ADVANCED PROCESS MATERIALS FOR THE AUTOMOTIVE INDUSTRY ENABLE LIGHT-WEIGHT SOLUTIONS

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ABSTRACT

Sika provides the Automotive Industry with solutions for increased structural performance, added acoustic comfort and improved production processes, supporting it to manage increasing challenges of safety, CO_2 emissions and fuel efficiency. Two representative product solutions, SikaReinforcer® and SikaPower®, are analyzed, as well as the gains from their enabling light-weight design of vehicles. Aside from other benefits (e.g. increasing passenger safety, simplifying the manufacturing process), it is shown that Sika's solutions higher carbon footprint is largely compensated by gains during the use phase, namely in terms of fuel consumption and carbon emissions, just by allowing light-weight solutions.

INTRODUCTION

Sika is a global supplier of processing materials for sealing, bonding, damping, reinforcing and protecting load-bearing structures. Sika is also a development partner and supplier of the Automotive Industry, with solutions for increased structural performance, added acoustic comfort and improved production processes. This industry is facing challenges in terms of safety, CO_2 emissions and fuel efficiency. The balance between weight reduction, needed to reach new CO_2 legislation, and improved safety and acoustic comfort performance is a complex equilibrium for both Original Equipment Manufacturers (OEM) and Automotive suppliers, which Sika processing materials support.

Moreover Sika aims to assess its portfolio and compare all "costs", financial as well as non-financial (from raw materials, production, application and disposal) with potential "gains" for the customers (from product application and use) on both environmental and economic dimensions, using the Life Cycle Assessment (LCA) methodology. LCA provides a method to quantify and evaluate potential environmental impacts throughout a product's life cycle - from raw material purchase through production, use, end-of-life treatment, to final disposal.

Two representative product solutions for the Automotive Industry are SikaReinforcer® (components of epoxy and polyamide for structural reinforcement of cavities and crash reinforcing) and SikaPower® (structure adhesives based on epoxy, polyurethane and rubber, for crash and structural bonding, hem-flange, sealing and anti-flutter applications). Both solutions also enable light-weight design. They are analyzed here using data from real customer projects and LCA.

METHODS

A cradle to gate LCA was performed on a SikaReinforcer® (SR) component and SikaPower® (SP) adhesives, which covers raw material acquisition, processing and manufacturing of the product, including packaging. Using real customer projects, the "costs" are set against the use phase "gains" these solutions may bring when compared to alternative technologies, mainly by enabling light-weight design of vehicles, lowering fuel consumption in the vehicle's use phase. The Global Warming Potential (GWP 100a) impact category was analyzed, as the sector is facing stronger regulation and customer demands on carbon emissions along the value chain. The LCA Software GaBi 6.0 and databases were used and the impact assessment method was CML 2001-Nov. 2010.

SikaReinforcer® Case Study

An example case study to assess the "costs" and "gains" of replacing a 5 kg high strength steel[1] component with a 2 kg SikaReinforcer® component (including polyamide PA 6.6 GF35[2]) is calculated. The SR's epoxy formulation, production (compounder, in Switzerland) and storage was modeled, as well as the components processing (injection molding, in Switzerland) and packaging (carton box). The steel component needs additionally 51 welding points to be installed. The energy input per welding point is included (based on Stephan, 2007)[3].

SikaPower® Case Study

To illustrate how Sika's adhesives contribute to weight reduction in the use phase, as well as reducing the number of welding points needed in the vehicle production, two different setups were calculated for a high class car model. The first setup represents the serial production car and the second an optimized body with less welding points and thinner metal sheets. Both achieved the required stiffness and crash resistance. By using SikaPower® adhesive it was possible to eliminate 1000 welding points (thus allowing cost and welding energy savings) and to reduce 30 kg weight. The SP's formulation, production (in Italy) and packaging (23 L hobbock) were modeled. The energy inputs for welding and for bonding are included (based on Stephan, 2007).

Use phase gains

For the use phase gains, the standard mileage used for service life is 150'000 km. According to Gies (2009), weight reduction brings gains in terms of carbon emissions from less fuel consumption. In Koffler and Rohde-Brandenburger (2010), fuel reduction values are calculated for the weight-induced fuel consumption and then adapted to the power train (to achieve equal driving performance). According to the authors, the adapted values should be

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[1]Reinforcing steel dataset from ecoinvent was taken as proxy for high strength steel, since no data was available (also no processing is included).

[2] PA 6.6 GF30 dataset from ELCD/PlasticsEurope.

