



Injection Adhesives for Vehicle Body Construction

New lightweight concepts for reducing CO₂ emissions from vehicles and the trend toward electric vehicles are two global trends that call for new vehicle designs. The use of aluminum profiles and castings is particularly increasing in these areas. Castings are often used as so called nodes for joining profiles. In particular, the bonding of these components by means of adhesives presents new technical challenges. Sika has now developed a new adhesive solution for this purpose.



AUTHORS



Michael Gutsell
is Department Manager Research
and Development Body-in-White
Adhesives at Sika Technology AG
in Zurich (Switzerland).



Noah Munzinger
is Department Manager Research
and Development Body-in-White
Foams at Sika Technology AG
in Widen (Switzerland).

TECHNICAL CHALLENGE

In order to further reduce the CO₂ emissions from vehicles, lightweight designs are an issue that automobile manufacturers approach with different concepts. The most important one is certainly the mixed material concept. This involves the optimal combination of different materials such as steel, aluminum and plastics according to their properties and using them in the same car body. The different thermal expansion coefficients of the individual materials can lead to problems during cooling and, in extreme cases, to failure of the bond. In order to solve this problem, Sika developed the SikaPower MBX technology some time ago. Not only the use of different materials can cause problems with lightweight structures, but structural hurdles also have to be overcome.

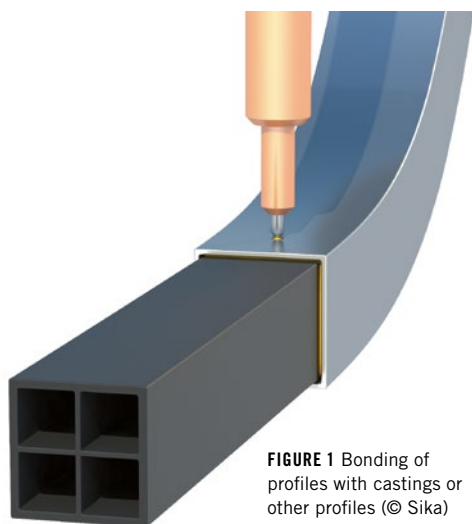


FIGURE 1 Bonding of profiles with castings or other profiles (© Sika)

An important application in this context is the bonding of cast aluminum nodes with aluminum profiles. In skeletal bodies, better known as space frame structures, profiles are connected via nodes, **FIGURE 1**.

As with push-in connectors, the bonding of joints such as these is usually not easy to solve. Due to the low gap dimensions, most of the adhesive previously applied to the profile or casting is removed during bonding. As a result, these types of joints are now largely mechanically joined, such as by riveting. Modern electric vehicle architectures have a particularly high proportion of profiles, for example in battery frame structures. This is partly due to the fact that the size of the battery restricts the structural space and that it tends to require use in a straight line. The more intensive use of profiles in car body construction has increased

| – | SikaReinforcer | High Strength Bonding | SikaPower SmartFlow |
|---------------------------|---|--|--|
| Concept | Structural part with integrated adhesive foam | Structural part glued in with adhesive | Structural glued in with injectable adhesive |
| (Crash) resistance | + | ++ | ++ |
| Process | ++ | + | ++ |

TABLE 1 Comparison of concepts (© Sika)

the need for a suitable adhesive solution. Sika has developed the SikaPower SmartFlow injection adhesive for bonding such push-in connectors.

Another area of application concerns the bonding of plastic reinforcement parts into the car body, **FIGURE 2**. Glass fiber-reinforced polyamide parts, known under the trade name of SikaReinforcer, are generally used for this purpose. There are several concepts for joining these structural parts to the car body. The structural parts can be hooked into the body. During hot curing the adhesive foam expands to the metal and thus creates a bond. Alternatively, such structural parts may also be glued directly into the cavity with a structural adhesive. At Sika, this process is referred to as High Strength Bonding (HSB). This procedure offers various advantages from a mechanical perspective, **TABLE 1**.

In contrast to foam (SikaReinforcer), bonding the structural part with an adhesive (HSB) leads to a stiffer and more (crash) resistant structure. Depending on the process, however, manufacturing challenges may arise. In particular, the reliability of the nesting process for individual parts cannot always be ensured. The SikaPower SmartFlow

injection adhesive provides a remedy for this. In this case, the bonding adhesive can be partially or fully injected directly into a metal structure which has already been joined. This method is particularly suitable for reinforcing A and B pillars and for reinforcing battery frame structures in vehicles. For this application, the stiffening part can be designed so that the adhesive flows from the injection point to all four sides and thus ensures optimum bonding of the structural part to the metal structure.

