The Way to the Perfect Hem Flange Bond

Hem flange bonding is one of the most demanding joining processes in car body construction, as the hem area is particularly susceptible to corrosion. The challenges for car manufacturers lie in the complex geometries of the car parts, the optimal filling of the hem area, avoiding the creation of any air channels which may lead to corrosion, and in achieving a clean, sharp-edged application.

Udo Mößner

Hem flange bonding is used in the automotive industry for closure parts such as doors, front or trunk lids and fenders (*Figure 1*). This joining technology ensures the mechanical and chemical ("hybrid") connection of the structures and also fulfills a visual function by concealing the cut edges of the metal sheets. In hem flange bonding, an outer and an inner sheet are positioned parallel to each other and joined together so that the outer component encloses the inner one (*Figure 2*). Before the outer sheet is folded over ("flanged"), a high-strength structural adhesive is applied to the edge of the outer sheet, which then fills the hem after mechanical forming. The adhesive inside the hem holds the inner and outer parts in place, improves crash safety, and protects against corrosion. The long-term stability of this hem flange bond depends on the distribution of the adhesive in the hem. *Figure 3* depicts the most important criteria.

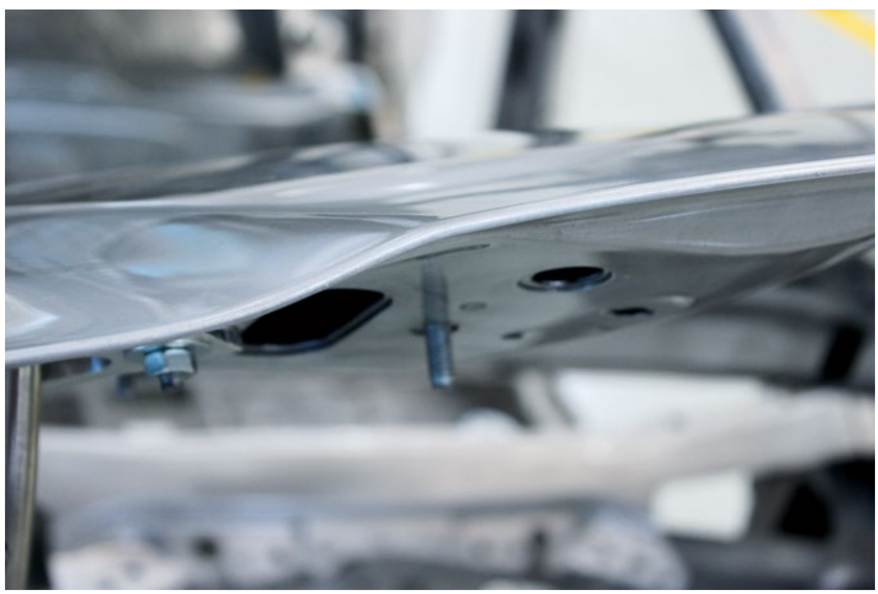

Figure 1 > Motor and trunk lids are typical mounted parts that are folded and bonded during the production process.

Hem flange bonding process

During hem flange bonding, the component is subjected to a force which deforms it and simultaneously distributes the adhesive within the hem area. The selection of the hemming method depends, among other things, on the size and contour of the components. The processes currently available for this are table-top, roller hemming (*Figure 4, Figure 5*) as well as press hemming.

Epoxy resins and rubber-based as well as two-component (2C) adhesives are usually used for the hem flange bonding in car body construction. Epoxy resins in particular offer high structural strength and also adhere to oil-wetted surfaces without the need for prior cleaning. This is an advantage because many components are oiled during production to protect them from corrosion. In addition, many hem flange bonding adhesives contain fillers, such as small glass spheres, which ensure a defined distance between the sheets and improve the mechanical connection by penetrating the sheets.

