Vimansys
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Mercedes-Benz

TÜRK-ALMAN ÜNİVERSİTESİ
TÜRKISCH-DEUTSCHE UNIVERSITÄT

"Comparison of Topology Optimization Potentials of Truck Cab Suspension Unit Depending on Material Selection Regarding Lightweighting and Mechanical Properties "

Agenda

Who we are?

- Türkish- German University
- Vimansys Digital
- Mercedes Benz-Türk

Introduction

- Target and Overview of this Study

Methodology

- Finite Element Method
- Topology Optimization Method

Results and Conclusion

- Topology Optimization and Finite Element Analysis Results

Turkish- German University

- The Turkish-German University (TAU) in Istanbul is a state university established on the basis of an agreement between the Republic of Turkey and the Federal Republic of Germany, subject to Turkish higher education legislation.

- The aim of its establishment is to combine the most important achievements and achievements of the Turkish and German higher education traditions in the fields of research and education and to make significant contributions to the scientific, economic and cultural cooperation between the two countries.

Vimansys Digital

- Vimansys serves the aerospace, automotive, and defense industries by providing innovative engineering and manufacturing solutions.
- The goal is to provide responsive, safe and reliable solutions to our customers with the highest quality, most reliable, cost-effective engineering, design and manufacturing services in both global and local aerospace, automotive and defence industries.
- The company specializes in material-based projects and virtual mechanical simulations (FEA) to optimize process effects and parameters.
- Vimansys also collaborates with companies and universities on funded projects to drive technological advancements and strengthen consortiums.

Mercedes Benz-Türk

- Mercedes-Benz Türk operates one of the largest bus and truck factories in Turkey, located in Hoşdere and Aksaray, respectively.
- The Hoşdere Bus Factory, established in 1995, is a state-of- the-art facility that manufactures buses for both domestic and international markets, utilizing advanced production techniques with a strong emphasis on quality and innovation.
- The Aksaray Truck Factory, operational since 1986, serves as a key hub for truck production, catering to diverse market demands. The center is instrumental in developing new vehicle designs, conducting comprehensive simulations, and performing rigorous testing to ensure that the highest standards of safety, performance, and sustainability are met. This robust R&D capability enables Mercedes-Benz Türk to lead in creating sustainable and connected mobility solutions, reinforcing its position at the forefront of the automotive industry in Turkey and beyond.

