FRONTIERS IN AUTOMOBILE PRODUCTION TECHNOLOGIES NOW AND IN FUTURE

1. FRAUNHOFER SOCIETY (WHERE AM I FROM …)
2. SOME TRENDS
3. AUTOMOTIVE TECHNOLOGIES

The Fraunhofer-Gesellschaft (Fraunhofer Society)


Fraunhofer Headquarter in Munich

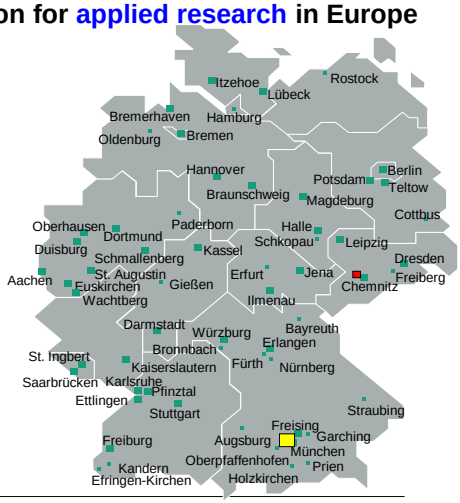
The Fraunhofer-Gesellschaft undertakes applied research of direct utility to private and public enterprise and of wide benefit to society.

Our Customers:

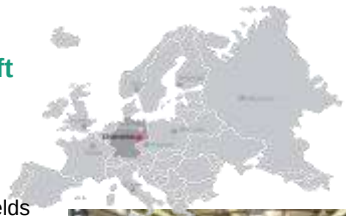
- **Industry**
- Service sector
- Public administration

Fraunhofer - the largest organization for applied research in Europe

- 66 Fraunhofer Institutes
- more than 23,000 employees, (natural sciences and engineering)
- research volume >2.0 bill. € per year (1.6 billion by contract research)
- International collaboration, representative offices in Europe, the US, Asia and the Middle East



THE **FRAUNHOFER IWU**
One Institute of the Fraunhofer-Gesellschaft



Short profile

- about 550 employees
- 33 million Euro “budget” (2014); (½ from industry)
- large production technology “laboratories” → testing fields
- locations in: Chemnitz, Dresden, Augsburg, Zittau

IWU Campus Chemnitz 2012*

R&D Competence **„Resource efficient production“**

Fields of expertise

- Machine Tools - Mechatronics
- Lightweight Components
- Cutting Technologies
- Forming Technologies
- Joining and Assembling
- Production Management

Mainforum Mexico 2014-03_Pz

Automotive Frontiers. mainforum2025.com

Automobile view - automotive development

(recent) keywords of OEM’s and suppliers:

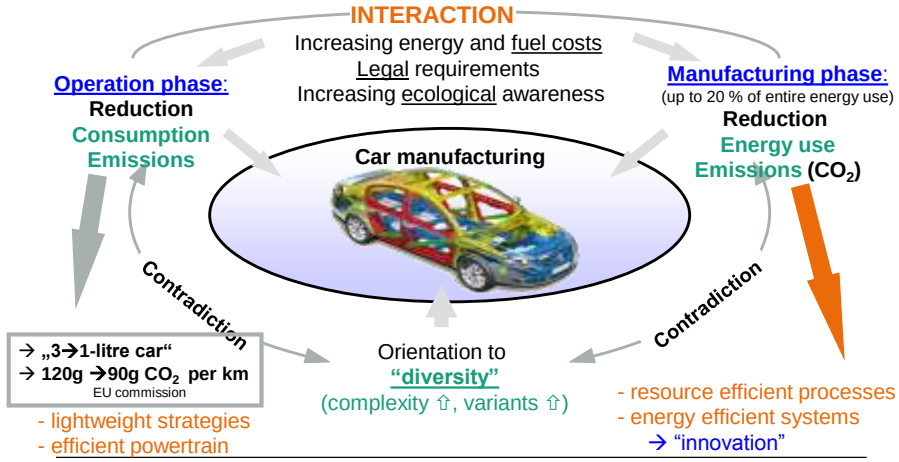
- Market share and Profit
- Product innovation and diversity
- Output and Productivity
- Competition
- …

- CO_2 – “output”
- E-Mobility
- New engines
- Lightweight cars
- Energy and Resource Efficiency
- Green / Blue production
- Advanced Information Techniques in Production

Mainforum Mexico 2014-03_Pz

Automotive Frontiers. mainforum2025.com

Challenges / Innovation



Automotive Frontiers. mainforum2025.com

AUTOMOTIVE TECHNOLOGIES ….

