

## Impact Simulations of Fiber Reinforced Plastics with LS-Dyna and Digimat

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## Content

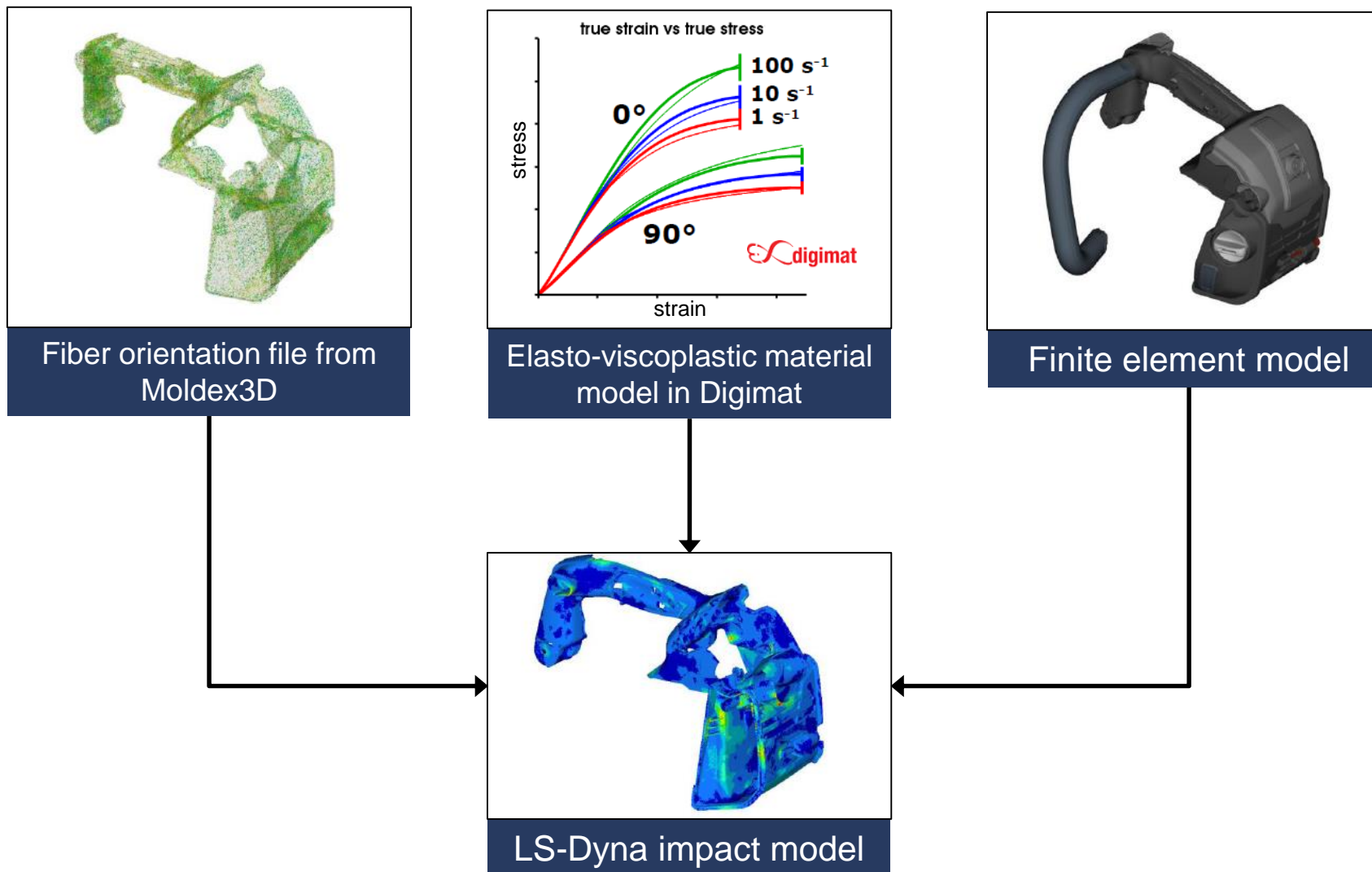
- About Husqvarna Group
- Simulation work-flow for glass-fiber reinforced plastics
- Correlation of simulation method
- Example of complete impact simulation model

# This is Husqvarna Group

- A global leading producer of outdoor power products including chainsaws, trimmers, robotic lawn mowers and ride-on mowers
- Approximately 13,000 employees in 40 countries
- Net sales in 2017 amounted to SEK 39 billion
- European leader in watering products through the Gardena brand
- A global leader in cutting equipment and diamond tools for the construction and stone industries



# Simulation work-flow

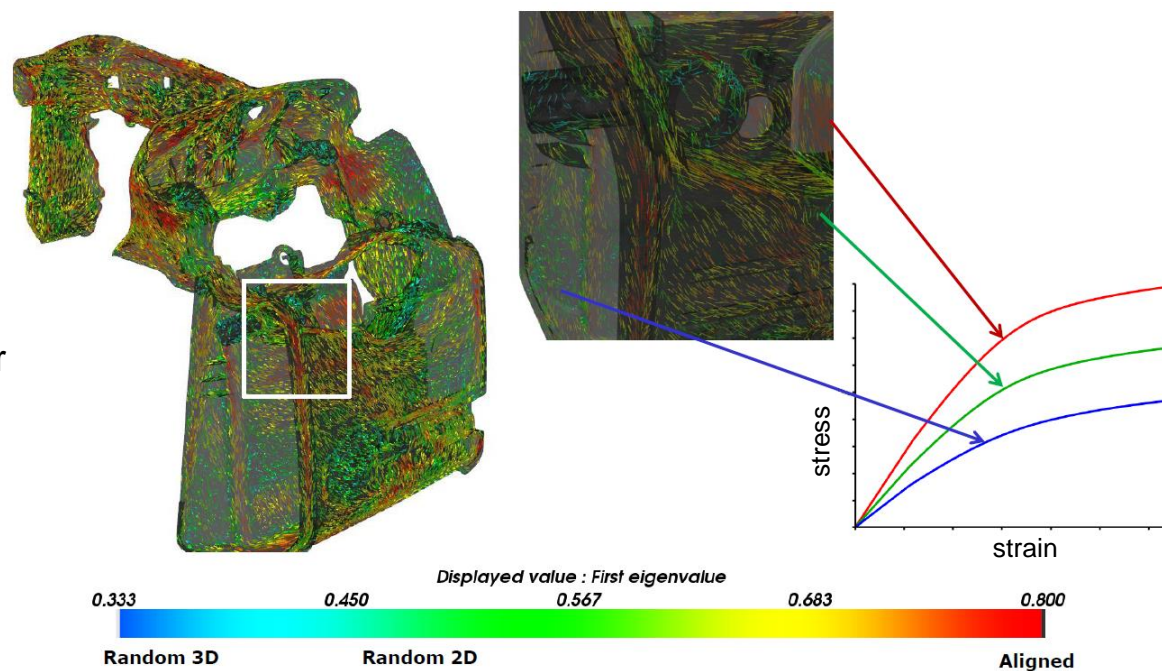




# Simulation work-flow

The information in the fiber orientation tensor is output from the FEA interface in Moldex3D

