

Optimization of Link for Different Manufacturing Processes



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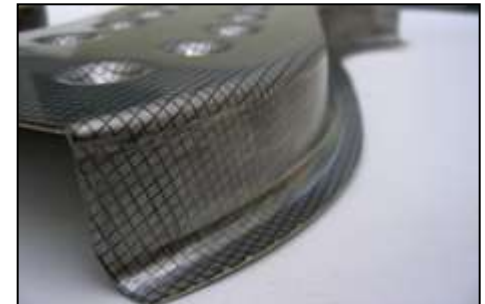
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Presentation outline

- Presentation of Swerea
- The project Swerea Light-Weight
- Case Study - Link for a powered wheelchair
- Conclusion



The Swerea group

The Swerea Group creates, refines and conveys research results within the fields of materials, process, product and production technology.

The objective is to create business benefit for members and customers and to strengthen the capacity for competition and innovation in the Swedish economy.

Vision ” *Swerea shall be a world-class Swedish research group.*”

Five research institutes

Swerea IVF industrial product, textile, polymers, ceramics

Swerea KIMAB material usage, materials and process development, corrosion

Swerea MEFOS process metallurgy, heating, machining environmental technologies and energy efficiency for iron and basic metals industries

Swerea SICOMP composite materials, process and product development

Swerea SWECAST cast metal - product, materials, process and environmental development



The project Swerea Light-Weight

- Vision – Swerea Light-Weight is the leading supplier in Sweden of advanced R&D intense weight efficient concept solutions for industrial production.
- Lighter designs – *“The time is right”*
- Drive within the vehicle industry and other industries such as construction, aviation and windmill industry.
- Light weight design = A weight efficient solution
- Swerea Light-Weight offers industrial costumers comprehensive integrated solutions covering all technologies section of the product realization of light-weight structures. This means everything from material selection, design, optimization, simulation, environmental and production aspects.
- In this project topology optimization with Altair OptiStruct and shape optimization with ROpt (Alfgam Optimering) has been used on among other things a link from Permobil AB.



Case study – Permobil AB

- The world's leading manufacturer of powered wheelchairs
- About 20 different models
- www.permobil.com



The link



■ Function

- Shock absorber mounting
- Buckle the chair in the car
- Wheel support



Target

- Decreased manufacturing cost
- If possible: weight reduction



Concepts

- Concepts generated using brainstorming
 - Cast design (high pressure die cast)
 - Composite profile
 - Extrusion profile (with machining)
 - Sheet metal
- Ranking criteria
 - Potential weight reduction
 - Investment cost
 - Material cost
 - Manufacturing (complexity)
 - Degree of manual work