[3] EU-27 electricity mix dataset from PE International.

used, though it is difficult to quantify how large the weight reduction for a single component needs to be to allow for a power train adaptation if other lightweight measures are likely to appear in the vehicle but not known comprehensively. The life-time energy savings are also influenced by performance, efficiency of the transmission, engine and energy supply (IFEU, 2003). Based on Gies (2009) and Koffler and Rohde-Brandenburger (2010), and assuming a linear relation between weight reduction and carbon emissions and fuel consumption, those gains can be estimated through the following equation (with 1 L Diesel corresponding to 2.63 kg CO_2):

$$Fuel\_reduction/100km = -\frac{\Delta mass(kg) * 0.3l(Diesel)/100km}{100kg}$$

RESULTS

For the SikaReinforcer® case study, Δmass = -3 kg, so the total gains during the use phase coming from weight reduction and consequent fuel reduction amount to 34 kg CO_2., which is 2.5 times greater than the costs. For the SikaPower® case study, where Δmass = 30 kg, the total gains in the use phase amount to 355 kg CO_2, i.e. 15 times the costs. The cradle to installation costs vs. use phase benefits are shown in Figure 1 and Figure 2, respectively.

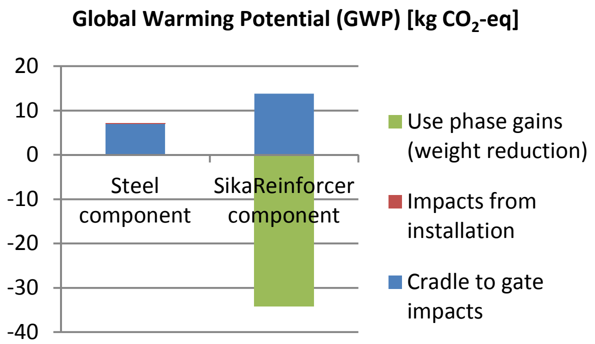

Figure 1. SikaReinforcer® vs. Steel: GWP for the materials in and emission reduction during use phase of the vehicle.

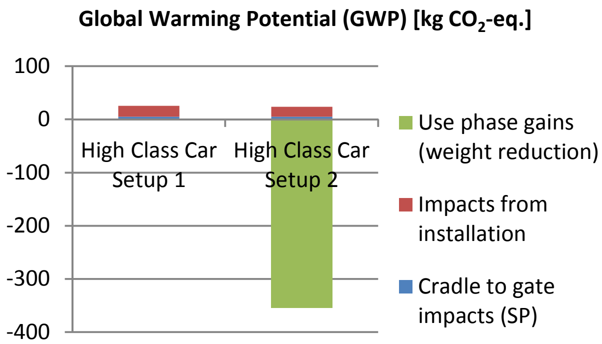

Figure 2. SikaPower® application: GWP costs and emission reduction during use phase of the vehicle.

DISCUSSION

SikaReinforcer® is used for structural reinforcement of cavities for stiffness and for enhancing crash properties through absorption of the impact energy or redistribution in the car structure. It improves the crash performance by adding a structural component that creates a rigid assembly with panels or eventual support. By this, sheet metal thickness can be reduced and steel reinforcement plates removed. SR contributes to reduce the weight of vehicle and may also avoid creation of vibrations (and thus noise and fatigue cracks in the structure).

SikaPower® adhesives are heat-curing adhesives combining properties such as toughness, flexibility, elongation, mechanical strength and an excellent adhesion spectrum on various substrates. SP can be used for crash and structural bonding, hem-flange, sealing and anti-flutter applications. These Crash Resistant Structural Adhesives increase passenger safety, improve car stiffness, and save costs due to decreasing of spot welding points and to simplification of the manufacturing process. They also enable bonding of composite material mix (metal/alu/plastic) and improve long term car durability.

Both case studies demonstrate that these solutions also allow savings in the automobile's production process (by substituting welding and allowing the use of thinner steel sheets) and during its use phase, namely in terms of fuel consumption and carbon emissions (by making a weight reduction possible). It is important to note that specific energy savings for a weight reduction also allow for a higher payload, and that they depend on the vehicle's use and the general physical specifics, with higher energy savings taking place for vehicles which are used with frequent stops and accelerations (IFEU, 2003).

CONCLUSIONS

There is increasing demand for a transparent picture of the environmental performance of products. Particularly in the Automotive sector, the search for lighter, eco-friendlier vehicles, fuel efficiency or "greener" energy sources, are industry drivers. More and more, the fuel efficiency and carbon emissions of the car weigh on consumer decisions. Meanwhile, the quality, safety and security standards must be ensured or even surpassed.

Apart from other benefits, like increasing passenger safety, it is demonstrated that, using high performance adhesives and components for structural reinforcement, the higher cradle to gate carbon footprint is over-compensated by gains during the use phase, namely in terms of fuel consumption and carbon emissions, by allowing light-weight construction. The results and lessons from the assessments can be adapted for similar studies and projects with OEMs as well as for further R&D activities.

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