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Cost Minimization for the Planet Carrier by Optimizing the Topology

3rd European HyperWorks Technology Conference

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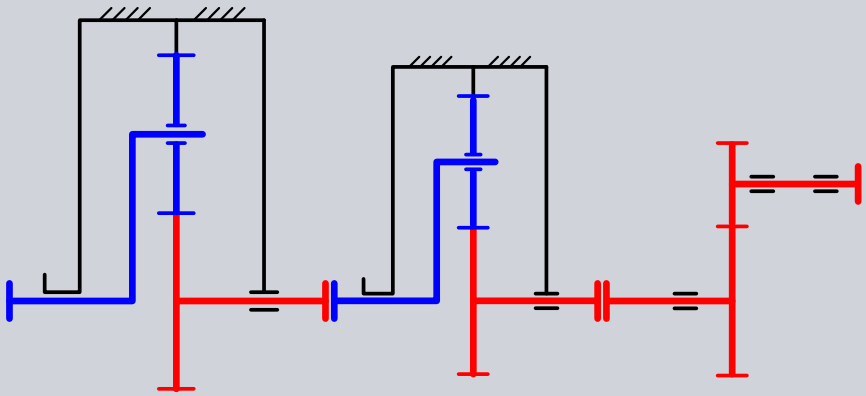
Flender catalog for planetary gear boxes

Introduction of a new optimization software

Two planetary stages and one spur wheel stage



Job Definition

What do we know about the optimization potential ?

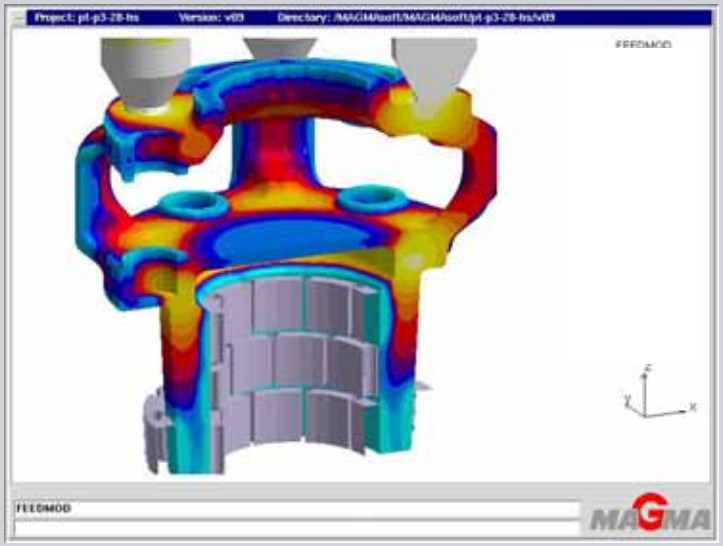
Past: Experience

Present: Experience, simulation, computer-assisted optimization (OptiStruct)

