DFM+
A New Approach to Casting Development

13th Jan 2022

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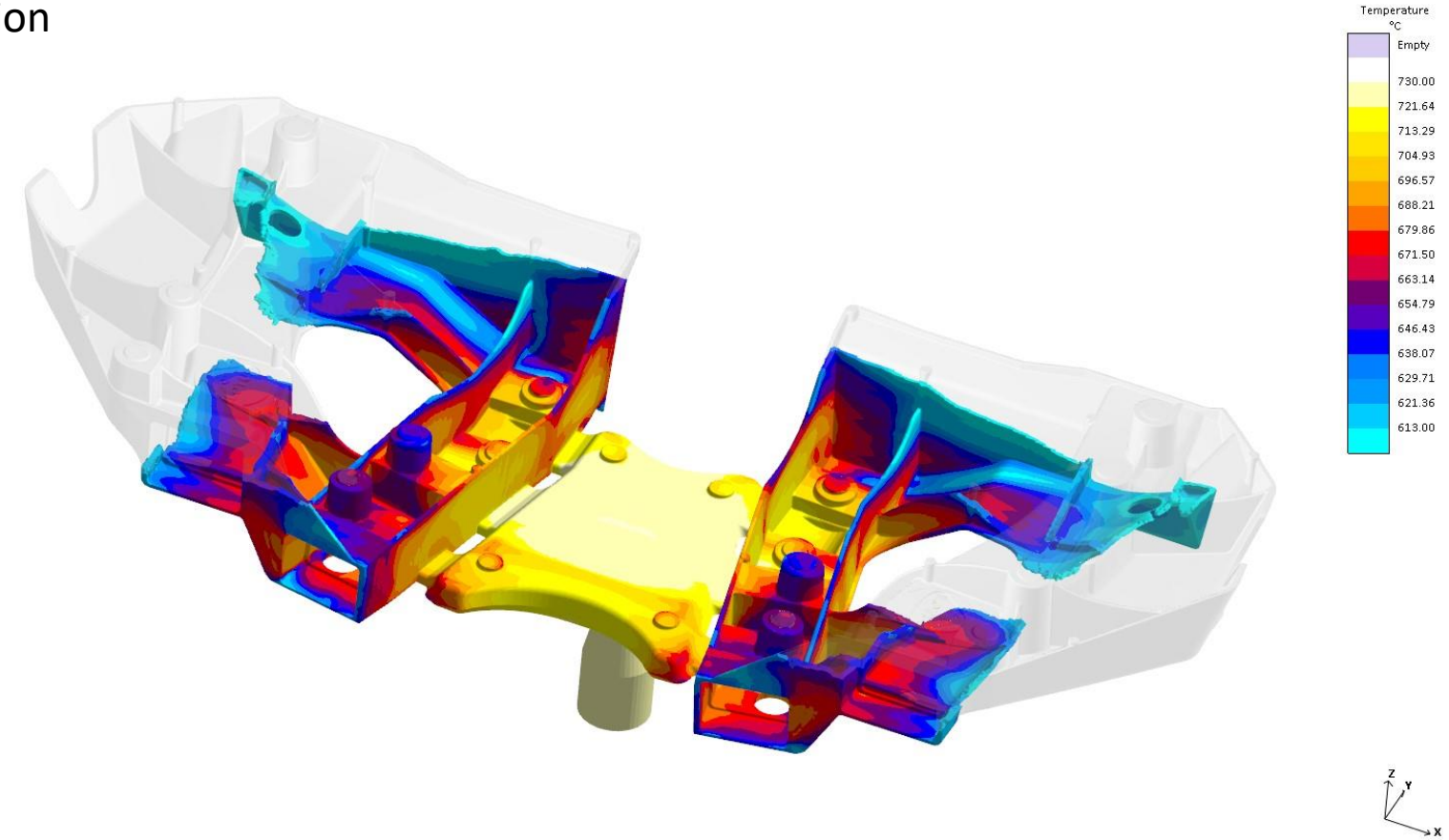
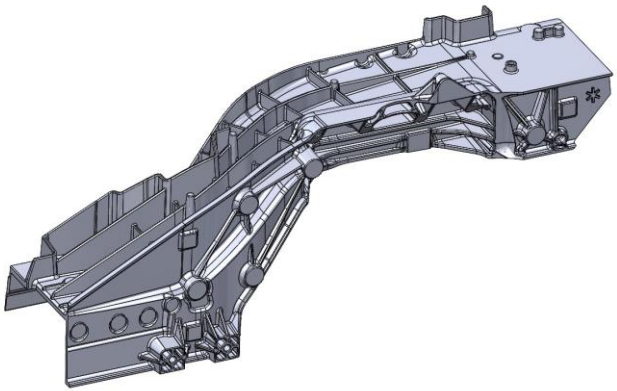
Introduction