MB Conecto S&G

ACTROS

AROCS

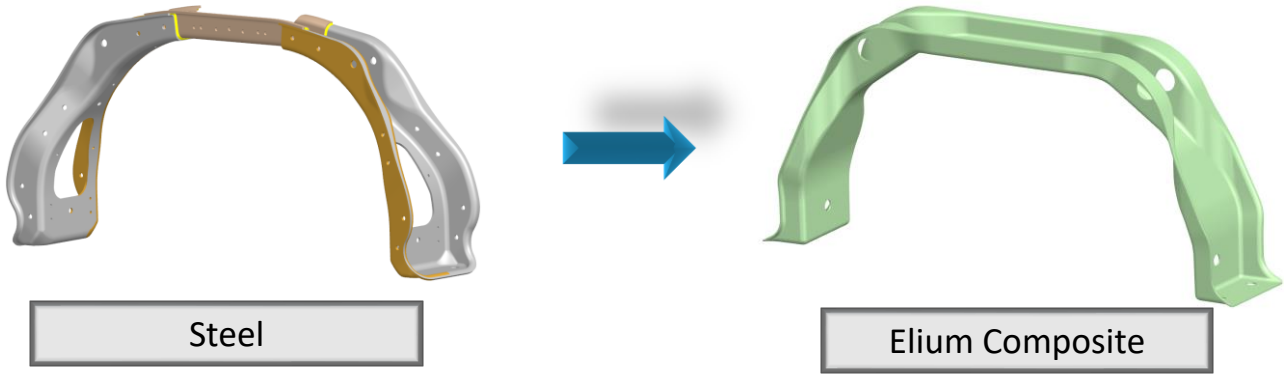
MB Tourismo

Setra Low Entry

Introduction

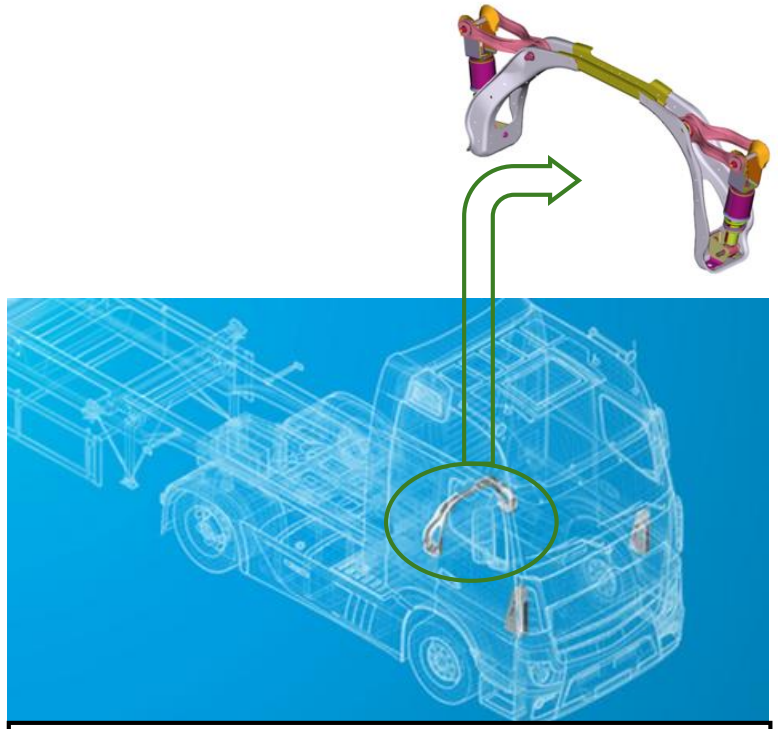
Aim of this Study/ Suspension Bearing

- Suspension bearings are mainly positioned on the Truck structure between the front and rear axles.
- It's typically constructed from durable materials such as steel or aluminum, and is enhanced with rust-resistant coatings.
- In the RECOTRANS project carried out under the EU Horizon 2020 programm with project number 768737, the suspension bearing was designed from Elium composite.



Steel

Elium Composite



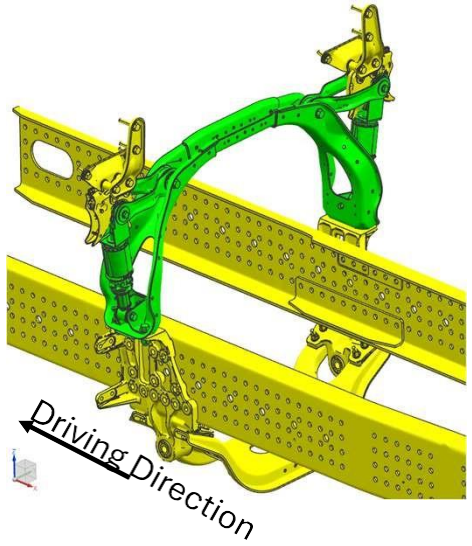
Position of suspension bearing

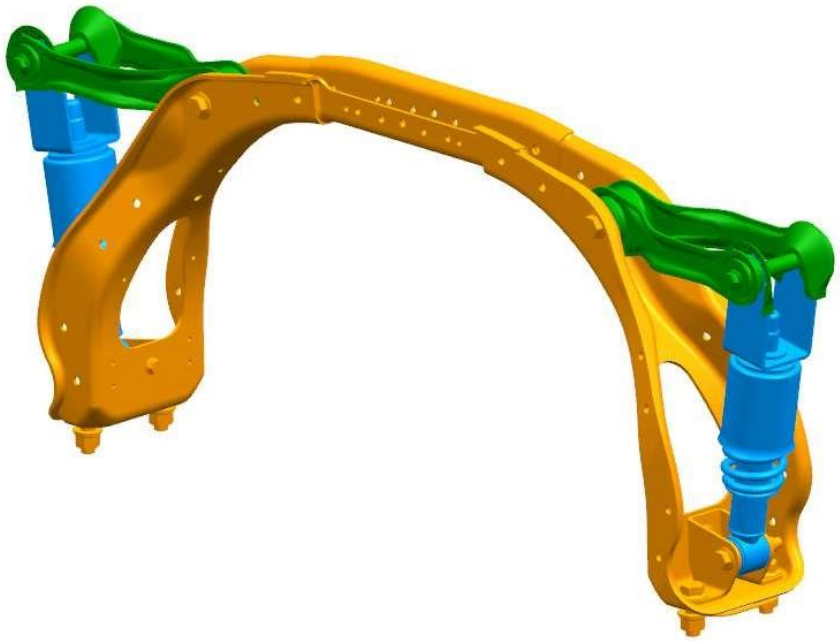
Aim:
Improve the mechanical properties of this suspension bearing

Introduction

Aim of this Study/ Suspension Bearing

Weight for Cab Rear Suspension Connection Sheet





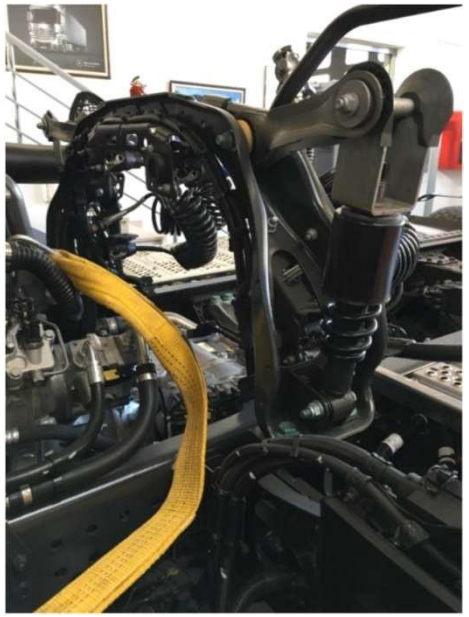
Bow Carrier	20 kg
2 Suspension Arm	7 kg
2 Spring-Damper	7 kg
System	**36 kg**

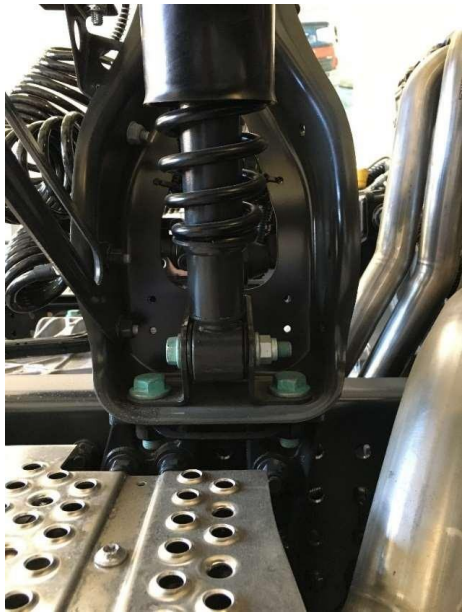
One of the most important targets of this project is to reduce the weight of the entire system.