- Increase of Product Properties
- Increase of Product Functionality
- Increase of Production Efficiency
- Increase of Flexibility in Production

→ Selected approaches and case studies

1 Car Body

2 Powertrain

Automotive Frontiers. mainforum2025.com

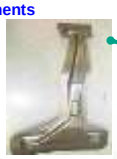
Car body Technologies

- ➔ component development + characterization
- ➔ process development + tool design
- ➔ material characterization + simulation

- sheet metal components for **body shells**
- deep drawing
- tempered forming
- cutting processes

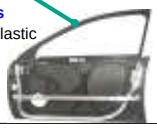
- **structure profiles**
- hydroforming
- bending

- **sheet metal components**
- deep drawing
- tempered forming
- incremental forming
- active media forming
- cutting processes



- **ultra high strength components**
- press hardening of sheet metal
- press hardening of profiles

- **hybrid workpieces**
- forming of metal / plastic
- tempered forming



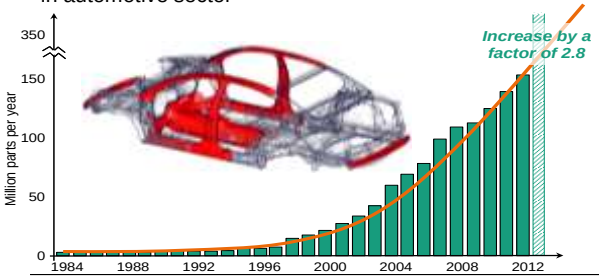
- **joining/assembly**
- mechanical joining (clinching, punch riveting, seaming)
- bonding/mechanical joining
- thermal joining

Automotive Frontiers. mainforum2025.com

Form Hardening

Form or press-hardened components

- High-strength components with tensile strength up to 1700 MPa
- Tailored properties → e. g. B-pillar
- Continuously increasing demand for press-hardened parts in automotive sector



Source: VW, Schuler

Automotive Frontiers. mainforum2025.com

Form Hardening of Tubes

Tubes
Material: 22MnB5
Dimensions: ∅70 x 2 mm, 400 mm
Coating: x-tecR CO 4020

- Temperature **monitoring** by pyrometer (inductor)
- Temperature **measurement** by infrared thermometer (tooling)

Time for handling t = 12 s

delta T ≈ 120 K

Mainforum Mexico 2014-03_Pz

Automotive Frontiers. mainforum2025.com

Magnesium Forming of Large Carbody Components

Temperature Supported Forming and Joining Technologies

Profile Bending and Gasforming

Deep Drawing

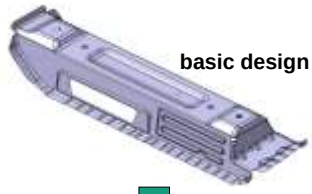
Stretch Forming

Hemming

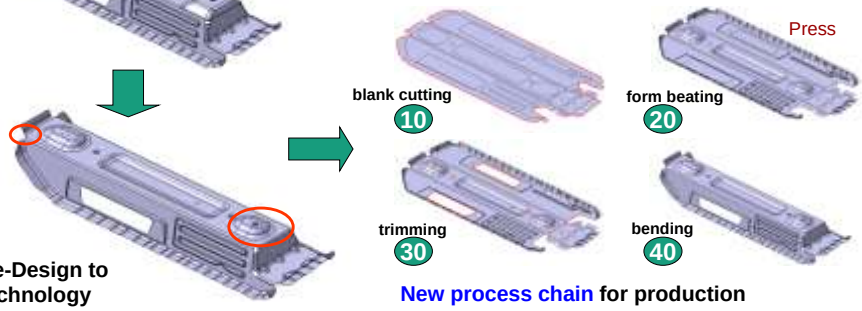
Mainforum Mexico 2014-03_Pz

Automotive Frontiers. mainforum2025.com

New Forming Concepts at Reinforcement Parts (Seat Cross Member)