Concepts

Concepts generation

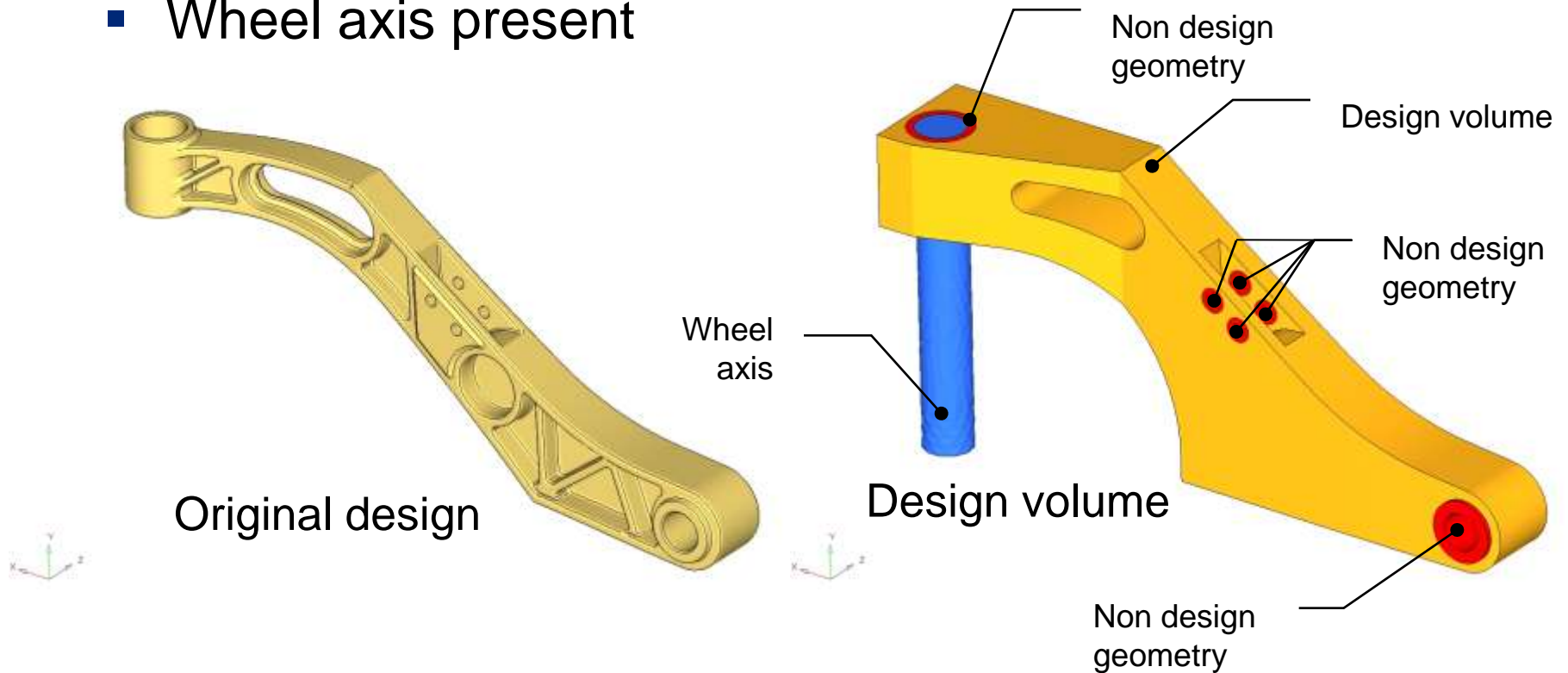
with

**Topology & Shape
Optimization**



Topology optimization model

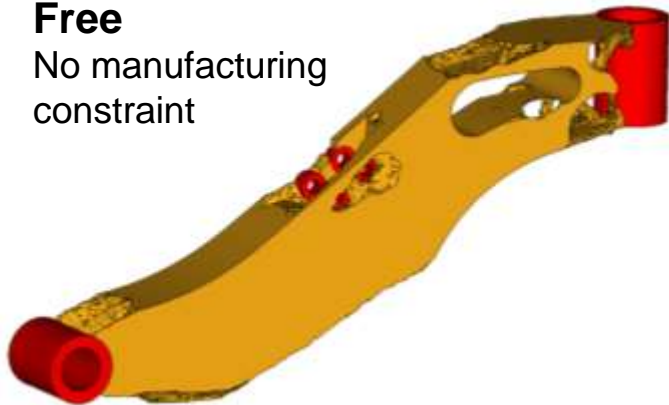
- 5 load cases
- Wheel axis present



Topology optimization results

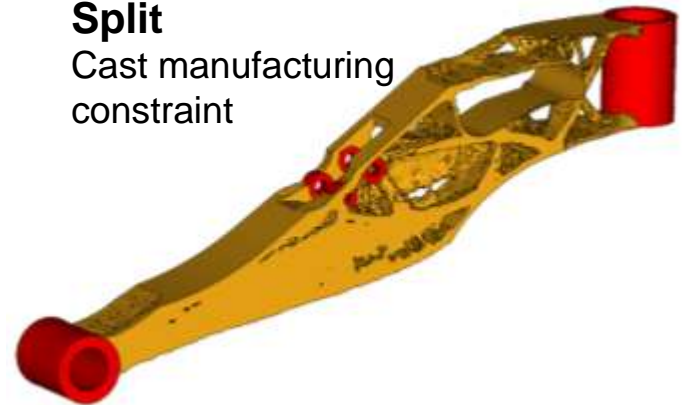
Free

No manufacturing constraint