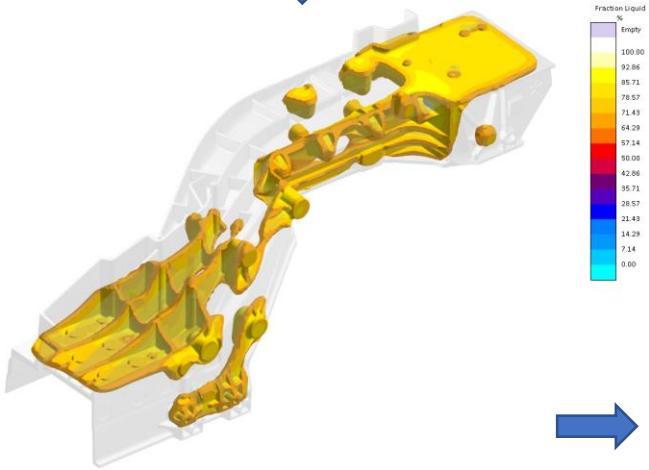


Sarginsons have recognised for some time, through casting testing and calibration, that the simulated CAE homogenous figures inputted in vehicle CAE development do not replicate the reality. We have therefore developed digital twin solutions that can – at the concept and design development phase – simulate the mechanical property variability from the casting and heat treatment stages, map this to FE meshes and export for intelligent further CAE work. This allows the customer to make informed decisions on design suitability, offers opportunity for significant light-weighting by removing geometrical pessimism and allowing for integrated optimised topology, identifies areas of reduced strength before manufacture, and critically compresses the development timescales.

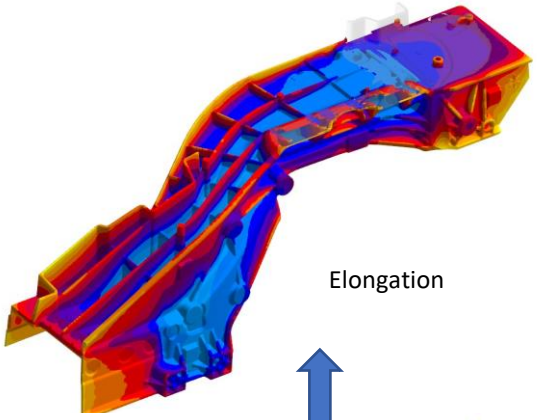
Material Property Mapping Process



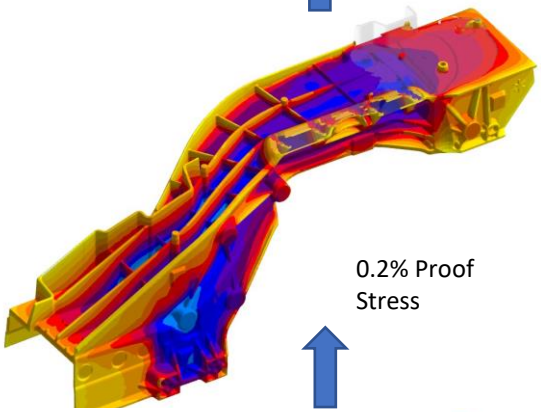
Casting is analysed and developed for manufacturing suitability



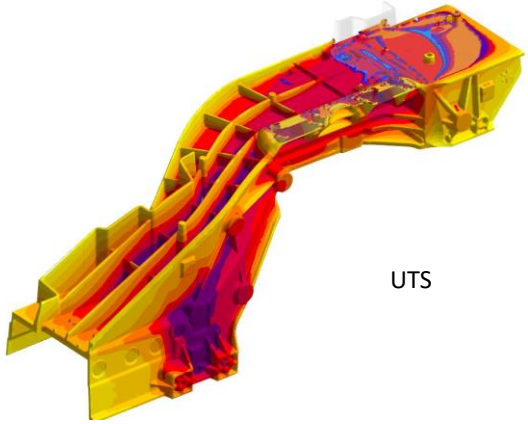
Magma software used for casting and heat treatment simulation