- **Basic:** seat cross member – deep drawing (transfer press)
- Re-Design for one forming step '20' (form beating) and flexible forming machines '10', '30', '40'



Re-Design to technology

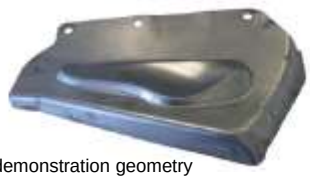
New process chain for production

Automotive Frontiers. mainforum2025.com

15

Technology Development "Form Beading"

„Form Beading" = deep drawing without or with just a partial blank holder



demonstration geometry "reinforcement rear light" (serial part)

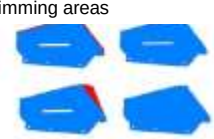
benefits:

	blank size	blank weight
old	680 x 280	**1495 g**
new	620 x 230	**1122 g**

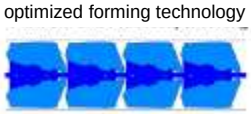
savings in material costs at ca. 96.000,-€/productioncycle (7 years)

method plan and geometry optimisation supported by FE-analysis

technological surfaces and trimming areas



optimized forming technology



progressive die
light blue: final part; dark blue: scrap

Automotive Frontiers. mainforum2025.com

16

Increase of Flexibility in Production

Individuality

- increasing demands concerning design, comfort, performance, safety…
- car ➔ status symbol
- fun-oriented design

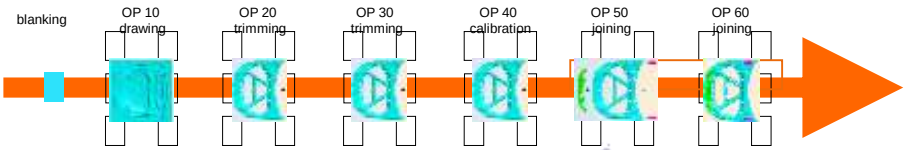
- ⇨ **variant number** ⇧
  caused by
  - variants
  - engine variants/sizes
  - interior options
  - ...
- ⇨ **part number** ⇩
- ⇨ **complexity** ⇧
- ⇨ **manufacturing period** ⇩
- ⇨ **cost pressure** ⇧

FLEXIBILITY

➔ **a tooling and system topic !**

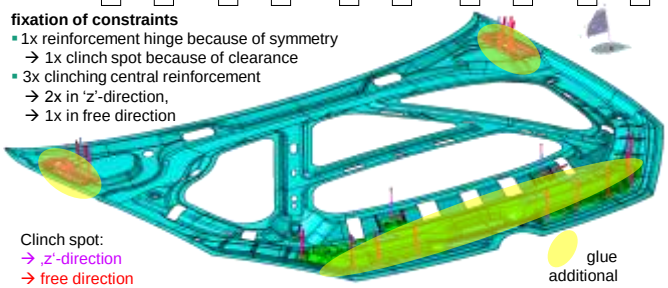
Technology Interaction + Combination in Press Lines

Reduction of Process Steps - **Usage of 'Free' Presses for Joining**



fixation of constraints

- 1x reinforcement hinge because of symmetry
  → 1x clinch spot because of clearance
- 3x clinching central reinforcement
  → 2x in 'z'-direction,
  → 1x in free direction



Clinch spot:
→ „z'-direction
→ free direction

glue
additional

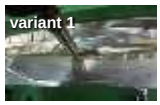
flexible, tool integrated
clinching unit

