

Optimising front and side structures with complex phase steels

Lighter components with good crash performance at lower costs

Background

The general trend of lightweighting in the automotive industry does not wane. On the material level, R&D departments are constantly searching for ways to make components even lighter to help meet the current and coming regulations for CO₂ and fuel consumption. As the Body-In-White (BIW) represents a considerable amount of the car's weight, which is mostly made of steel, the steel industry is developing new material solutions that help to reduce weight further.

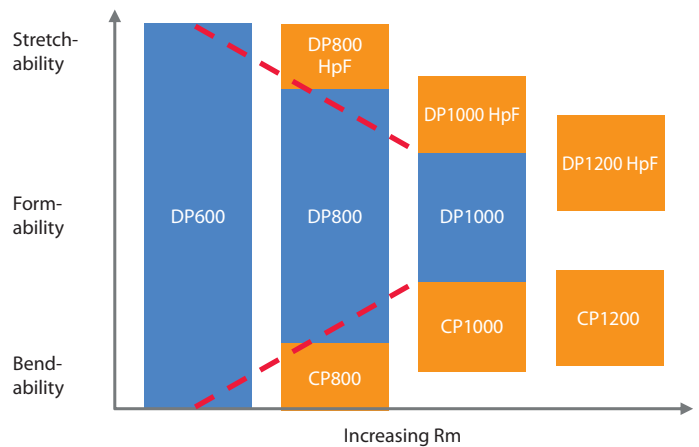
Advanced high-strength steels (AHSS) offer a good solution to achieve this goal. Depending on the requirements of a car manufacturer, other factors – such as the end product performance or the production cost per part – need to be taken into consideration. With new steel grades and technology to comprehensively assess their potential, Tata Steel is now able to determine the most suitable steel for a particular component. The company offers an ever-growing range of metals with different properties, plus a set of accompanying services that can show manufacturers their optimal balance between lightweight potential, performance and costs according to their priorities.

Supporting steel selection

To identify an adequate steel grade that can reduce weight in the front and side impact structures, the company conducted several tests with its high strength CP800 complex phase and DP1000LY dual phase steels. These steels are supposed to be able to replace the commonly used DP800 dual phase steels in parts like sills, seat cross members and A-pillars. In addition to the weight reduction potential, Tata Steel compared their performance, manufacturing behaviour and related costs so that manufacturers can consider all these parameters during the selection of the material.

When looking at the lightweighting potential of a material for BIW parts two other material properties remain central: their performance during a crash and their manufacturability during the deep drawing process. The crash performance of steel largely depends on the bendability of the material – relating to the yield strength – while good manufacturability is related to the stretchability of the material. The higher strength required for the weight reduction, unfortunately, coincide with decreased levels of either the required bendability or stretchability (image 1).

Image 1: Specific formability developments HyperForm® for stretchability



To optimally meet the requirements of car manufacturers for various parts, Tata Steel is currently developing and extending its steel families. A manufacturer therefore has to define which limitations are acceptable for a particular component.

Crucial crash performance

To support manufacturers in their selection, Tata Steel assessed the crash performance by studying the bending and fracture behaviour of a closed top hat (image 2). Here, bending is very apparent in a crash and the study of the fracture location and appearance indicates that failure through shearing is a common result. For safety reasons, generally as much energy of the crash as possible should be absorbed in the bends.

