FEA-BASED DEVELOPMENT OF NEW LASER-WELDED CAN

Dipl.-Ing. Thomas Lieber

Fraunhofer IWU

Application orientated Research in Germany

FEA-BASED DEVELOPMENT OF NEW LASER-WELDED CAN

- Agenda
  - Short Introduction of Fraunhofer Association
  - Three piece aerosol tinplate can - laserwelded
  - Base for FEA-Optimisation
  - Component Optimisation by FEA
  - Component and Can production
  - Summary and Outlook

Fraunhofer IWU

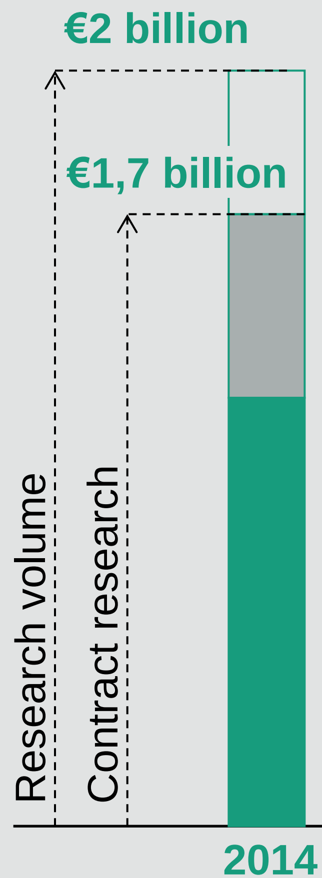
FEA-based development of new laser-welded can

- Fraunhofer Association – in general

Applied research for immediate utility of economy and benefit of society

More than
24 000 staff

66 Institutes and
research units



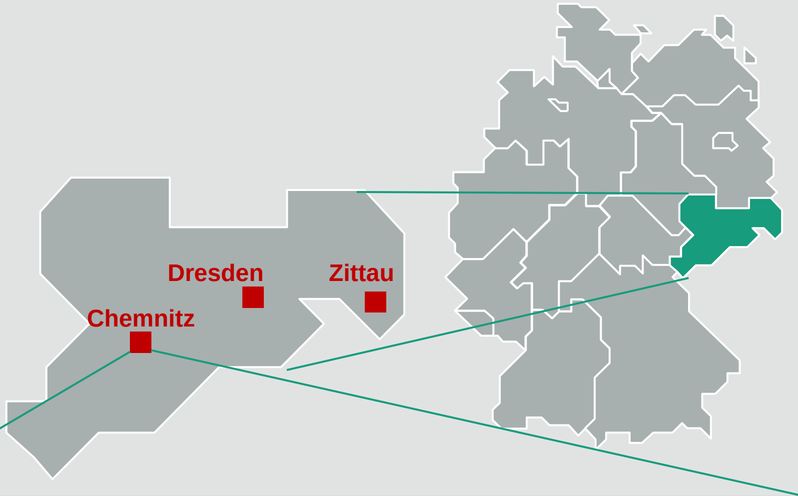
roughly **30%** are contributed by the German federal and *Länder* governments

roughly **70%** are generated through contract research on behalf of industry and publicly funded research projects

Fraunhofer
IWU

FEA-based development of new laser-welded can

- Fraunhofer Institute for Machine Tools and Forming Technology - IWU
  - founded in 1991
  - about 620 employees
  - €41,5 million annual budget
  - in **Chemnitz**, Dresden and Zittau



Main Scientific fields

- Mechatronics and lightweight structures
- Machine tools, production systems and machining
- Forming technology and joining

Fraunhofer IWU Chemnitz

Fraunhofer IWU

FEA-based development of new laser-welded can

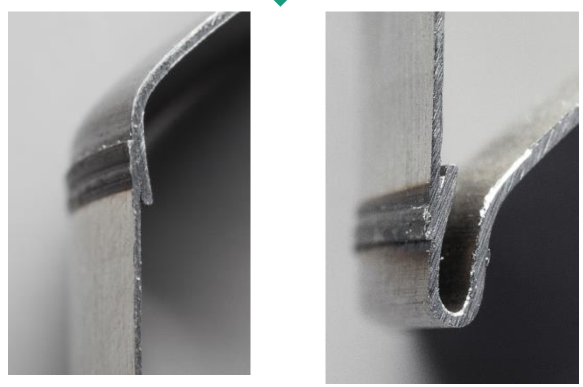
- Fraunhofer IWU – Department Sheet Metal Forming
  - sheet metal forming / hot forming
  - media and energy based forming technologies
  - cutting technologies
  - materials testing and characterization
  - coupled simulation of forming processes
  - development and manufacturing of toolings

FEA-based development of new laser-welded can

- Three piece aerosol tinplate can

- **State-of-the-Art**

- **Seamed can**



- **Laserwelded can**

caprosol

FEA-based development of new laser-welded can

- Base for FEA-Optimisation – Start up geometry

- **Can Prototype Diameter 45**

- **CAD-Model of Diameter 45 can**

- **Components – initial geometry**
  - can top end
  - can body
  - can bottom end

- **Initially ends cover the body and laserwelds on both ends outside**

- **<u>Challenge</u>:**
  Prototype safety was not sufficient for market introduction –> Optimisation of can components for lighter and more safe product needs to be done !