Using **Process Combinations** - Deep drawing + Incremental forming

Example: **Gear console left**

Forming step 1 ⇨ Uniform pre-form (deep drawing)
Forming steps 2/3 ⇨ Final geometry / derivate realization (incremental forming)

Part areas to be post-formed



Incremental post-forming

Uniform pre-form

Effects

- Reduction of tool number from **10 to 6**
- Further potential: Reduction to 4 tools (process-related design)

⇨ **Better Material Use**

Mainforum Mexico 2014-03_Pz

Modular Tool Systems (for sheet metal forming)

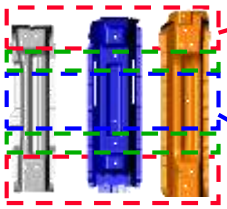
Results (example: crossbeam)
realization of **different part geometries**, based on **variable adjustment** of active **tool components**

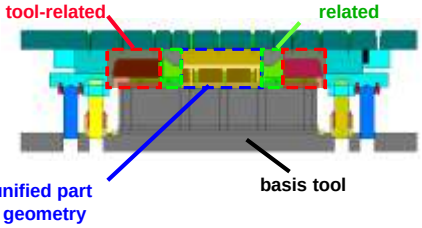
Further potentials
- **forming-oriented** part **design**
  ⇨unification of non-functional areas
- determination of suitable **part families**

Re-Usibility
- components of basis tool
  → up to **80%**
- active components
  → up to **50%**

➔ savings: - material
- processing

examples for different cross beams





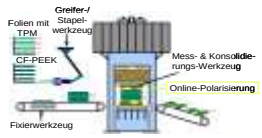
Mainforum Mexico 2014-03_Pz

Increase of Functionality in Products ….

"Vision "– Integration of "Functions" into Structural Components

PT-PieSA **Large Scale Production Technologies for Components out of Light Weight Metals and Fibre-reinforced Composites with Integrated Piezo Sensors and Actors**

Integration into Carbon-Fiber-Components with thermoplastic-Matrices



Forming of Piezo-Metal-Modules

Integration by Die Casting

Trans-regional **Collaborative Research Centre** (in total 12 sub-projects)
2006 to 2014 and ongoing; funding by DFG (German Research Foundation)

Mainforum Mexico 2014-03_Pz

Automotive Frontiers. mainforum2025.com

Selected approaches and case studies

1 Car Body

2 Powertrain

Mainforum Mexico 2014-03_Pz

Automotive Frontiers. mainforum2025.com

Powertrain Technologies

- camshaft
- mill turning
- assembly
- grinding
- deep hole drilling
- fine blanking

- camshaft
- hydro forming
- grinding

- propeller shafts
- spin extrusion
- flow forming

- gears
- cross rolling

- cylinder crankcase
- fine drilling
- honing
- milling/drilling

- conrod
- precision-forging

- injection nozzles
- micro-EDM
- micro-ECM

- gear shafts
- cross rolling
- spin extrusion

Automotive Frontiers. mainforum2025.com

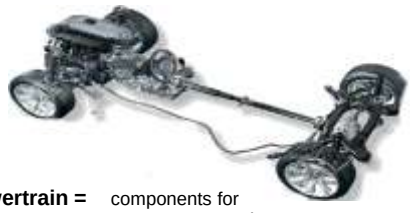
Energy + material efficient Powertrain Technologies

Strategic Products

➔ **Low-Energy Engine**
- CAMSHAFT
  weight reduction: ≈ 60 %
- CRANKSHAFT
  weight reduction: ≈ 20 %
  CON-ROD
  weight reduction: > 20 %

➔ **Lightweight Gearing**
- GEARS (by rolling)
  process time: ≈ 50 %
  material use: ≈ 30 %

➔ **Lightweight Cardan/Drive Shaft**



powertrain = components for
- torque generation
- torque transmission

„from engine to wheel“

Automotive Frontiers. mainforum2025.com

Hydroforming of Camshafts

Overview

State-of-the-Art

initial situation
camshaft – cast, forged

[2,4 kg]

TKPresta camshaft
[1,4 kg, - 42 %]