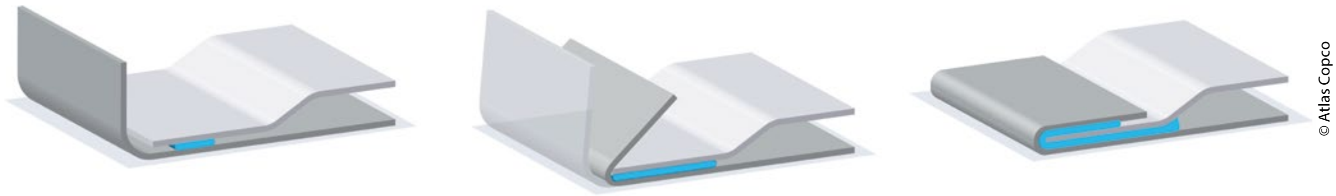

Figure 2 > Nesting (top): The inner plate is nested with the outer plate to which adhesive has already been applied. Plane-parallel nesting ensures an optimal result.
Hemming (center): Mechanical forming using various processes that give the hem its final shape.
Final hem (bottom): The adhesive is completely compressed. An optimally filled hem without air pockets prevents corrosion.

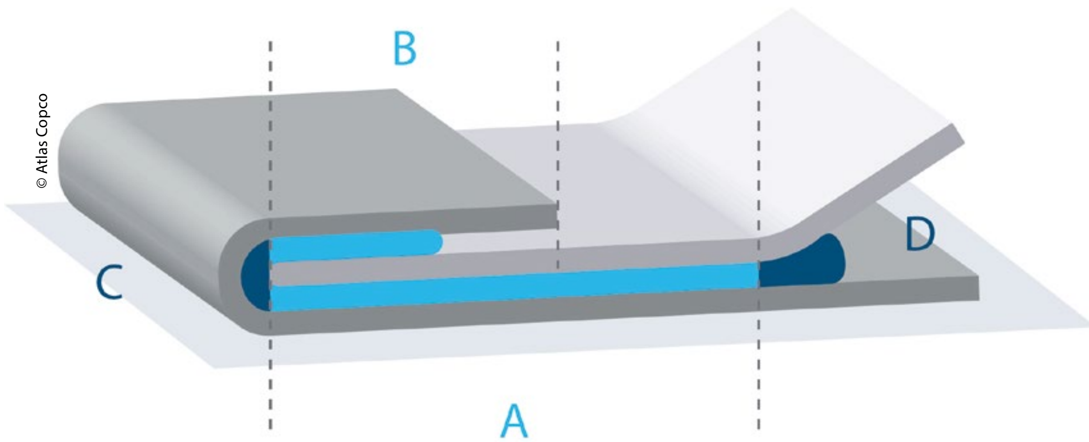

Figure 3 > The long-term stability of this hem flange bond depends on the distribution of the adhesive in the hem. There are four relevant criteria for this.
A: 100-percent bonding between the inner and outer sheet,
B: defined X-percent bonding between the inner and outer sheet,
C: complete filling of the outer bead with adhesive,
D: sufficient distribution of adhesive on the inside bead.

Adhesive is applied manually or automatically

The adhesive can be applied manually or fully automatically by a robot. With manual adhesive application, the material supply is generally connected directly to a manual applicator. The quality of the manual application depends very much on the experience of the worker. Manual application is typically used in prototype phases or in small series. Reasons for choosing such solutions are good accessibility, high flexibility and low investment costs.
Higher quality and repeat accuracy as well as shorter cycle times are achieved with automatic systems. An automated body shell gluing system usually consists of a material supply, a system control, a meter and an applicator. With automated systems, the user can set process parameters such as the adhesive volume or the speed of material application with great precision.
All processes aim to achieve a clean application and thus an optimal distribution of the adhesive within the hem, without excess material escaping during the hem flange bonding process.

Swirl application particularly suitable

This application can be done in a number of ways. In addition to conventional adhesive beads in various diameters, the so-called swirl application is also suitable for the formation of hem flanges (*Figure 6*). Here, the adhesive is applied in circular movements, which enables a particularly even filling and distribution within the hem when the two sheets are joined together. The optimized filling level enabled by this method ensures better quality: an improved sealing and better corrosion protection are achieved for sheet overlays and less adhesive is required.
The swirl method also increases flexibility in automated adhesive application. While bead application requires that the distance between applicator and component correspond to the bead diameter, the swirl method allows larger distances of up to 50 millimeters. Changing the distance does not affect the application pattern. This makes robot programming easier, allows higher speeds and facilitates accessibility, especially for complex geometries.

Uniform distribution of the adhesive

At the same time, swirl applications ensure a material distribution optimized for hem flange bonding applications: the same material quantity is distributed over a larger surface. The application is still precise with a high edge definition. This has a positive effect on press-

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Figure 4 > Roller hem bonding: first step by means of a pre-folding roller. The process achieves a high surface quality, especially for complex component geometries.