Introduction

Aim of this Study/ Suspension Bearing

Assembly examples on vehicle

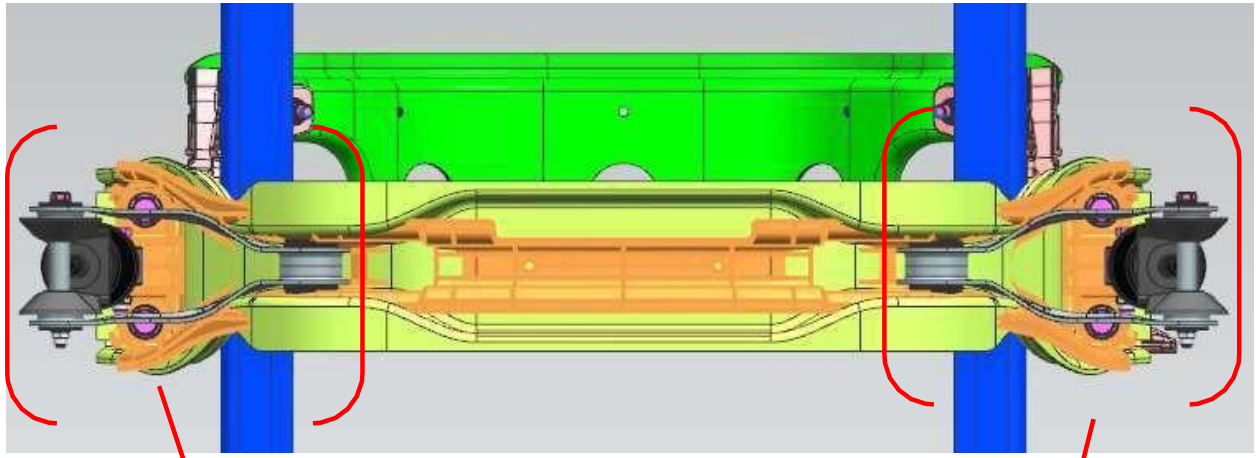


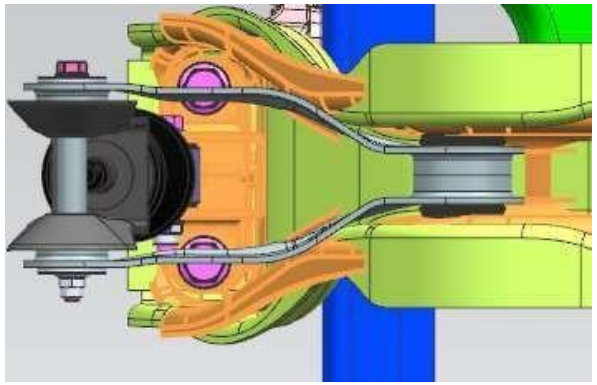


Introduction

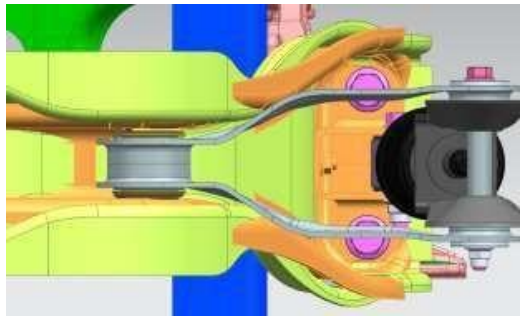
Aim of this Study/ Suspension Bearing

Geometrical Differences between current and the optimized designs





Fixing points are crucial for the design, and the dimension of them should be identical



Introduction

Aim of this Study/ Elium®

- Elium®, a thermoplastic resin, is an innovative recyclable material that offers performance comparable to conventional resins.
  - Reactive at low temperature
  - Easy to use
  - Performance
  - Productivity
  - Recyclability

Kazami et al. investigated the use of Elium® resin in laminates. Test results show that this resin has mechanical properties comparable to thermoset-based resins. Furthermore, fractographic analyses reveal that this new material has a wide potential for use in industry.

- It provides a wide range of applications in many sectors such as energy, marine, automotive and aerospace.

- In this study, Elium 151SO material, which is suitable for marine and industrial use, was used and its mechanical properties were strengthened by using glass fibre as reinforcement material.

