Optimization of Link for Different Manufacturing Processes

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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 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

Extrude (contact included)
Manufacturing constraint

Draw (contact not included)
Cast manufacturing constraint

Draw (contact included)
Cast manufacturing constraint
Shape optimization model

- Shape optimization using ROpt from Alfgam Optimering 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

Befor

After
Shape optimization results

Stress for one of the load cases

Befor

After
Development of cast components

Topology Optimization → Design

New design

FEM & Solidification

FEM

Cast simulation

Solidification time → Mould filling

Re-design
Cast simulation of the link

Fill time = 55 ms
Solidification time ≈ 2 s
The “final” results

Welded sheet metal
1.2 kg
High strength steel

Composite
0.9 kg
Carbon fibre reinforced epoxy

Original
1.3 kg
Aluminium

Forged

High pressure die cast
1.3 kg
Aluminium

Extrusion profile
0.9 kg
Aluminium

Machined gap
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

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

*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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