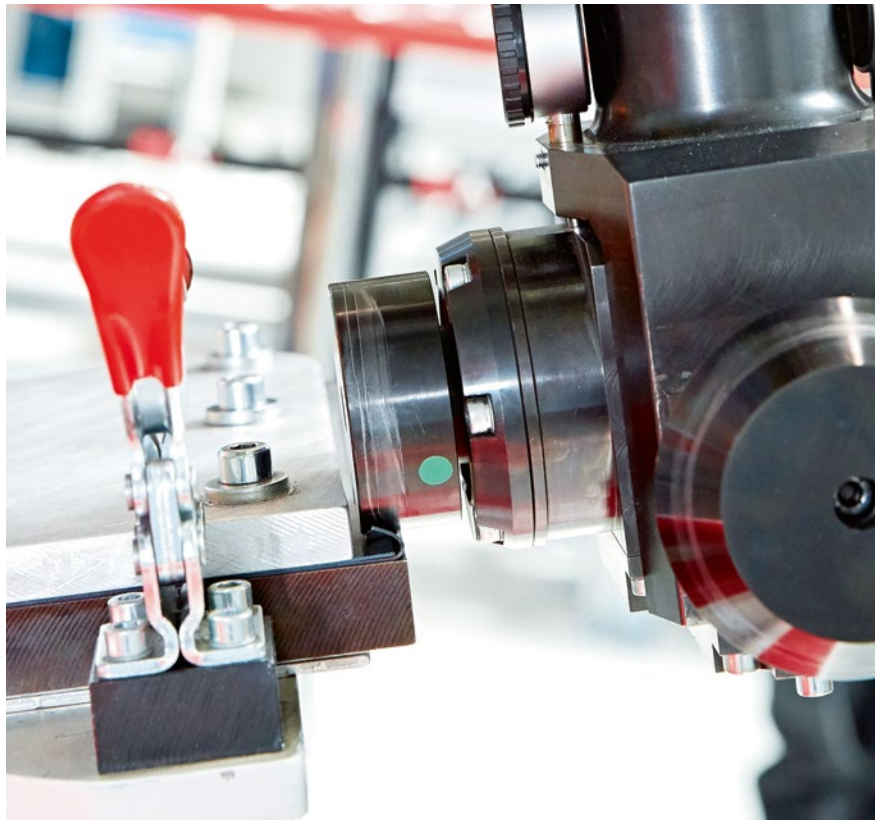

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Figure 5 > Roller hem bonding: second step with the finishing roller

ing in the hem flange bonding process. With modern swirl applicators, the width of the application can also be adjusted precisely. In places where less material is required, the applied volume can be systematically reduced while still maintaining a consistently high application quality (*Figure 7*). This allows the adhesive application to be perfectly adapted to the geometric shape of the flange, and prevents material leakage and a need for reworking. At the same time, adhesive consumption is reduced.

Different applicators are available depending on the required flow rate, viscosity of the adhesive or bead geometry. One good example of an applicator that can create different types of beads is the E-swirl 2 AdX BIW from Atlas Copco (*Figure 8*). It has an adjustable eccentric that allows to switch between a bead and a swirl application. The device offers users three different ways to apply adhesive: conventional bead application, swirl application with a constant diameter and swirl application with necking. Another important function of the E-swirl 2 AdX is its heatability. This means that even high-viscosity adhesives such as epoxy resins or rubber can be processed very well.

Typical errors and their causes

The quality of the bonded joint has an effect on the downstream processes, such as the electrophoretic deposition (EPD) process or the painting of the car body. If the adhesive application in the hem flange does not meet the quality requirements, material may, for example, leak from the hem. This would mean that the component has to be reworked to ensure that the EPD is not contaminated. If faulty parts reach the painting line, the leaked material can cause problems with the cosmetic sealing process. Common defects are adhesive escaping from the gap, meandering patterns in the (cured) material and PVC bubbles in the seam sealing.

Adhesive can leak if either too much material was applied during assembly because the position of the bead was not correct – for example, due to incorrect robot programming – or if the hem flange bonding was executed incorrectly (for example, pressed too tightly).