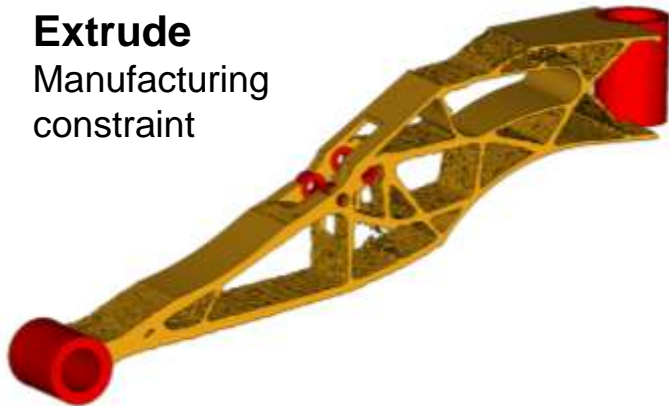
Split

Cast manufacturing constraint



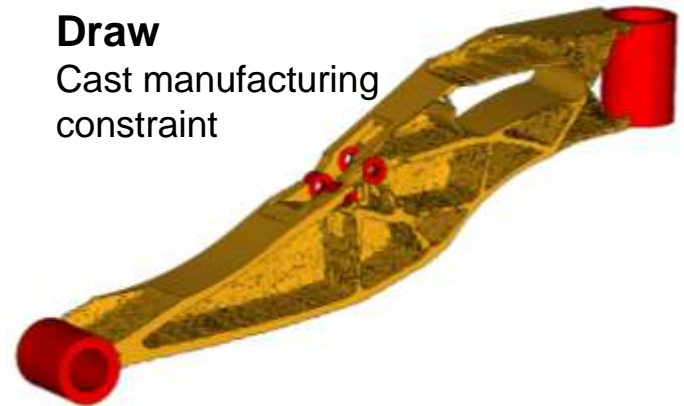
Extrude

Manufacturing constraint



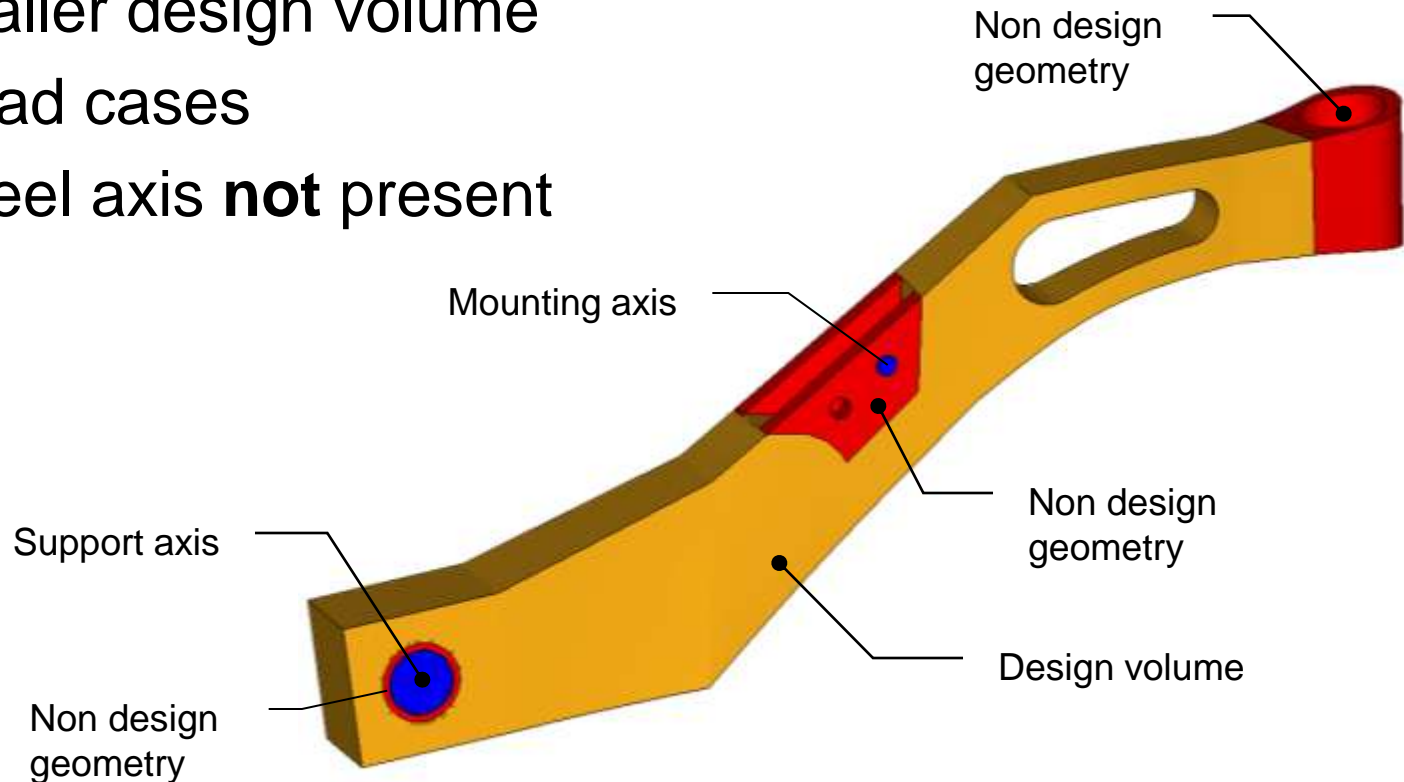
Draw

Cast manufacturing constraint



Topology optimization with contact

- Contact at shock absorber mounting and support
- Smaller design volume