- **<u>Questions</u>:**
  What geometries and materials are needed for fullfillment of the product safety tests ?

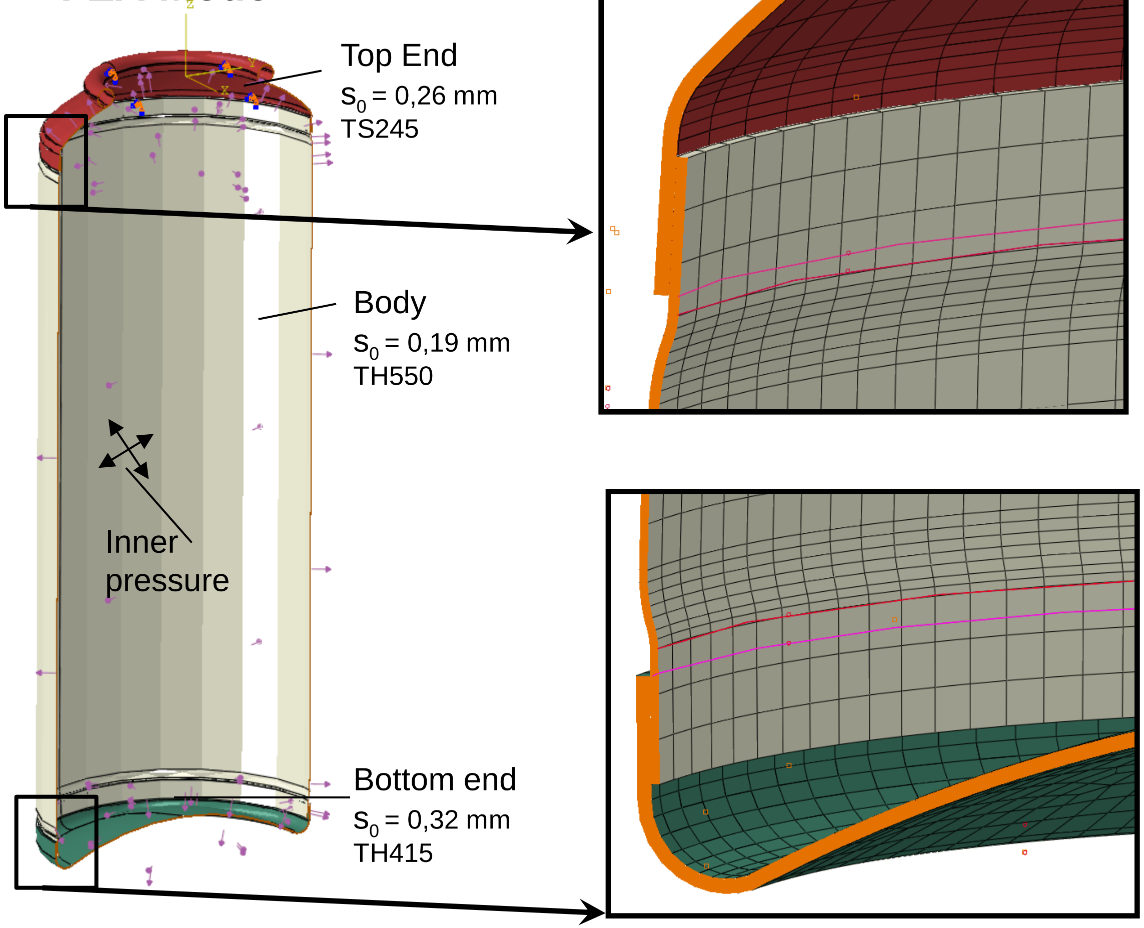
Fraunhofer
IWU

FEA-based development of new laser-welded can

Base for FEA-Optimisation - FEA of pressure test

- **Specifications for pressure test: 15 bar buckling point**
- **Assumptions on materials and thicknesses from several cans on the market as starting point**
- **Result in FEM: At what pressure does the can collaps ? Which material and thickness does the can need to reach the specifications?**

