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JOINING TECHNOLOGY

SCREW GEOMETRY for Composites of Aluminum and Steel

More sustainable due to b&m-ECCO TEC® forming technology: Products such as the b&m-REPTO® B threaded bolt shown here performs with one hundred percent material utilization, high strength thanks to strain hardening and uninterrupted fiber runs.

From local screw dealer to a global supplier

Laboratory work: b&m application engineer Maxim Ort at the screw test rig.

High precision and best quality "Made in Germany": b&m produces at the company headquarters in Ober-Ramstadt.

Founded in 1932 as a local screw dealer, today active around the globe as a member of the Würth Group with 500 employees at nine locations in Europe, Asia and North America: baier & michels (b&m) with headquarters in Ober-Ramstadt (Germany) support the manufacturing industry in the field of cold forming.

The basis for this is provided by fasteners as well as closing and sealing systems from in-house development and production; with particular focus on the chipless process b&m-ECCO TEC®: It allows rotationally symmetrical components with a wide range of external contours to be manufactured – not only precisely and quickly, but also efficiently in terms of resources and energy.

Customers include primarily OEMs and suppliers in the automotive industry, electrical and medical technology sectors as well as in toolmaking and plant engineering. In addition to this, baier & michels offer application consulting, training courses and the b&m-PORT® – an online portal that supports industrial companies with standardizing their C parts.

Innovative direct screwing concept

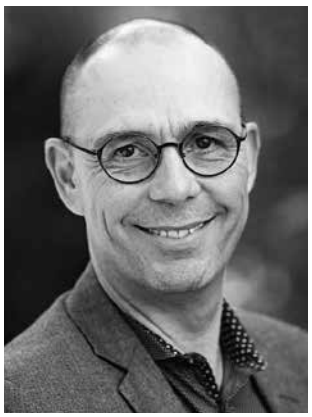
Dear readers,

Screws are the most important fasteners in automotive engineering. Experts estimate that there are 250 safety-related screw connections in a modern vehicle alone. In addition, there are countless other screw connections for the assembly of other vehicle components. Alternative joining methods such as gluing have not been able to change the still high value of screw connections in vehicle construction. On the contrary, due to the unique selling point of being easy to reverse, screw connections are even gaining new importance when considering CO_2 emissions and energy requirements over the product life cycle "from production to recycling".

Automotive engineering in particular is about the willingness to constantly question developments in the interplay between quality, cost efficiency and ecological balance and to rebalance them when necessary. With the ever-increasing demands placed on modern vehicle concepts, standard solutions in the field of bolting technology are often no longer sufficient. Problem solvers are increasingly in demand, superseding the mere part suppliers. Offerings such as in-house laboratories and technical development expertise enable the assistance of automobile manufacturers with tailor-made threaded connection solutions. One example is the connection technology with direct screwing systems utilizing thread-forming screws, which can significantly increase efficiency in production and assembly by eliminating work steps and avoiding metal chip waste. However, conventional directly threaded connections in the automotive sector are increasingly reaching their limits. baier & michels has therefore moved away from the standard concept of trilobular direct screwing and, in cooperation with the Mercedes-Benz Group, has developed a new, groundbreaking screw geometry with a circular thread cross-section for direct screwing systems. Thanks to the load-bearing flank overlap along the entire circumference, the new approach enables a particularly high transmission of force compared to conventional direct screwing systems. In addition, the concept offers an enhanced sealing effect, low risk of corrosion, process reliability during screw installation as well as a low installation torque and at the same time high failure torque. The system is already being used successfully in several Mercedes-Benz series, including the C, E, G and S classes.

I wish you an exciting read of the following technical paper on the innovative direct screwing concept.

Dr. Alexander Heintzel
Editor in Chief



Screw Geometry for Composite Aluminum-steel Structures

Modern automotive manufacturing brings together a variety of different requirements and materials. The objective is to make the vehicles more efficient, safer and more sustainable. This also applies to fastener technology. The Mercedes-Benz Group and fastener manufacturer Baier & Michels have jointly developed a solution that can overcome many of the challenges presented by composite aluminum-steel structures.

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The term “thread” refers to a helical ridge that continuously wraps around a central cylinder shape. When and where exactly this principle originated is unclear. It was first mentioned in the essays on the “Archimedes screw”, written by Greek mathematician Archimedes of Syracuse (287 to 212 before Christ). Since then, screws have become established as helpers of technical progress [1]. Today, they are standardized machine elements that come in a number of different variants. As a fastening screw, they are one of the most common joining elements overall [2]. In contrast to other joining methods, such as welding or gluing, threaded connections provide reliably detachable joints that can

FIGURE 1 The b&m-Tight M14 × 50 connection ensures reliable fastening of the integral subframe during the chassis-to-body marriage (© b&m)

be disassembled again at any time without destruction [3].

DIRECT SCREWING SYSTEMS

Direct screwing systems play a special role in this context. Thread-forming screws are not only fasteners, but also act as the tool for chipless cutting of a female thread in the part to be joined. This constellation is a considerable advantage when it comes to the efficiency of highly automated automotive manufacturing systems with a focus on cycle times. Another benefit provided by this solution are the cost savings during the manufacturing steps upstream of the screw installation, **FIGURE 1**. Conventional threaded connections in an aluminum housing, for example, require a relatively complex process: drilling the core hole, cutting the thread and – especially for blind holes – removing the chips. Thread-forming screws, on the other hand, only require a molded-in core hole and can therefore additionally use the higher strength of the casting skin.