- 5 load cases
- Wheel axis **not** present



Topology optimization results with contact

Extrude (contact not included)

Manufacturing constraint



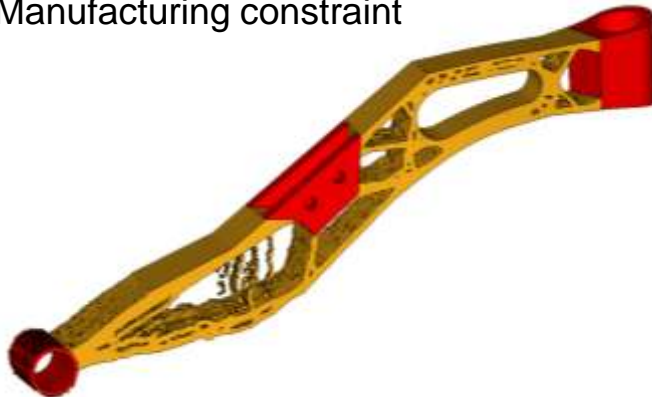
Draw (contact not included)

Cast manufacturing constraint



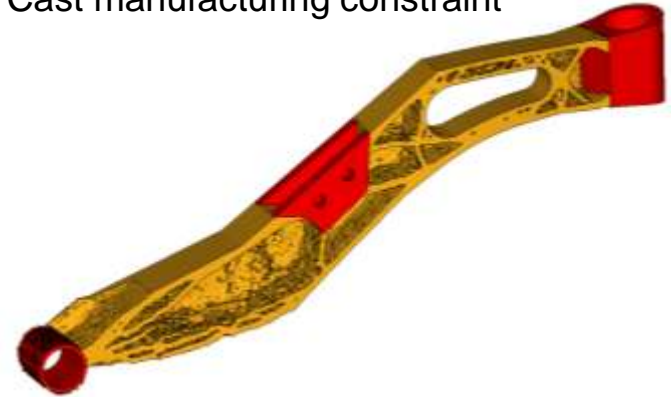
Extrude (contact included)