Properties Elium® 151SO

Property	Value
Shore D Hardness	85-90
Elongation at break, %	2.8
Flexural Strength, MPa	111
Flexural Modulus, GPa	2.91
Tensile Strength, MPa	66
Tensile Modulus, GPa	3.17
Compression Strength, MPa	116
Compression Modulus, GPa	3.93

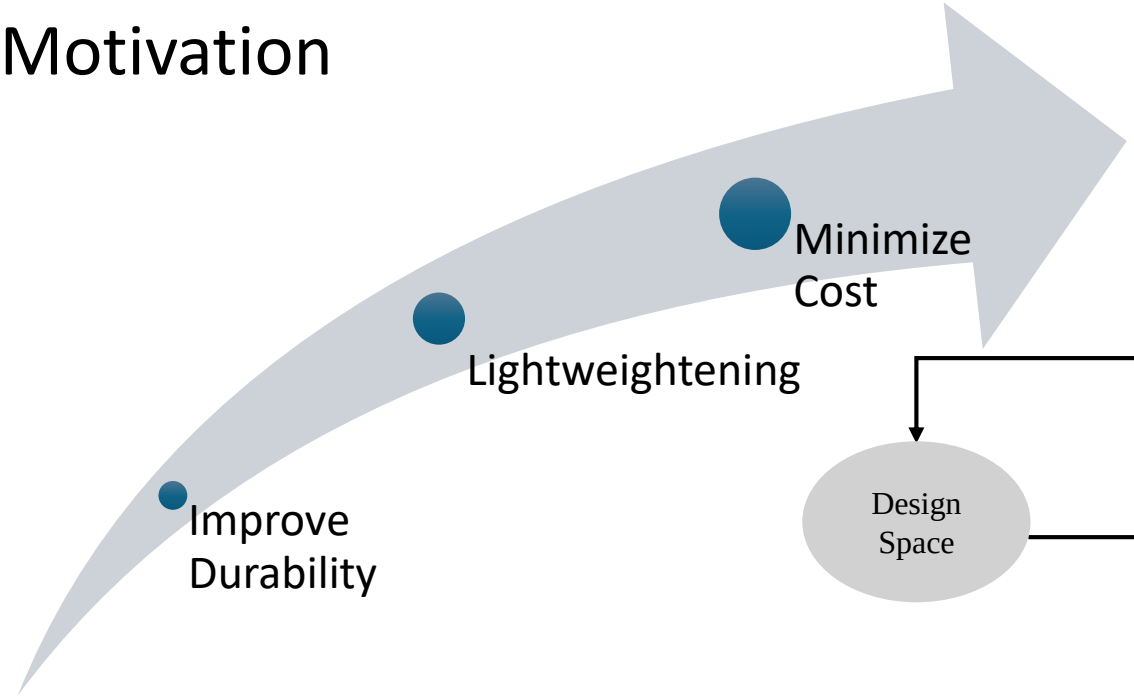
Bakkal et al. İnvestigated the fatigue properties of Elium®-based glass fiber-reinforced composites with different fiber orientations were. The 0°/90° fiber orientation showed the highest fatigue strength, while the 0°/90°/±45° configuration exhibited more temperature increase and stiffness degradation.

$$E_c = E_m V_m + E_f V_f$$

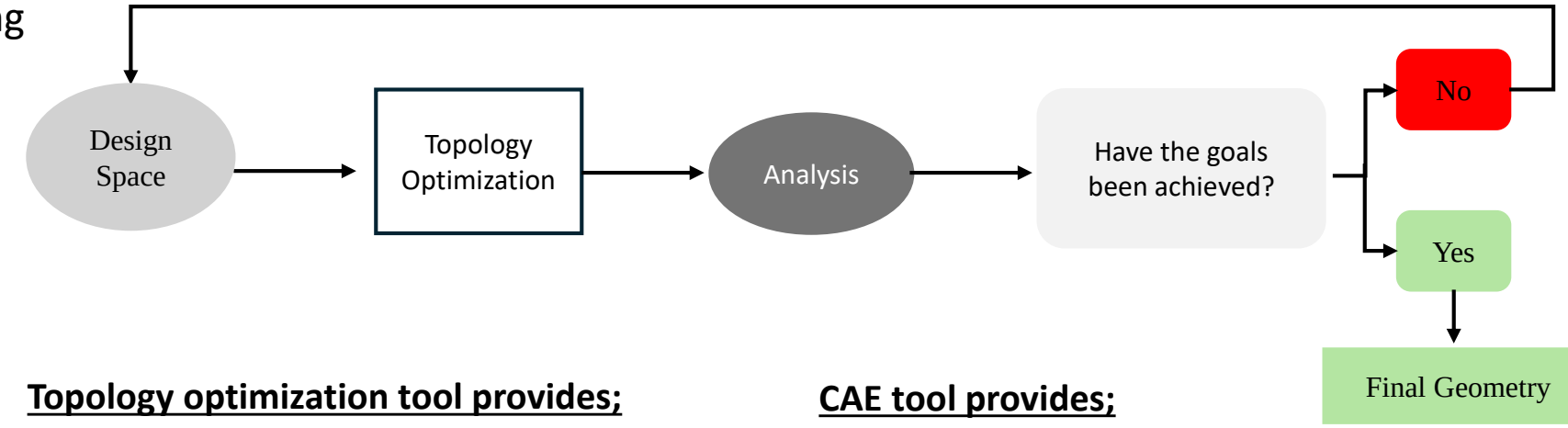
Proporties of glass fiber

Property	Value
Tensile Strength, MPa	2527
Tensile Modulus, GPa	79.15

Motivation



Topology Optimization



Design tool provides;

