

Lightweight Automotive Seating Structures – Concepts and Challenges

By Colin Pawsey

Carbon emission reduction targets have changed the shape of the automotive market over recent years, with large SUV-type vehicles making way for more fuel efficient, smaller cars. With fuel efficiency in mind, one of the key trends in the industry is the reduction of vehicle mass, with the aim of reducing emissions. No part of the car has escaped scrutiny when it comes to ‘lightweighting’, and seating is an area that has seen a raft of new concepts and ideas to help reduce overall vehicle weight.

Weight reduction

A study undertaken by the International Council for Clean Transport (ICCT) in 2013, included a weight reduction forecast on light-duty vehicles in the EU which was conducted by the FEV Company. The paper focused on the change in manufacturing costs when implementing weight reduction techniques, and how much emission cuts cost in relation to weight reduction. The study was based on 2010 models, including the Toyota Yaris, Ford Focus, Toyota Camry, Ford Transit Connect, and Ford Transit. FEV’s conclusion was that an estimated 18.3% of the total vehicle weight could be reduced by 2020.

Figures taken from the study relating directly to seating, estimated that the driver’s seat base mass of 26.91kg could be reduced by 4.72kg (17%); and that the base mass of all the seats in a vehicle, of 92.55kg, could be reduced by 23.39kg (25.3%).

It’s essential for OEM’s and seat manufacturers to view the process holistically, as various other factors come into play when taking steps to reduce weight. For example, the reduction in weight of one particular seating component may not significantly improve upon fuel efficiency or weight reduction, but the cost of manufacturing could increase significantly due to the change. However, by taking a system approach, manufacturers are able to assess the impact on other areas of the vehicle. If the weight reduction of that particular component allows the use of a more efficient or cost-effective drivetrain, for example, the overall effect can be a positive one.

Seat requirements

While the main focus in seating is on weight reduction through new materials, structures and manufacturing techniques, this must be set against a background of the natural function of the seat. The driver’s seat is the most complex, and generally the heaviest of the seats, due to the functions it must perform. A seat must be ergonomically designed and well-shaped/cushioned to afford the driver a comfortable driving position. The structure must protect the driver, along with seat belts and airbags, in the event of an accident; and the seat should also provide the driver with the ability to adjust the seat, either manually or electrically, depending on the vehicle specification.

Each of these considerations must be taken into account, and not negatively affected, when altering designs and components for the purposes of weight reduction.

Current lightweight trends

Several interesting new trends have developed over the last couple of years, which can be highlighted by looking at some of the new concepts to have been brought to market during that time.

Faurecia

One of the biggest suppliers of seating and related components to the automotive industry, Faurecia, is developing new modular seating structures with metal alloys to achieve significant weight reductions. In 2013 the company announced that it had entered a partnership with FAW Foundry, the biggest automotive foundry in China, to develop seat structures made from magnesium alloys. Faurecia aims to use this project to produce more lightweight products, and estimates that seats manufactured from magnesium alloys could result in a 25% weight reduction compared to last-generation steel seating structures.



Source: Faurecia

During the same year Faurecia also revealed its Seat Metal Techno Show Concept demonstrator, pictured above, which consists of an optimally lightweight seat structure that conforms to the highest safety standards. The concept features mechanisms that are 35% lighter than those of previous models, and seat tracks that reduce overall vehicle weight by up to 1kg.

The concept has been designed with manufacturing in mind, and the modular approach means that numerous functions can be incorporated into the seat as required by OEM's. The structure is manufactured from high-resistance steel alloys and composite materials to create a much lighter, modular seat.

Future Steel Vehicle

The World Auto Steel 'Future Steel Vehicle' concept is a lightweight body structure concept for future electric and hybrid vehicles, which demonstrated a 35% reduction in weight compared to the project baseline vehicle, and a 23% weight reduction compared to current production small vehicles. As part of the project, Tata Steel was tasked with designing and developing the front seat structure for the Future Steel Vehicle (FSV).