INTELLIGENT INJECTION ADHESIVE

Either high temperatures and/or high pressures are required to inject standard body adhesives into a cavity. In addition, it is necessary to provide guidance of where the adhesive is to flow. This is usually achieved when the cavity is closed and only needs to be filled. However, targeted injection becomes particularly difficult when the cavity is not closed. The assemblies described at the beginning are usually not form-fit or sealed, which means they are open on at least one side. When an adhesive is injected into a bond that is open on the side or not form-fit on the side, the

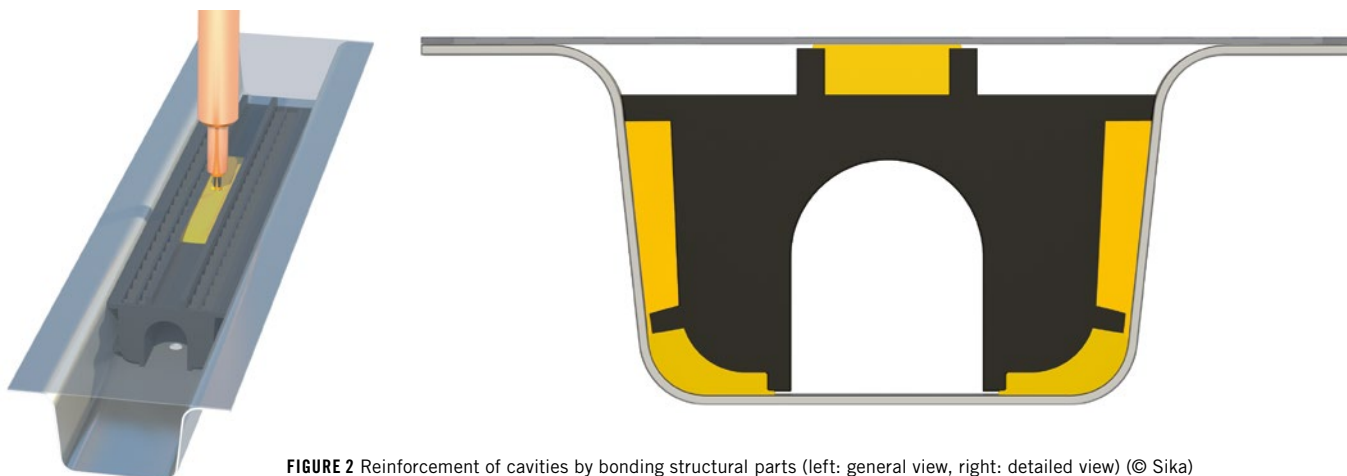
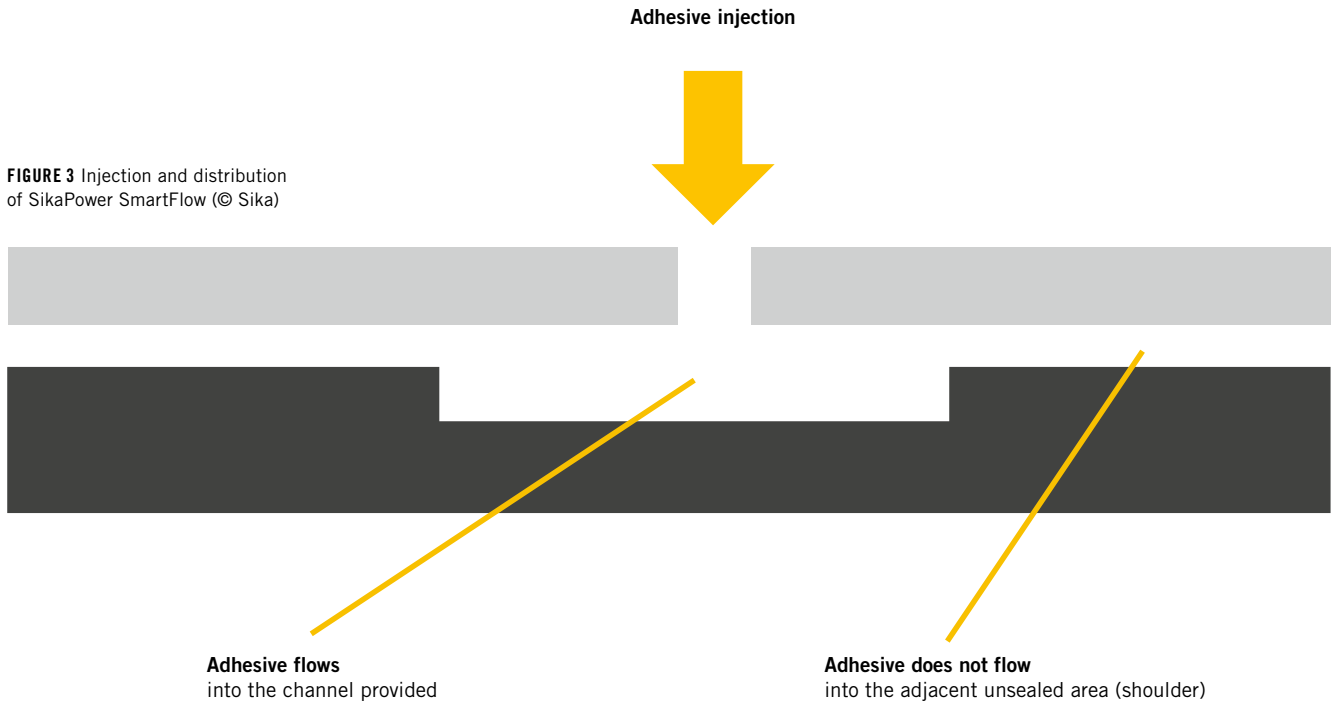