- 3D Modeling and Surface Design
- Assembly Design
- Drafting and Detailing
- Design Validation
- Interoperability with Different Design Software
- Design Output for Optimization and Simulation

Topology optimization tool provides;

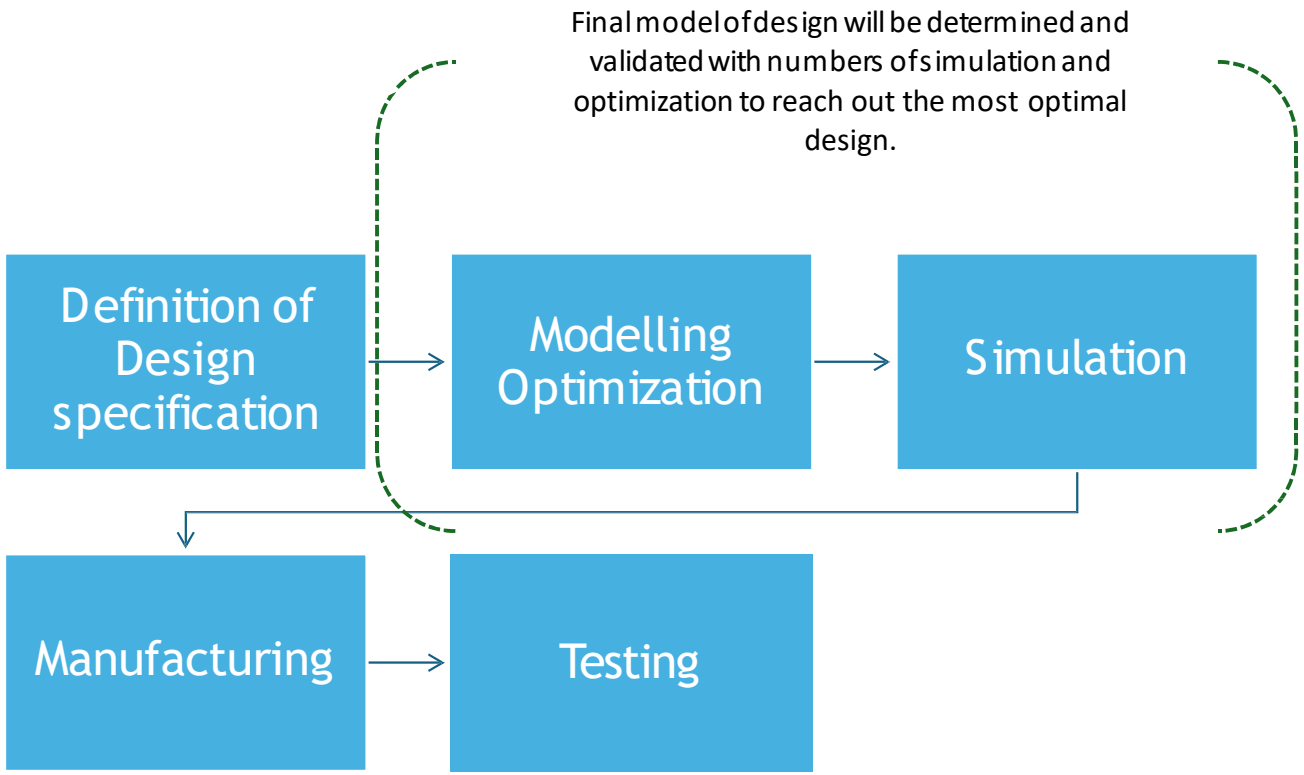
- Geometry Optimization
- Material Distribution Analysis
- Performance Criteria Maximization
- Boundary Conditions and Load Application
- Manufacturing Constraints Incorporation
- Data for simulation

CAE tool provides;

- Fixing the problems on the geometry
- Meshing the geometry according to its structural properties
- Applying boundary conditions and loads
- Transferring mapped data
- Calculating Progressive Failure Analyses
- Integration with CAD

Methodology

CAD – OPT– CAE Circle



A novel part, which has the optimized weight and durability is developed after the CAD-OPT-CAE methodology.

ENHANCED SUSTAINABLE PRODUCTION & EFFECTIVE LIGHTWEIGHTING

Methodology

CAD – OPT– CAE Circle

$$E(\rho_e) = \rho_e^p E_0$$

Formula 1 Relative density of the material

Because the relative density of the material can vary continuously, the Young's modulus of the material of each element can also vary continuously.

$$K_{SIMP(\rho)} = \sum_{e=1}^{N} [\rho_{min} + (1 - \rho_{min})\rho_e^p] K_e$$

Formula 2 Modular global rigidity

Ke is the element stiffness matrix, ρmin is the minimum relative density, ρe is the element's relative density, p is the and N is the number of elements in the proposed domain.

$$minC(\{\rho\}) = \sum_{e=1}^{N} (\rho_e)^p [u_e]^T [K_e][u_e]$$

Formula 3 Global flexibility

ue is the nodal displacement vector of element e, Ke is the stiffness of element e, and vector {ρ} contains the relative density of element ρe. In order for the topological optimization system to run logically, each stage of the iteration must always meet the global balance of stiffness forces with the required constraint function (variable).

$$\sum_{e=1}^{N} \{v_e\}^T \rho_e \leq M_{target}$$

Formula 4 Global balance of power

Ve is the volume of the element and M target is the target optimization weight.

