worldsteel
ASSOCIATION

ENVIRONMENTAL CASE STUDY
Automotive

The World Steel Association (worldsteel) case studies use a life cycle assessment (LCA) approach to measure the potential greenhouse gas impacts from all stages of manufacture, product use and end-of-life. worldsteel has developed this series of case studies to demonstrate the reduction of CO_2 emissions through the use of high-performance steels.

An Advanced High-Strength Steel family car

Steel is reinventing itself to provide significant automotive performance advantages at little or no additional cost to automotive manufacturers or consumers. New grades of Advanced High-Strength Steel (AHSS) provide lighter optimised body designs for improved vehicle crashworthiness, improved fuel economy and reduced total greenhouse gas emissions (GHGs).

The aim of this case study is to show how the use of AHSS provides a sustainable solution for reducing GHG emissions over the complete life cycle of the vehicle.

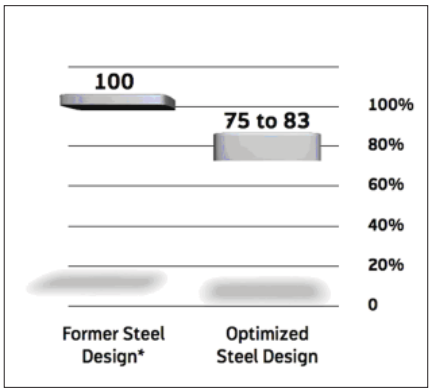
If the body structures of all cars produced worldwide were made of AHSS instead of conventional steel, 156 million tonnes of CO_2 equivalents would be avoided.

New steel grades and optimised designs

Optimised AHSS designs take advantage of the strength and forming characteristics of these new steel grades to develop stronger body structures using lighter gauge steel, multiple welded blanks for part consolidation, and unique part geometries that could not previously be achieved.

Steel and automotive engineers have replaced conventional steels with AHSS for the car body, or the body in white (BIW), resulting in 17% to 25% mass savings. With today's AHSS grades, savings of 25% are typically achieved and this corresponds to a total vehicle weight reduction of 9%.[1,2]

MASS REDUCTION POTENTIAL FOR THE BODY-IN-WHITE



When applied to a typical five-passenger family car, the overall weight of the vehicle is reduced by 117 kg, which corresponds to a lifetime saving of 2.2 tonnes of CO_2 equivalents[3] per vehicle, based on LCA.[4]

This saving in emissions is more than the total amount of CO_2 emitted during the production of all the steel in the vehicle.

Body-in-white of a five-passenger family car

The studies also show that for every 10% reduction in vehicle weight, fuel economy (litres of fuel per 100 km driving distance) is improved by between 1.9% and 8.2%. This range is based on driving cycle, vehicle size and powertrain selection. Values of 6% to 8% are possible with powertrain resizing for equivalent acceleration for conventional gasoline powertrains.

Automotive greenhouse gas emissions

The use of road vehicles is estimated to account for 10% of man-made global GHG emissions[5]. This figure is set to grow, as the automotive sector is one of the fastest growing sectors. With increasing recognition of climate change issues and the contribution from the transport industry, improving vehicle fuel economy and emissions are the top challenges facing the industry.

As a result, there is now a significant focus on vehicle mass reduction and alternative powertrain technologies to improve fuel efficiency. For both of these cases, the technological solutions for reducing emissions should be analysed by taking a life cycle perspective, to avoid an unintended increase of CO_2 emissions in material production and end-of-life.

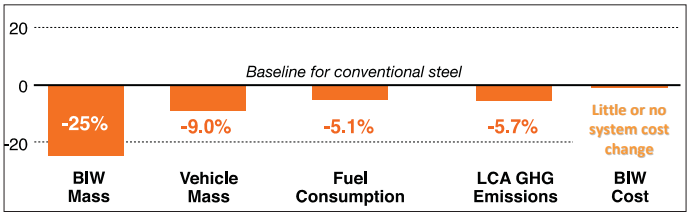
GHG reductions

The total weight of a typical five-passenger family car is 1,260 kg, with the BIW structure accounting for 360 kg. By replacing the BIW with an optimised structure made of AHSS products (at little additional cost relative to conventional steel[6]) the overall weight saving is 117 kg or 9%. Due to this weight reduction, the powertrain can be down-sized to achieve vehicle performance comparable to that of the heavier, conventional steel structure vehicle. The resultant fuel saving is 5.1%.