FIGURE 2 Reinforcement of cavities by bonding structural parts (left: general view, right: detailed view) (© Sika)



adhesive spreads not only in the desired direction but in all directions. The specification of a channel in a component provides very little help. In comparison, the SikaPower SmartFlow adhesive only spreads in the specified channel, even if the channel is open at the side, **FIGURE 3** and **FIGURE 4**. This is a property which proves to be particularly advantageous

in the case of the tolerances prevailing in bodywork. To simplify matters, the injection cavity in this report is referred to as the channel, and the lateral surface, which does not have a form-fit bond, is referred to as the shoulder, **FIGURE 3**. The height of the shoulder indicates the distance between the two joined parts in the area of the shoulder.

The new bonding technology has been tested and validated on various laboratory models. In all illustrations shown in this article, the channel depth is 3 mm, and the shoulder height is 1 mm. Although the difference is quite small, the adhesive flows only in the channel and not in the shoulder. Studies have shown that the ratio of channel

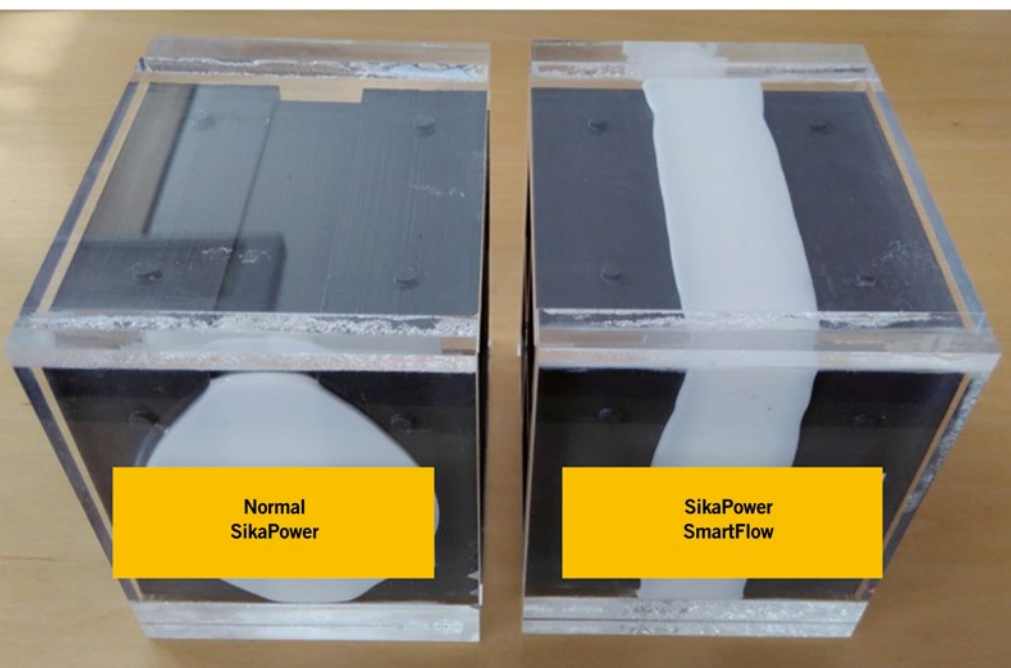


FIGURE 4 Adhesive distribution with SikaPower Standard (left) and SikaPower SmartFlow (right) (© Sika)