Results

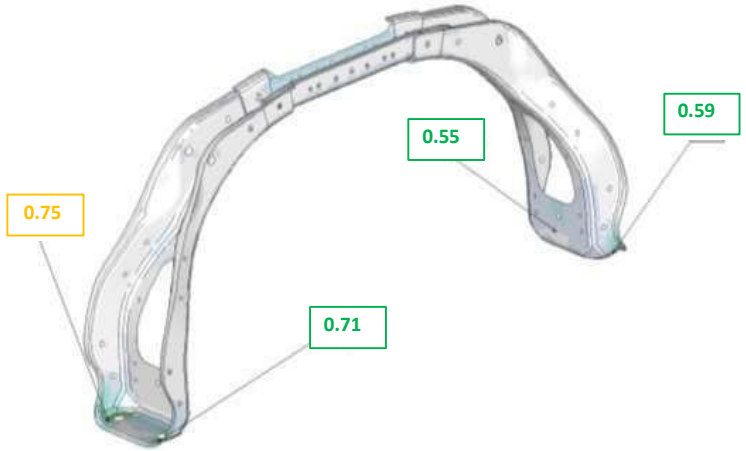
STATIC & DYNAMIC VEHICLE SIMULATIONS

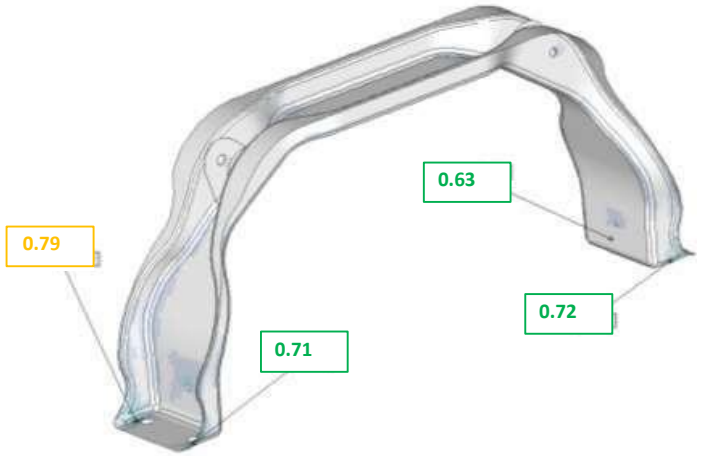
- The standard Static analysis includes approximately 12 load cases. The most critical 3 analyses are chosen to report based on the stress and deformation occurred on the console. Most critical load cases are;
  - 2.5 g loading
  - Cornering
  - Asymmetric Braking.

- For the evaluation of the results, the stress value occurred on the console is divided by the yield strength of its material. In other words, the values seen below are scaled values and it means as long as the value is below 1, the analysed part is strong and durable enough, the part passes the test.