Elongation

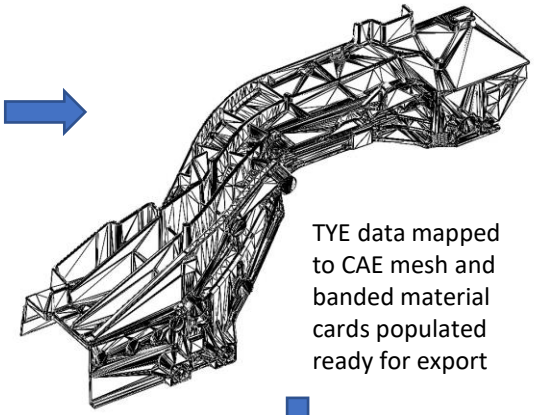


0.2% Proof Stress

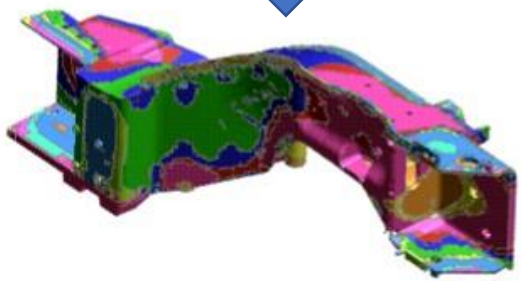


UTS

Mechanical property variability due to geometric and manufacturing processes specified



TYE data mapped to CAE mesh and banded material cards populated ready for export



Fully mapped mesh as seen in CAE software (in this case LS DYNA)

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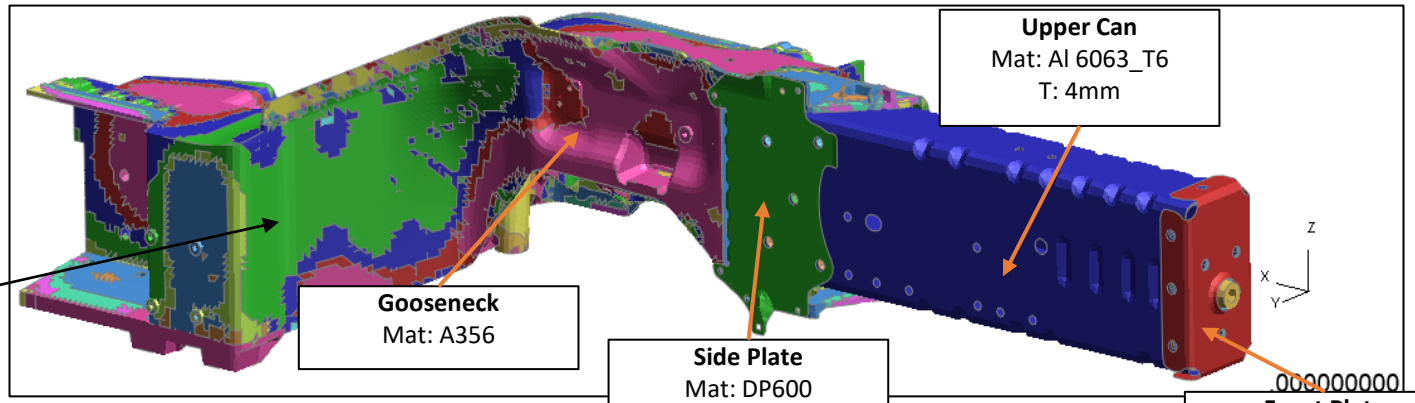
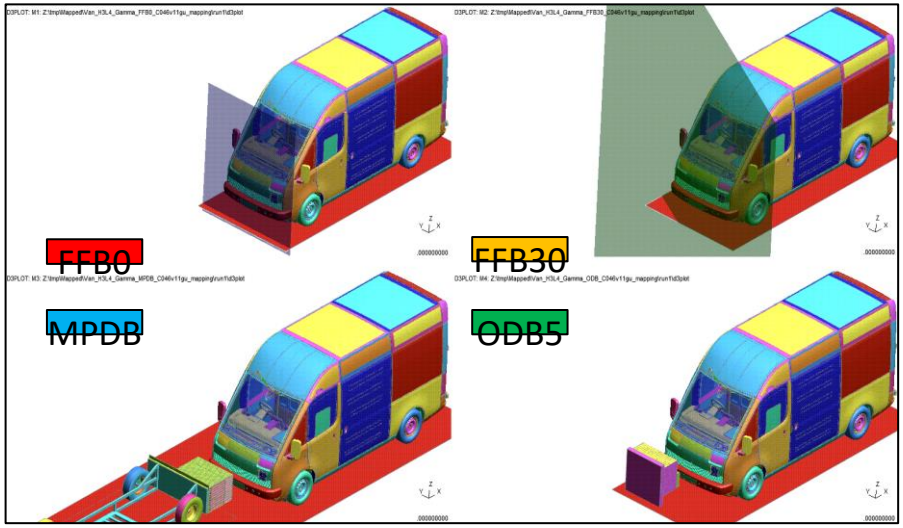
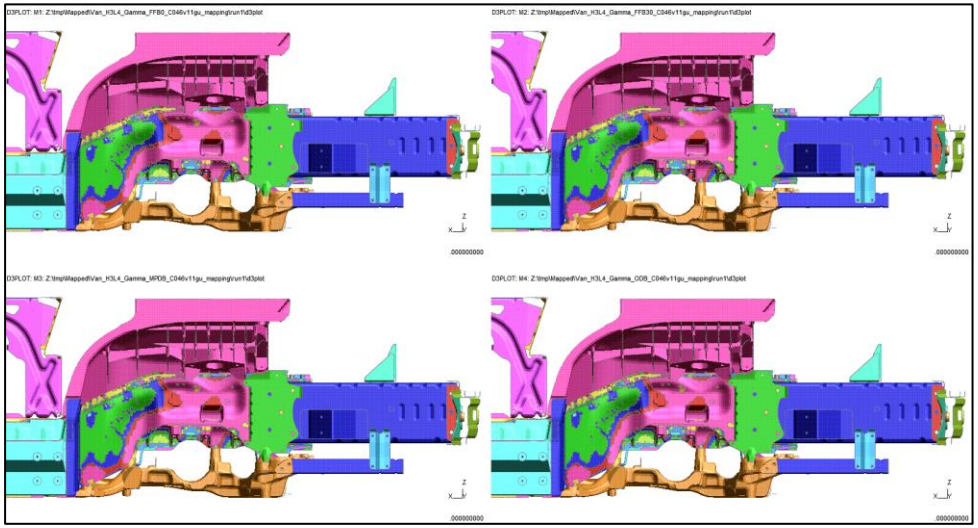
Mapped Data Application