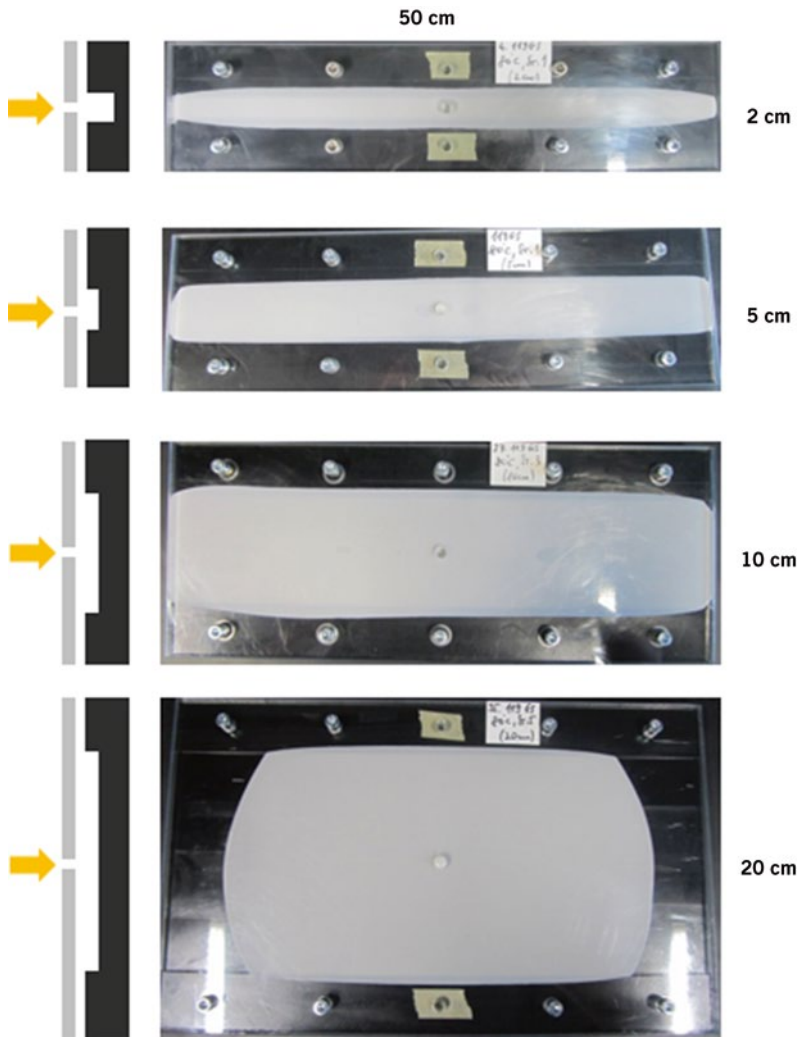


FIGURE 5 Injection into various channel widths (© Sika)

depth to shoulder height is decisive, and the design must take this into account. At a given channel depth of 3 mm, it has been shown that the greater the shoulder height chosen, the worse the spread of the adhesive in the channel and the better the flow of electrocoating can be guaranteed.

If electrocoating is not absolutely necessary, a shoulder height of < 1 mm has proven to be optimal. If perfect electrocoating must be guaranteed, a shoulder height of 1 to 2 mm is necessary. However, this does not pose a problem, because up to a shoulder height of 3 mm, the wash-out resistance in pretreatment and dip coating is good, as is the stability during heat-curing. A certain shoulder width is also necessary to prevent an overflow of the adhesive from the channel into the shoulder. A shoulder width of > 5 mm has proven to be ideal. Extensive injection tests have shown that both narrow and wide channels can be filled without problems, **FIGURE 5**. Channel widths of up to 20 cm were filled during the tests without any problems. Taking these specifications into account, the channel can be integrated either directly in the structural part or, in the case of push-in connectors, in the casting.