Manufacturing constraint

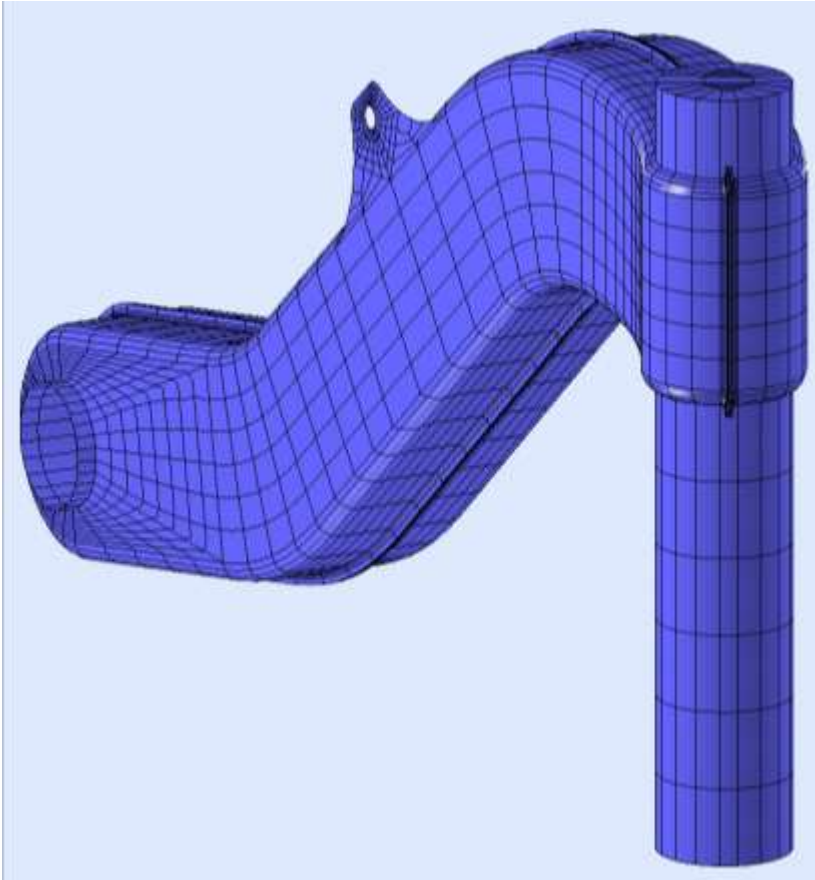


Draw (contact included)