Cast form with variable mechanical property data banded and mapped



Technical definition of the upper load path
Mapped LPDC Gooseneck from Sarginsons

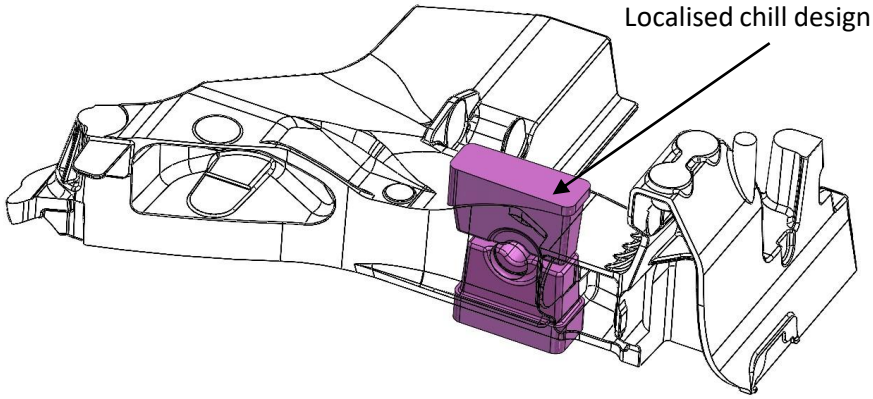




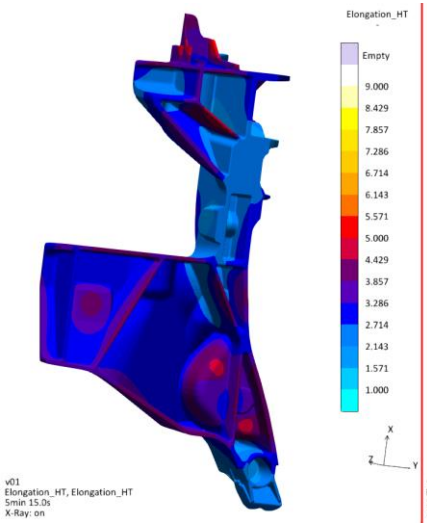
Once re-imported into CAE software, the mapped casting data (the number of data bands can be specified as required) can be used to give a realistic replication of the casting performance. This allows the engineer to make intelligent and informed decisions at the development stage that are simply not achievable with fixed homogenous material data that is currently used in most CAE. Opportunities for light-weighting, redesign, and process adaptation are enormous. Development loops can be shortened, errors avoided, and substantial cost savings made.