In the process of developing the front seat structure, Tata Steel compared cost and weight against the project baseline seat design for equivalent performance. Their analysis showed that by using various grades of steel for different components, the seat could meet its structural performance requirements with a 30% weight saving. Simulation techniques were used to confirm that the structure was feasible for volume production, and a production cost study was undertaken to ensure that volume production would be cost-effective. The study included all the necessary manufacturing steps, and despite the advanced high-strength steel used in the design being more expensive, the overall production costs were reduced due to weight reduction and the ease of manufacturing and assembly.

The final assessment was the seat structure's effect on CO₂ emissions, and it was shown that while the advanced high-strength steels result in similar emissions to lower grades during steel production, they contribute to reduced emissions over the vehicle lifetime due to lower weight. The estimated overall vehicle savings with Tata Steel's seat design are 4.3kg in weight, 3.60 Euros in manufacturing costs, and 8.6kg of CO₂ emissions.

New Concepts

Materials are a key factor in all aspects of vehicle design, and the development of composite materials is having a significant impact on the seating sector. Some of the new concepts we've seen this year are taking advantage of the versatility that these new materials provide to make further reductions in weight.

Johnson Controls

In late 2014 Johnson Controls was awarded first prize in the Green category of the Innovations Awards 2014, for its work on the CAMISMA research project. The project was initiated to develop a new seating structure that reduced the amount of steel and light alloys used, by replacing them with multi-material systems. With equivalent performance in terms of safety, the CAMISMA seats are more than 40% lighter than conventional seat structures.



Source: Johnson Controls

The CAMISMA project (Carbon-Amide-Metal-based Interior Structure using a Multi-material System Approach) has been running since 2011, and the initial focus was on developing the multi-material system.

CFRP materials offer great strength and design flexibility, but the drawback is that costs are still too expensive for large-scale series production. The project team began to develop a multi-material system which incorporates four different components; steel, fibre-glass reinforced plastic, and carbon fibre non-woven and thermoplastic tapes made of carbon filaments. The four materials are combined in a complex multi-layer structure, in a newly-developed thermoplastic forming process.

The project is ongoing until Spring 2015, but according to the current status, the CAMISMA seats are 40% lighter than conventional metal seats, and the number of manufacturing steps is substantially reduced through the number of attachment parts needed, which helps to compensate for some of the additional cost. This could be a significant development in terms of seating for the future, as it may enable the high-volume and efficient use of carbon-fibre in series production in the future. According to current project planning, the products could be available as soon as 2019.

Summary

Weight reduction has become a key issue in the automotive industry in recent years, and it is a trend that's set to continue as manufacturer's look to eke out every bit of extra fuel efficiency from their vehicles.

This has led to rapid development in the seating sector, but any new ideas and innovations must still retain the safety and functionality of standard seats, particularly that of the driver. The challenge for designers is to develop seating which can reduce weight without affecting performance, and which will be cost-effective to manufacture in large volumes.

We have already seen various developments with lightweight metal alloys and high-strength grades of steel, but the most significant advance may be the use of carbon-fibre materials. These materials provide similar strength and performance to steel, but at a much lower weight. When these materials can be incorporated into mass manufacturing, at viable cost levels, we can expect to see even more improvements in weight reduction.

Sources:

<http://www.johnsoncontrols.co.uk/content/gb/en/news.html>

<http://publications.lib.chalmers.se/records/fulltext/202376/202376.pdf>

http://www.tatasteelautomotive.com/static_files/StaticFiles/Automotive/new-2013/Tata%20Steel%20-%20Lightweight%20seat%20concept%20-%20case%20study%20leaflet.pdf

<http://www.faurecia.com/en/faurecia-starts-developing-magnesium-seat-structures>

<http://www.faurecia.com/en/seat-metal-techno-show-concept>