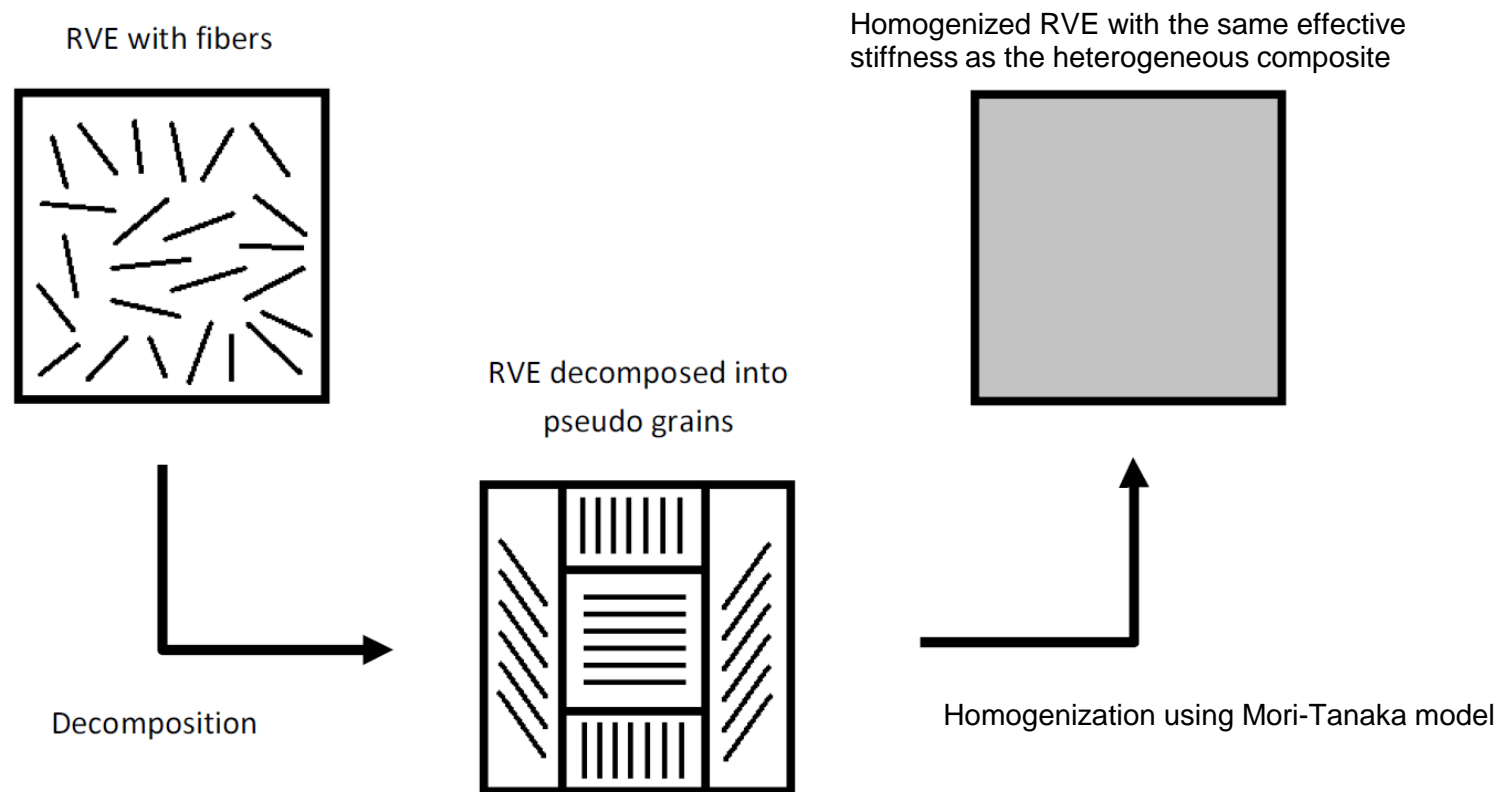
The direction of the vectors show the dominating fiber direction and the color represents the amount of alignment.



Digmat is used to map and simulate the non-linear material properties including failure. The structural mesh uses tetrahedral elements and the fiber orientation can vary within the element.

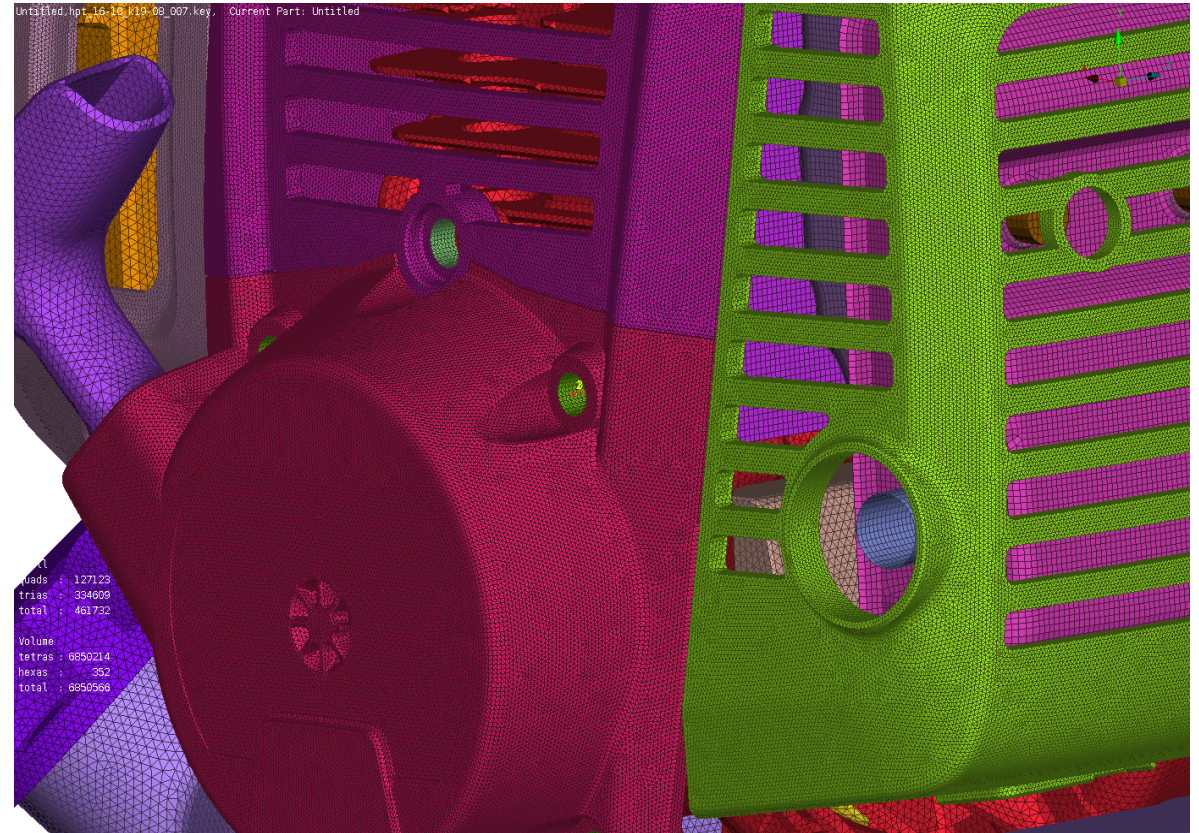
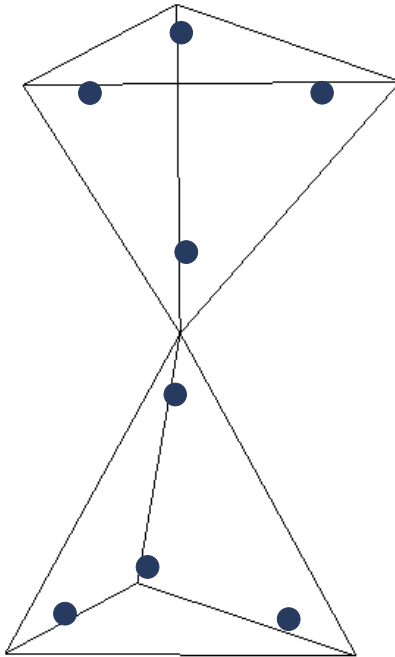
# Simulation work-flow

## Mean-field homogenization



The fibers are first decomposed into a finite number of unidirectional pseudo grains. Then the pseudo grains are homogenized both individually and collectively to obtain the homogenized RVE (Representative Volume Element).