This weight reduction means that less steel is required for each vehicle, which reduces emissions from steel production. The fuel savings also reduce emissions from driving the vehicle.

For every 1 kg of AHSS used in a vehicle, total life cycle savings of 8 kg GHG (reported as CO_2 equivalents) are achieved. This is a 5.7% reduction in GHG emissions over the full life cycle of the vehicle.

THE ADVANTAGES OF AHSS COMPARED TO CONVENTIONAL STEEL



Thus, there is a lifetime saving of 2.2 tonnes CO_2 equivalents[7] per vehicle. These savings more than offset the total CO_2 emitted during steel manufacturing for all the steel used in the vehicle. If the body structures of all cars produced worldwide (predicted to be 71 million in 2008[8]) were made of AHSS instead of conventional steel, this would result in total lifetime emission saving of 156 million tonnes CO_2 equivalents.

Lean and green structures

As we seek global reductions in GHGs, the automotive industry is moving towards more advanced powertrains and fuel sources, and GHGs from material production will account for a much larger percentage of total GHGs. The material choice therefore becomes increasingly significant.

Steel is successfully re-inventing itself. For a typical five-passenger vehicle with an internal combustion engine, GHGs from material production account for up to 9% of the total GHGs emitted during the entire life of the vehicle. Steel production results in much less GHG emissions than competing automotive materials and new steels are continuously being developed to meet changing needs.

Materials that compete with AHSS for light-weighting can be costly to the environment. Many of the most potent greenhouse gases, such as perfluorocarbons (commonly-known as PFCs) and sulphur hexafluoride, have a much stronger global warming impact (kg for kg) than CO_2 and are emitted in the production of competing automotive materials such as aluminium and magnesium.

This is why life cycle assessment, which includes the analysis of a vehicle's material production, use and end-of-life phases, is necessary to fully evaluate where the true GHG impact on the environment occurs and where any potential system improvements can be made.

LCA captures environmental impacts across the life cycle, and thus is the responsible approach for measuring environmental costs and implementing effective, global solutions. It can also help to ensure that the material choice decision is combined with other relevant environmental initiatives in order to have an impact.

When one considers the extreme cost pressures in today's automotive market, AHSS is the only material choice that meets today's combined requirements in terms of cost, environment and performance.

Did you know?

- Steel is fully recyclable, and its production uses much less energy compared to competing automotive materials.
- Steel is safe. The use of AHSS in today's automotive structures results in improved crash protection, keeping you and your family safe.

Footnotes

1. ULSAB research (WorldAutoSteel), automakers' own body structure designs in recent years
2. FKA. Determination of Weight Elasticity of Fuel Economy for Conventional ICE Vehicles, Hybrid Vehicles and Fuel Cell Vehicles; Report 55510; Forschungsgesellschaft Kraftfahrwesen (FKA): Aachen, Germany, 2006
3. A metric measure used to compare the emissions from various greenhouse gases based upon their global warming potential (www.epa.gov).
4. An LCA-GHG Parametric Model, Dr Roland Geyer, Dr Donald Bren School of Environmental Science and Management, University of California Santa Barbara, 2006. This study also forms the basis for other statements and calculations made in this case study.
5. World Resources Institute, www.wri.org
6. The Massachusetts Institute of Technology
7. In the short-term, AHSS grades are being used in 50% of vehicle body structures. Within 10 years, 100% of steel body structures will be entirely AHSS.
8. Organisation Internationale des Constructeurs d'Automobiles (www.oica.net)