Image 2: Type of fracture in crash

Study of fracture behaviour „Closed-Top-Hat“

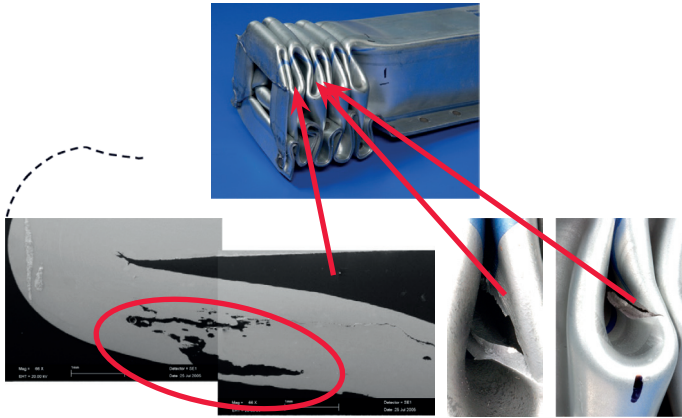
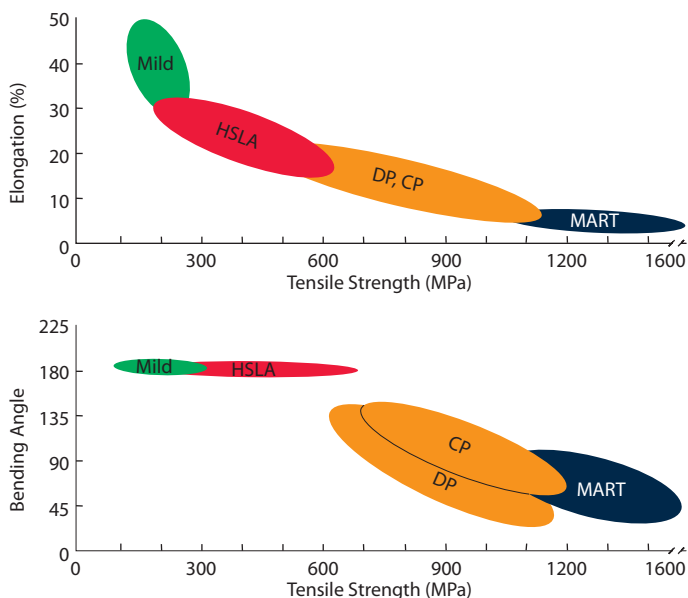


Image 3: Elongation and bending performance of steel products

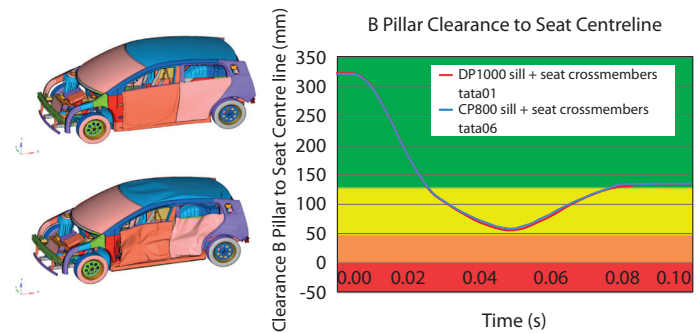


A three point bend test with a bending VDA angle at 1mm and a shear test measuring the failure strain, in a comparison between DP800 (image 3), DP1000 and CP800, showed that the CP grade offered much better performance for bending and shearing than the DP grades, resulting in a better crash behaviour. This can be related to the different microstructure of CP800.

To further examine the crash performance for sills and seat cross members, Tata Steel simulated and compared the side impact of a crash on components made of CP800 and DP1000LY using the Future Steel Vehicle (FSV) model (image 4). The simulation showed no major

Image 4: Crash performance of CP800 versus DP1000LY

Side impact results for FSV model



differences in the deformation of the components made of CP800 and DP1000LY, so both steel grades show an equivalent crash performance.

Ease of manufacturing

To assess the manufacturability of components made out of CP800 and DP1000LY, a forming analysis for an A-pillar lower, a critical forming part, was conducted for the first draw of the deep drawing process and after flanging/cutting. The simulation showed a slightly better formability of DP1000LY compared to CP800, which is related to the better stretchability of dual phase steels. For the lower A-pillar, this does not have to be critical and can be solved with minor geometric adjustments to the layout if necessary. Nevertheless this indicates that, for components with more complex geometries, DP1000 steel is somewhat better suited to achieve lightweighting in other areas.

Quantifying the costs

To complete the assessment, Tata Steel conducted a cost analysis for the new grades related to each of the tested parts. The analysis showed a clear cost benefit for CP800 compared to DP1000, ranging from 0.03 Euro for floor cross beams, 0.12 Euro for the A-pillar reinforcement, and up to 0.18 Euro for a sill.

Conclusion

Advanced high-strength steels have the potential to reduce weight throughout the entire BIW. However, the variety in steel grades with different properties offer even more than that, and Tata Steel is able to support manufacturers in the assessment of materials to meet the exact requirements in regard to safety, performance, lightweighting and costs for particular components. The present study proves that CP800 can compete with DP1000LY when it comes to lightweight design of crash components. CP800 shows a similar formability and crash energy absorption potential as DP1000LY, but against lower costs, making the steel particularly interesting for mass production applications.

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