# Simulation work-flow

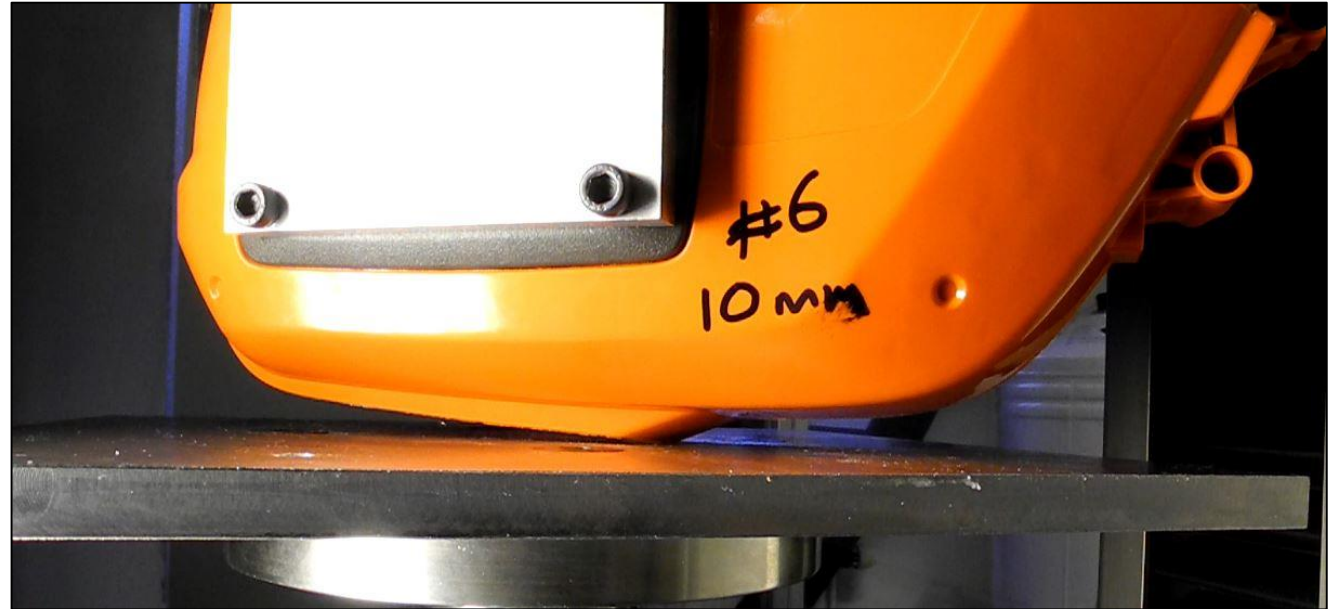
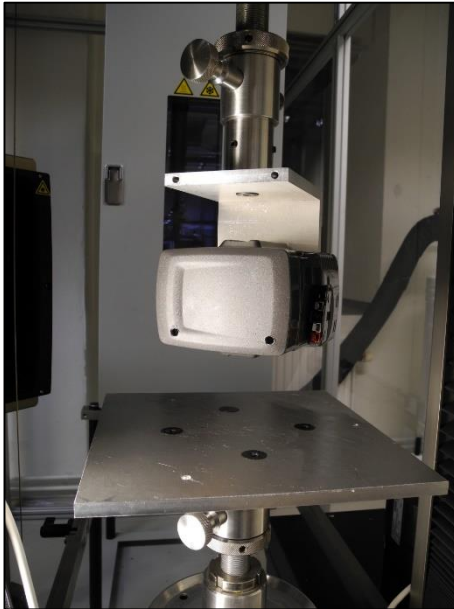


Linear tetrahedrons with 4 integration points (type 4 solids)  
The element is deleted when 3 integration points have reached failure  
Always at least two elements through the thickness. Element size ~0.7 mm.



# Correlation

Test setup for correlating the simulation method by crushing a battery housing



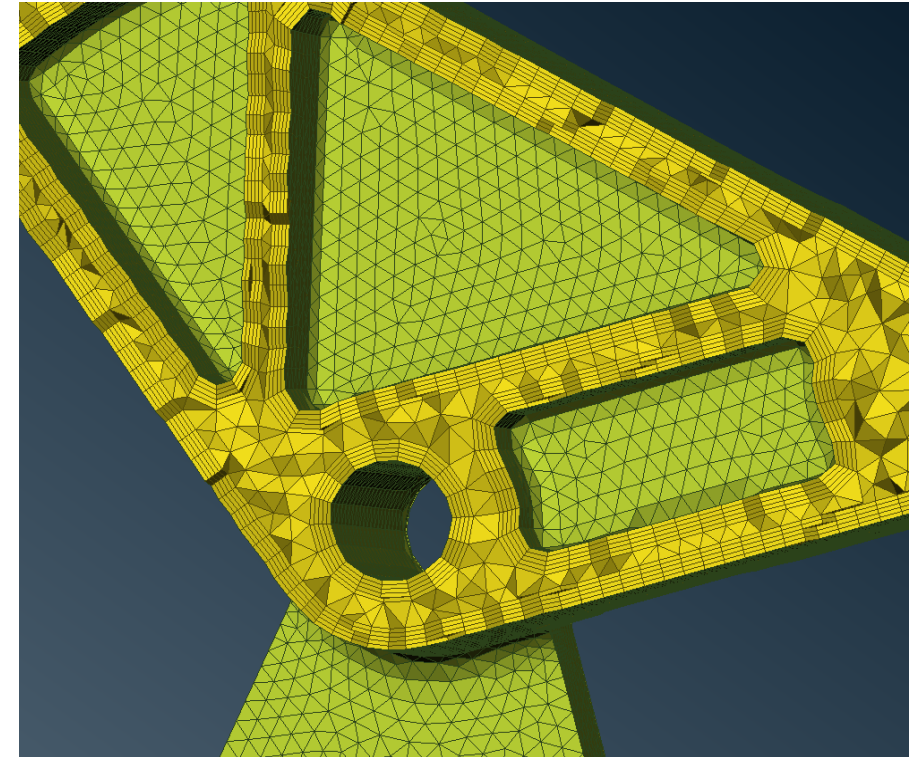
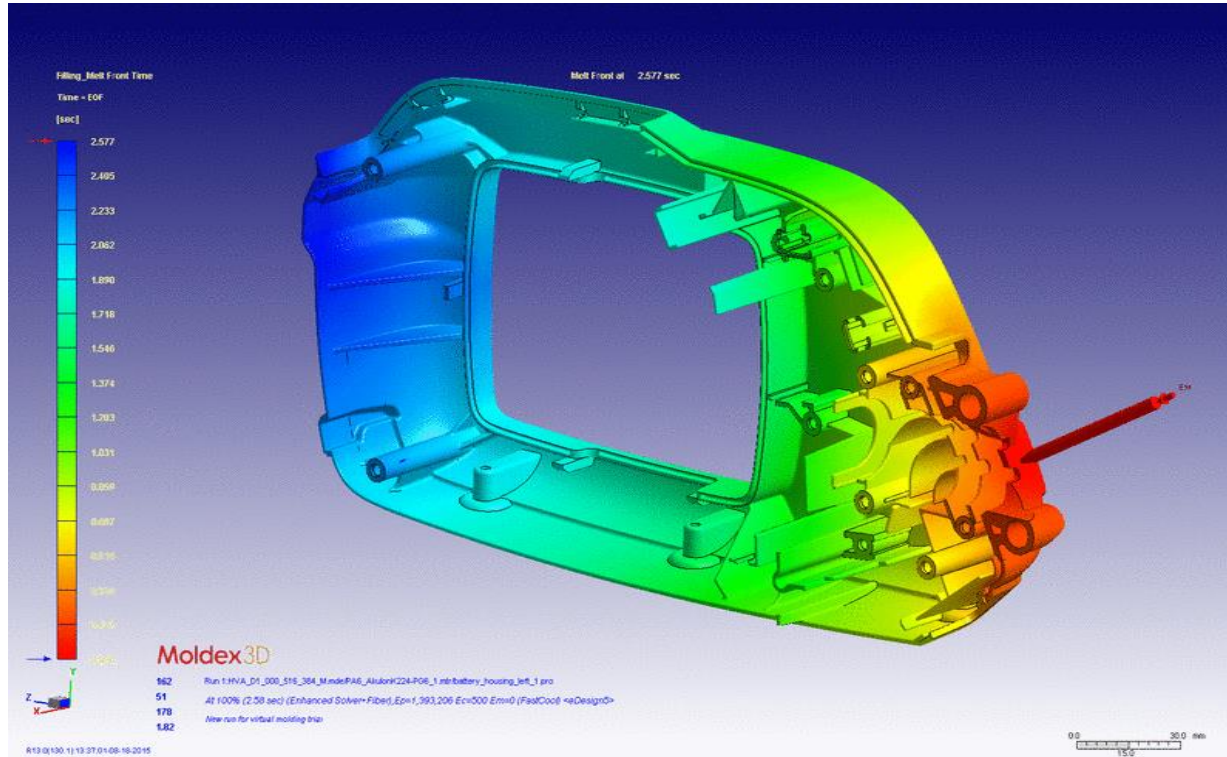
A stiff battery dummy was used.  
Deformation speed: 5 mm/min.  
The flat surface was lubricated to avoid influence of friction.  
Material: Dry Akulon K224-PG6 (PA6 30% GF)





