TATA STEEL

TATA

Lightweight chassis study

New advanced steel grades can help to unlock 20% weight reduction in chassis assemblies

Introduction

Steel is strong, stiff, formable, widely available and cost-effective and it's for these reasons it continues to be the material of choice for the chassis systems in mainstream passenger cars and light commercial vehicles. Conventional micro-alloyed high-strength steel grades remain the most commonly used in chassis applications because this product family offers designers a cost-effective material featuring the necessary strength combined with excellent durability performance.

However there is increasing pressure on automotive designers to reduce the weight of new cars in order to deliver better performance, including better fuel economy. This focus extends to the chassis, but reducing chassis weight is a difficult task. The system is often positioned within a heavily package-constrained area which means that the designer only has a very limited space in which to design an optimised assembly (see figure 'Package constraints in chassis'). The design must also meet critical performance requirements related to durability and stiffness. Reducing weight by replacing a panel with a thinner, higher strength material will not necessarily work in the chassis system because stiffness performance will be negatively affected.

Material solutions can help designers achieve lighter chassis designs. Stronger materials increase component durability or safety performance and more ductile materials allow the designer to develop more complexly shaped components which fit smaller package spaces. Tata Steel has developed a suite of advanced high-strength steel grades that meet both needs by combining high strength with improved ductility.

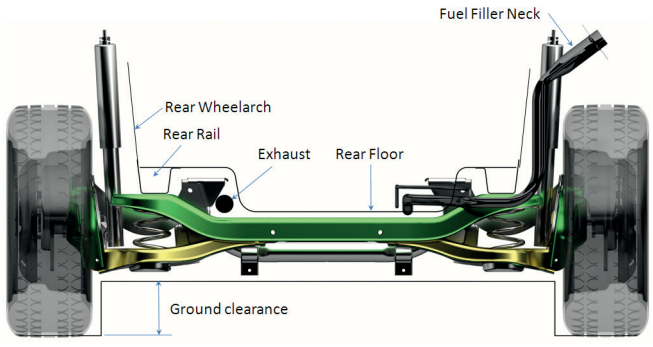
This paper describes a benchmark study to evaluate the optimal use of Tata Steel's advanced high-strength steel grades to save chassis weight without any compromise to package or performance requirements.

Benchmarking

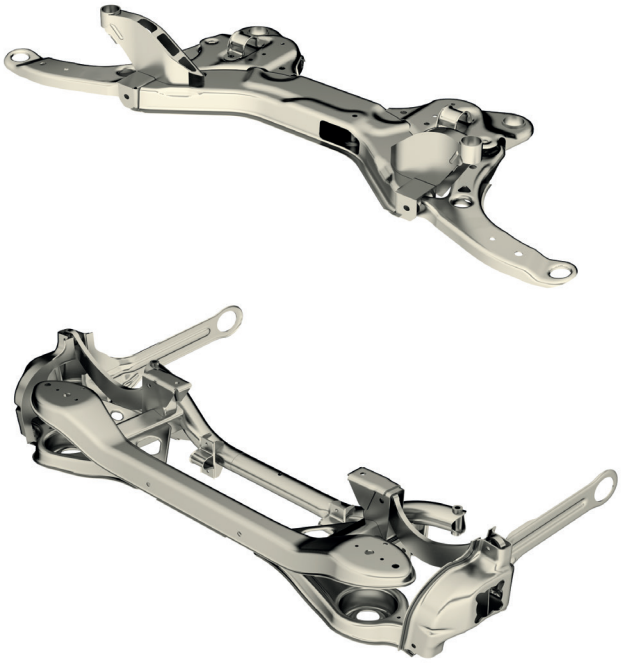
Engineers from Tata Steel's automotive engineering centre first performed a benchmark study to understand the system design and weights of typical passenger cars produced in Europe. Several front and rear chassis configurations from different OEM vehicle classification combinations were assessed.