Cutting treatment

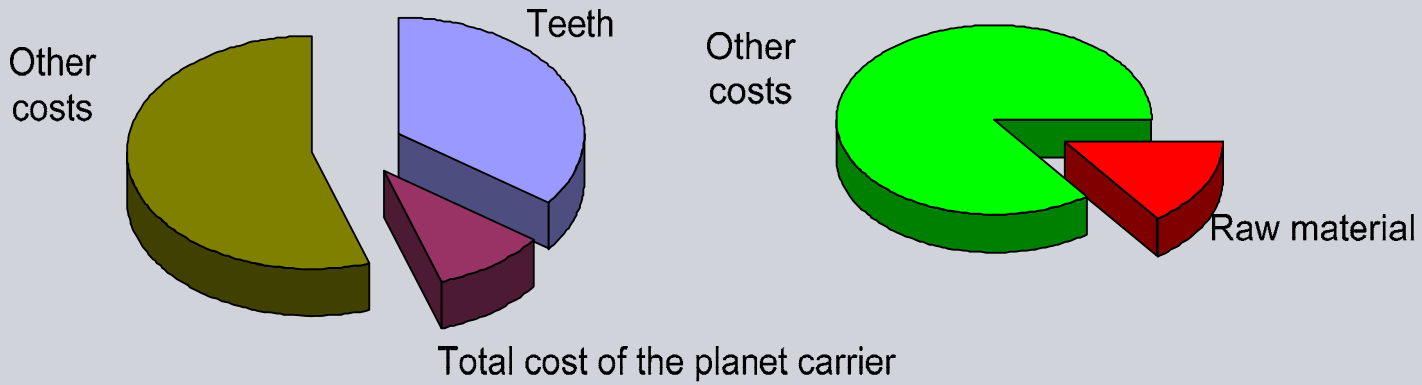
Source: Flender

Casting technology



Cost Check

Total cost of the gearbox



Raw material represents 1.5% of the whole gearbox

- **Cost reduction by reducing the amount of raw material is unimportant**
- **However – we may be able to optimize**
  → weight
  → stiffness

Topology Optimization – What is it?

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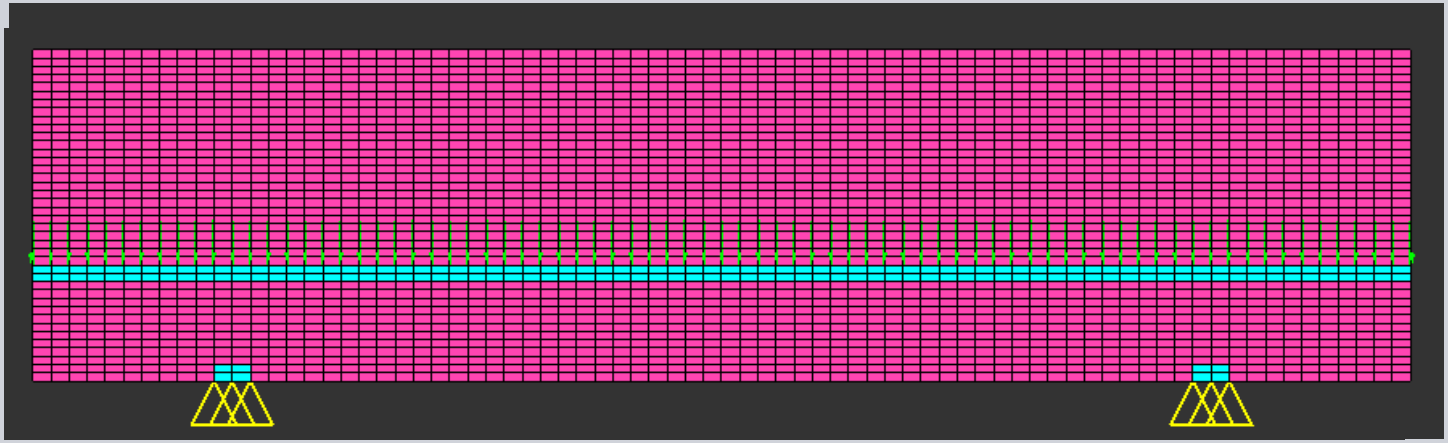
“A CAE tool to create ideas in the development process”

Used: OptiStruct software



Source: Altair Engineering

Method: change finite elements by density

100 % density
solid material (red)

0 % density
no material (blue)