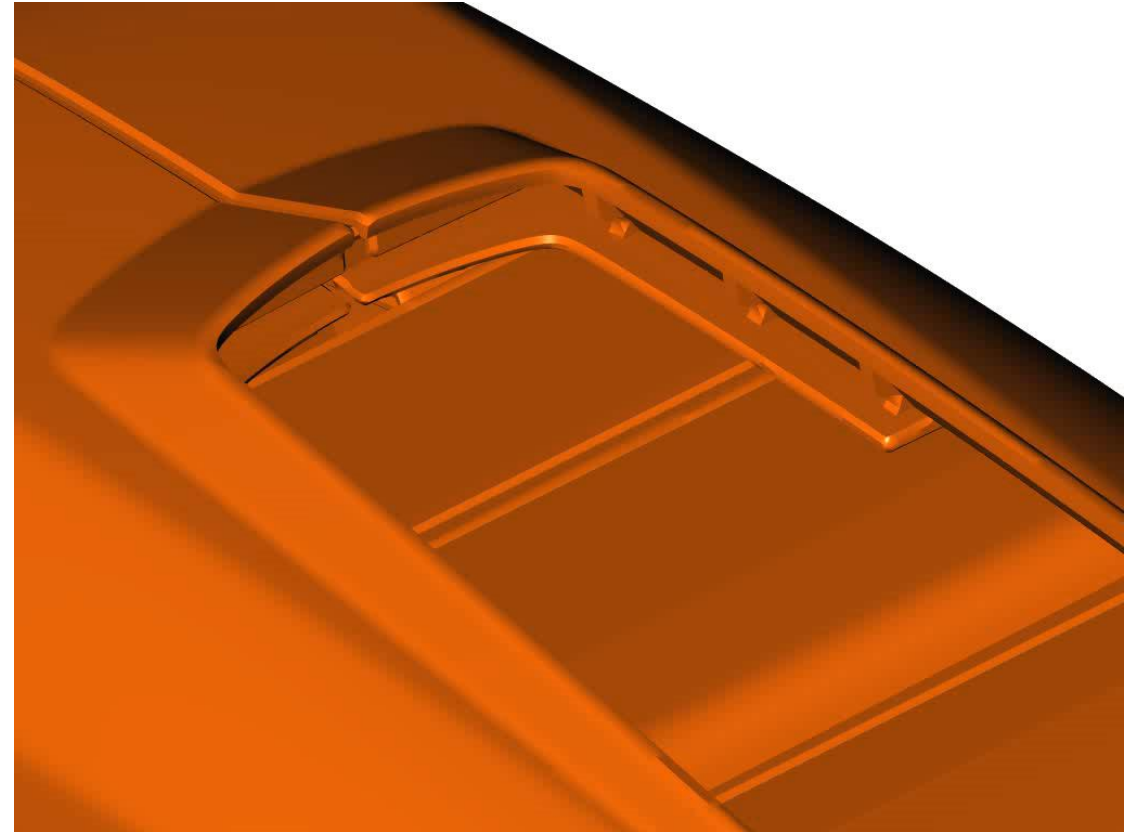
# Correlation

Moldex3D simulation to calculate fiber orientations in the battery housing



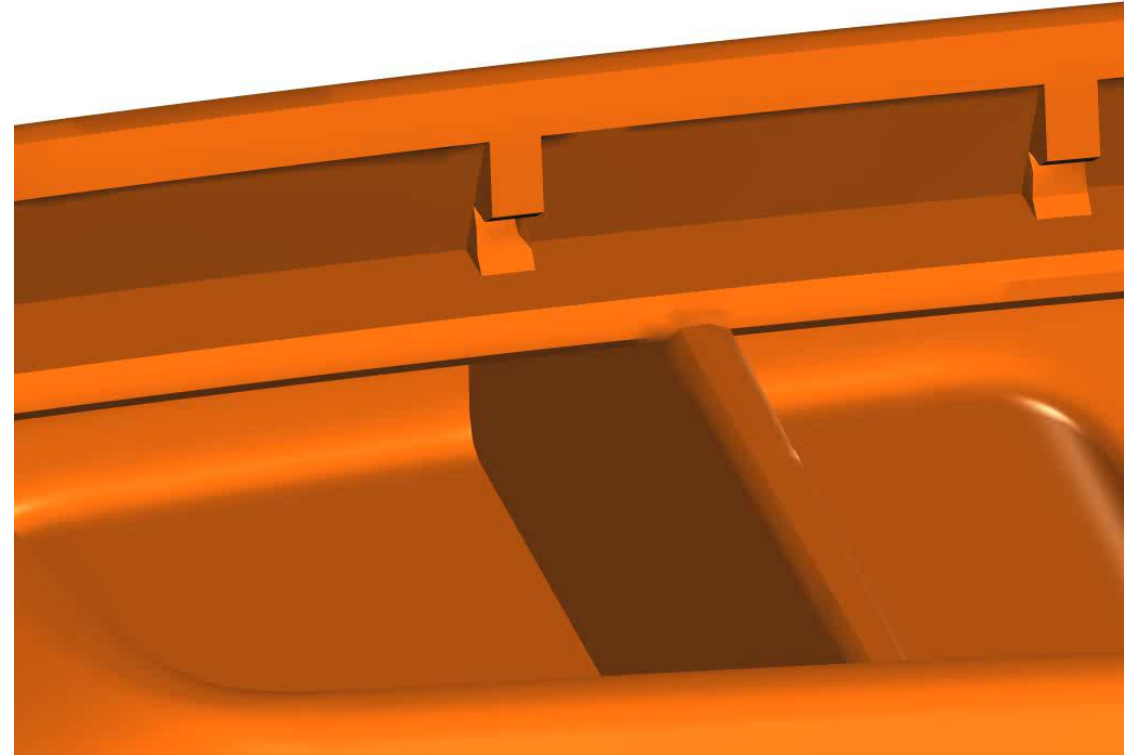
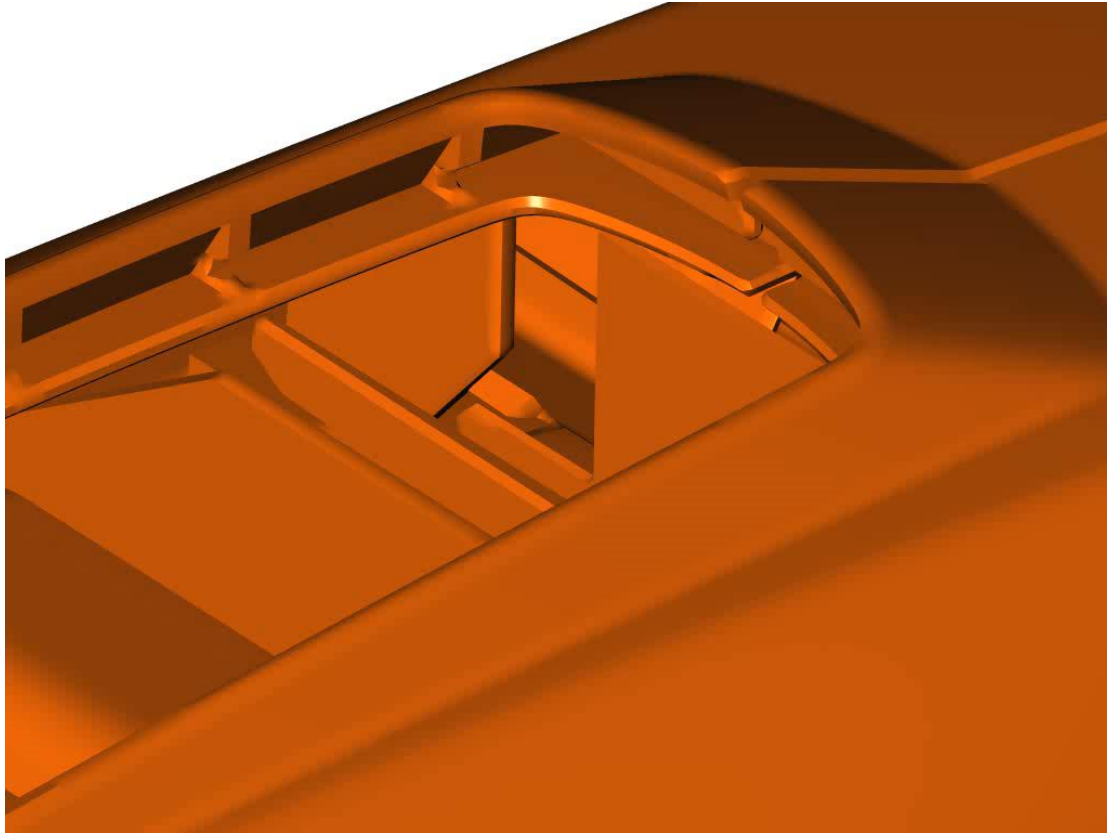
Boundary Layer Mesh (5 layers), meshed in Moldex3D designer (solid), 2.3e6 number of elements in cavity  
Runs on 8 processors and only fill phase is necessary to calculate fiber orientations

