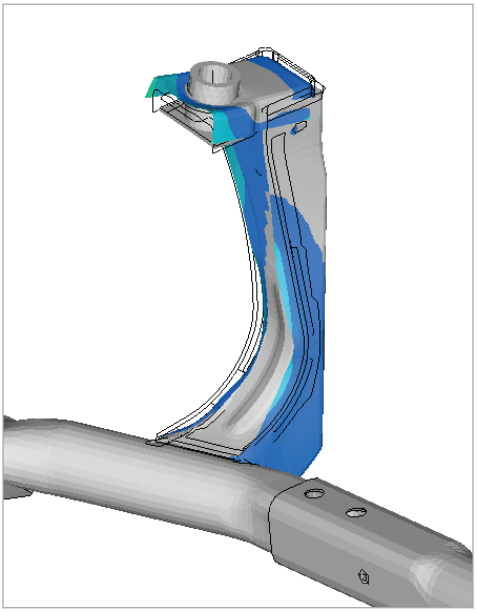
Reducing Weld Distortion by 93% with HyperStudy



Gestamp

Key Highlights

Industry
Automotive

Challenge
Accurately predict weld distortion and optimise the weld pattern to reduce it

Altair Solution
Use HyperStudy to find the most effective pattern to minimise distortion

Benefits
Significant time and cost savings while maintaining high performance

Weld distortion is a significant issue in sheet steel product manufacture. It adds costs to the product in numerous ways. This is especially the case in the automotive sector where tolerances are tight and complex high performance components are the norm.

The contraction caused by the welds cooling leads to distortion substantial enough to require additional processes to recapture the lost geometry.

The sequence in which a part is welded largly effects the distortion of the part as the stiffness changes significantly depending upon which welds have already been executed.

Reducing unnecessary processes by adopting the latest technologies to minimise weld distortion presents a distinct business advantage.

Customer Profile

Gestamp Tallent Ltd is a world class designer, developer and manufacturer of cutting edge, chassis structural and suspension products, body in white structures, modules and systems for the automotive industry.

Gestamp Tallent group specialise in developing innovatively designed products to achieve increasingly safer and lighter vehicles, thereby reducing energy consumption and environmental impact. With 96 manufacturing plants in 20 countries and a workforce numbering over 30,000 employees worldwide, Gestamp continues expanding in growth markets.

Gestamp Tallent used the BMW MINI front subframe tower to demonstrate the weld distortion optimisation approach. The tower is particularly susceptible to distortion due to its tall and thin dimensions. The objective

Keywords: Optimisation, Welding, HyperStudy, Distortion, Automation, Scripting

Gestamp Tallent Success Story

"HyperStudy allows flexible, multi-platform optimisation management and is generic and applicable to any weld distortion project without any adaptation."

Adrian Chapple
Analysis Supervisor
Gestamp Tallent Ltd

of this optimisation was to minimise the distortion of the tower measured by the displacement of the top of the tower as the weld sections cool.

Weld optimisation with HyperStudy

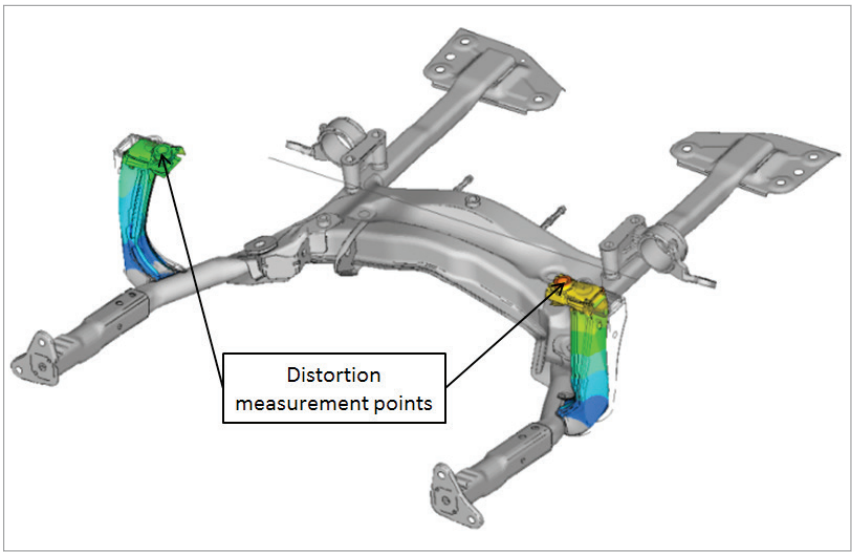
Many years ago, Gestamp Tallent selected Altair's HyperWorks CAE platform for use on their optimisation projects. In order to further investigate weld removal optimisation they chose Altair HyperStudy. HyperStudy enables users to run Design Of Experiments (DOE), optimisation and stochastic studies on models from numerous simulation codes.

