LESS WEIGHT OR LIGHTWEIGHT
Jaguar Land Rover’s Life Cycle Approach

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CASE STUDY: OPTIMIZING VEHICLE LIGHTWEIGHTING FOR FLEXIBLE PRODUCTION

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Sikaflex® High-performance, primerless PUR adhesives for bonding a wide variety of substrates, including lightweight and dissimilar materials

SikaPower® High-strength bonding for crash-durable and structural applications on conventional and non-conventional substrates, including mixed-material bonding

SikaReinforcer® Precision-engineered, lightweight, crash and structural reinforcement inserts, integrated to create lighter-weight, high-performance structures

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LIGHTER | STRONGER | SAFER | QUIETER | GREENER
BETTER VEHICLES START WITH SIKA
Optimizing Bonding & Reinforcing Solutions

Key to Lighter, Stronger and Safer Vehicles
A new generation of innovative joining technologies are supporting the migration to new vehicle lightweighting architectures.
One billion! That is the number of registered passenger vehicles on the road today, and the number is growing every year. As more vehicles are produced and with the challenges of resource scarcity, rising energy consumption and increasing CO₂ emissions, both consumers and government regulators are demanding greater fuel economy.

While a few grams of CO₂ or a little material or energy saved by shaving several kilograms off one vehicle’s weight may seem modest, the results are significant over the millions of new cars manufactured every year. The trend requires new ideas, technologies and production methods to develop lighter weight and more efficient vehicles for the future. To achieve the goal of lightweighting, automakers have adopted different strategies, such as the use of non-traditional materials including high-strength steel, aluminum, magnesium and carbon-fiber-reinforced plastics. Another strategy is to adopt lighter-gauge metal or even eliminate sheet metal. But this creates unique challenges in assembly processes and introduces unwanted effects on durability, vehicle dynamics and crash performance. To further advance lightweighting, automotive OEMs have developed new vehicle architectures with radical manufacturing techniques using non-traditional materials. Even long-established assembly processes have been rethought. Body-in-White (BIW) assembly is not only manufactured in the conventional body shop, but more and more, BIW can be realized in a non-traditional, cold body shop.

Most modern BIW is full steel, full aluminum and most recently, full CFRP (Carbon fiber reinforced polymer) bodies. However, in the future, more and more bodies will be designed with a mixture of dissimilar material, taking advantage of their unique properties at the right place in the BIW. Automakers call it “The right material at the right place.” The result is an irreversible trend to build bodies using mixed materials.

Given these strategies developed by the automakers, advanced bonding and reinforcing technologies have emerged as the key enablers in making vehicle lightweighting possible while still maintaining strength and keeping occupants safe. Sika has been working with automakers to develop a full range of joining technology solutions to efficiently support the migration to new vehicle lightweighting architectures.

BONDING SOLUTIONS FOR LIGHTWEIGHT AND MULTI-MATERIAL JOINING IN TRADITIONAL BODY SHOP

While sustainable vehicle design has become a major trend in car production, so has sustainable performance realization. Performance expectations, economic, legislative and environmental targets are influencing automotive
OEMs’ thinking and driving the need for durable body-shop adhesives that improve stiffness, crash durability and fatigue performance, as well as contribute to weight-reduction strategies. These include incorporating mixed-material joining. Sika provides a broad range of innovative solutions for crash-durable, semi-crash, structural, hem-flange, anti-flutter, mastic and sealing applications to match challenging design requirements. Our body-shop adhesives have been used in 25 million cars and trucks, reducing weight without reducing safety. Crash-durable bonding is now the most important joining process in the body shop because it directly influences the car body structure sections during a crash.

SikaPower® crash-durable adhesives contribute to a significant increase in energy absorption during collisions, which makes them an ideal solution in comparison to traditional metal-joining techniques. Superior impact peel values leading to reduction of car body intrusion space make SikaPower products an increasingly effective bonding solution for high-performance vehicles. Lab tests on crash beams confirm intrusion reduction of 20 percent using these adhesives.
Structural bonding with SikaPower delivers a long list of performance and process benefits, among them increased car-body stiffness, excellent oil absorption and washout resistance, long-term corrosion resistance, fewer spot-weld points and long shelf life. For hem-flange bonding applications, typically used with hang-on parts, the inclusion of glass beads also makes SikaPower products suitable in body structures. The glass beads are good for “zero-gap” avoidance, thus ensuring a minimum adhesive interface. This produces better adhesion, mechanical performance, aging and corrosion properties. In anti-flutter and spot-welding paste-sealing applications, SikaSeal® adhesives provide excellent adhesion to standard OEM steel and aluminum substrates and produce vibration-free panel isolation joining, while also protecting durable metals against age-related corrosion from the elements. They also prevent bondline-read-through (BLRT), will not reduce the strength of welding spots and can be employed as a spot-weld paste adhesive.

