Minimising Mass and Increasing Durability of a Vehicle Suspension System Using HyperStudy & OptiStruct

Gestamp

Key Highlights

Industry
Automotive

Challenge
Reduce mass and increase durability of a rear twist beam suspension system

Altair Solution
To develop a set of custom tools within the HyperWorks suite, eliminating an initial 'trial and error' design loop

Benefits
Reduction in lead time while producing competitive low cost, low mass RTB designs

Rear Twist Beam (RTB) Suspension systems are commonly used in A, B and increasingly C class vehicles due to their low manufacturing cost, small package requirement and the acceptable vehicle handling performance they produce.

RTB Design is a complex challenge which requires careful consideration of elastokinematic performance in addition to meeting stiffness and durability targets. Design of Experiments (DOE) and optimisation methods are being used to explore the available design space and minimise the mass of a low cost RTB design.

Customer Profile

Gestamp is a global chassis component supplier for customers such as Ford, VW, BMW and Honda. Its technical centres which are based in the UK, Spain and Germany support an expanding global business with manufacturing sites throughout the world in developing low cost, high volume chassis products. Component mass and cost (strongly linked to mass) are drivers for every customer and Gestamp have been using an optimisation driven design process, based on Altair products, since 2005.

Shape optimisation has been utilised to tune a low cost “U” section RTB concept design for stiffness targets and reduce the

Keywords: Design of Experiments, HyperMesh, HyperStudy, Optimisation, OptiStruct

Gestamp Success Story

"We have found the optimisation capability of OptiStruct and HyperStudy to be an asset to our RTB design process. The support that we have received from Altair has also been exceptional."

Andrew Charlesworth
Design Analyst
Gestamp

stress in critical welds for the antiphase rolling durability load case. This durability requirement has been identified as one of the main mass drivers for this type of RTB design.

Methodology

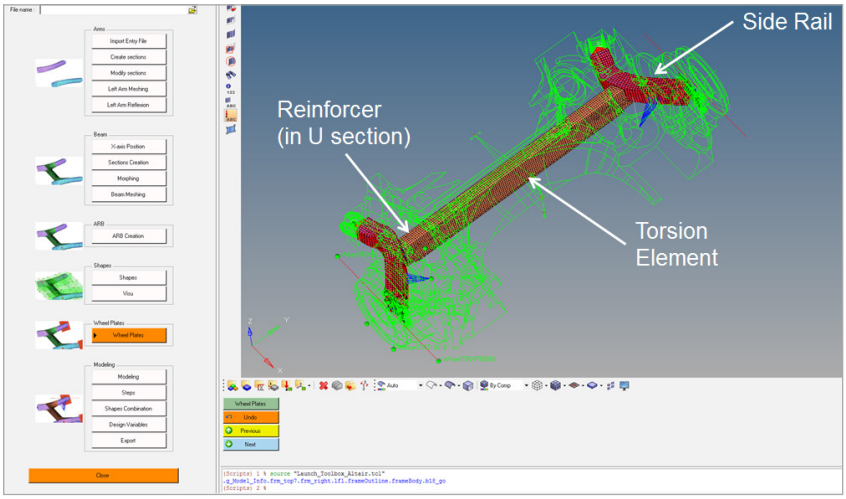
Design of a "U Section" RTB typically requires consideration of several interlinked targets. Two key targets which define the shape and positioning of the main structural members are Roll Stiffness and Roll Steer. Both are strongly influenced by the shape, position and gauge of the torsion element (the cross member of the RTB).

Gestamp selected Altair to develop a set of custom tools, referred to as "The RTB Toolbox," which can be used to generate an initial RTB concept which meets Kinematics and Compliance (K&C) requirements such as Roll Stiffness/Steer, thereby eliminating an initial "trial and error" design loop.

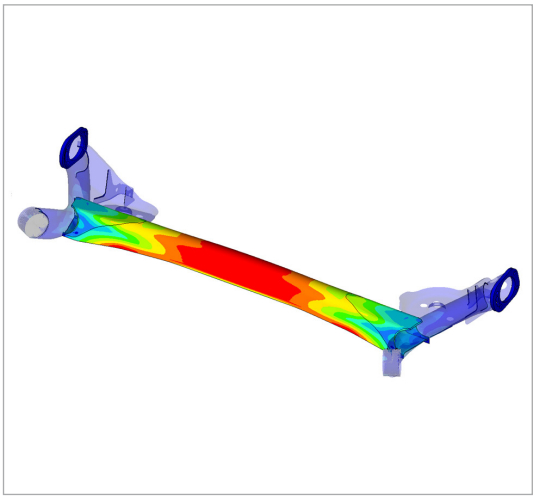
This software used the functionality available within high-performance pre-processor HyperMesh to set up shape design variables for each component in the RTB assembly. HyperStudy was used to control DOE studies, which provided a detailed understanding of the sensitivity of each target to input parameters. This was then followed by a final optimisation step from which the concept surfaces were generated.

The next stage of the design process was to create a CAD model from the optimised Toolbox output. This model served as a baseline for work to meet durability and strength criteria.