# Correlation, component test



Simulation in LS-Dyna with contacts and Digimat anisotropic material model that included failure criteria.  
The battery housing was compressed 10 mm.  
Resembles a drop test where the heavy battery will apply a large force to the housing.

# Correlation, component test

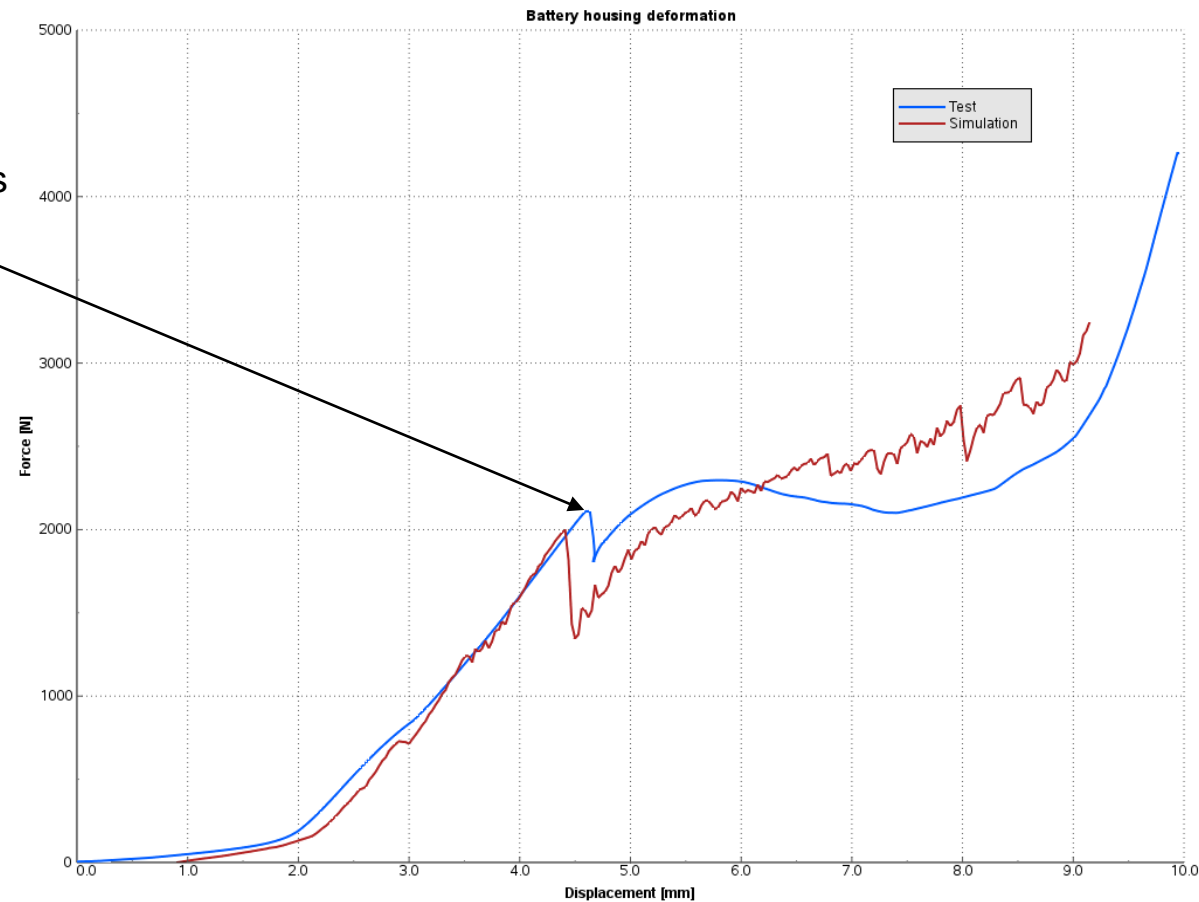


When failure is reached for a finite element it is deleted and a crack opens up.