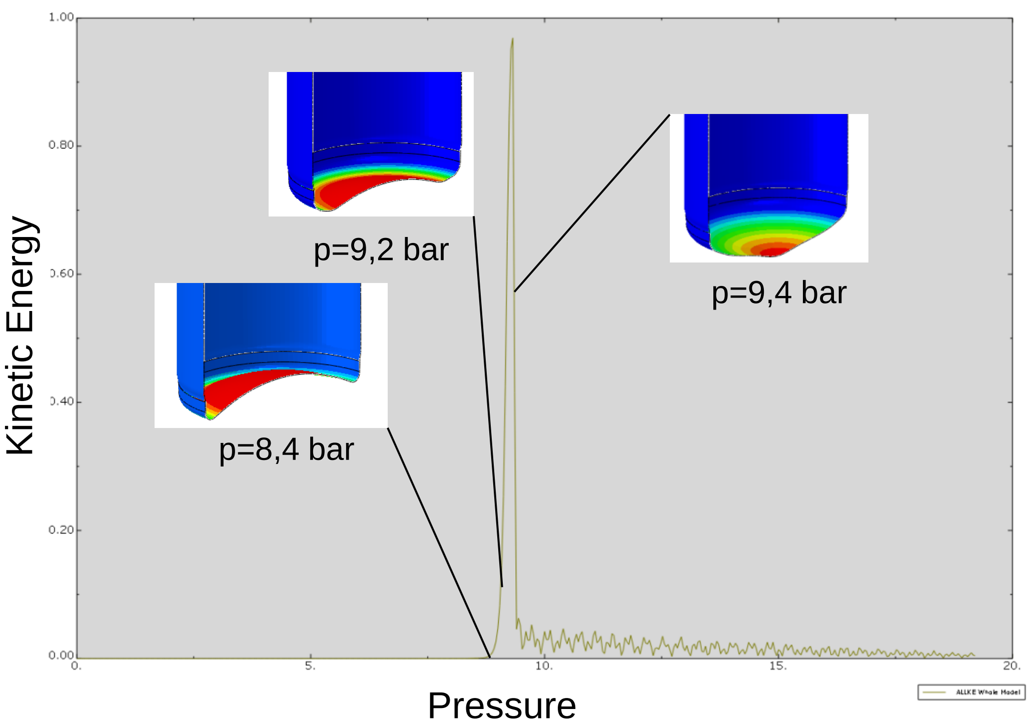
FEA-Model

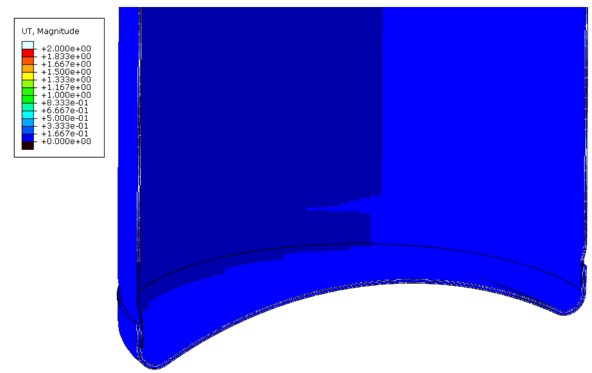


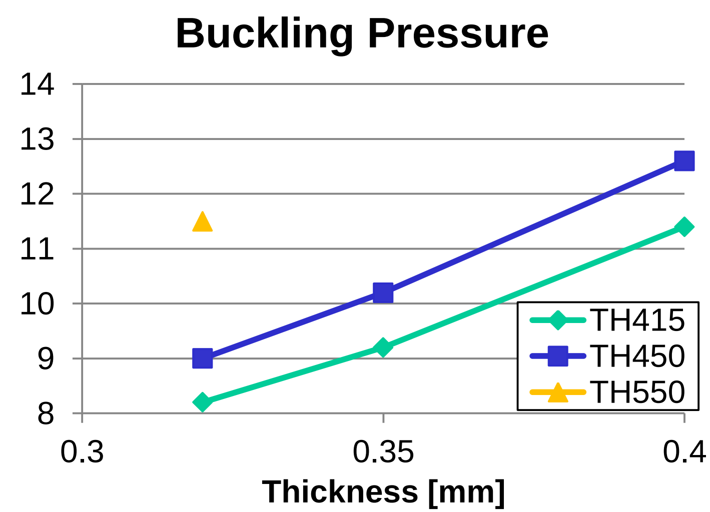
FEA-based development of new laser-welded can

- Base for FEA-Optimisation – Results of pressure test

  - **Results of pressure test**







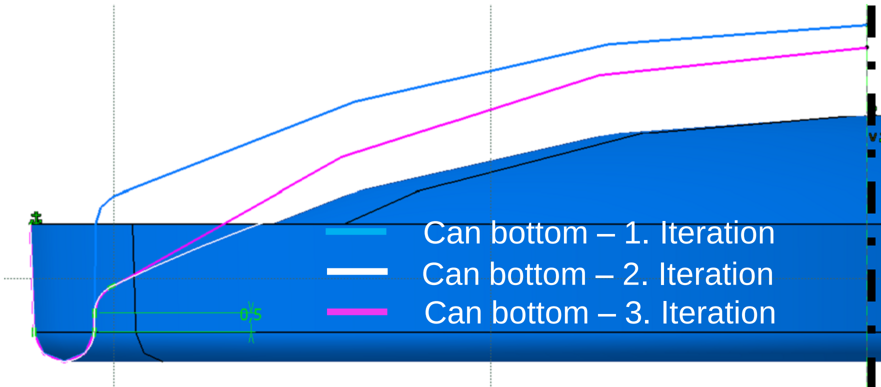
Fazit: No way of reaching the specifications -> can bottom needs to be optimised !