Cast manufacturing constraint

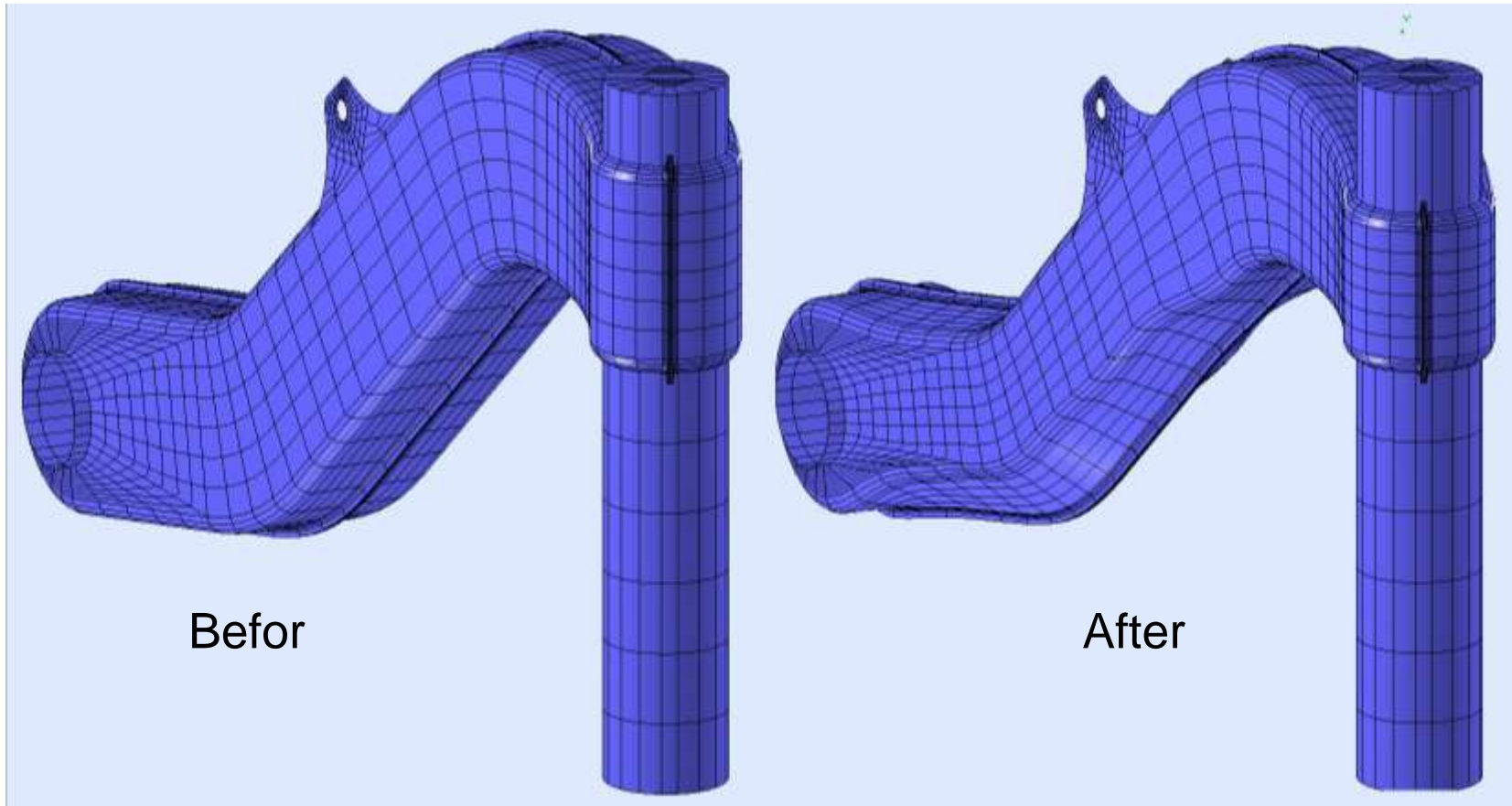


Shape optimization model



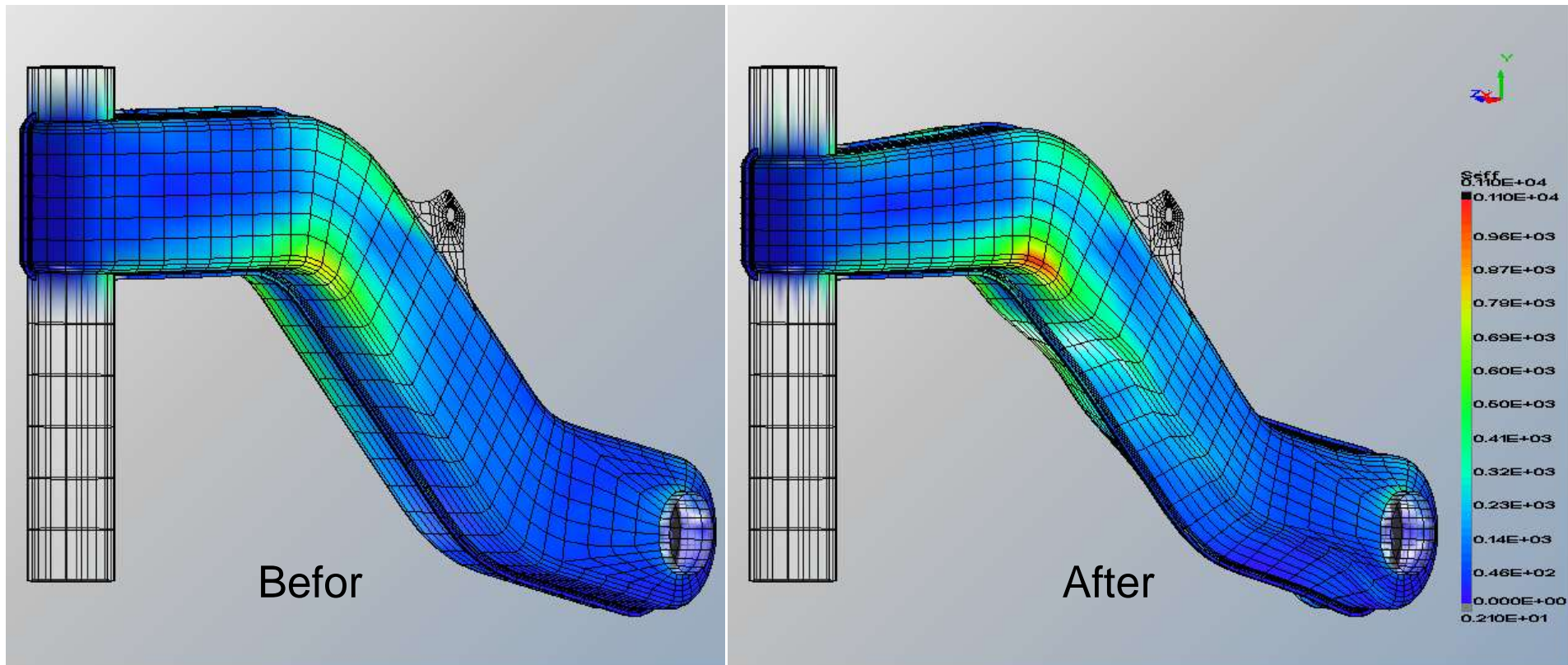
- Shape optimization using ROpt from Alfgam Optimizing AB, a general platform for solving optimization problems using gradient method (MMA).
- Height of the profile used as design variable
- Edge radii **not** changed
- 5 load cases
- Wheel axis present