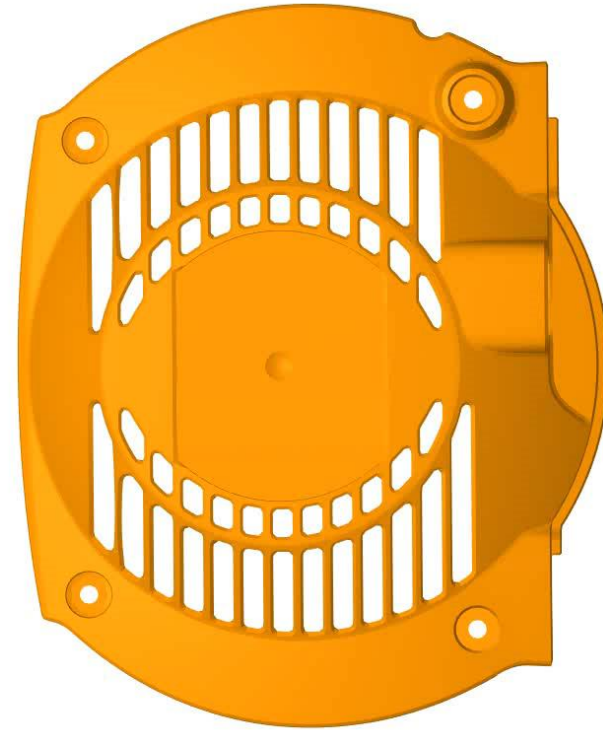
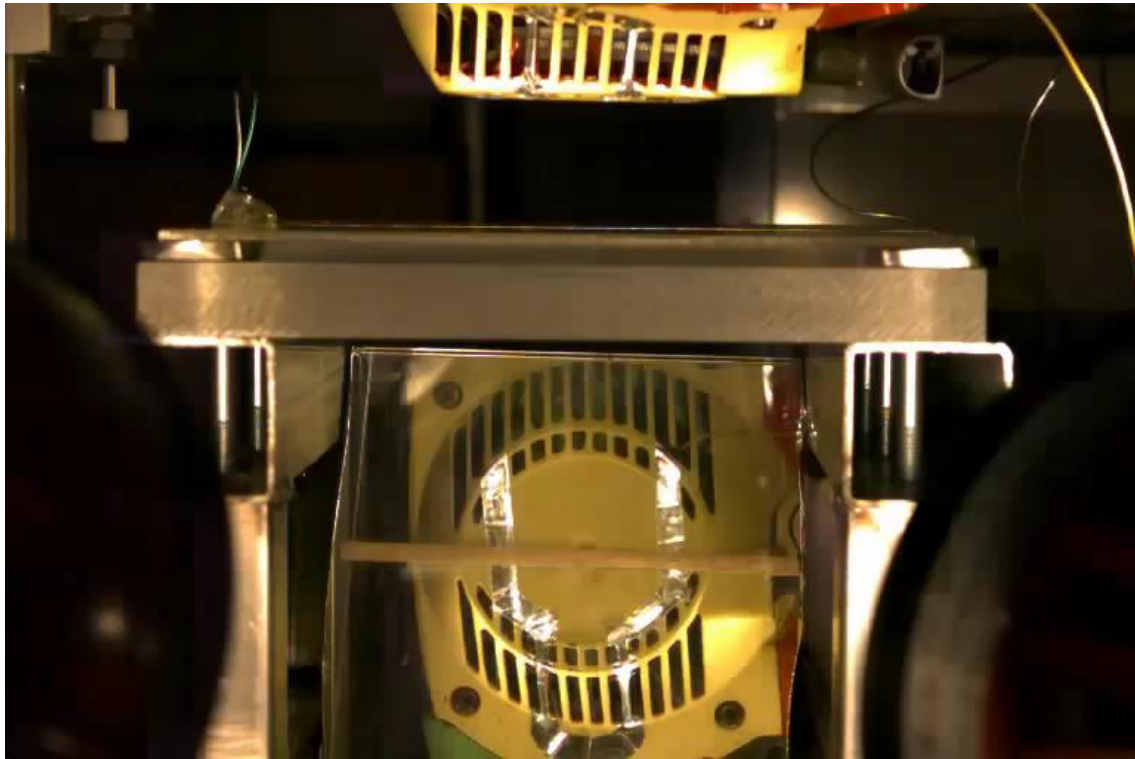
# Correlation, component test

“Snap through” effect when  
accumulated internal stresses  
due to contacts are released



# Correlation, drop test

Drop simulation of complete clearing saw model







# Example cases



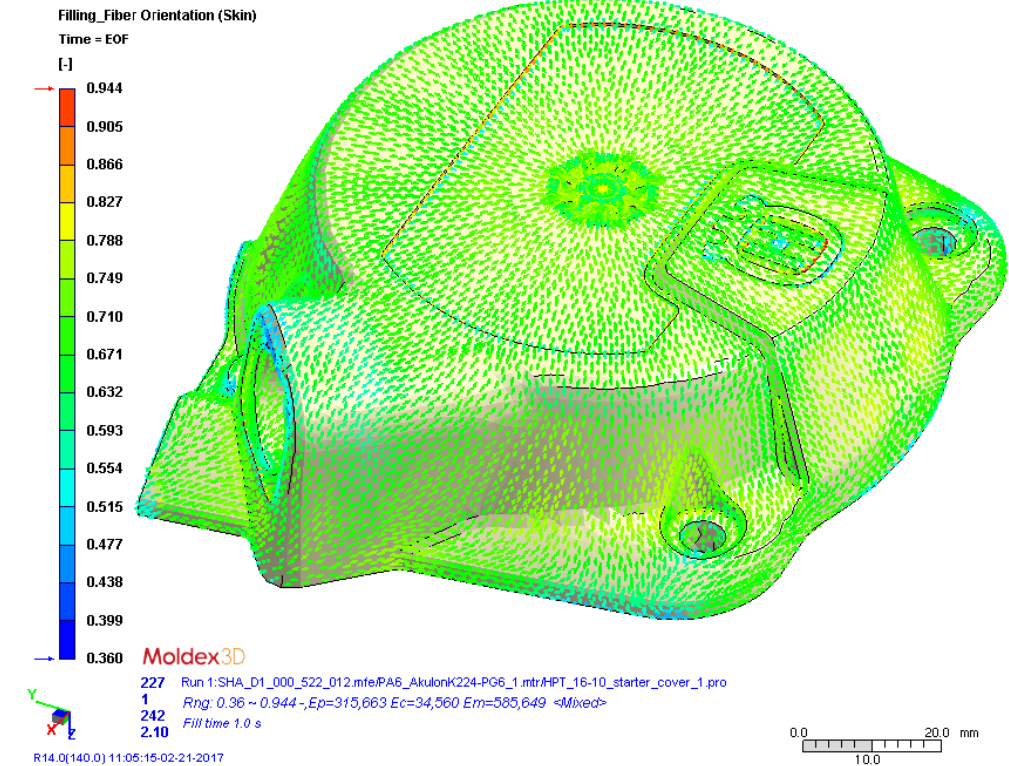
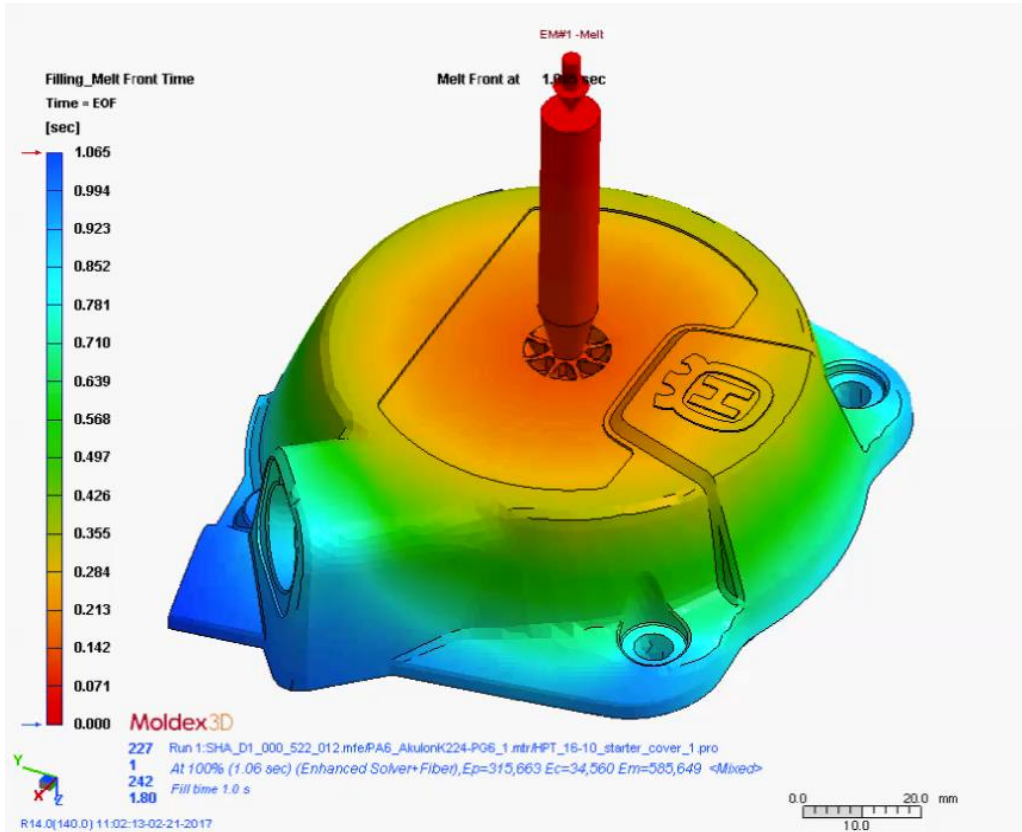
# Impact on starter cover