Model

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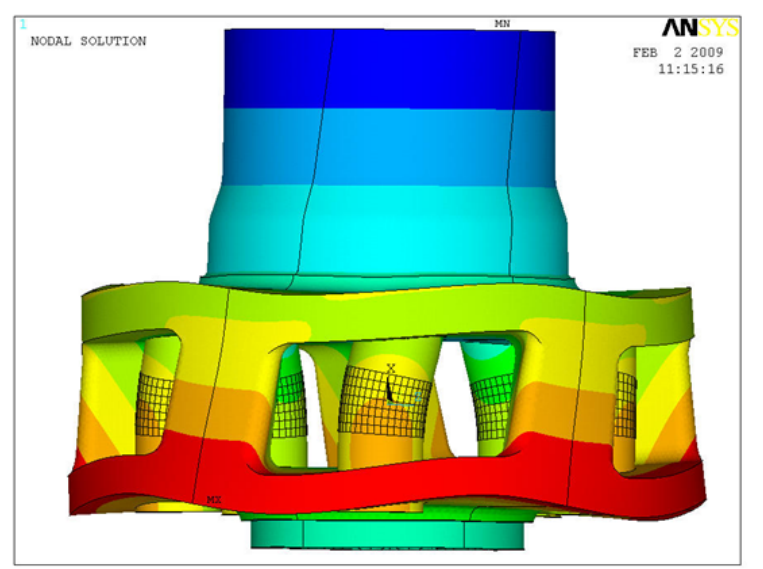
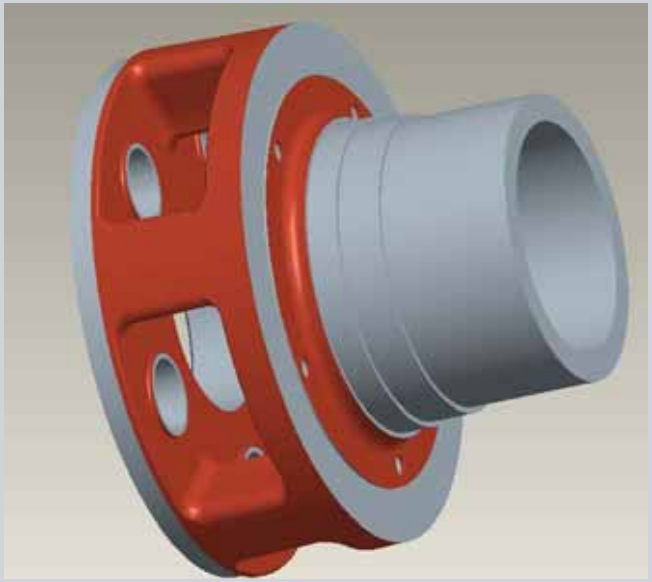
Main problem: Misalignment of the planet axis

→ worsens the teeth contact

→ reduces the lifetime of bearings and teeth





Model

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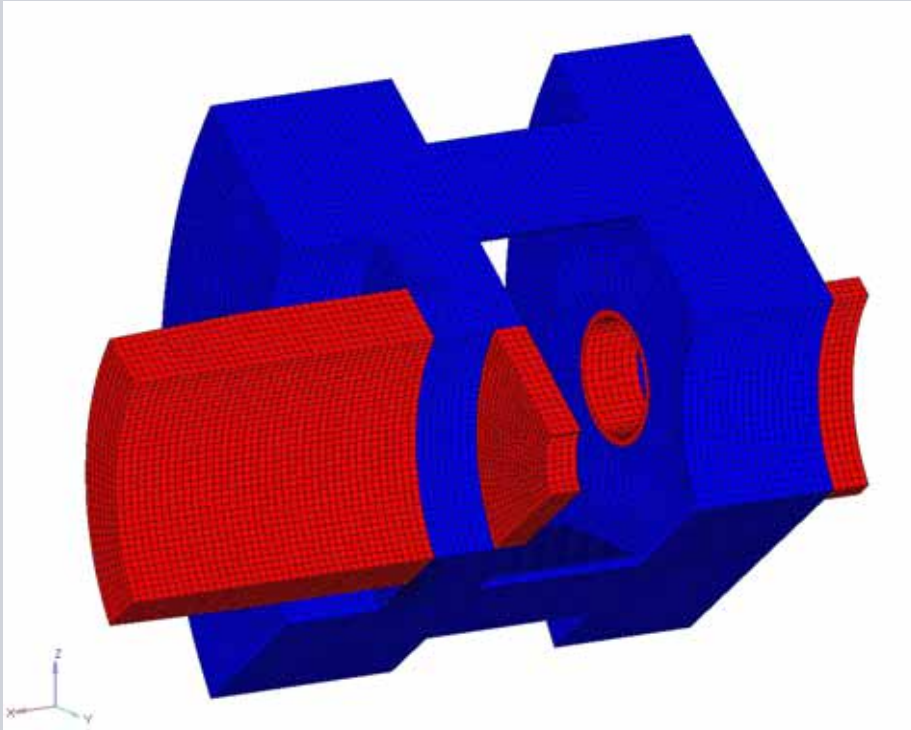
Designed space consists of finite elements