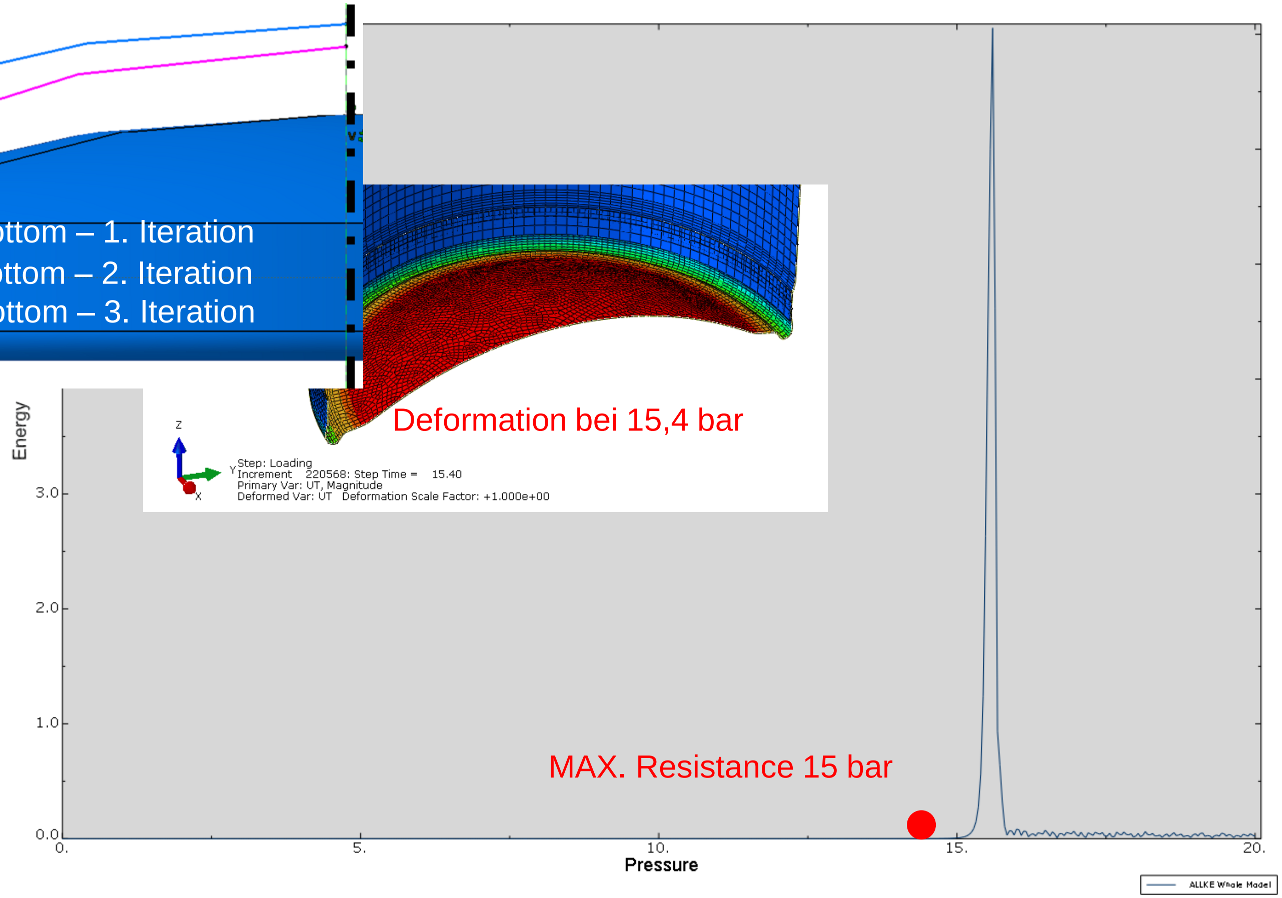
Fraunhofer IWU

FEA-based development of new laser-welded can

- Base for FEA-Optimisation – Initial geometry change on can bottom

  - **Cross-section of can bottom**





Results on 1. Iteration

CAN - Bottom

s_0 = 0,32 mm

TH415

Results on 3. Iteration

CAN - Bottom

s_0 = 0,32 mm

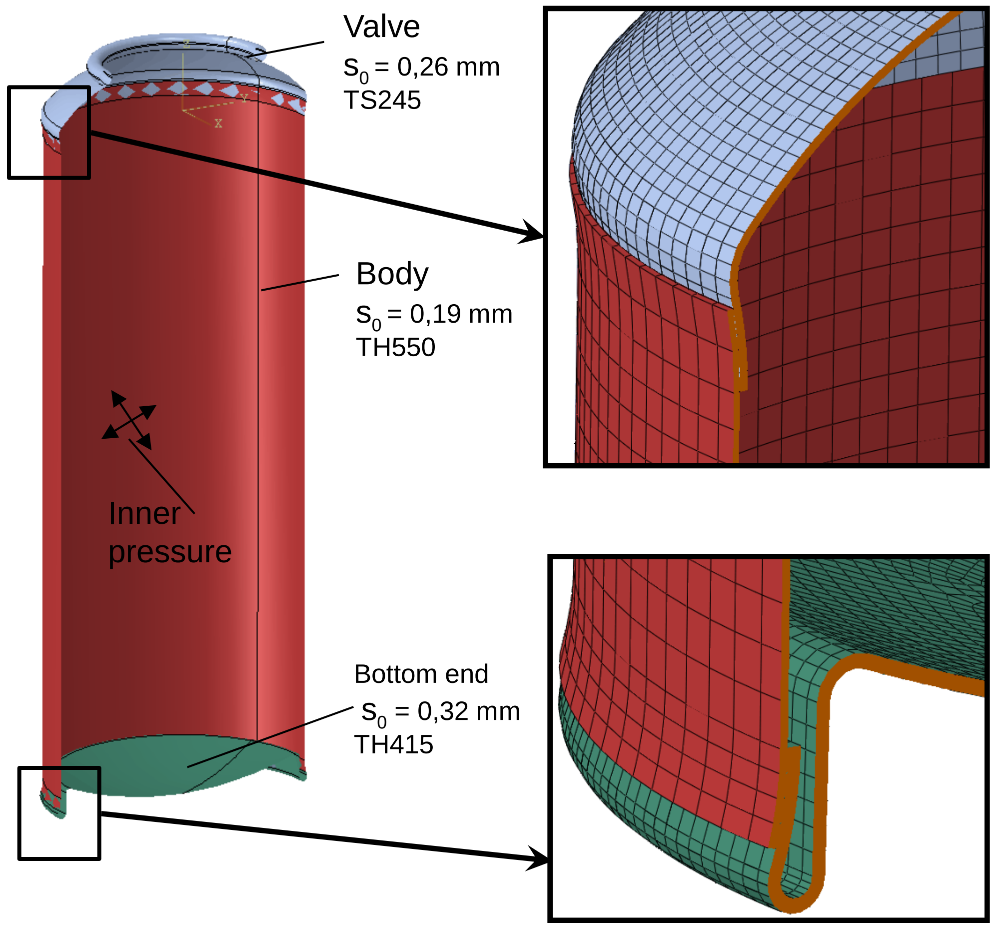
TH415

Fazit: Seems to work but more material effort -> can bottom needs to be optimised !

