

Tubular solution to light weighting

Comparison of the benefits of hydroform tubes over traditional chassis design

Background

All powertrain solutions demand that every part of the vehicle is as light as possible to maximise vehicle range, performance and efficiency. What is essential in vehicle design, with strict safety targets and narrow profit margins, is balancing weight, with the performance of the materials, and the cost of the process. Tata Steel's total cost of ownership (TCO) Concept Studies can offer designers a solution in finding their preferred balance of the three. These studies quantify the TCO reduction potential that advanced steel solutions offer for specific automotive applications.

Following a customer request to propose affordable solutions to reduce the weight of a front chassis subframe, Tata Steel studied how replacing stamped and welded assemblies with a tubular intensive design could meet this objective. Tubular structures are more structurally efficient than welded stamped components, and offer the possibility of part-count reduction, feature integration and improved joint configurations. These benefits can be combined to reduce mass and cost. The resulting chassis design maximised these tubular benefits and ensured suitability for high-volume production.

Modelling

A conventional passenger car front subframe was selected as the baseline structure, and Tata Steel engineers redesigned the structure using the company's own tubes. These tubes were made from hot-rolled steel grades with gauges above 2.0mm, to prevent the need for galvanising and to avoid welding issues.

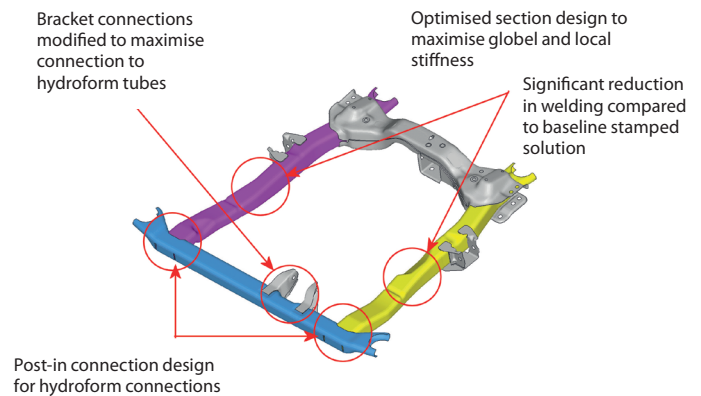
Different tubular processing solutions were considered, but hydroforming - pumping fluid into the metal at high pressure to force the tube to take the shape of the die - was selected, as this process can produce complex shape options whilst maintaining the required dimensional accuracy.

The tubular structure was designed using computer-aided design (CAD) combined with Tata Steel's bespoke Knowledge Based Engineering (KBE) toolkit, which takes into account the ductility of the material, to assess the hydroforming manufacturing feasibility, including assembly. All package constraints - the available space for the structure to avoid clashing with other critical areas such as the engine, wheel envelope and ground clearance - were maintained. Particular attention was given to the joint design, building on tubular joint design information generated by Tata Steel Research and Development, to ensure maximum stiffness in the final solution. Material selection was optimised between achieving best performance whilst ensuring the robust manufacturability of the tubular components during the hydroforming process.

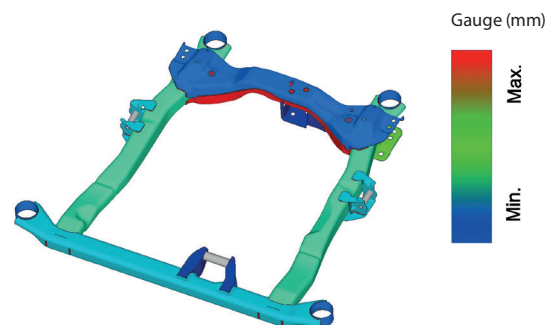
Analysis

Linear and non-linear computer-aided engineering (CAE) was used to baseline the stamped structure performance in terms of 'noise, vibration and harshness' (NVH), static-deflection and durability.

Resulting tubular intensive design



Gauge optimisation



CAE techniques were coupled with hydroforming feasibility assessment tools to ensure that optimum gauge and grade combinations were defined for each component

Any mass saving must be affordable, and any lighter-weight solutions should maintain safety and manufacturability performance. Tata Steel's TCO Concept Studies, recognise the fact that the performance and cost of components are just as important as weight reduction to many customers, and supports them in finding their preferred balance of the three - the TCO triangle.