Results

STATIC VEHICLE SIMULATIONS – 2.5 g Vehicle Load

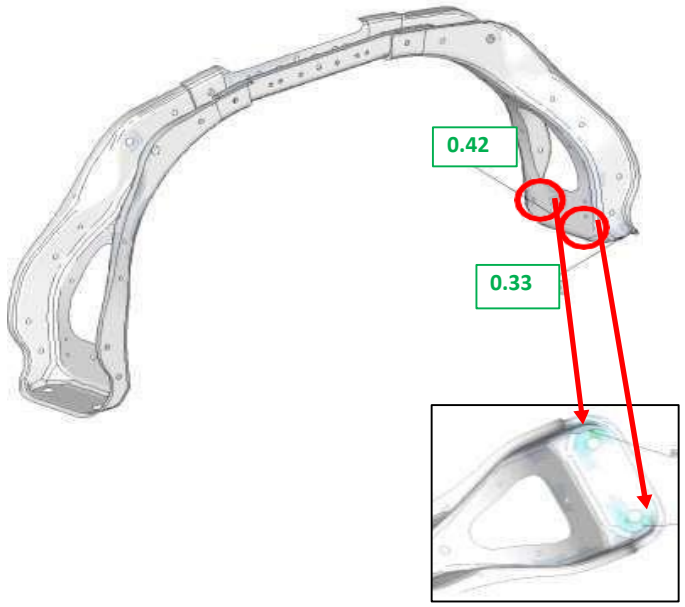


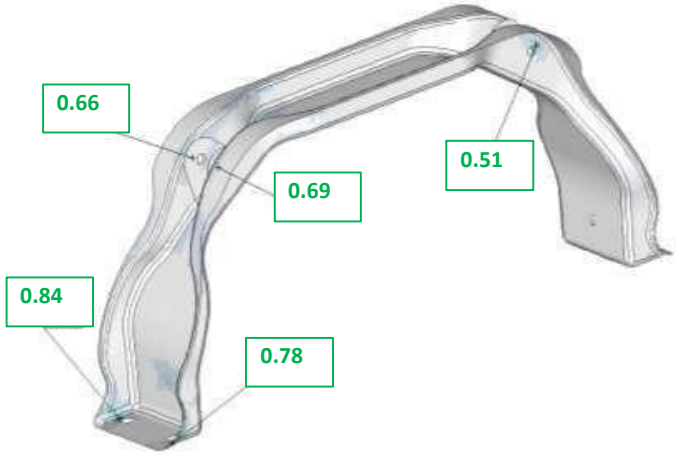


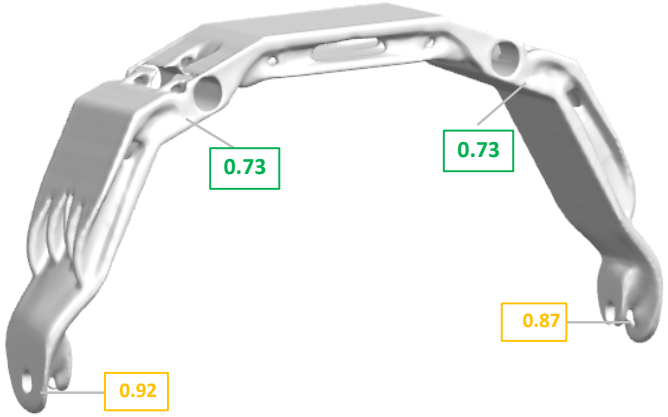
*The results are scaled to their own Yield Strength

Results

STATIC VEHICLE SIMULATIONS – Cornering Vehicle Load

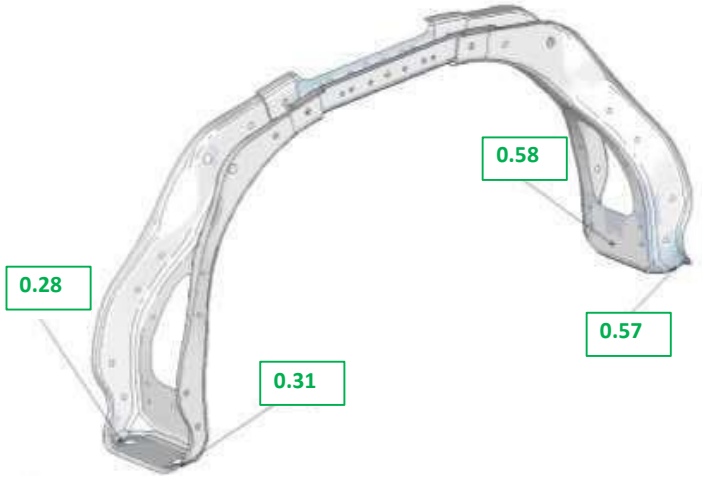


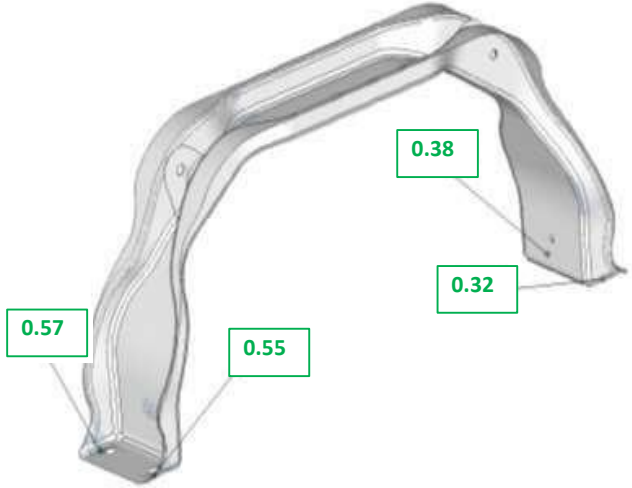




Results

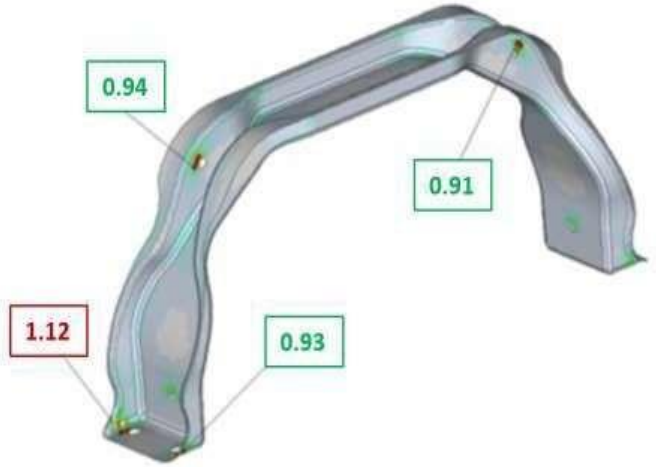
STATIC VEHICLE SIMULATIONS – Assymetric Braking Vehicle Load