Fraunhofer IWU

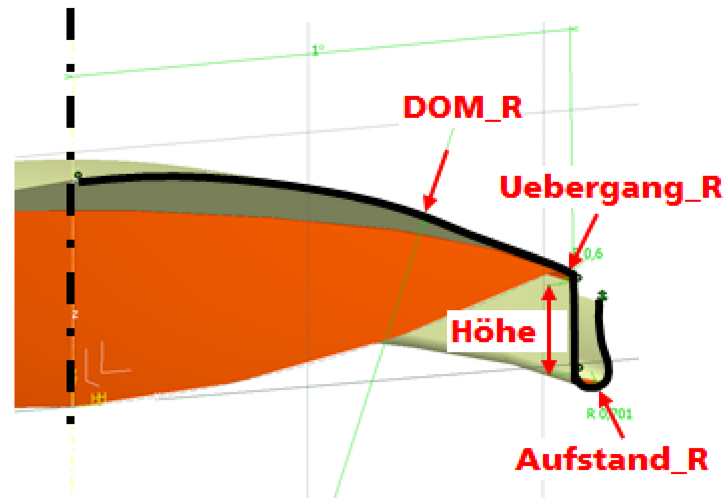
FEA-based development of new laser-welded can

- Component Optimisation by FEA – concept change + DoE



FEM-Optimisation by DoE

Cross-section of can bottom



Parameters on can bottom:
- DOM_R - Radius of dome
- Uebergang_R - Transitionradius dome
- Höhe - Height of dome starting point
- Aufstand_R - Transitionradius bottom