To prevent the optimisation algorithm from removing too much weld from the tower and compromising the structural integrity a constraint on the tower stiffness under loading was introduced.

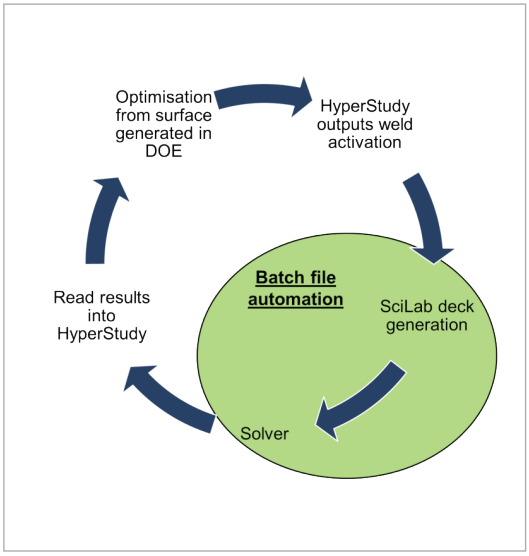
The initial optimisation algorithm used was HyperStudy's Adaptive Response Surface Method (ARSM) managed by HyperStudy.

After the ARSM algorithm gave a local solution, a genetic algorithm was run to investigate the possibility of a better global solution. This algorithm allows the full utilisation of multiple CPUs within a cluster and is applicable to discrete problems. However the number of iterations required to find a global optimum proved to be too costly.

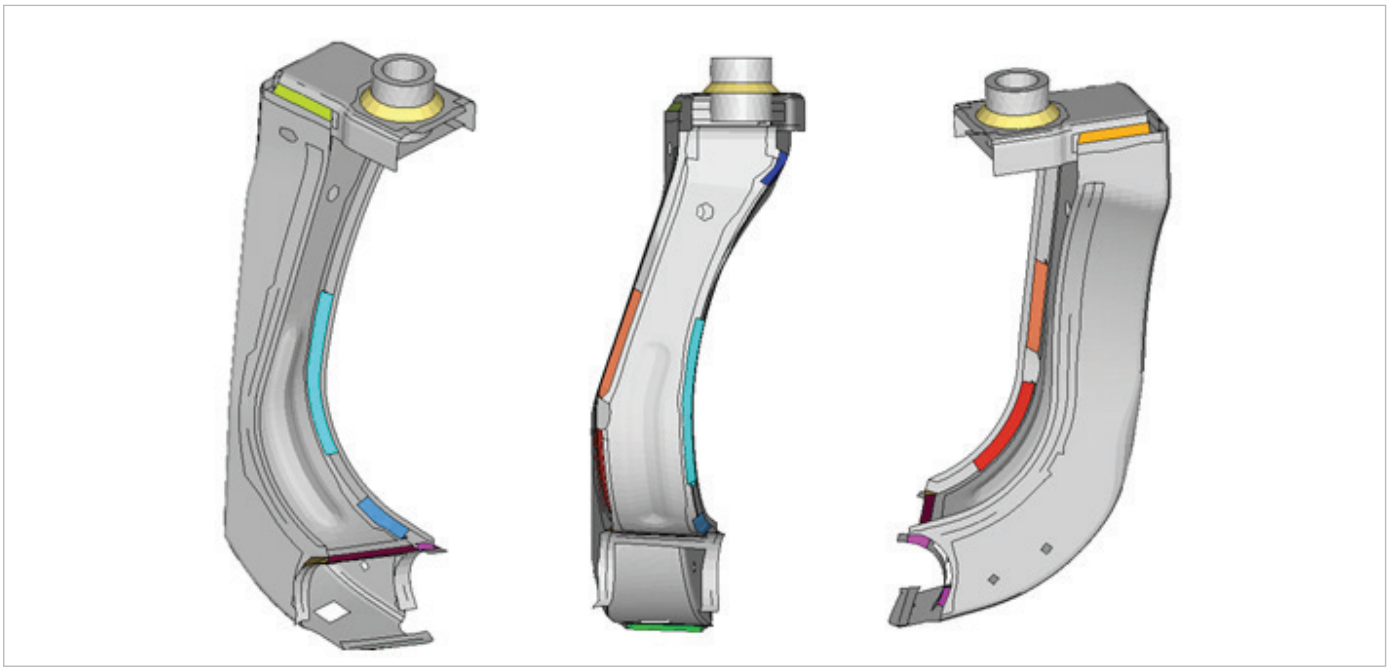
A Hybrid Method Multi-Objective (HMMO) was then utilised for both gradient and global searching algorithms. The HMMO