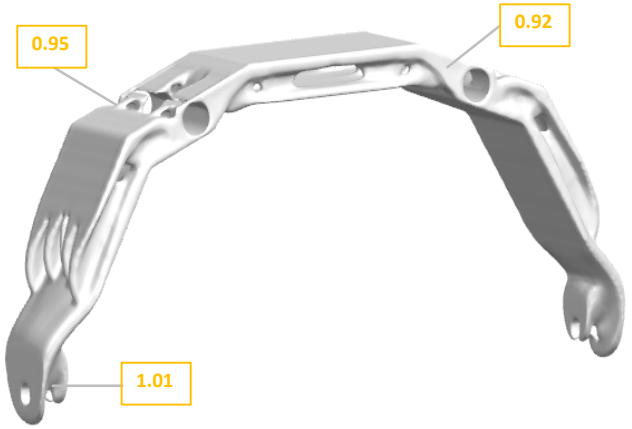




Results

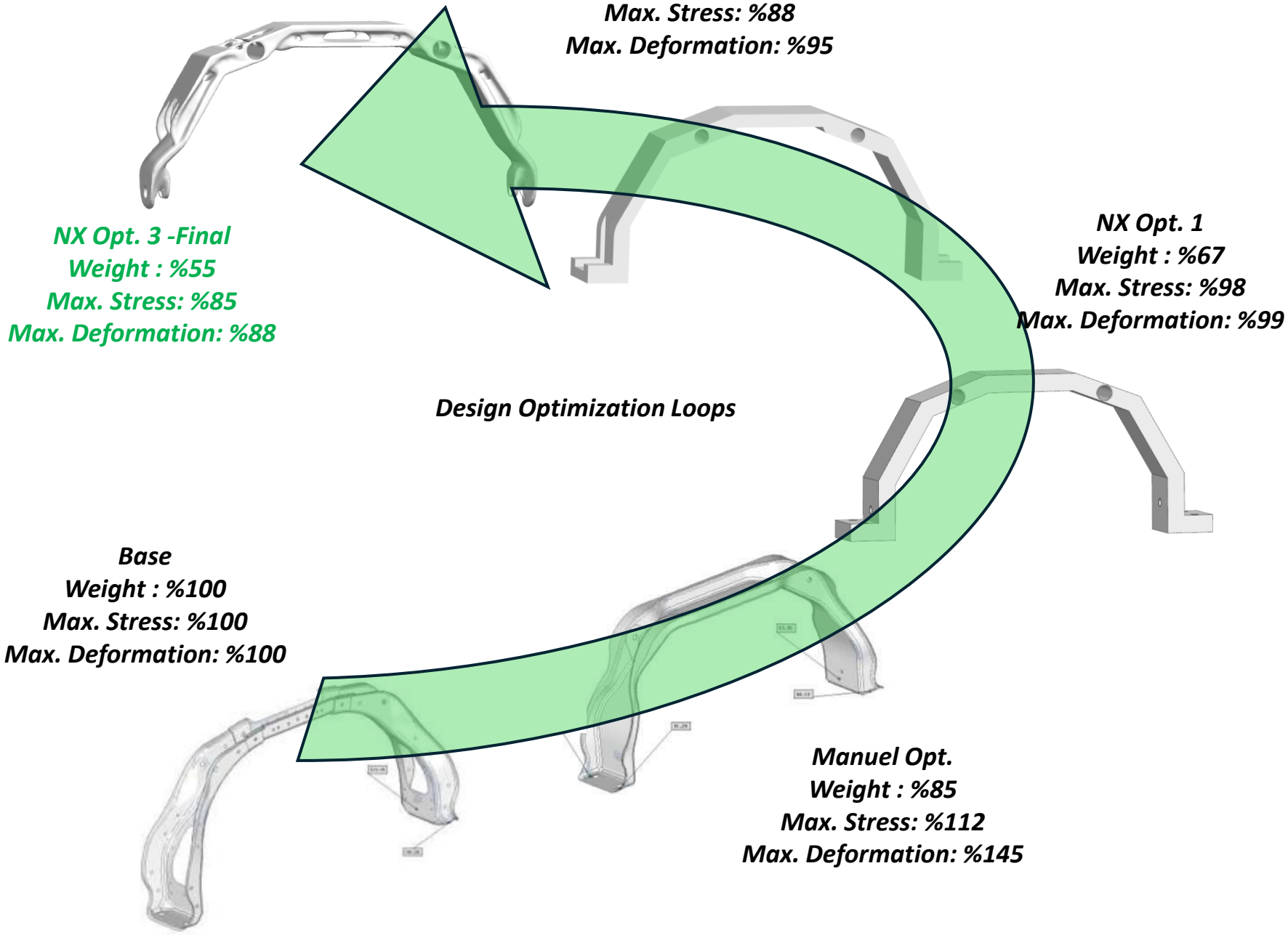
STATIC & DYNAMIC VEHICLE SIMULATIONS– Real Rough Road Test Conditions





Critical stresses occur where the console is connected to the chassis with the bolt. This region should be re-evaluated especially in terms of part reinforcement possibilities; about laser welding fatigue property.

*The results are scaled to their own Yield Strength


NX Opt. 2
Weight : %59
Max. Stress: %88
Max. Deformation: %95
NX Opt. 3 -Final
Weight : %55
Max. Stress: %85
Max. Deformation: %88
NX Opt. 1
Weight : %67
Max. Stress: %98
Max. Deformation: %99
Design Optimization Loops
Base
Weight : %100
Max. Stress: %100
Max. Deformation: %100
Manuel Opt.
Weight : %85
Max. Stress: %112
Max. Deformation: %145

Thank you for your attention!