Shape optimization results

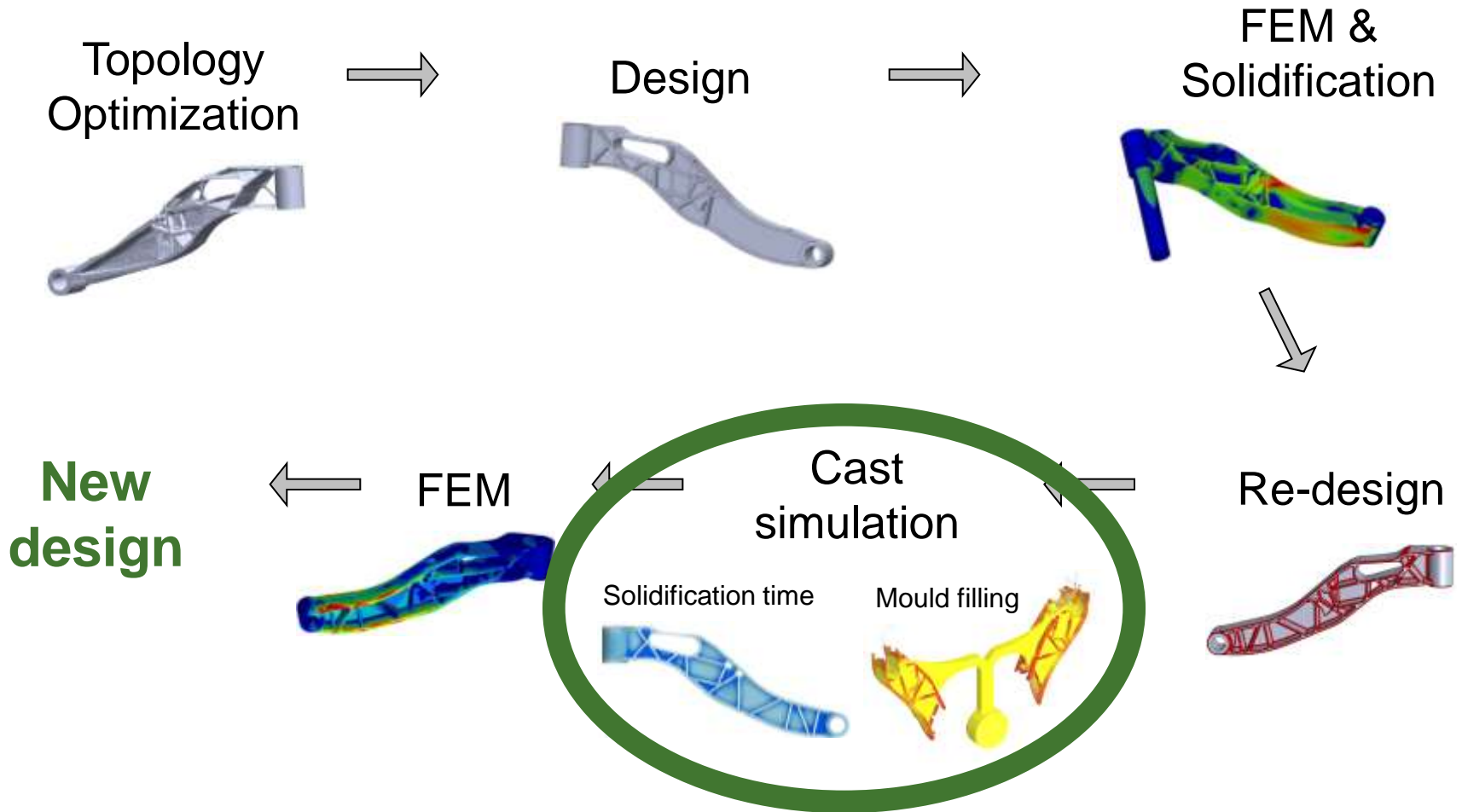


Shape optimization results

Stress for one of the load cases



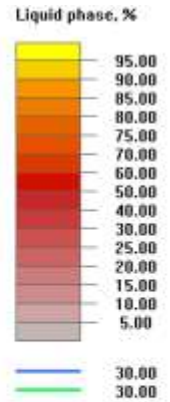
Development of cast components



Cast simulation of the link

Fill time = 55 ms

Solidification time \approx 2 s



EN AC-46000 [SS4250700.0
Orvar Supreme_stres#00.0
Air_in mold 20.0

Time, [h,m,s] 000:00:00,000
Filled volume, % 0.04
Liquid phase, % 99.96
Shrinkage, % 0.00