Manufacturing Considerations

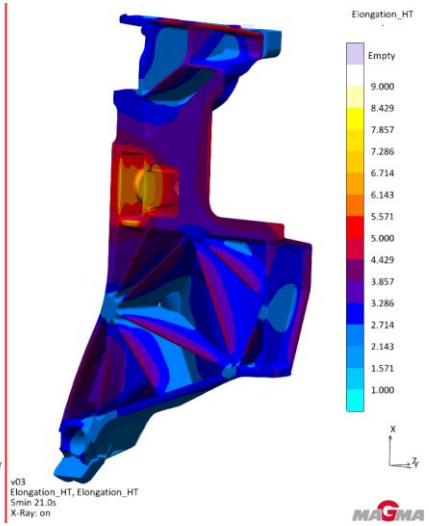
Targeted Chilling



Pre chill elongation



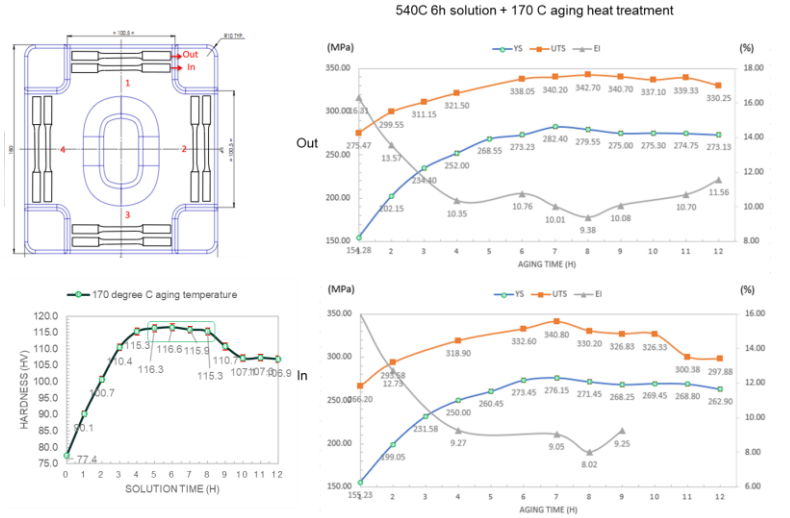
Post chill elongation

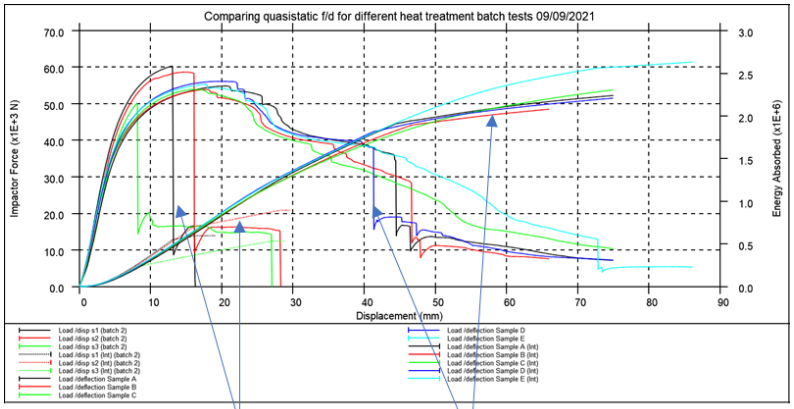


Localised use of chills in sand casting can address areas of high stress/strain and elevate mechanical properties to allow successful deployment. This approach can be fully simulated and mapped for CAE analysis. For permanent mould there is the opportunity to explore 3D printed cooling channels to work in the same way with key areas of high stress.