- Petrol trimmer drop simulation with Digimat material model in LS-Dyna
- Weight: 3.52 (engine) + 4.32 (shaft assembly) + 0.47 (fluid in tank) = 8.31 kg
- Drop height: 600 mm
- Impact energy: 48.9 J
- The drop test will be made with dry material at room temperature.



# Impact on starter cover

Mold filling simulation of the starter cover. Material: Akulon K224-PG6 (PA6 30% GF)



# Impact on starter cover

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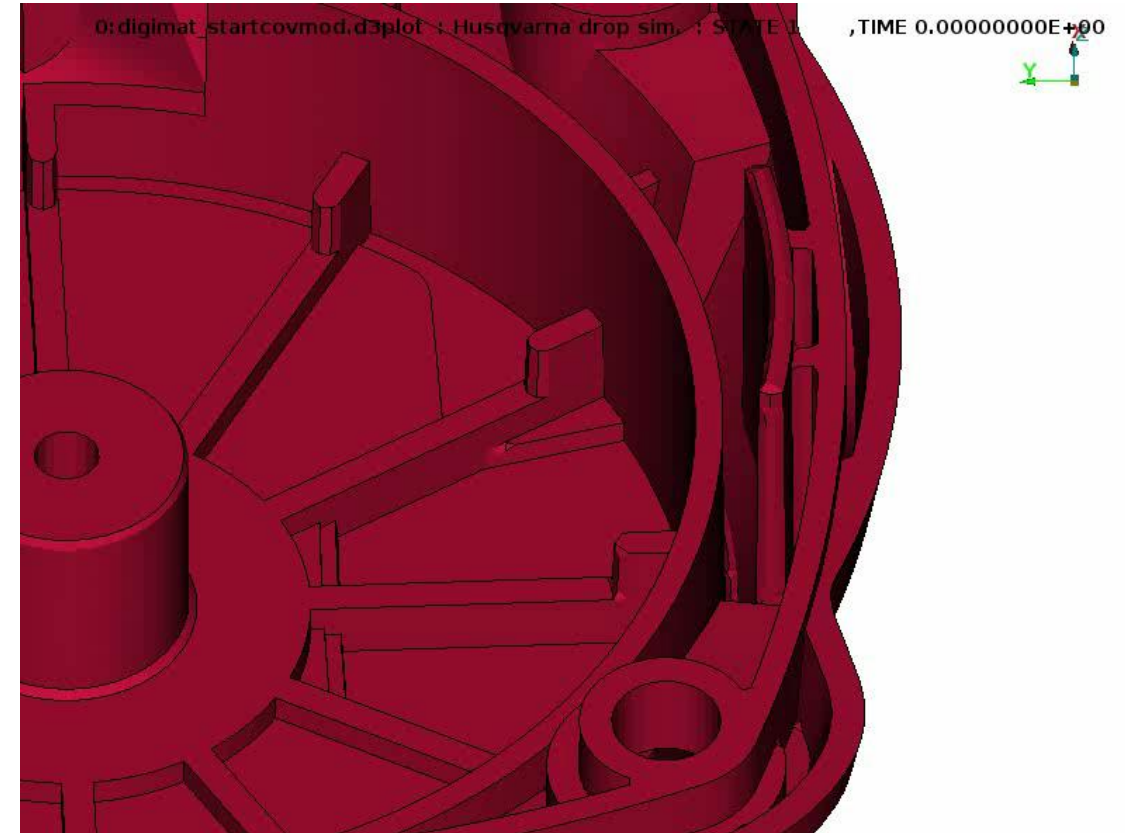
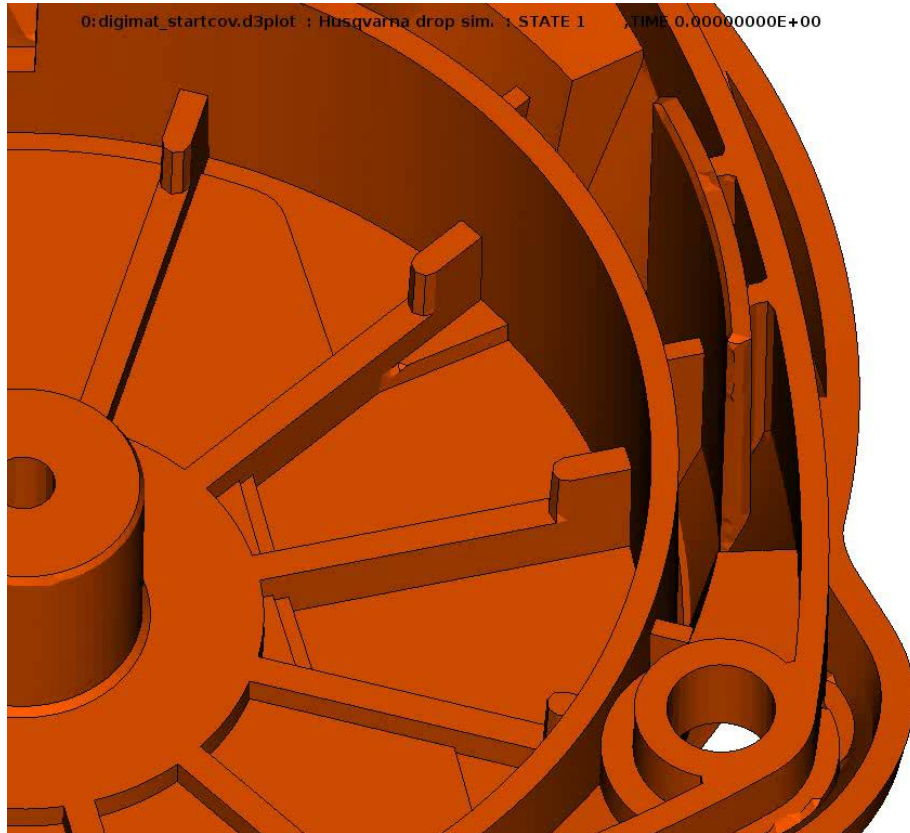
Simulated time: 3 ms