Meandering material creates additional loops and/or a twisted pattern in the cured adhesive. This may have several causes:

- Springback/shearing movements of the sheets after hem flange bonding,
- too little adhesive was applied,
- the pressing force exerted during hemming was too high and thus caused shifting of the adhesive,
- excessive oiling of the sheets (a maximum of 5 g/m² for steel and 0.5 g/m² for aluminum is permissible), which impairs optimum adhesive distribution and adhesion.

Excessively high tolerances in the thickness or geometry of the sheets can also reduce the quality of the hem flange joint. If the cavities are not properly filled with adhesive, air pockets may form and, as a result, small pockets may occur during the subsequent cosmetic seam sealing with PVC. This air expands during the curing process, which leads to so-called PVC bubbles. As a result, the appearance and the

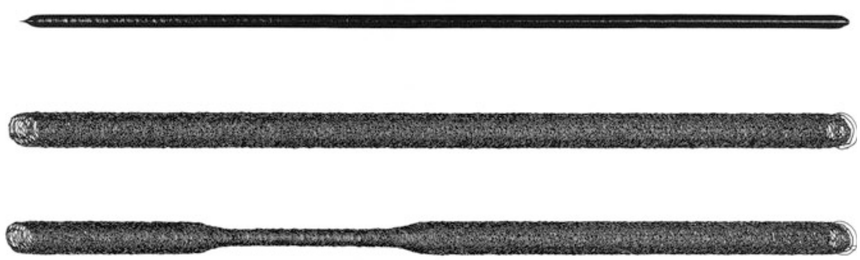

Figure 6 > Types of application: traditional bead application (top), swirl application (center) and swirl application with necking (bottom)

Figure 7 > Application with necking – applied using the swirl method to the outer sheet of a component to be folded. In places where less material is required, especially in curves, the adhesive volume can be systematically adjusted while still maintaining a consistently high application quality.

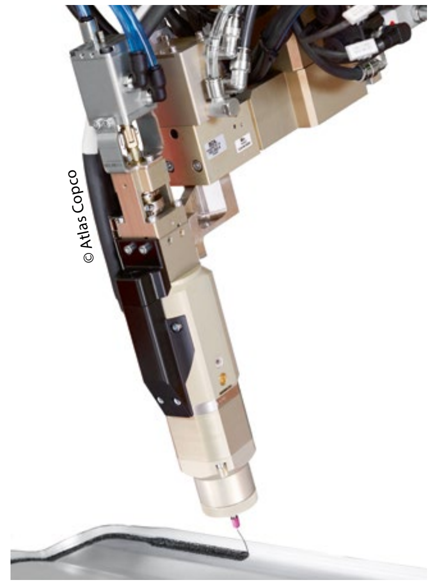

Figure 8 > Bead and swirl applicator rolled into one: The applicator E-swirl 2 AdX BIW enables traditional bead applications as well as swirl applications with equal precision.

effectiveness of the seal against corrosion are adversely affected.

Air bubbles can also be present in the unprocessed adhesive, which then lead to interrupted seams during application. If such defects are only discovered on the finished part, this would necessitate expensive rectification of the defect. If the fault is not detected and the defective component is actually fitted to the body, this may lead to corrosion after several years.

Automatic in-line quality assurance with visual inspection

The quality of the adhesive application can be monitored using visual inspection systems, both continuously and directly during application. Modern systems generally check the width, position and continuity of the bead or seam. Intelligent solutions offered by Atlas Copco with its application and dispensing systems of the SCA product line also include an in-line bead repair function. This system automatically corrects a bead interruption in the same cycle.

Systematic errors in the process can be identified by destructive testing on a random basis. In order to find out, for example, whether the bond meets the requirements for structural strength and corrosion resistance, the hem of a few finished components is ripped. The tester is then able to detect insufficient filling levels, air pockets or poor distribution of the adhesive. The disadvantage is that the defect is only discovered after the EPD process and the component can no longer be used afterwards.

A more recent development is ultrasonic testing, which checks the bonded joint over the entire seam by means of non-destructive testing. Defects in the material reflect the ultrasonic pulses, which can be displayed on a monitor. This allows weak points in the application process to be traced in a targeted manner.

In Atlas Copco’s global innovation centers, flanging and other joining processes can be simulated in close cooperation with automotive manufacturers and material suppliers. In this way, targeted solutions can be found that meet the individual parameters and process requirements. //

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