Heat Treatment Variables

Aging heat treatment – TYE (A356)





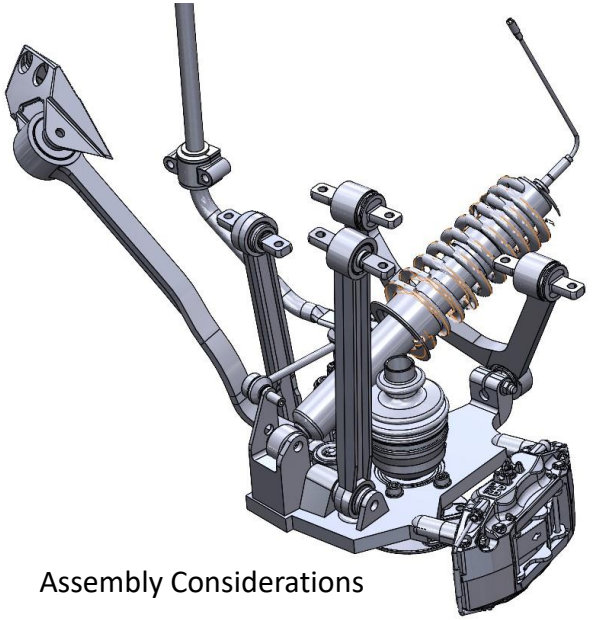
Results for lower elongation/higher yield (test run 2)

Results for higher elongation/lower yield (test run 1)

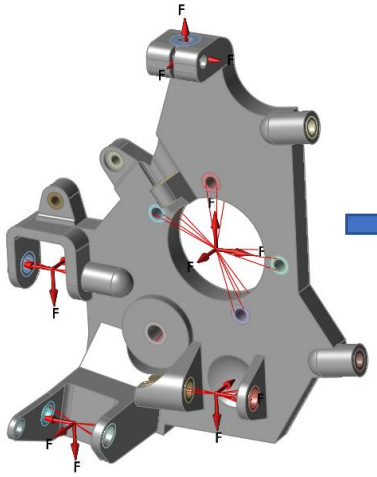
Mechanical properties in aluminium cast forms can vary significantly during the heat treatment process, due the impact of precipitation through the ageing process. Sarginsons have built a comprehensive library of this data that allows a specific heat treatment to be simulated and specified for parts with certain requirements. For example, elevated ductility.

Optimised Topology +

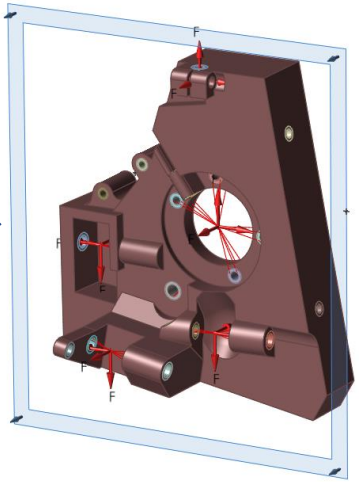
The integrated use of advanced casting simulation with optimised topology is key to maximising light-weighting opportunities in future vehicle design. By fully understanding the impact of organic geometry on cooling rates, manufacturability, and mechanical strength castings can be lighter, stronger and lower cost.



