LightHinge+:
Additively manufactured lightweight hood hinge with integrated pedestrian protection
EDAG Engineering GmbH: Portfolio

**PRODUCT DEVELOPMENT**
- Design concepts
- Body in white development
- Function development
- Vehicle validation and testing
- Electrics/Electronics

**PRODUCTION SOLUTIONS**
- Control engineering and automation technology
- Production engineering
- Production process planning
- Factory and logistics planning
- Tool and vehicle body systems
EDAG Engineering GmbH: AM projects

Hybrid Power Electronic Housing [2015]

GenLight [2015]

EDAG Genesis [2014]

EDAG Light Cocoon [2015]

Power electronic housing [2013]

Classic Cars [2016]

Next-Gen Spaceframe 2.0 [2017]

Next-Gen Spaceframe [2015]
Introduction
active engine hood | project team

Engineering
conception | topology optimization | design | prototyping | testing

Process simulation
calibration | model setup | simulation | compensation | validation

Conclusion
outlook | award
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Active engine hood lifting systems are established as an important pedestrian protection device in mass production.

Reasons against use in small-series and sports cars:
- complex kinematics
- many components
- high weight
- negative impact on design
- high costs for small quantities
Introduction: Project team

EDAG Engineering GmbH
- Initiator and independent engineering company
- Experts for lightweight construction and additive manufacturing
- Project lead, concept and component development

voestalpine Additive Manufacturing Center GmbH
- Material supplier and AM contract manufacturer
- Prototype production and AM know-how

simufact engineering GmbH
- Simulation software provider for manufacturing processes
- Distortion minimization through Simufact Additive Software

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With kind support from:
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DE: https://www.youtube.com/watch?v=2z-3vqAKkBU
ENG: https://www.youtube.com/watch?v=n1tm-fwFmO4
- Topology optimization for weight reduction
- Resulting in a support volume of over 50%
- Support reduction due to design adaptations
  - 1st step: 30%
  - 2nd step: < 18%

Support reduction for low post-processing and low costs
- Maximum component and function integration in a design- and weight-competitive package
- Use of bionic principles
  - E.g. tension triangle method and tree branching according to C. Mattheck
- Integrated pedestrian protection
  - Predetermined breaking elements for an additional degree of freedom
DE: https://www.youtube.com/watch?v=2z-3vqAKkBU
ENG: https://www.youtube.com/watch?v=n1tm-fwFmO4
- weight: 1.490 g
- number of components: 19
- tied-up capital: high
- needed package: high

Lightest construction for a hood hinge

- 720 g
- 6
- very low
- low

Engineering: The result
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Process simulation: Calibration of manufacturing process loads

- Cantilever specimens with different scanning strategies were printed by voestalpine.
- The cantilevers were cut and the deformation measured.
- Deformations were translated into **simufact additive**.
- The inherent strains that reflect the manufacturing process loads were calibrated.
Process simulation: Model setup for AM simulation

- Import part geometry
- Import support structure geometries
- Select material from database – 316L steel
- Define process chain to be simulated (build part, cut from plate, remove supports)
- Mesh geometries with voxels
Process simulation: AM simulation of single parts

- Simulation of
  - Building of the part
  - Cutting from plate
  - Removing support structures

- Calculation times
  - Lower bracket
    - 13.6 hrs on 14 cores
  - Upper bracket
    - 8.6 hrs on 8 cores

https://www.youtube.com/watch?v=VJaFm7Fj8Dw
Process simulation: AM simulation results

- Model is stabilized as it loses its reference after being cut from the plate
- Therefore displacement values are not unique, but dependent on relative position to original mesh
- Nevertheless prediction of part distortion is unaffected
Process simulation: AM simulation results

- Effective stresses shown

- Stresses are calculated based on non-linear elastic-plastic material model with realistic stress-strain relationship (flow curve)

- Yield stress at 585 MPa
  - Plastification leads to permanent deformation = distortion

- Ultimate strength is 685 MPa
Process simulation: Pre-deformed shape for distortion compensation

- Simulated distortion is inverted
- Inverted distortion is mapped on surface STL
- Pre-distorted STL is exported
- Exported STL was used for optimized AM of distortion compensated parts

NB: shown distortions are overscaled by a factor of 10 for better visualization
Process simulation: Distortion compensation

Original distortion of manufactured part vs. CAD

Distortion compensated based on simulation results
Process simulation: Distortion compensation

Original distortion of manufactured part vs. CAD

Distortion compensated based on simulation results
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Conclusion: Process simulation

- Significant reduction of the initial distortion up to 80% by AM simulation
- Further improved results possible by additional simulation iterations (Only one in project)
- No necessity for building expensive and time consuming trial parts
- No necessity for expensive compensation of distortion based on optical measurements
- AM part can already be within the given tolerances after the first build job

Manufacturing time and costs are reduced dramatically
Conclusion: Engineering

- Safety and lightweight construction combined in a distortion- and production-optimized design
- Exploiting the full potential of additive manufacturing
  - Rethinking applications from scratch
  - Solving problems and generating added value
  - Apply to visible components in order to be recognizable to end customers

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DE: https://www.youtube.com/watch?v=2z-3vAKkBU