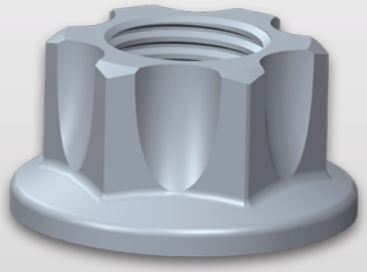
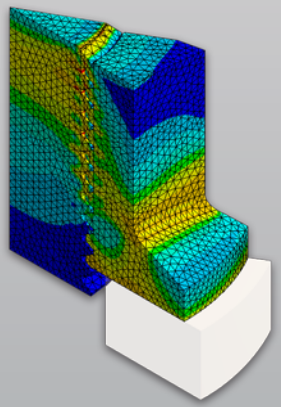


- Recesses at sites without functional relevance
- Verification of strength in simulation and test
- **Δm = 5.6 g (16 %)**

Series



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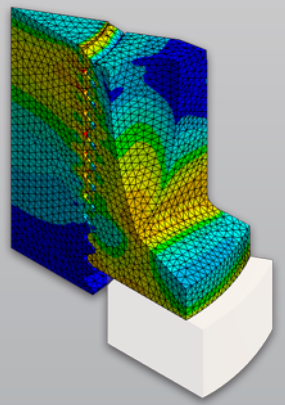

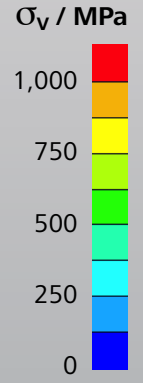

Source: Hirschvogel, HEWI

Selected Lightweight Design Potential

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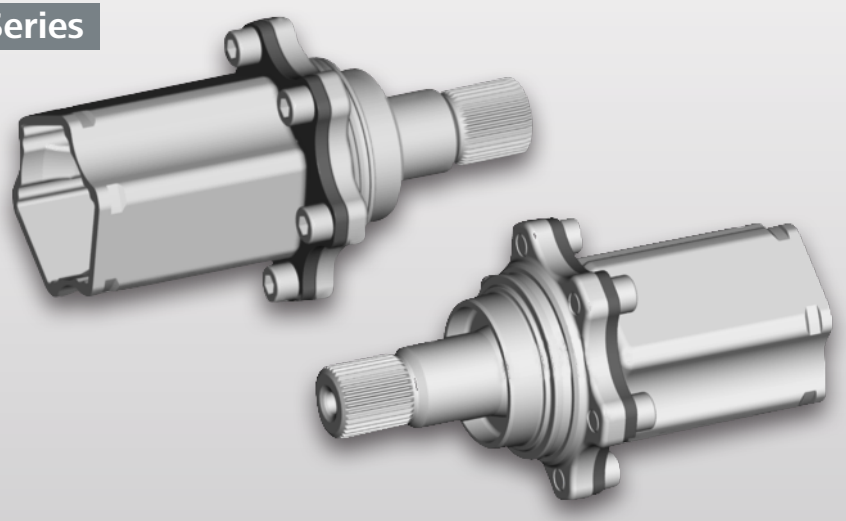
Conceptual Lightweight Design

Series



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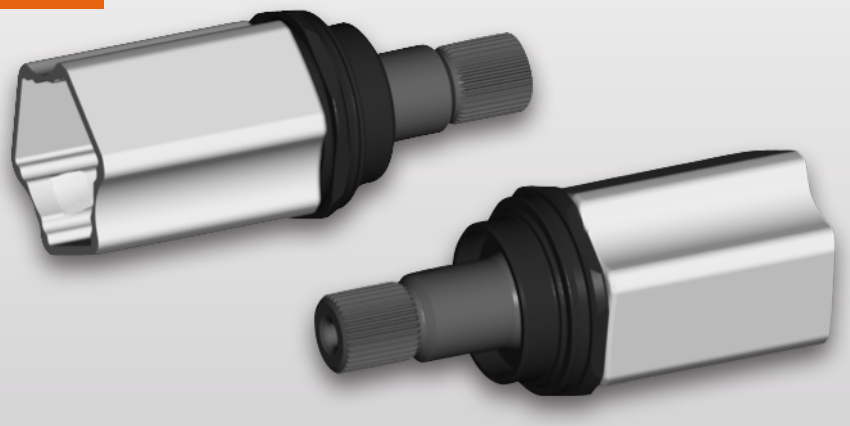
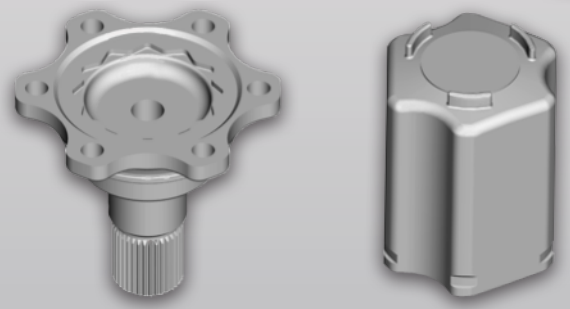
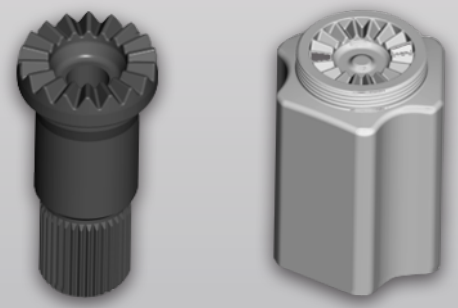
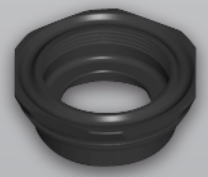




- Replacement of screw flange connection with Hirth gear pairing
- Omission of welded connection of sheet metal flange / tripod
- Replacement of six individual screws with union nut
- Reduction in assembly efforts
- Hirth gear is proven to be highly capable of bearing loads in a small assembly space
- **Δm = 828 g (33.5 %)**





Source: Hirschvogel

Outlook

- Launch of **Phase II Light Commercial Vehicle**, at the beginning of 2015 with 28 companies
- Launch of **“Lightweight Forging“ Research Network**, May 2015, duration: 3 years

Further information: www.massiverLEICHTBAU.de