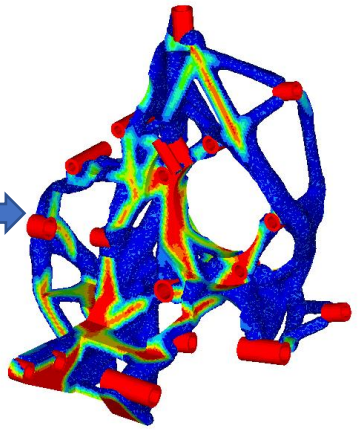
Assembly Considerations



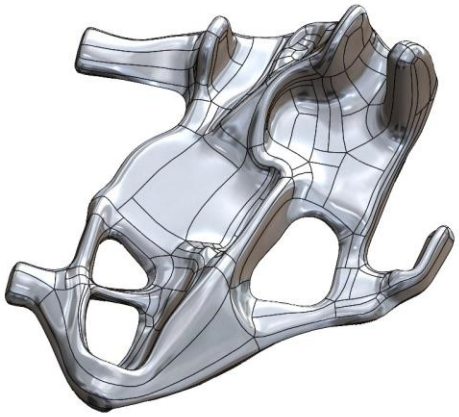
Model Import with Baseline Load Data



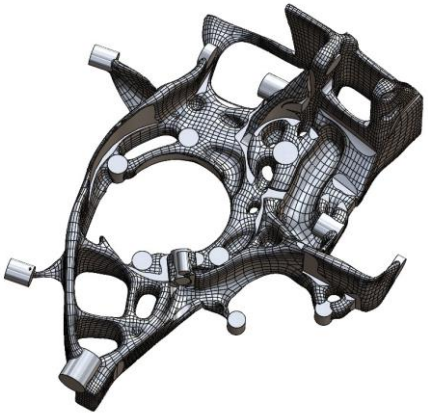
Design Space Definition



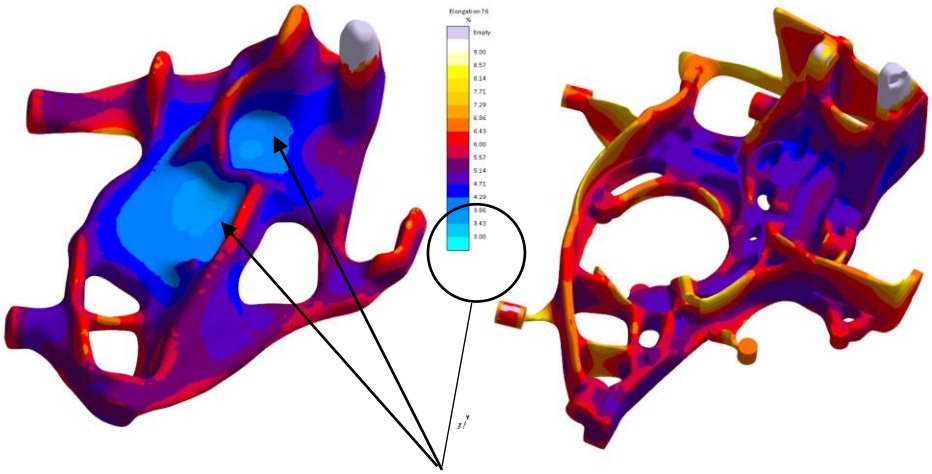
Analysis & Optimisation



Customer Optimised Cast Form – 4.13kg (49% higher mass)



New Sarginsons Optimised Cast Form – 2.78kg



Lowest Elongation in areas of increased mass. Reconsidered form is lighter, stronger and more manufacturable

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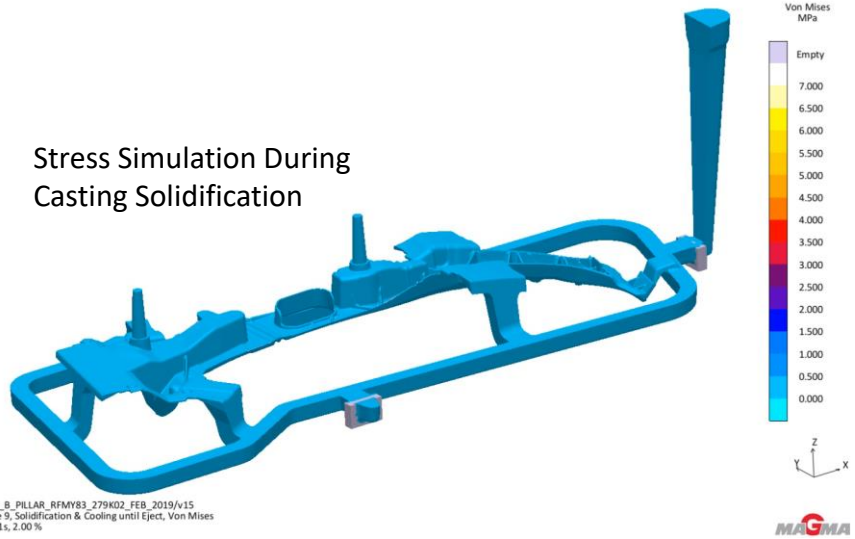
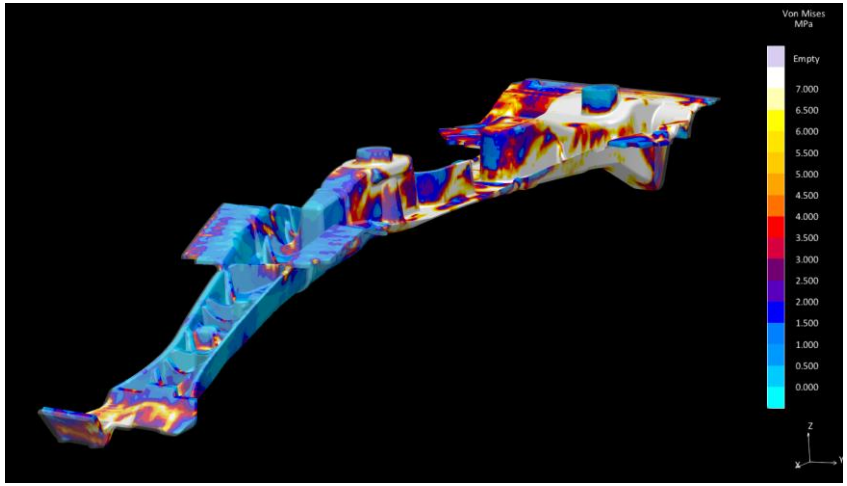
Stress Mapping + Predictive Deformation