- Designed space (blue) → changeable
- Non-designed space (red) → not changeable
- Cyclic symmetry
- Linear computation model



Model

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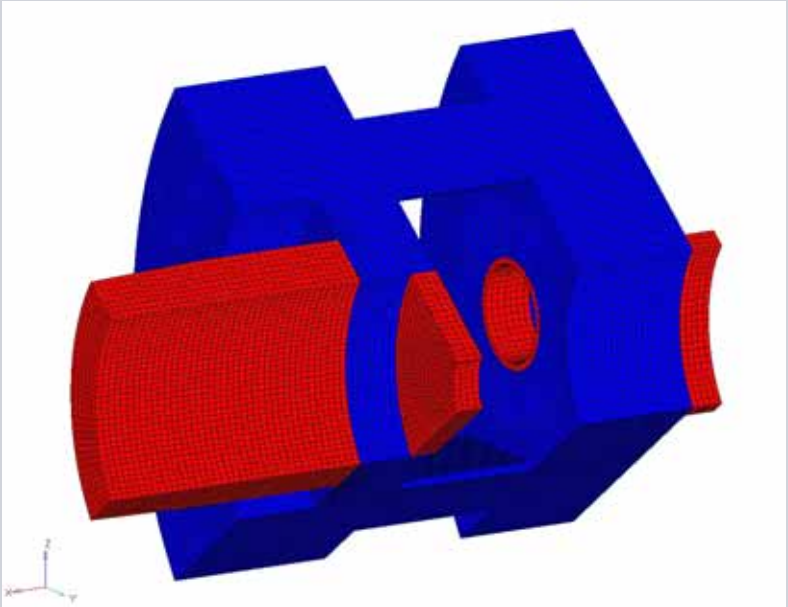
Boundary conditions:

- Specified force & torque



Results:

- Misalignment of planet axis
- Volume

3 different kinds of optimization:

- Minimize volume by specific misalignment of planet axis
- Minimize misalignment of planet axis by specific volume (30%)
- Minimize misalignment of planet axis by specific volume (50%)

Results

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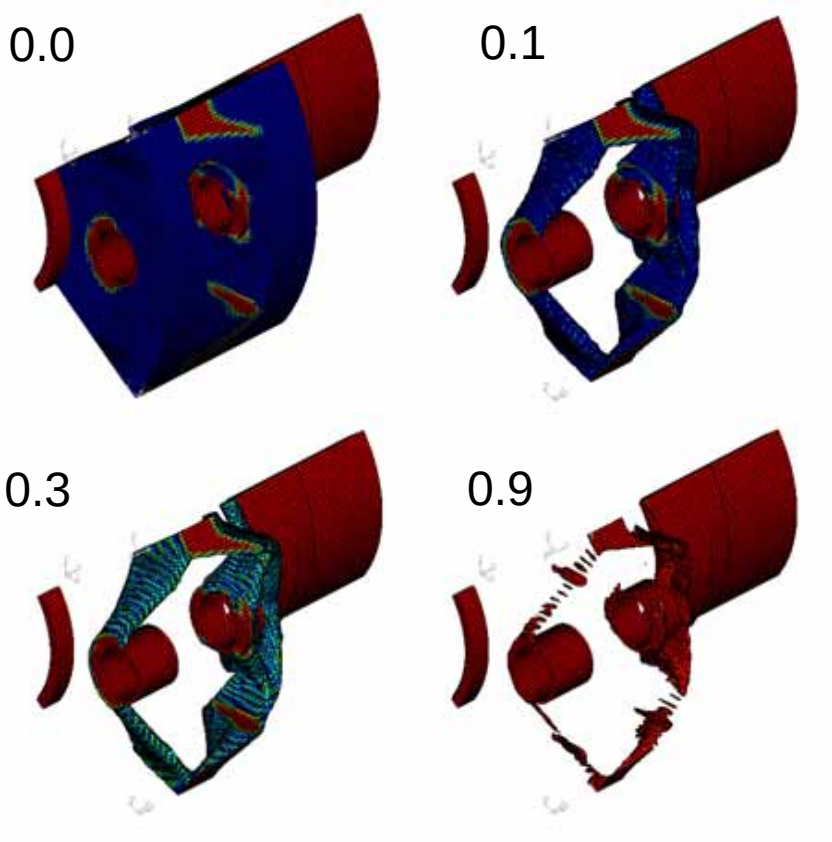
The results are not digital - one or zero!