Fix Parameter:
- Surfaces for laser welding

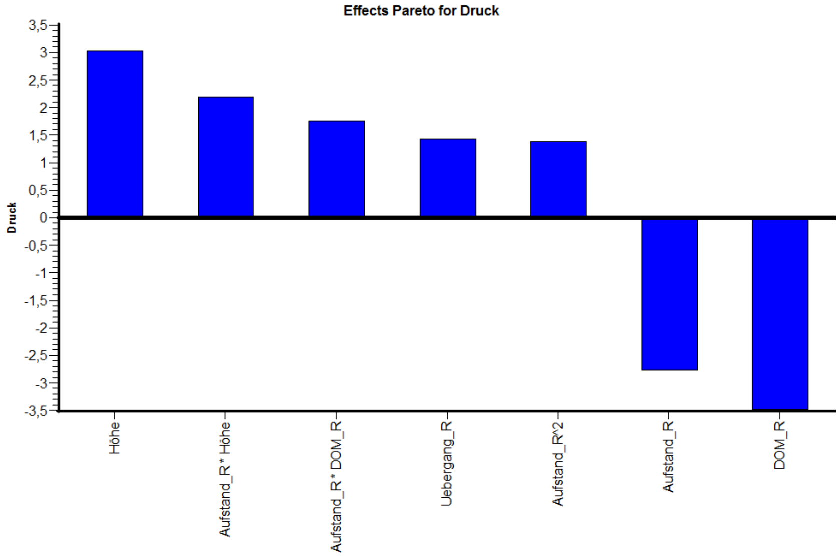
Fraunhofer IWU

FEA-based development of new laser-welded can

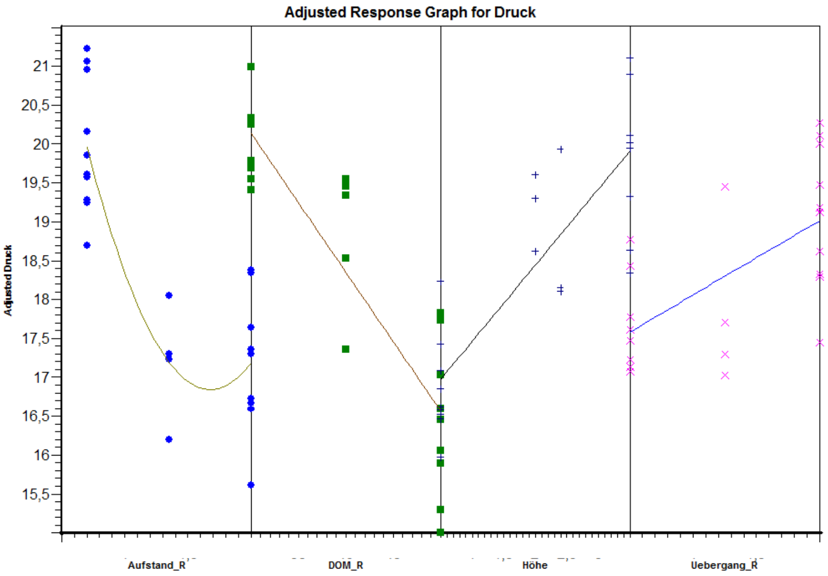
Component Optimisation by FEA - Parameter influence

- **DoE Setup of 20 Run's**
  - D-Optimal design
  - including Interactions and
  Quadratic terms for regression model

- **Pareto Chart of influences**



- **Response Graph of influences**

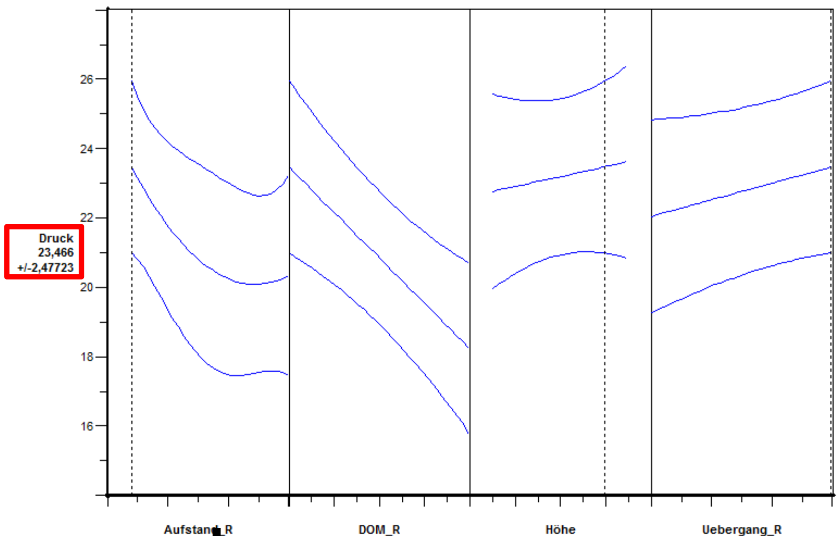


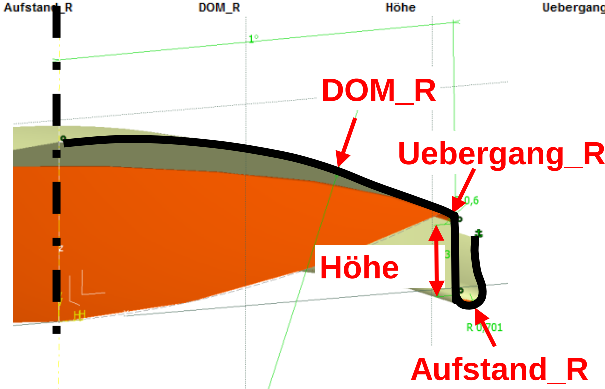
Fraunhofer IWU

FEA-based development of new laser-welded can

Component Optimisation by FEA - Optimisation on Regression model

- **Regression Model for optimisation**





- **Results discussion**

  1. Übergang_R of lower influence
  – should be on maximum

  2. Höhe of lower influence
  – should be minimized to reduce material effort

  3. Aufstand_R is of higher influence

  4. DOM_R is of highest influence

- **Material reduction potential**

can bottom thick. [mm]	buckling press. [bar]	Weight [g]
0,32	22,6	7,275
0,28	17,4	6,365
0,26	**15**	**5,911**
0,22	10,8	5,001

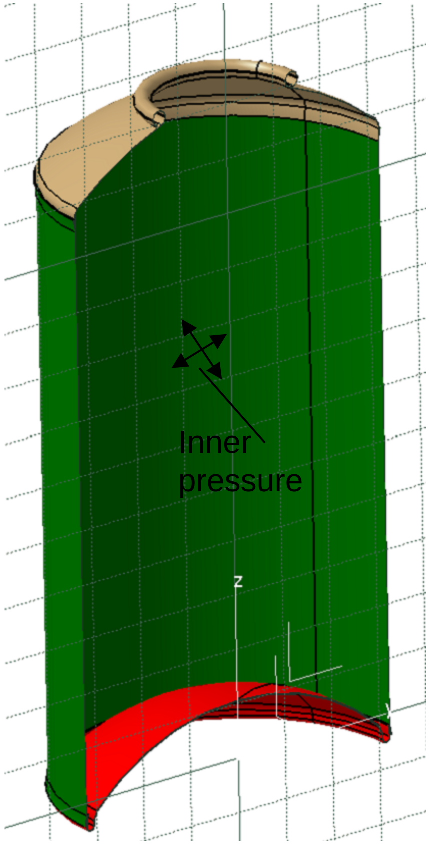
Fazit: Works for Diameter 45 - Does it work for other diameters ?