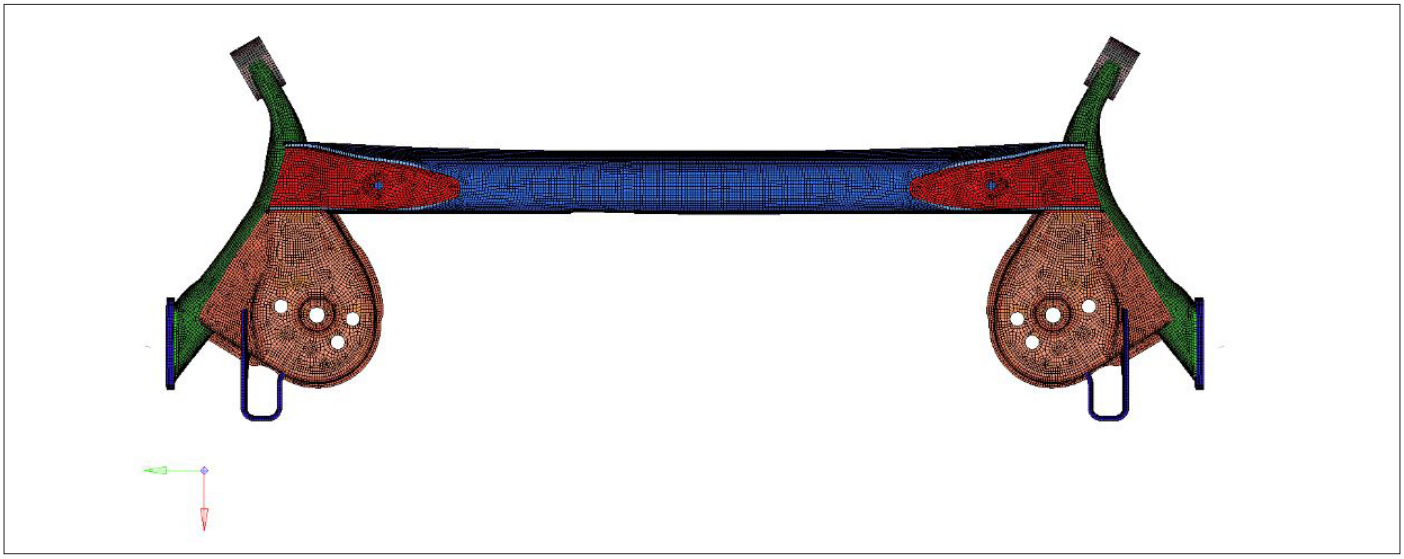
The Antiphase Rolling Durability load case was identified across several customer projects as a significant mass driver. In this test, opposing vertical displacements were applied to the Wheel Centres of an RTB system in order to simulate repeated cycles



RTB Toolbox Interface



Stress Contours for Critical Antiphase Fatigue Load Case



Optimised Rear Twist Beam Design

of vehicle cornering. Generally an increase in Roll Stiffness reduced the fatigue performance.

Durability analysis and prior experience can be used to define stress limits for welds in critical areas such as those between the reinforcer and torsion element. The relationship between these two components had a marked effect on the roll stiffness performance and the fatigue life in this area. A combined shape optimisation of the reinforcer length and torsion element gauge allowed an optimum solution to be achieved; minimising mass whilst respecting durability and roll stiffness constraints. The presence of several competing effects means OptiStruct is a powerful tool for developing the design.

Results

The development of the RTB Toolbox resulted in a reduction in design lead time for the initial concept which was carried through the project.

An additional benefit of the Toolbox design approach was the use of DOE studies. These studies have proven to be valuable as a means of quickly gaining an understanding of the sensitivity of various K&C targets to input parameters, including the shape and position of individual parts within the assembly, along with their gauges.

The optimisation capability offered by OptiStruct was used extensively in order to tune the Toolbox Output design in order to meet durability targets, whilst ensuring that K&C performance is maintained. Local shape optimisation of the torsion element trim edge was also used to successfully generate design variants with different levels of Roll Stiffness.

Conclusions

RTB designs which feature a “U” section torsion element are typically seen as a simple, low cost solution. However, a material thickness of over 6mm is sometimes required to meet performance targets, which significantly increases mass in comparison to designs using a more expensive “squashed tube” torsion element.

Gestamp have recognised the potential for mass reduction through optimisation of a “U” section design. The use of the RTB Toolbox software in addition to the HyperWorks package allowed the quick creation of an RTB geometry that met specified K&C targets, eliminating an initial trial and error design loop. The shape and gauges of the torsion element and reinforcer were optimised to minimise mass whilst meeting durability targets. Through this process, Gestamp can react quickly to produce competitive low cost, low mass RTB designs.

Next steps in developing the Gestamp RTB design process include:

- Consideration of external factors such as hardpoint positions, spring and bush rates in order to identify an even more optimised solution when looking at the system level performance. MotionSolve would be used for this activity.

- Target challenge and trade off analysis in order to identify where small target reductions can yield large mass reductions.

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From computer-aided engineering to high performance computing, from industrial design to cloud analytics, for the past 30 years Altair has been leading the charge to advance the frontiers of knowledge, delivering innovation to more than 5,000 corporate clients representing the automotive, aerospace, government and defense industries and a growing client presence in the electronics, architecture engineering and construction, and energy markets.

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