Advanced high-strength steels (AHSS) have emerged as one of the most sophisticated materials available for highly engineered product design.

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Over the past 20 years, steel – and the North American industry that produces it – has evolved to a sophisticated level. Today’s steel features improvements in quality and uniformity, and is more versatile than ever before. In addition, steelmakers have invested billions of dollars to update their equipment as well as to streamline and automate their processes.

Along with this transformation there has been a significant penetration of steel into new markets, such as homebuilding, roofing and electrical distribution (utility pole market). It also has enabled steel to become a more effective product in traditional markets, such as construction and automotive.

A Better Grade

The new steel comprises many high-tech products that were not available 25 years ago. Today’s new steels are stronger, more durable and more formable than ever before, allowing manufacturers great versatility in applying the new steels to many products. They allow lighter-weight, more-efficient structures to be built.

For example, the new advanced high-strength steels (AHSS) have emerged as some of the most sophisticated materials available for automotive production. These advanced materials gain their high-performance properties in strength and formability by incorporating multiphase microstructures, which result from precise control of chemistry and thermal treatment.

The high strength and formability of AHSS work synergistically to offer vehicle designers more freedom in how they address crashworthiness, packaging, styling and mass reduction. Using AHSS, designers can create safe, affordable, fuel-efficient and environmentally responsible automobiles for the general public.

In 1978, steel comprised 59% of a vehicle. Today, it makes up 54% of the mass of the vehicle, and high-strength steel is the fastest-growing lightweight material in automotive design. In years to come, as automakers continue to apply advanced high-strength steels, steel will remain the material of choice.

Showcase for AHSS

The newest conceptual vehicle design initiative by the steel industry – the ULSAB-AVC, for UltraLight Steel Auto Body-Advanced Vehicle Concepts – demonstrates the innovative use of advanced high-strength steels (AHSS) in automotive applications. (Upper left) Tailored blanks, tailored tubes, hydroforming and related joining technologies permit part integration for a significantly reduced part count. Thanks to steel, only 81 major parts are required to build the ULSAB-AVC body structure.
Final results show that the ULSAB-AVC concepts have the potential for achieving five-star safety ratings (as administered by the National Highway Transportation Safety Administration). In addition, fuel consumption for the North American concept would be 52 to 73 mpg; the manufacturing costs would be $9,200 to $10,200.

The study is a result of collaborative efforts by 35 steel companies from around the world. The North American Steel Company members of the consortium are also members of the Automotive Applications Committee, American Iron and Steel Institute.

In addition to the highly efficient body structure, which contains only 81 major parts, the ULSAB-AVC has other design advances, including an innovative front-end module, a highly economical powertrain and efficient front and rear suspension systems. All are aimed at balancing fuel efficiency, environmental performance and safety while fostering low-cost assembly and ease of servicing.

Advanced high-strength steels make up more than 80% of the ULSAB-AVC body structures while other grades of high-strength steel account for the remaining 20%. In addition to the use of advanced, high-tech steels in the body structures, the concept vehicles feature a range of steel grades in other applications including the front suspension, wheels, instrument panel beam, fuel tank, seat frames, bumper beams and closures.

ULSAB-AVC includes design and material concepts from consortium research projects on closures and suspensions. Successful integration of these concepts into a complete vehicle system confirms the mass-reducing and performance-enhancing potential of steel.

**Five-Star Results**

Computer-simulation tests predict that the ULSAB-AVC designs would receive "Five Stars" in the U.S.
New Car Assessment Program (NCAP) and Side-Impact NCAP crash safety tests, the highest possible rating in the United States. In addition, the concept cars would receive the top rating for performance against standards of the Insurance Institute for Highway Safety – as well as receive the equivalent to a Five-Star rating in European NCAP tests.

ULSAB-AVC consortium steel experts provided dynamic strain-rate sensitivity data, which engineers used in their computer crash models. Compared to use of data for static properties, whose application has been standard practice for years, use of dynamic data provides more accurate prediction of vehicle crash performance. Plus, use of such data provided further opportunities for engineers to optimize the structural efficiency of the body design.

ULSAB-AVC engineers, in computer modeling crash tests, subjected the designs to higher speeds and/or more severe loads than current standards in seven simulated crash events. They evaluated body structure behavior during the tests using such typical metrics as the crash pulse at the B pillar and intrusion into the safety cage. Results validated the capability of steel to maintain its position as the material of choice for safe vehicles. The ULSAB-AVC study also demonstrates that the concepts would cost no more to build than comparable vehicles.

Virtual Simulation

The application of high-power computers and sophisticated software, especially in automotive, minimizes the need for engineers to build hardware prototypes to perform structural analyses and crash tests. In the 2002 ULSAB-AVC study, for example, engineers worked with virtual vehicles, and the results proved to be readily acceptable to the automotive industry.

Thanks to advancements in software technology, engineers are able to evaluate structural performance in 3D, stereoscopic view. In crash analyses, they can see the structures collapsing under different load conditions. The results compute acceleration and other parameters without having to build and run a full-size operating vehicle into the wall.

We see several trends emerging with the new steel. First, with the use of advanced high-strength materials, industry will use less mild steel, resulting in a significant reduction in natural resources and power. Second, industries will use more value-added steel, such as the high-strength and advanced high-strength steels. Many of these products will be custom-tailored to specific applications. Third, the material and methods developed in business segments where steel has traditionally flourished, such as construction and the auto markets, will find roots in other markets as well. The various committees of American Iron and Steel Institute are committed to this further development of steel.

Modernizing the Industry

Over the past 20 years, the steel industry in North America has become the most modern and the most efficient of any steel industry in the world today. During the past 25 years, North American steelmakers have spent $60 billion ($35 billion since 1995) in modernization.

The industry has retired the old, cumbersome and inefficient ingot-casting practices, replacing them with highly technical, computer-controlled continuous casters, which are totally enclosed systems capable of creating semifinished steel products in one continuous process. Also, new computer-controlled gage and shape control systems for rolling and ultramodern continuous annealing and galvanizing lines are now in place.

Together, these investments have led to improvements in quality and uniformity. This modernization effort by steel resulted in the tripling of labor productivity and the elimination of 60 million tons of obsolete capacity, far more than the European Union and Japan combined.

Computer simulation crash modeling shows that the ULSAB-AVC (Partnership for a New Generation Vehicle-Class) could achieve a Five-Star Safety Rating. The use of dynamic properties for modeling enhances the simulation crashworthiness prediction capabilities.

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