It is important to select the correct injection speeds to prevent the adhesive from overflowing at the edges. An injection speed that is too high tends to lead to overflowing. However, if the speed is too low, the adhesive may not spread through the channel as intended. Basically, a low, controlled inflow of adhesive into the shoulder is preferred. The temperature also has an influence on the injection result, as the viscosity of the adhesives depends upon it. Using fully automated application systems, the most important injection parameters, such as extrusion speed and temperature, can be specifically controlled. This allows consistent, comparable results to be achieved. The injection point should also be carefully selected. It should be noted that the volume of the cavity must be approximately the same in all flow directions, so that overflow can be prevented at the points close to the injection point.

Several test bodies were set up in order to test the flow behavior of the adhesive as realistically as possible. The gluing of a reinforcing part into a steel structure was to be illustrated with

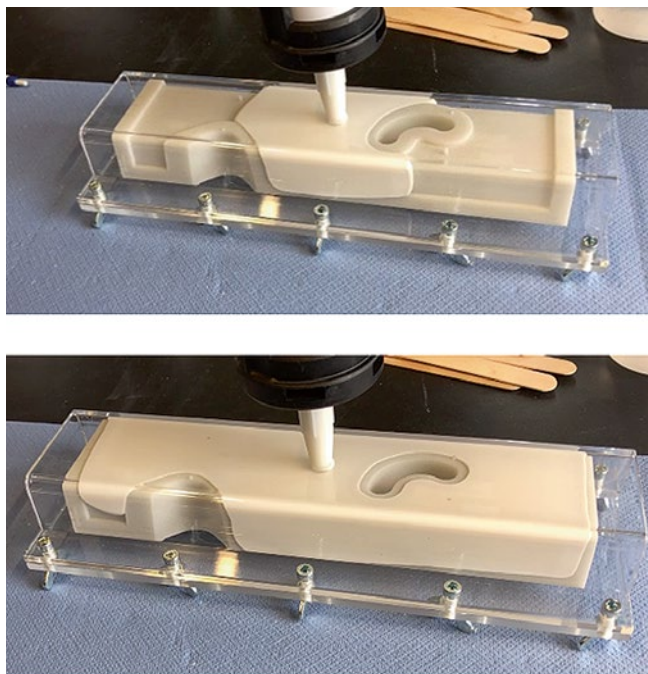


FIGURE 6 Flow behavior with large channels with SikaPower Standard (top) and SikaPower SmartFlow (bottom) (© Sika)



FIGURE 7 Multiple injections with SikaPower Standard (top) and SikaPower SmartFlow (down) (© Sika)

| – | SikaPower-497 | SikaPower SmartFlow |
|-------------------------------|---------------|---------------------|
| Lap-shear strength | 30 MPa | 25 MPa |
| Impact resistance | 40 N/mm | 35 N/mm |
| T-peel resistance | 10 N/mm | 9 N/mm |
| Open time | Good | Good |
| Application temperature range | 50 to 60 °C | 50 to 60 °C |

TABLE 2 Comparison of important material properties (© Sika)

the selected test piece. This geometry was selected primarily because of the large channels for the tests. The relevant structural parts were produced using a 3-D printer, **FIGURE 6**. A suitably shaped Plexiglas housing was used instead of the metal structure to optically track the flow behavior. The tests have confirmed that large channels can be filled without overflowing at the edges and the shoulders. It was also shown that typical elements such as holes or recesses for such components do not pose a problem for the spread of the adhesive. In such a case, the adhesive flows around the obstacle and then flows together again without leaving any air pockets behind, **FIGURE 6**. If it is necessary to fill even larger channels or to shorten the filling time, the adhesive can also be injected in several places at

the same time, **FIGURE 7**. In this case the flow fronts flow together seamlessly. The innovative adhesive is based on the well-known SikaPower adhesives which are intended for use in the body shop. Thus, the most important product properties of the new adhesive are also comparable with those of known systems, **TABLE 2**.

SUMMARY

The adhesive SikaPower SmartFlow allows new bonding solutions. This means that push-in connectors such as those found in electric vehicles or lightweight designs can be reliably bonded. The same adhesive can also be used to bond structural parts over the entire surface, resulting in higher stiffnesses and strengths.