

Steel meets the world's toughest auto safety standards

The steel industry has released details of novel ideas for the powertrain and chassis elements of its Ultra-Light Steel Auto Body - Advanced Vehicle Concepts (ULSAB-AVC) study. The study also reveals that when the dynamic properties of steels are taken into account in design calculations the overall deformation of a vehicle structure can be reduced for a given crash deceleration. These concepts have major implications for passenger safety with the potential, for example, of less intrusion into the footwell in a frontal collision.

With a final presentation of its concepts planned for the second half of 2001, the £6m (10m Euro[RP1]) study is being carried out by Porsche Engineering Services on behalf of a global consortium of leading steelmakers. A major role for the steel companies involved is to provide technical information on steel's strain hardening properties, an influence that increases with the speed of impact. Steel's ability to become harder when crushed means it becomes stronger on impact, allowing the steel to absorb more energy. Determining the values of these vital properties for the latest high strength steels through experimental tests is of increasing significance to the carmakers.

"This role for the steel companies is particularly important if we are to achieve ground-breaking innovations without recourse to simply substituting high strength steels in existing designs," said Frank Walker of Corus Strip Products and chairman of the ULSAB-AVC technical committee. "Since 1998, when the work on the original UltraLight Steel Auto Body study was completed, computer-aided design, analysis and simulation techniques have evolved almost as rapidly as new steels have been developed. This has enabled us to take a new approach to crash design taking into account our improved understanding of the strengthening effect of modern steels when under impact."

One of the key features of this process is the shorter crash pulse associated with the use of steel's dynamic properties and the lower level of deformation and crash intrusion that can be achieved. This new data on the latest steels provides an additional opportunity for meeting future crash requirements with mass efficient lightweight structures and is a significant change in the way in which the design approach was adopted for the original ULSAB project.

To absorb the impact of a frontal collision without serious deformation to the passenger compartment the AVC study contemplates employing this knowledge in tailored steel hydroforms for the single front rails, which would eliminate the need for both upper and lower front rails. This is an excellent example of how the AVC study is taking full advantage of designing with steel to minimise the mass of a crash resistant structure. Clearly, with work in progress and new steel developments at every turn there is every possibility that these conceptual designs could evolve even further before the study is reported next year.

Similarly, another innovative conceptual feature contemplated by the AVC design is the bulkhead tunnel situated between the driver and front passenger, which would provide space for an equally novel powertrain design. To achieve anticipated 2004 frontal impact requirements and, in particular, the target for low footwell intrusion, the whole powertrain has been inclined at a shallow angle to the horizontal. During a crash event, this would allow the powertrain to move backwards into the tunnel without intruding into the passenger compartment. To ensure it clears the tunnel a narrow-V three-cylinder engine concept is also being considered, with the engine located behind a forward facing gearbox.

The powertrain employs state-of-the-art petrol and diesel engine designs, each with a displacement of 1,2 litres, which is considered sufficient to achieve the targets for both vehicle performance and low emissions. Preliminary calculations for carbon dioxide emissions, using the vehicle target kerb weight of 950kg (250-300kg less than a current small European family car), show that less than 140g/km of CO₂ can be achieved with both engine variants.

Similarly, the powertrain is likely to employ a state-of-the-art 5-speed automated manual transmission, which would use computer control to select the optimal shift points for maximum fuel economy. The transmission would either be hydraulically actuated as in the Volkswagen Lupo 3L or electrically actuated as in the new Opel/Vauxhall Corsa.

The position of the powertrain behind the front axle would also contribute to an ideal 50/50 load distribution front-to-rear, which is rarely achieved in front-wheel drive vehicles. Combined with the relatively long wheelbase, in proportion to the overall length, this would dramatically improve vehicle dynamic handling for avoiding collisions in the first instance.

The ingenuity of the AVC design is further demonstrated by the powertrain, front suspension, radiator and steering rack all being positioned on a simple high-strength steel tubular sub-frame which, in turn, is mounted to the body structure. The entire sub-frame system is designed to be installed as one unit from underneath the vehicle for ease and speed of assembly and, similarly, could be removed as one unit for major servicing - with quick release connections for power, heating, hydraulics and steering column under consideration.

A steel double-wishbone front suspension concept was selected because it allows for integration of the suspension with the sub-frame cradle. Yet it does not require disassembly of the strut when the complete module is removed, eliminating the need to readjust suspension alignment each time the engine is serviced. The spring is designed as a single transverse thin taper leaf, thereby eliminating the need for a traditional shock/spring tower in the body structure.

The design of the powertrain and suspension system and forward location of the front wheels results in a very low profile for the front end of the vehicle, which has the additional advantage of reducing the impact of hitting a pedestrian, while also enhancing aerodynamics for reduced fuel consumption.

A steel twist-beam system, which would be manufactured using high-strength tubular hydroforms, was considered the optimum choice for high volume production of a mass-efficient rear suspension. The twist-beam is a development of the same concept utilised by the recently completed UltraLight Steel Auto Suspensions (ULSAS) study, but designed by Porsche Engineering Services specifically to suit the kinematics and compliance characteristics of the AVC vehicle.

Like the front module, one of the novel aspects of the lightweight rear suspension is that it can be serviced from outside the vehicle.

As part of the AVC study, a working group within the steel consortium led by Simon Kragtwijk of Corus and Jody Shaw of USX is carrying out a detailed economic analysis of the programme. Early results of this study indicate that a steel intensive vehicle employing AVC concepts for high volume production can provide a route to increased vehicle safety and improved fuel economy at a significantly lower cost than using alternative ideas.

"What we are aiming for within AVC is to establish a manufacturing cost base for a fuel efficient vehicle, which breaks into new ground in terms of CO₂ reduction at an affordable price," says Simon Kragtwijk.

“We are only midway through the programme yet already making excellent progress as the designs are further optimised to take into account rapidly advancing steel technologies.”

He added: “We are demonstrating that the long-term requirements for safe, affordable, fuel-efficient and environmentally-friendly cars can be met through innovative design, the application of appropriate manufacturing processes and a better understanding of the dynamic properties of modern high strength steels.”

The AVC project is relevant to a global automotive industry and features concepts that are equally applicable to a small European C-Class family car or a larger American PNGV-Class sedan. The study, therefore, also demonstrates just how far it is possible to stretch a common platform - a concept that is being widely adopted by high volume carmakers eager to reduce manufacturing costs.