It’s all about density distribution



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Layout A

Gear box

Job Definition

Cost Check

Optimization

Model

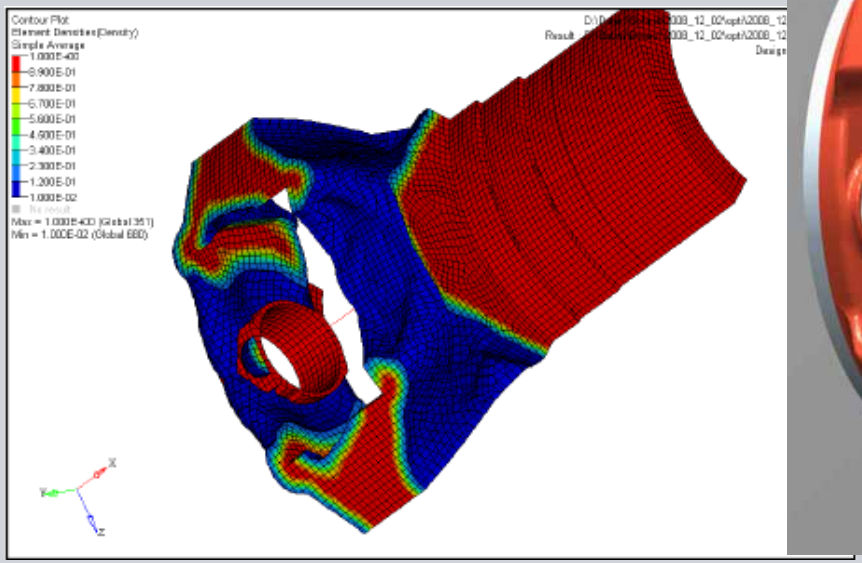
Result

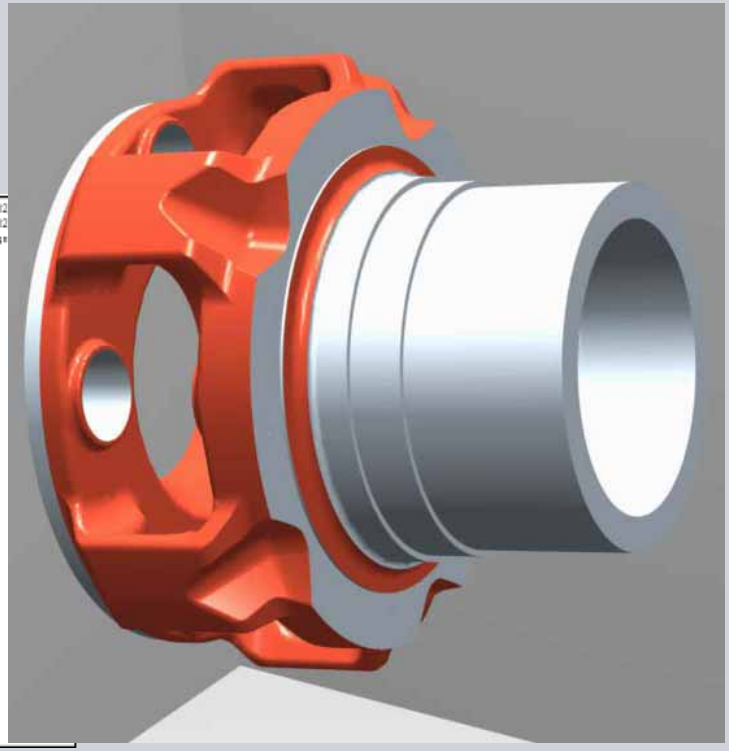
Benefit