The developed benchmark chassis system was considered representative of European C-Segment vehicles featuring a conventional sub-frame with lower control arm and a rear trailing arm system.

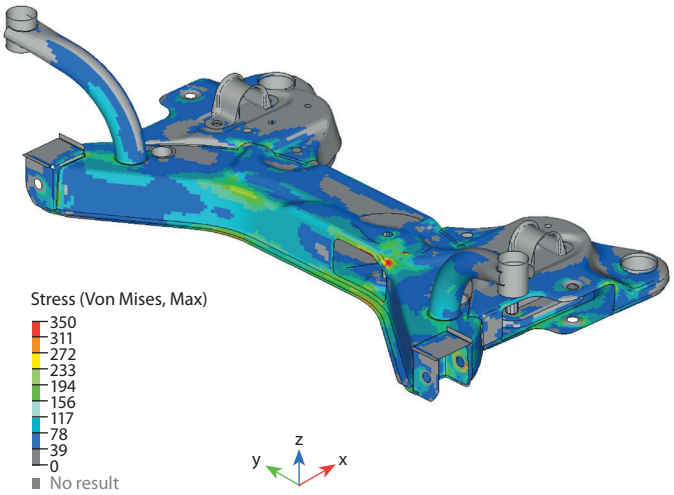
Package constraints in chassis



Front and rear chassis assembly for the benchmark chassis



Stress pattern resulting from the abuse load case - pot hole strike



Performance assessment

Computer aided engineering (CAE) simulation studies confirmed that the benchmark chassis system had representative performance to the similar systems considered in the benchmarking exercise. The performance metrics assessed related to the stiffness, strength and durability performance required to meet the main proof load cases, for example, those experienced during braking, cornering or abuse loading.

Material portfolio

Tata Steel's advanced high-strength steel family includes offerings at two different strength levels:

- At 590MPa strength, HR DP600-UC offering strength and high elongation for complex shaped parts, HR FB590-UC offering strength and high edge expansion or hole expansion capacity (HEC) particularly suited to match the stamping process of many chassis components
- At 780MPa strength HR CP800-UC offering high strength and a balanced combination of elongation and HEC for relatively complexly shaped components needing very high strength

In addition to these advanced high-strength steel grades, Tata Steel offers a new generation of hot-rolled steel called XPF that promises a major breakthrough in automotive structural materials technology. The XPF family addresses the known challenges of current high-strength steels in terms of forming and manufacturing by combining the mechanical strength and fatigue resistance that designers require, with a formability that provides even greater freedom to reduce vehicle weight without compromising manufacturing robustness or safety standards.

Material optimisation

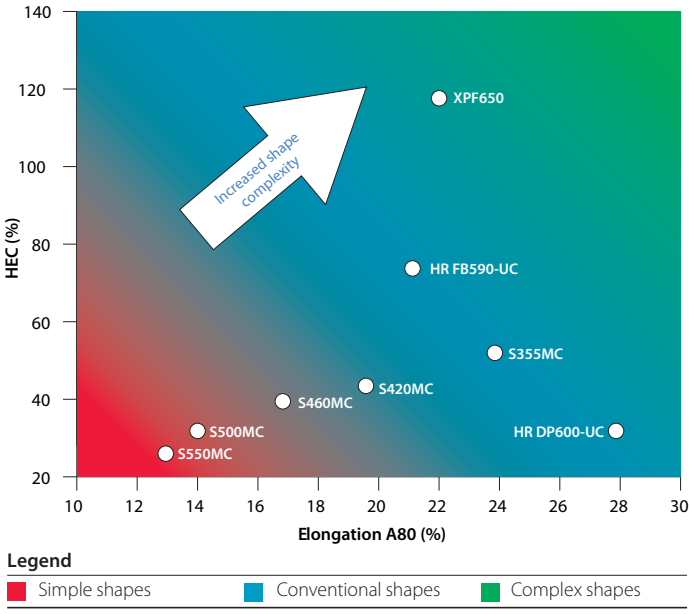
Tata Steel engineers performed a virtual concept study to evaluate how the use of advanced steels can offer an optimum balance between performance, light weighting and cost – otherwise known as lowest Total Cost of Ownership (TCO).