Fraunhofer IWU

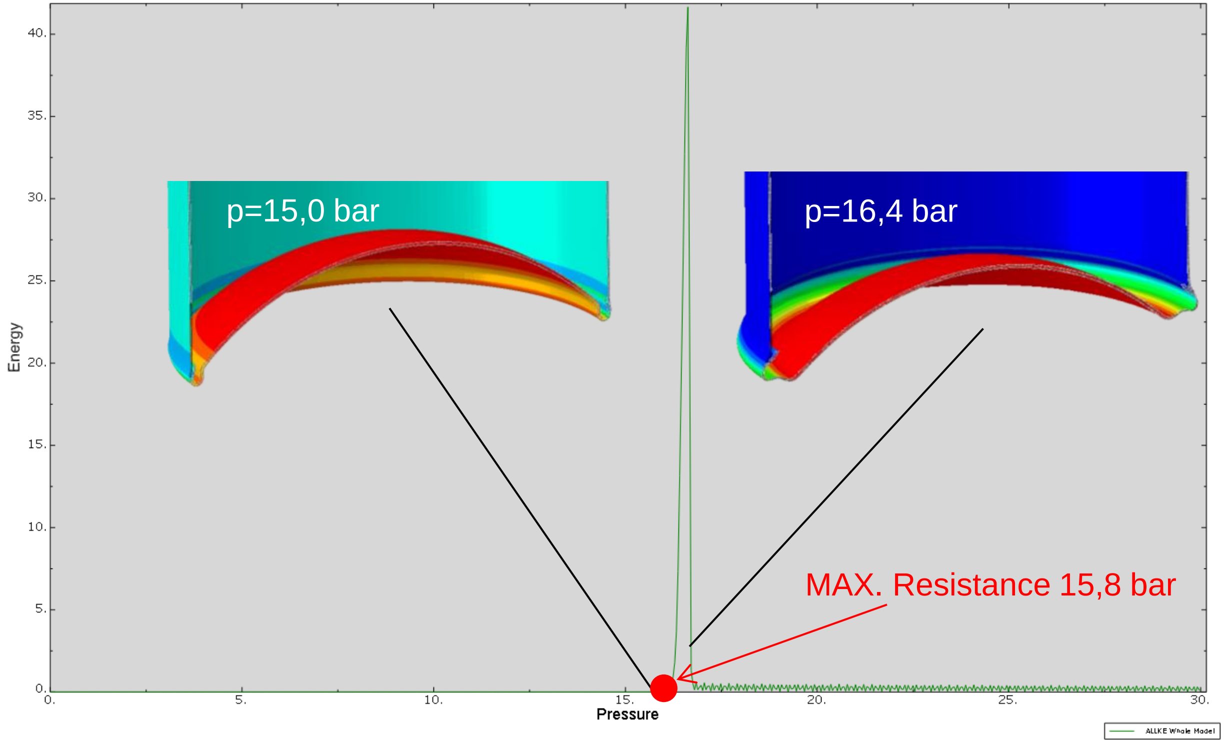
FEA-based development of new laser-welded can

- Component Optimisation by FEA – Transfer to diameter 65

  - **Transfer to Diameter 65**



  - **Results on Diameter 65**



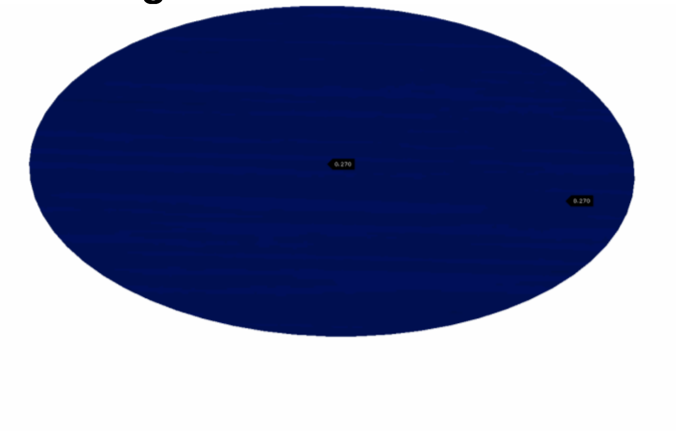
Fazit: Works for other Diameters as well. But what about real life ?

