Next generation vehicle

Stainless steel in structural automotive applications

When you think of stainless steel and the automotive sector, more likely than not it is exhaust systems that spring to mind. There are, of course, many other applications, such as stainless steel trim. And then, there are applications which may be rather less obvious - windscreen wipers, cylinder head gaskets, and fuel systems. New potential opportunities are opening up all the time, such as the use of stainless steel in fuel cells.

However, one of the most promising areas for stainless steel in the automotive sector would seem to be in structural applications. This explains the launch at the end of 2004 of the "Next Generation Vehicle" project. The aim of the project was to demonstrate to the automotive industry that stainless steel can be used to reduce weight and cost in the manufacture of motor vehicles, and at the same time improve safety and sustainability in automotive body structures.

In view of the complexity of the topic, and the large experimental effort required, the project was organised jointly by the three European stainless steel producers ThyssenKrupp Nirosta GmbH, ArcelorMittal Stainless, and Outokumpu Oy. The European car manufacturers were represented by Audi AG, BMW AG, Daimler AG, Saab Automobile AB, Volvo Cars, and the Centro Ricerche Fiat.

Four grades of stainless were used in the NGV project – three austenitic and one duplex. These were the austenitic grades 1.4376, 1.4318 (1.4318 C1000), and 1.4310 (1.4310 C1000), and the duplex grade 1.4162. These were tested to determine their suitability for use in carmaking from the point of view of mechanical properties, corrosion resistance, and their ability to be formed, machined, and joined to other materials.

A key characteristic of the austenitic materials tested is their high work hardening rate. This means, on the one hand, that their strength increases as they are cold formed into the shape of the component by conventional or advanced forming methods like hydroforming. Significant reductions in weight can be achieved as a result. But there is a second advantage. The work hardening rate depends on the speed of deformation. In the event of a collision, the stainless steels investigated can absorb more energy than the usual structural steels. Stainless steel can not only help to reduce weight, but also to enhance passenger protection.

Cost is, of course, always a factor, and it is clear that in view of the higher cost of stainless steel, it is only really beneficial to use it where it works best. The "Next Generation Vehicle" project has developed a cost model which allows the use of different production methods and materials to be compared directly and the optimum stainless steel solution determined.

The NGV project also clearly demonstrated that stainless steel can be welded with some adaptions to the carbon steels

Crash Test Rig for Components

currently used in automotive production. This means that stainless steel can be used selectively in those parts where its properties are beneficial, but that carmakers can continue employing their traditional metals in other parts.
One of the key aims of the "Next Generation Vehicle" project was to draw up processing guidelines for stainless steel as a prerequisite for its use. Beyond that the available software programs for metal forming were optimised in collaboration with the leading suppliers of simulation programs by taking into account the special work hardening effect of metastable austenitic stainless steels. These advanced models and their simulation results were verified by designing, building and crashing different types of B-pillars (door pillars).
Beside the guidelines how to properly use stainless steel, the development of software programs which simulate forming and crash behaviour and the specific cost model for all stages of production are considered to be a major breakthrough. It allows engineers to see how different grades and fabrication processes can improve the finished product, and avoids the need to build and test parts which ultimately prove to be unsuitable.

The NGV project's findings have been summarised in the paper "Next Generation Vehicle - Engineering Guidelines for stainless steel in automotive applications". The conclusions of this paper are as follows:

- Stainless steels show very good combinations of strength and ductility which is of special interest in automotive applications. The use of this material presupposes the safe and correct use in all stages of automotive development and production.
- In tooling and forming, stainless steels show the same restrictions as high-strength carbon steels. Special coatings are recommended in order to withstand the high forces and allow an accurate forming.
- Joining of stainless steel in uni-material and mixed joints is possible. In some cases, the parameters are different from those typical of carbon steels, but in general the range is not greater than for different grades of carbon steel.
- To ensure corrosion resistance of the joints, the seam can be protected by wax or by coatings which provide a cathodic protection.
- The implementation of the results into the design of several B-pillar concepts shows, on the one hand, the potential for a further weight reduction and, on the other hand, the cost efficiency of some concepts.

New growth through structural applications

The significant growth rates in stainless steel consumption experienced over the past many years were attributable in particular to its corrosion resistance, aesthetic appeal, and hygienic properties. It has already become clear that stainless steel is increasingly being applied in many areas for its mechanical properties such as a combination of very high strength and excellent formability, together with high energy absorption properties. These properties are particularly applicable to the automotive sector, where they can lead to significant weight savings and, at the same time, to safety improvements.
The "Next Generation Vehicle" project has demonstrated this to the automotive industry, and the use of stainless steel in structural applications in this sector looks set to take off. The NGV consortium has now concluded its work. The stainless steel story has been taken to a point where it is maturing inside the OEMs. The NGV findings may have come at a good moment in time. As demonstrated at the recent Frankfurt Motor Show, electrically driven and hybrid cars are becoming a top priority, and in these cars weight reduction is more important than ever.