Once the tubular design was optimised in terms of geometry and connection design - to ensure as much use of the package spaces was made as possible, and connections were stiff - the next stage was to optimise the material grade and gauges. Linear optimisation techniques were deployed to calculate the optimum combination of grade and gauge for the tubular assembly, ensuring baseline performance was maintained.

The final solution was checked using CAE techniques to confirm stiffness (global and local), modal performance and durability, including weld and metal fatigue.

Analysis results

The results of the CAE optimisation suggest that specification of Tata Steel tubes in combination with the final design for the main subframe components results in all structural performance requirements being met, with a 10% reduction in weight, a net reduction of eight components through hydroform adoption (11 stamped components replaced with three hydroform components) and nearly 5m less continuous welding ensures a leaner production.

Cost savings

Tata Steel then completed a full assembly cost study to ensure that the optimised subframe design was cost-effective for volume production. This study compared production tooling, component and assembly costs of the optimised subframe design with those of the baseline.

The tubular structure assembly process also matched the number of operations of the baseline structure but with considerably less welding (approximately 5m less continuous welding). The tubular structure featured 10 stampings and three hydroform components, excluding bought-out components, compared with the baseline assembly featuring 21 stampings. The result is an approximate 45% reduction in tooling and investment cost, with the part cost reduced by approximately 12% (excluding scrap return, plant overhead and tooling amortisation).

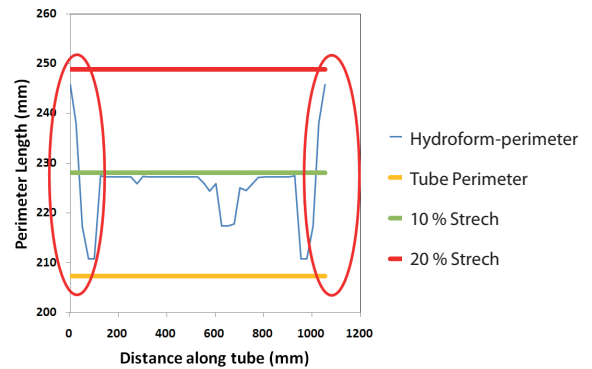
Summary

The study shows that tubular assemblies can address the challenge of reducing the weight of the car front-chassis subframe without any loss in performance, and at the same time reduce the manufacturing cost. This is achieved by fully utilising the inherent structural efficiency improvement of closed sections versus welded stampings. Part count reduction can also lead to both lower assembly investment and lower assembly costs.

As well as meeting customers' cost-saving, performance and light weighting needs, Tata Steel's strong experience in automotive manufacturing, materials, and knowledge of the chassis and suspension sector, ensures reliable, relevant, good-quality solutions for its clients' design challenges.

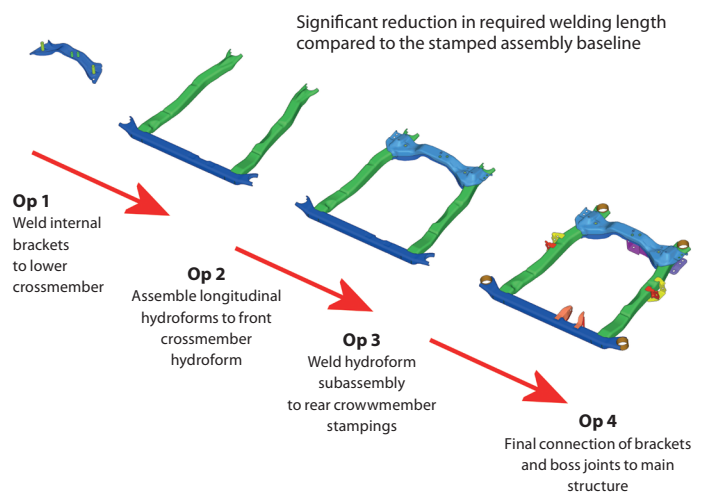
Early peer-to-peer discussions and regular contact with the client ensure Tata Steel engineers fully understand their requirements.

Hydroform process



End feeding is applied to prevent excessive thinning caused by high elongation at each end of the hydroform

Assembly process



Savings per subframe	Improvements
Mass	10% reduction
Cost	12% reduction
Investment	45% reduction

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