Target: minimize volume by a specific misalignment of planet axis

Weight (raw material): -12%

Misalignment of planet axis +30%





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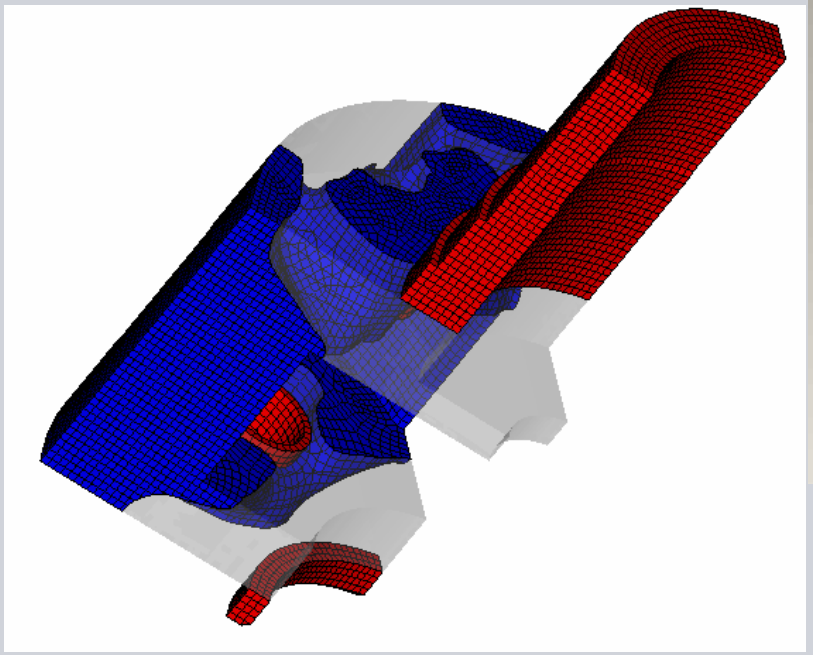
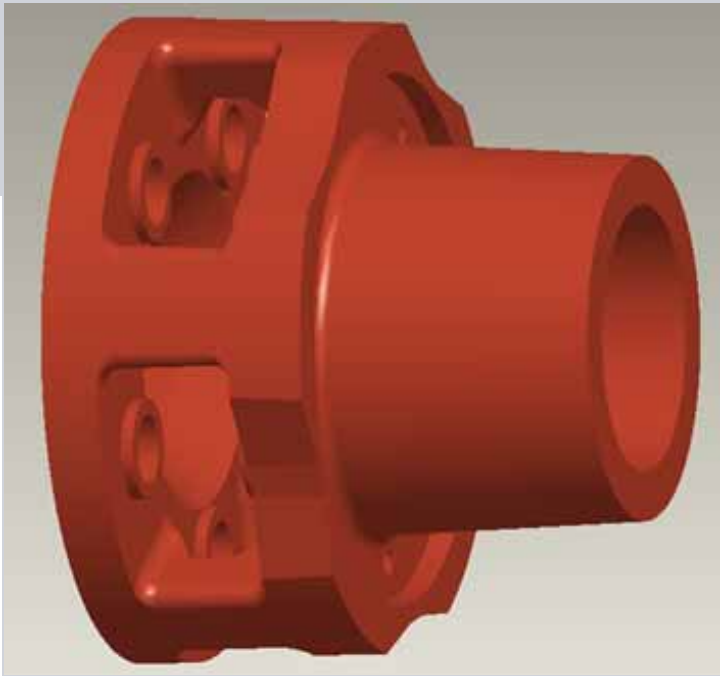
Layout B