The impact of casting deformation during cooling and particularly heat treatment can also be simulated, and results files created to align with nominal geometry allowing distortion risk to be considered at the design stage. Additionally, residual stresses inherent in the casting forms following these processes can also be predicted and mapped, much in the same way as TYE properties. This data can then be used for informed CAE fatigue and other engineering analysis

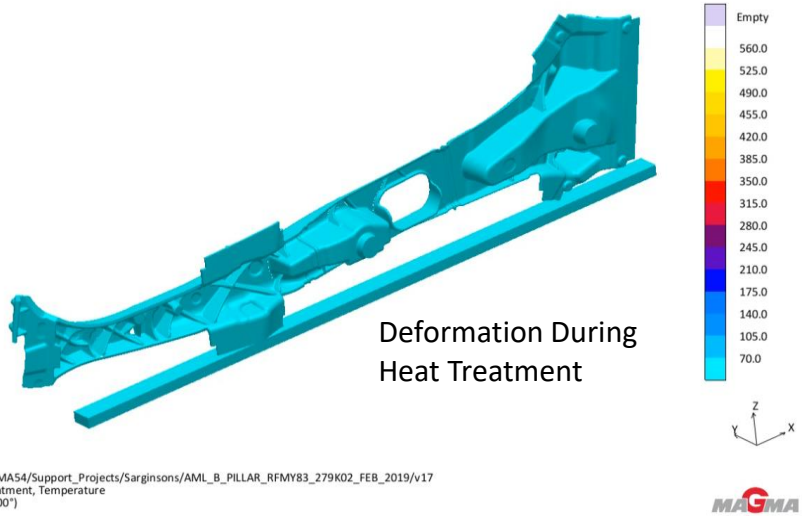
Stress Simulation During Casting Solidification

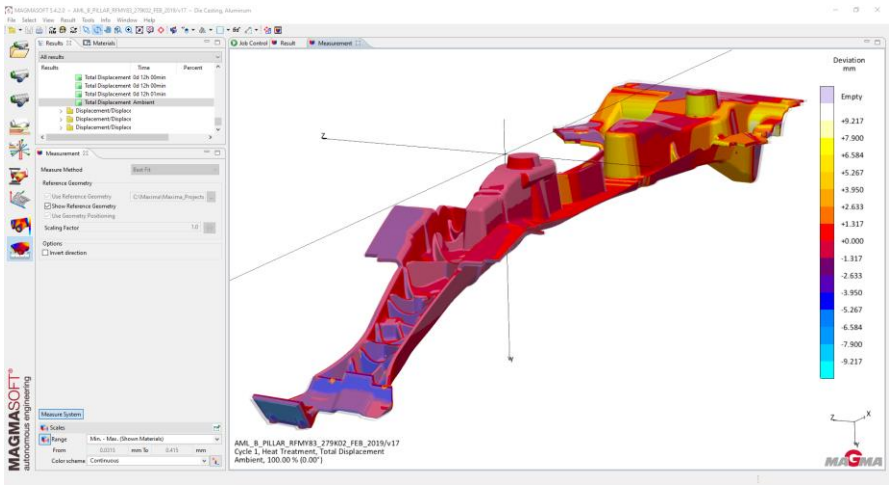




Stress Mapping – can be exported for CAE fatigue analysis

Deformation During Heat Treatment





Final Model with predicted levels of deformation (from nominal)

Thank you

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