By using non-traditional material in the BIW structure such as aluminum, which has a lower density than steel, significant weight reduction is achieved. One of the first vehicles to adapt a near all-aluminum construction was the Jaguar Land Rover Range Rover Sport, the first practical high-volume, all-aluminum platform. By using aluminum instead of steel, the Range Rover Sport saved more than 350 kilograms from the previous version. Note, however, that innovation does not come without challenges—aluminum is not a metal that can be easily welded. To solve the joining problem, Sika worked with Jaguar Land Rover and developed a specific type of SikaPower crash-durable adhesive to assemble this aluminum body. The finished vehicle meets a strict set of crash performance standards set by the OEM.

For multi-material, lightweight car-body construction, suitable joining technologies are needed. Recently, Sika created a family of novel bonding solutions optimized for these specific applications. Depending on the construction, substrates used, performance criteria required and production process, the best approach to the design can be evaluated and implemented. For instance, for a new application in the body shop, a hot curing, one-component adhesive technology was developed.
The 2014 Range Rover Sport has an all-aluminum BIW structure, which is joined by SikaPower® crash-durable adhesive. (Photo courtesy of Jaguar Land Rover)

Application of anti-flutter adhesive for BLRT sensitive applications
Conventional body-shop adhesives are not designed to relieve this stress, which can lead to adhesive failure, substrate failure or even substrate deformation.

SikaPower Mixed Bonding Excellence (MBX) technology made the mixed-material joining of steel to aluminum, steel to CFRP and aluminum to CFRP possible. The adhesive provides galvanic separation that improves protection against corrosion and increases vehicle durability. It also addresses a major issue of delta-alpha—mismatched expansion and contraction properties of dissimilar materials. In joining mixed material within a traditional body shop, as the temperature of materials is elevated and then cooled during the typical assembly process, high residual stress can build up in the interfacing layer of adhesive between substrates of dissimilar materials. This is due to differences in material coefficients. Conventional body-shop adhesives are not designed to relieve this stress, which can lead to adhesive failure, substrate failure or even substrate deformation. SikaPower crash-resistant adhesive absorbs the stress to prevent possible failure.

It was developed for the next generation of vehicles such as the BMW 7 Series sedan, which employs a mixture of aluminum, steel and CFRP to reduce weight while at the same time increase vehicle stability. The total Body-in-White weight reduction is 50 kilograms when compared to the previous...
generation. Innovative adhesive technology was needed to strategically bond the CFRP to steel and aluminum to steel. The SikaPower MBX products have the optimal balance of modulus, elongation and strength to ensure adhesion performance necessary while preventing any failure from residual tension during the entire vehicle service life.

BONDING SOLUTIONS FOR LIGHTWEIGHT AND MULTI-MATERIAL JOINING IN NON-TRADITIONAL ASSEMBLY

The trend toward lightweight structures in car-body construction also opens up a new broad application in the field of elastic adhesives. The mixed assembly of lightweight and composite materials such as aluminum, polycarbonates, CFRP can be a technical problem if the conventional BIW technologies of welding and structural bonding are used.

Considering this new demand from the market, Sika came up with an Ultra High Modulus (UHM), one-component elastic polyurethane adhesive to assist customers in improving body design and further reduce body weight.

The inventive properties of Sikaflex*-UHM offer a new flexibility to automotive OEM customers for new car design, allowing the use of lightweight materials, as well as more freedom in the body concept. Currently, two major premium OEM brands have placed this technology on their assembly lines. Daimler, since May 2013, has used Sikaflex-UHM for the bonding of the e-coated aluminum roof on the new S-Class. This product application is in all Daimler automotive production regions.

More recently, BMW successfully launched the new i3 and i8 lines, which are, from a concept point of view, the most innovative cars on the market today. Sikaflex-UHM,
combined with SikaBooster®, is used as the main technology for joining the CFRP life module to the aluminum driving module. Yes, you read this right—the passenger compartment is bonded to the chassis.