The first stage of this process was to determine the components that had the most significant effect on the overall stiffness of each assembly. Many of the identified components had relatively simple shapes, due to the formability limitations of the conventional high strength steel grades originally specified. However, advanced high-strength steels offer both high strength and higher levels of ductility. Using these grades enabled the engineers to make minor design modifications that improved the stiffness of the assembly without compromising either the component manufacturability or the package of the system.

The next chart shows the indicative level of component complexity that the different steel grades can achieve given the balance between material elongation and HEC. Conventional micro-alloyed grades such as S500MC or S550MC have high strength but relatively low levels of ductility. However, the new XPF650 offers the same level of strength but with ductility outperforming lower strength conventional grades such as S355MC. This grade can therefore help engineers to unlock more efficient component design that can lead to weight reduction.

Level of component shape complexity for different steel grades

Strength levels between 400 and 600MPa

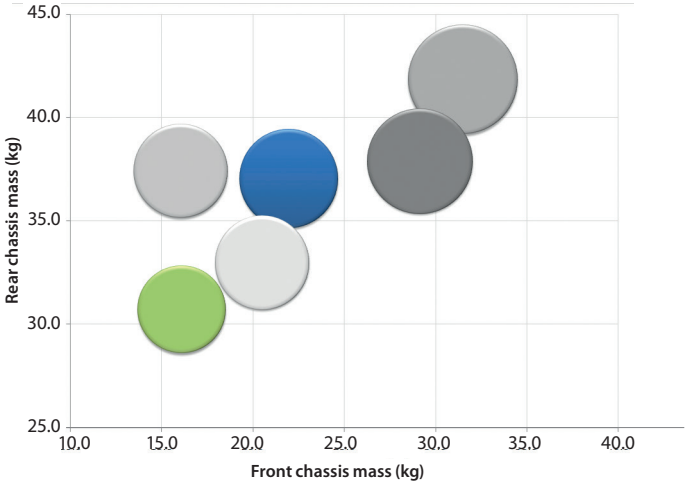


Results

Tata Steel automotive engineers were able to achieve an impressive 20% weight saving for the combined front and rear chassis assemblies. In the chart below the size of the "bubble" represents the combined front and rear chassis mass. The optimised solution (green bubble) met all stiffness, strength and durability targets for each of the major load cases.

Combined front and rear chassis mass

Relative weights, size of the "bubble" and the optimised result



Legend

- Vehicle#1
- Vehicle#2
- Vehicle#3
- Vehicle#4
- Benchmark
- Optimised

Much of this weight saving was achieved by exploiting the increased ductility of the advanced steel grades, XPF in particular, to develop components with more efficient shapes that would not be otherwise possible using conventional steel grades. Optimising a small number of key components also offered the flexibility to improve those around them. Durability performance was also ensured by the careful selection of higher strength grades coupled with the minor design modifications.

Optimised front and rear chassis assembly

Coloured by material grouping

Legend

- Conventional HSS
- HR FB590-UC
- HR CP800-UC
- XPF 650
- XPF800

Summary

Utilising the superior combination of strength and ductility of Tata Steel's advanced steel portfolio can yield significant lightweighting potential. Component shapes which were previously considered too challenging to make are now a possibility. This enables designers to integrate high strength and durable materials into their designs to fully unlock the potential of steel. This suite of advanced steel grades will support our customers in reducing their TCO, through offering a product optimised for the challenges of manufacturing chassis components.

www.tatasteeleurope.com

Tata Steel
Automotive
PO Box 10.000
1970 CA IJmuiden
The Netherlands
E:connect.automotive@tatasteel.com
www.tatasteeleurope.com/automotive

AM0217:750:EN:0516