Fraunhofer IWU

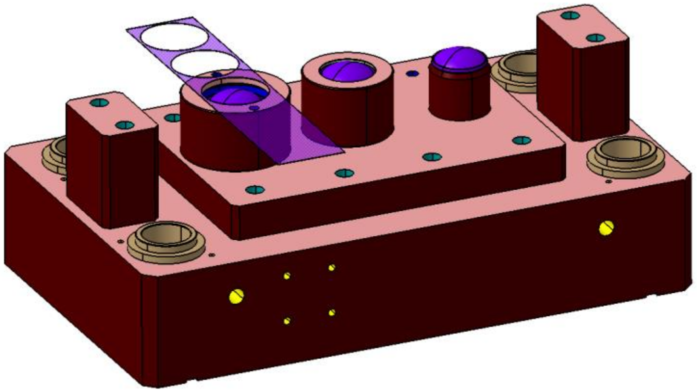
FEA-based development of new laser-welded can

- Component and Can production - Realisation of can bottom at Fraunhofer

- **Forming simulation**

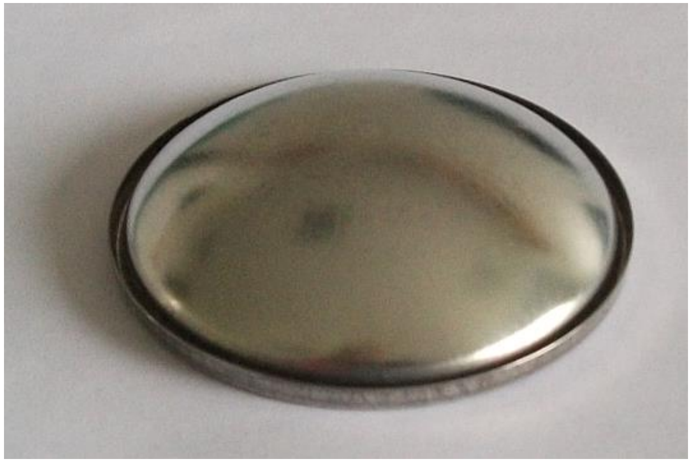


- **Tooling design (for prototypes)**



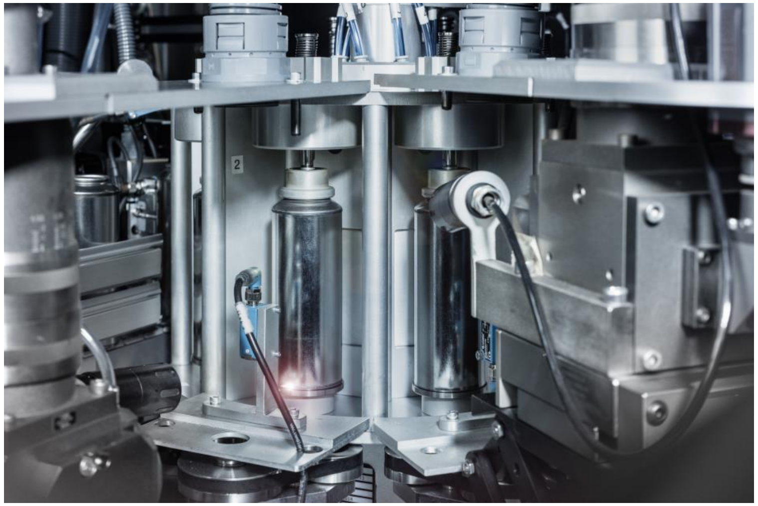
- **Manufacturing of dies and tooling**

- **Can bottom manufacturing**



FEA-based development of new laser-welded can

- Component and Can production - laserdom cans at caprosol
  - **Stand-Alone-Module for line inserting**
  - **80-100 cans per module and minute**
  - **Appr. Size 1,1 m x 1,2 m of module**
  - **Inner lacquering and powdering are possible**
  - **Sleeving and 3D-Printing are options**



caprosol Fraunhofer IWU

FEA-based development of new laser-welded can

Component and Can production – Pressure testing

- **Reality***
  (sheet thickness of can bottom = 0,27 mm)

Buckling pressure [bar]	Burst pressure [bar]
16,6	30
16,55	30
16,6	30
16,7	30
17,1	30
16,2	30
17,85	30
16,65	30
17,0	30
16,8	30
Avg. 16,81	30

*CAPROSOL AG

- **Simulation**

Thickness of can bottom [mm]	Buckling pressure [bar]	Weight [g]
0,26	15	5,911

- **Very close correllation of Reality and Simulation !**

Fazit: Works in Reality for Diameter 45 mm !

caprosol Fraunhofer IWU

FEA-based development of new laser-welded can

- Summary and Outlook - Overview on component material effort

- **All components have been investigated by FEA**

Material thickness of Laserdom components			
Can ø (mm)	**Top** (mm)	**Body** (mm)	**Bottom** (mm)
45	0.16	0.10	0.26
49	0.19	0.10	0.29
52	0.21	0.10	0.31
57	0.23	0.11	0.34
65	0.27	0.12	0.39

- **Further load cases (axial loading, inner vacuum) have been considered in FEA**
- **Material savings of 30 % and more are possible**
- **Detailed material savings can be determined online under**

www.caprosol.com

caprosol Fraunhofer IWU

FEA-based development of new laser-welded can

- Summary and Outlook

Fazit: Thank you for your attention. Ready for questions.