1. generation

hydroformed camshaft
[1,2 kg, - 50 %]

2. generation

hydroformed camshaft
[1,1 kg, - 55 %]

Constructed Camshaft

hydroforming with **coating**
[1,4 kg, - 42 %]

1. generation

hydroforming with **nitration**
[1,2 kg, - 50 %]

2. generation

Hydroforming with integrated **hardening**
[1,0 kg, - 59 %]

3. generation

Monolithic Camshaft

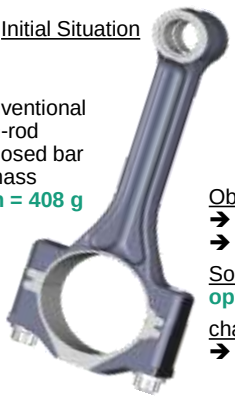
Mainforum Mexico 2014-03_Pz

Automotive Frontiers. mainforum2025.com

Lightweight Con-Rod

Initial Situation

conventional con-rod
- closed bar
- mass
  m = 408 g



cut | **forge rolling** | **spread forging** | **pre-engraving** | **finished engraving**

Objective
➔ part weight ⇩
➔ material use ⇩

Solution Approach
optimized con-rod design

challenges
➔ **feasibility/process stability**
- forging quality E (fine forging)
- fineness

lightweight con-rod

mass savings **> 20 %**

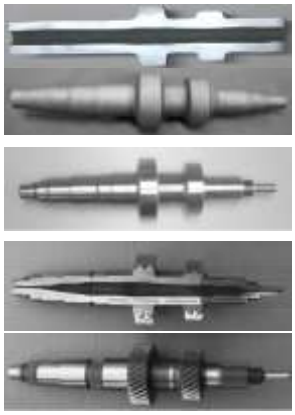
Mainforum Mexico 2014-03_Pz

Automotive Frontiers. mainforum2025.com

Hollow Gearshaft

Optimizing the entire process chain

- **hollow shaft** realization
  e. g. spin extrusion
- **pre-forming**
  e. g. - wedge rolling
  - radial/axial swaging
- **gear realization**
  e. g. - gear/profile rolling
  - axial forming
- **finishing**
  e. g. - turning
  - grinding



wedge rolling / swaging

soft maching / gear rolling

final hard maching
(after heat treatment)

Gear Rolling

Stub tooth gearing

- Tooth height factor y < 2

High Gears by rolling ?

- Tooth height factor y > 2 ?

2001 2003/2004 2005/2006 2008/2009 2010

State of art

State of research

$$\text{tooth height factor } y = \frac{\text{tooth height } h_z}{\text{normal module } m_n}$$

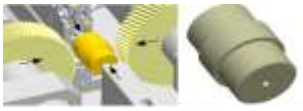
Cold rolling of high gears

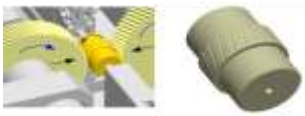
Gear Rolling

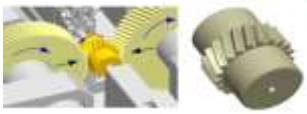
1 Part clamping

2 Start of rolling

3 Penetration / calibration phase







Gear Rolling

Examples

Year 2014

… by cold rolling !

Dry Finish Machining

electrical energy consumption in high rate grinding
- - 90 % for the coolant system (lubrication)
- - 10 % for the machining process (machine)

Dry- and MQL- Drilling of Deep Hole in Powertrain Components

Goal:
- substitution of wet-machining (705 l/h)
- by minimal quantity lubrication (0,03 l/h)


engine block

GG 25
∅ 12 mm
L/D 25


crankshaft

GGG 80
∅ 4 mm
L/D 25

High Performance Grinding


grinding of a cam shaft


grinding of a crank shaft

… there is further potential for innovation

in

production technologies

and

production systems

"… not the strongest
or
most intelligent
species are those, who
survive,

but rather those
who can react
fastest to
changes"

*)Charles Darwin

Mainforum Mexico 2014-03_Pz