Target: minimize misalignment of axis by specific volume (30%)

Weight (raw material): +3%

Misalignment of planet axis: -5%





Layout C

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Gear box

Job Definition

Cost Check

Optimization

Model

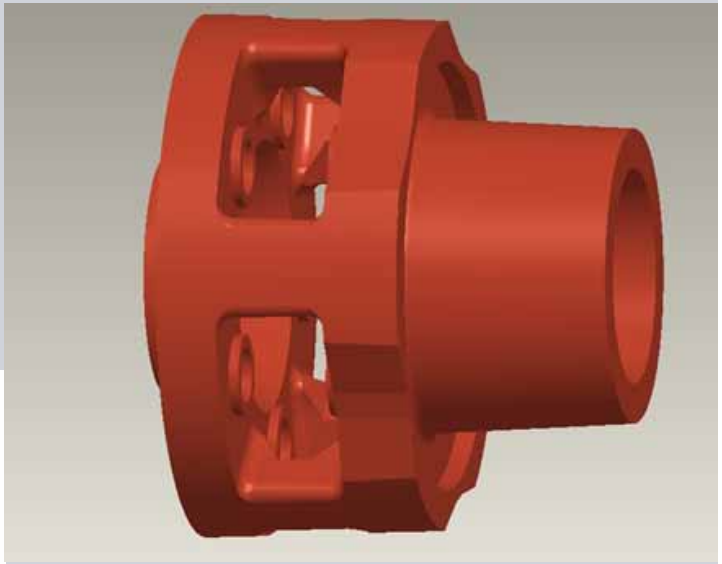
Result

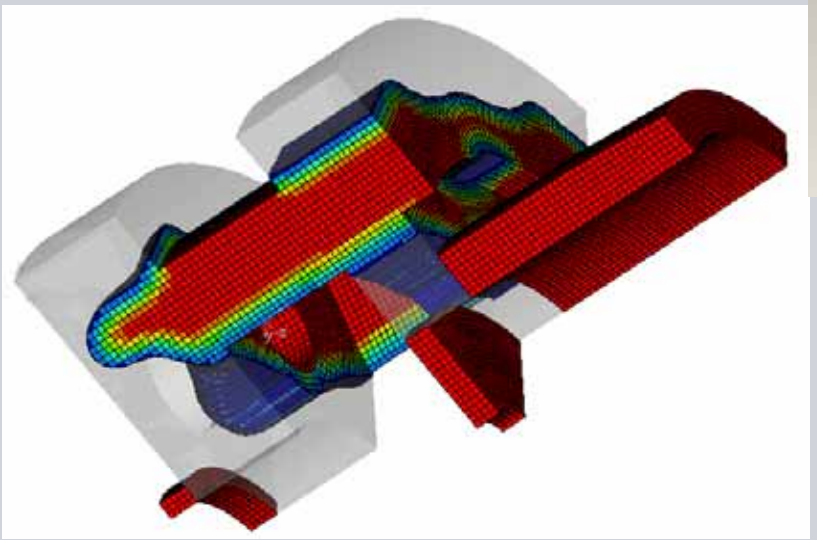
Benefit

Target: minimize misalignment of axis by specific volume (50%)