# Impact on starter cover

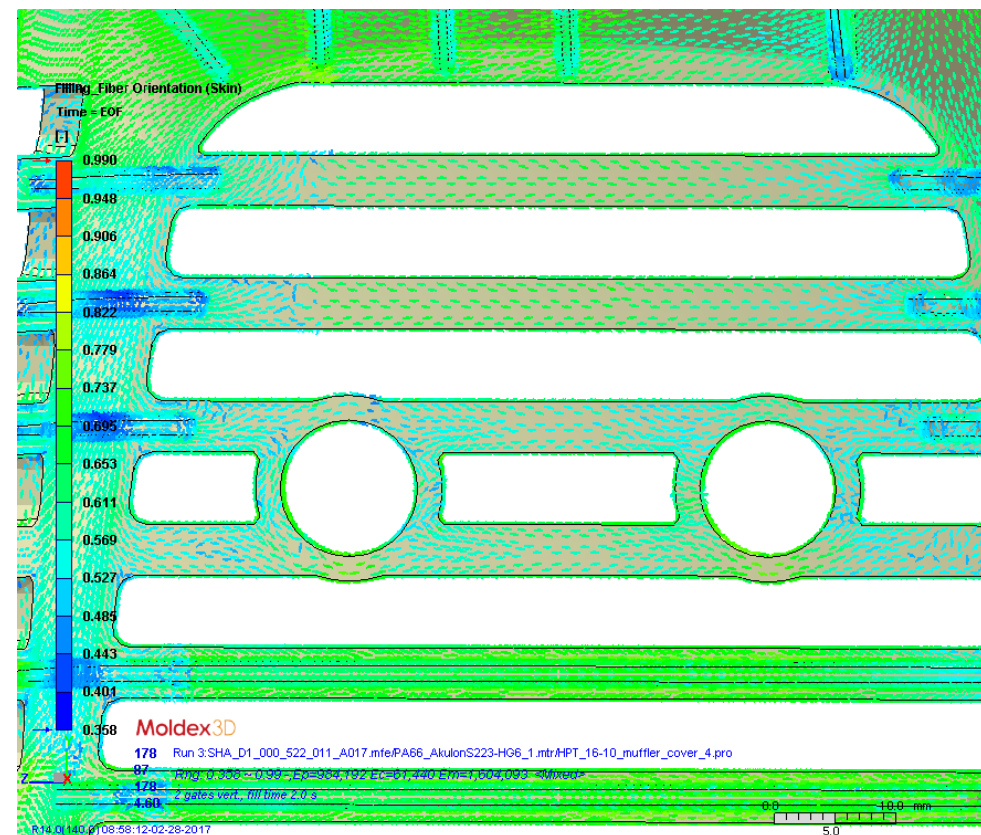
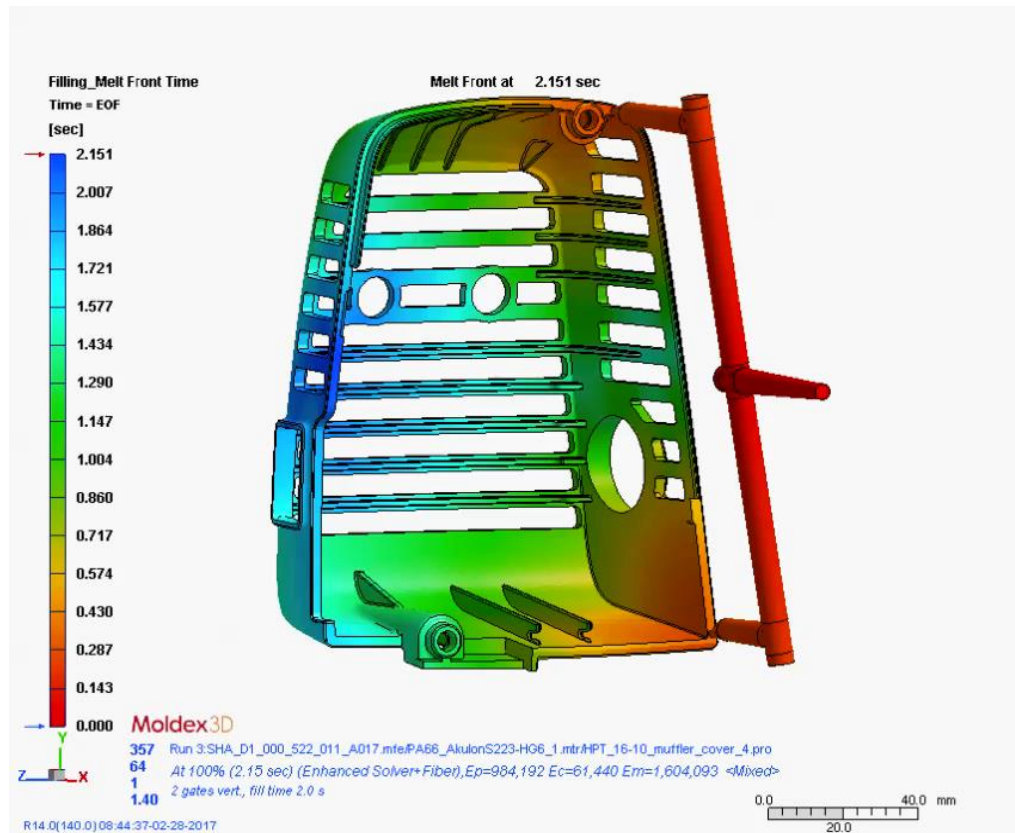
Animations of two variants of the starter cover



Removal of the connector that cracked solved a potential issue with the starter cover.  
The material model included fiber orientations and failure for increased accuracy.

# Impact on muffler cover

Mold filling simulation of the muffler cover. Material: Akulon S223-HG6 (PA66 30% GF)



Fiber orientation

# Impact on muffler cover

Results example, not final version



Drop height of engine part: 600 mm

Impact energy: 30.1 J

Simulated time: 10 ms



# Impact on muffler cover

Results example, not final version



Drop height of engine part: 600 mm

Impact energy: 30.1 J

Simulated time: 10 ms

## Summary

- Implemented simulation loop containing mold filling simulations are now used mainly for impact simulations of Husqvarna battery products.
- Gives an increased accuracy and a possibility to predict the amount of damage after a drop test.
- Our material supplier (DSM) provides correlated material models in Digimat format.
- Design engineers can do the Moldex3D simulations that are used by the calculation group.



**Husqvarna  
Group**

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