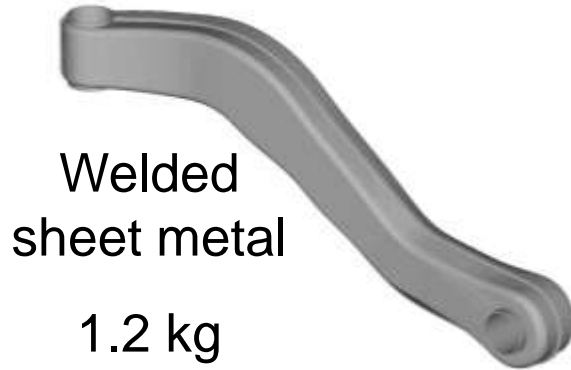
YZ plane, mm 573.50 [310]
linkarm_radrii_movedcentre_3_2010_10f

NovaCastFoundry Solutions AB
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Date 2010. 09. 03

NovaFlow & Solid
Control Volume

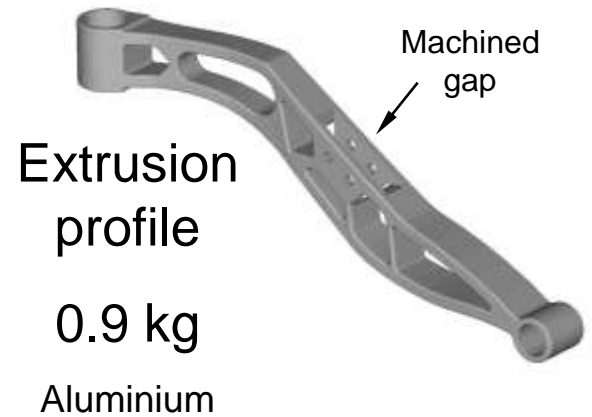
The “final” results



Welded
sheet metal

1.2 kg

High strength steel



Extrusion
profile

0.9 kg

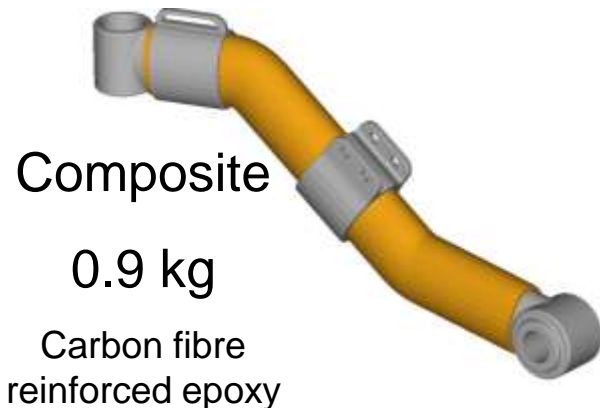
Aluminium



Original
Forged

1.3 kg

Aluminium



Composite

0.9 kg

Carbon fibre
reinforced epoxy



High pressure
die cast

1.3 kg

Aluminium

Summary of the concepts

- The different concepts have different advantages
 - Composite concept have great potential for other applications.
 - HPDC most cost efficient
 - Extruded profile light and cost efficient
 - Welded sheet metal, if welding is used in the production this is easy to include

Design	Material	Weight [Kg]	Weight reduction	Cost* [-]
Forged (original)	Aluminium	1,3	-	1,00
Cast	Aluminium	1,3	0%	0,32
Composite	Carbon fibre reinforced epoxy	0,9	31%	1,28
Extruded	Aluminium	0,9	31%	0,40
Sheet metal	High strength steel	1,2	8%	

* Cost based on approximately 10 000 parts per year.

Demonstrators

- Demonstrators were manufactured in the project
 - Composite \Rightarrow Resin transfer moulded
 - Extruded profile \Rightarrow Machined
 - HPDC \Rightarrow Sand cast
 - Sheet metal \Rightarrow Hand made

- The idea was not to make parts for testing



Conclusion

- The concepts generated in this study shows the potential of cost and weight reduction.
- Altair OptiStruct is **VERY** an useful tool for product development of components and concepts.
- Swerea is promoting topology and shape optimization for the Swedish industry.
- Lighter products is good for the environment.

Thank you for your attention !

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