Weight (raw material): +26%

Misalignment of planet axis: -36%





Comparison

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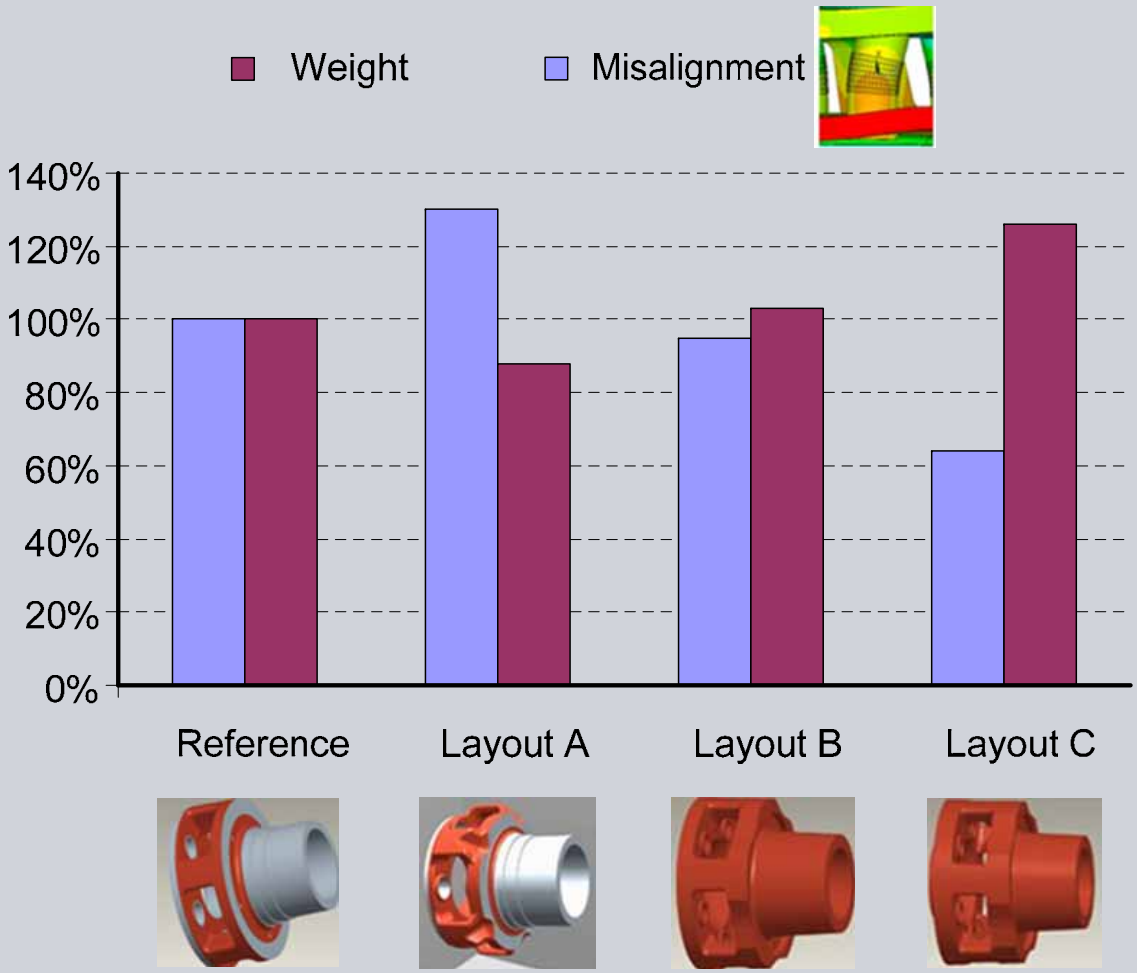

Benefit

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Benefit of this analysis:

- The carrier in our current products is in excellent shape
- Rules for design
- First experience gained in Siemens MD
- Future: apply in other areas - (gearbox housing…)

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Dr. Torsten Bunge
Siemens AG, Mechanical Drives
Research and Developement Department

Alfred-Flender-Straße 77
46395 Bocholt, Germany

Phone: 02871/92-2046
Fax: 02871/92-1500

E-Mail: torsten.bunge@siemens.com