BMW MINI Subframe



Optimisation process



Final weld locations

gave the same solution to the problem as the ARSM algorithm, indicating that the ARSM solution was the global optimum for the given stiffness constraint.

HyperStudy was also used to optimise the sequence of welding to give minimal distortion of the tower. This optimisation could be left unconstrained as the welds used were fixed from the previous optimisation and could not be removed, allowing the tower to retain the same stiffness found from the previous analysis.

Significant reduction in weld distortion

Initial analysis work identified 20% of the total welds were critical for the stiffness and strength of the tower while inducing minimal distortion. These welds were fixed in place during subsequent analysis in order to increase optimisation convergence.

The remaining 80% welds were then taken forward into the optimisation loop for weld removal in order to consider distortion.

The stiffness under loading was equivalent to the original model but with significantly reduced distortion. The peak stress analysis showed that the new proposed design also outperformed the old design in terms of the maximum stress induced in the tower under and envelope plot of 14 different load cases.
The weld removal optimisation gave a 56% reduction in the distortion predicted at the top of the tower for an equivalent design. Fast convergence to a global optimum with the ARSM optimisation method allows this method to be applied to larger problems such as a full subframe without the need for a DOE to reduce the number of design variables.

The weld sequencing optimisation resulted in a welding process with a predicted 93% reduction in distortion.

The Pareto Frontier generated from the HMMO optimisation gives a useful insight into the optimal designs around a given range of specifications; this could be used to swiftly adapt designs in the face of changing design targets.

This method is also best applied to areas in which welds can be balanced such that the distortional effects of one weld may be cancelled out or minimised by another.

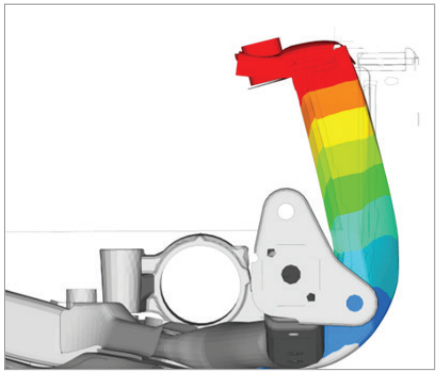
High performance through optimisation

By using HyperStudy, Gestamp Tallent was able to balance the welds and suggest the most effective pattern to significantly reduce distortion without adding additional process costs or reducing the performance of the part.

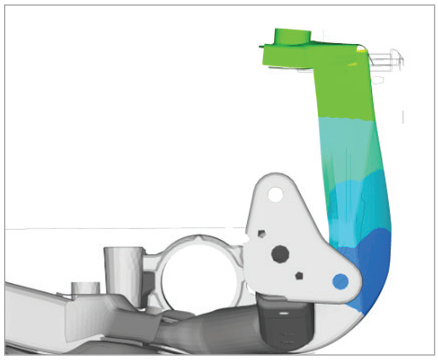
The use of HyperStudy to reduce weld distortion and define an optimum welding procedure produces high performance, manufacture friendly assemblies without expensive tool changes.

The technology used in this project is generic and can be applied to any weld distortion project without any adaptation.

For more information visit
www.altairhyperworks.co.uk/hyperstudy



Original weld distortion



Optimised distortion

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