As previously mentioned, the major technical challenge faced in assembling mixed lightweight materials is the difference of thermal expansions or delta-alpha, leading to an unequal deformation of the materials in the final bonded assembly parts. The Sikaflex-UHM also addresses this problem. Besides the high modulus to provide the required stiffness, the material is able to compensate these movements due to its high elasticity. This material, based on Sika-patented i-Cure®, is mainly characterized by a high shear modulus (up to 15 MPa) combined with high elasticity and elongation at break. Furthermore, the use of proprietary i-Cure pre-polymer allows the combination of Sikaflex-UHM with compatible SikaBooster. There is now very fast curing of the adhesive, a major customer requirement. Sika, through its unique chemistry, also extended the glass-transition temperature outside the service range, which guarantees the robustness of the adhesive joint in all climatic conditions.

As Sikaflex-UHM is designed for semi-structural, crash-resistant elastic bonding of various lightweight materials and mixed structures in body construction, in such applications, crash resistance is required for safety-related components and material properties must meet safety regulations. Therefore, crash-test simulations have been realized with Sikaflex-UHM, and the results have shown better performance compared to spot-welded structures.
VEHICLE BODY REINFORCEMENT EXPERTISE

By being involved early in development, Sika is helping engineers achieve additional weight reductions through the design and implementation of reinforcement solutions. As weight is removed, its reinforcement products can readily provide the same or better performance than traditional designs. SikaReinforcer® is a range of highly engineered reinforcement solutions based on highly engineered and molded carriers, SikaStructure®, bonded in the vehicle body with structural foam. A high-end performance variation of the system includes structural adhesive applied to the carrier, known as Sika High Strength Bonding (HSB).

SikaReinforcer can be used in place of steel reinforcement, which means lower weight without degrading performance. It will achieve both safety (as a strategically placed reinforcement) and environmental regulation objectives (through the weight reduction thus achieved). Automakers are largely using hot-stamping steel technologies. Thanks to its unique combination of very good hot-forming and very high tensile-strength properties, steel is optimized to reduce BIW mass. Light weighting techniques also take advantage of the new grades of steel coming online. These grades offer high crash performance, but as the desire to further lightweight the BIW, metal thicknesses are gradually reduced. By doing this, the global noise, vibration and harshness (NVH) performance of the body is reduced. Compensation is then necessary by utilizing local reinforcements. SikaReinforcer is easily placed at the strategic body nodes to achieve the goal. The most recent industry-leading example is the implementation of 16 parts in the steel body of the Mercedes S-Class, saving more than 10 kilograms per body.

SIKA HSB OPENS NEW DESIGN POSSIBILITIES

To achieve even greater structural reinforcement, a novel system of structural adhesive with a lightweight structural composite insert is available. Deformation of the BIW structure in the event of a crash can be further reduced by high-strength adhesive bonding of the engineered reinforcing elements in the cavities of the passenger compartment. High-strength bonding (HSB) from Sika strengthens the body when applied to connect vehicle structural elements where necessary. In this way, the vehicle body can be specifically designed to suit different model versions and markets by using different combinations of SikaReinforcer and Sika HSB. The union of crash-resistant adhesive and lightweight structures in HSB raises the effectiveness of reinforcing elements to a very high level. Crumpling of profiles from high local forces is possible, which means the overall component deformation is reduced significantly. The crash-resistant adhesive ensures the reliable transfer of tensile and shear forces along the body sections and further increases the overall performance.

Along with improved deformation and penetration characteristics in the event of an accident, HSB can result in greater body rigidity. This exciting new technology is being introduced in serial production for the automotive industry.
FIGURE (4) / Integration of SikaReinforcer® solution into Mercedes S-Class sedan

FIGURE (5) / Evaluating the performance of reinforcement technology using 3-point bending test
FUTURE OF VEHICLE LIGHTWEIGHTING

It is clear that the push for lighter automobiles will become more intense, and the technologies for lightweighting will need to advance. As automakers are proliferating different types of vehicle architectures using traditional and non-traditional materials, as well as light gauging existing body constructions, the role played by bonding and reinforcing technologies will become paramount. However, advance technology alone is not enough. Early involvement at the development stage with automakers is key to creating additional weight reductions through the design and integration of lightweighting solutions.

For more information on how bonding and reinforcing technologies can enable vehicle lightweighting visit sikaautomotive.com/lightweighting.

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