Because the thread is formed and not cut, the grain flow of the material is not interrupted, but rather reshaped and additionally strain-hardened, **FIGURE 2**. This creates an overall joint with higher strength and load capacity. Thanks to the self-locking provided by the elastic resilience of the formed material of the female thread, no additional adhesive or clamping screw locking is required to protect against unintentional release. The generated thread pairing is also play-free.

CIRCULAR THREAD CROSS SECTION

While conventional direct screwing systems primarily use a trilobular thread geometry, the Mercedes-Benz Group have taken a different approach in collaboration with screw manufac-

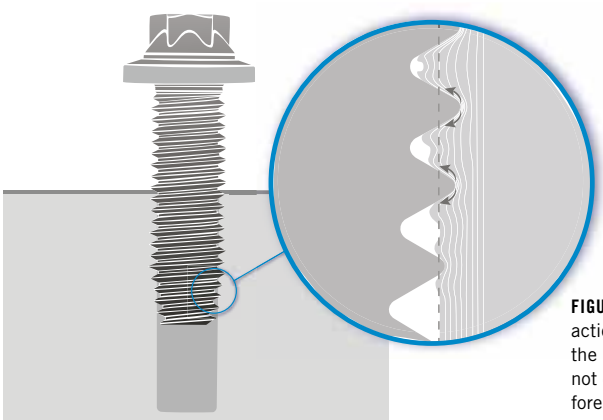

FIGURE 2 A thread-forming screw in action: In contrast to thread cutting, the material for the female thread is not cut away, but formed and therefore strain-hardened (© b&m)

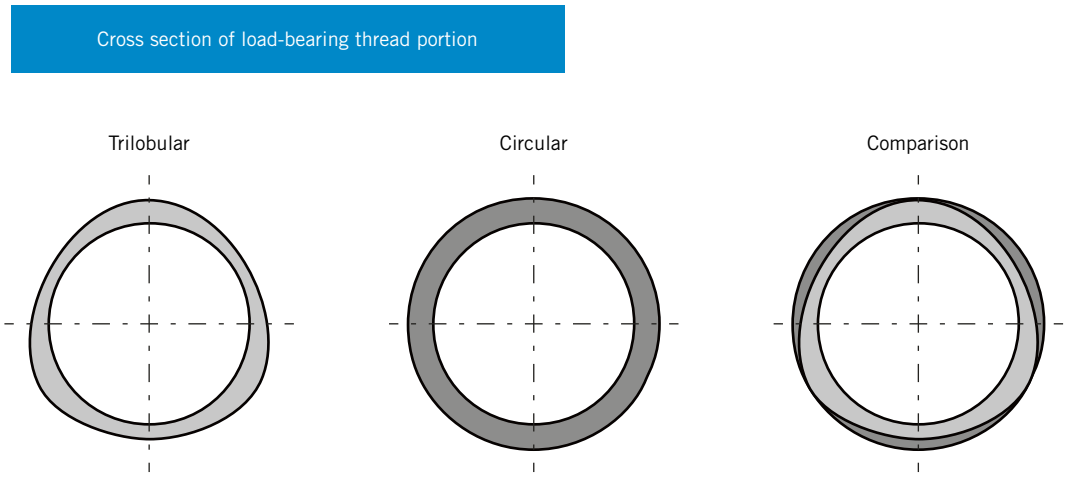

FIGURE 3 Compared to a trilobular solution, the circular shape of the b&m-Tight provides an additional load-bearing area (© b&m)

turer Baier & Michels, a member of the Würth Group. In trilobular systems, the cross section of the screw thread – similar to a thread forming machine – has the profile of a strongly rounded triangle, which results in relatively low forming torques during generation of the thread. The patent-pending screw geometry from Baier & Michels, on the other hand, has a circular thread cross section that provides a particularly high transmission of force thanks to the load-bearing flank overlap along the entire circumference, **FIGURE 3**.

The screw with the designation b&m-Tight has a specially designed forming zone geometry that support the material flow during generation of the female thread, ensuring low forming torques. With an appropriate core hole design, this method also provides a sealing function. This allows the screw to provide a leak tightness against liquids or gases up to 1 bar overpressure or underpressure as specified in the Mercedes-Benz standard MBN 10355 – without any additionally applied sealant. In contrast to trilobular systems, where the flank overlap is incomplete due to the geometry and allows moisture to enter into the thread area, the b&m-Tight minimizes the corrosion risk thanks to its self-sealing function. This means that the performance of the direct screwing system with the circular profile offers a positive effect in terms of corrosion resistance.

FIGURE 4 The direct screwing system b&m-Tight, here in the M14×50 version, is particularly suitable for composite aluminum-steel structures (© b&m)

ADVANTAGE OVER TRILOBULAR SOLUTIONS

And the screw also offers another advantage over trilobular solutions. Process reliability becomes a key issue in the case of threaded connections where the material of the female thread is a tough-soft wrought aluminum alloy, for example with a T5 temper. For large screw-in depths in particular, the conventional trilobular systems tend to seize during forming of the thread: Cold welding between the female thread material and the screw causes issues during the installation process. In these cases, the head of the fastener does not make contact with the surface of the part, or it cannot generate the preload force required for a reliable connection because the nominal tightening torque has already been reached.

This condition usually results in complex rework on the damaged joint, eliminating the original cost savings of direct screwing. The b&M-Tight is different: Its forming zone geometry, which was designed specifically for this problem, reliably prevents the connection from seizing.

Equipped with these features, the direct screwing system is used successfully in several product lines of the Mercedes-Benz brand, such as models from the C, E, G, and S Class, including the electric derivatives and the armored Guard special protection versions. With

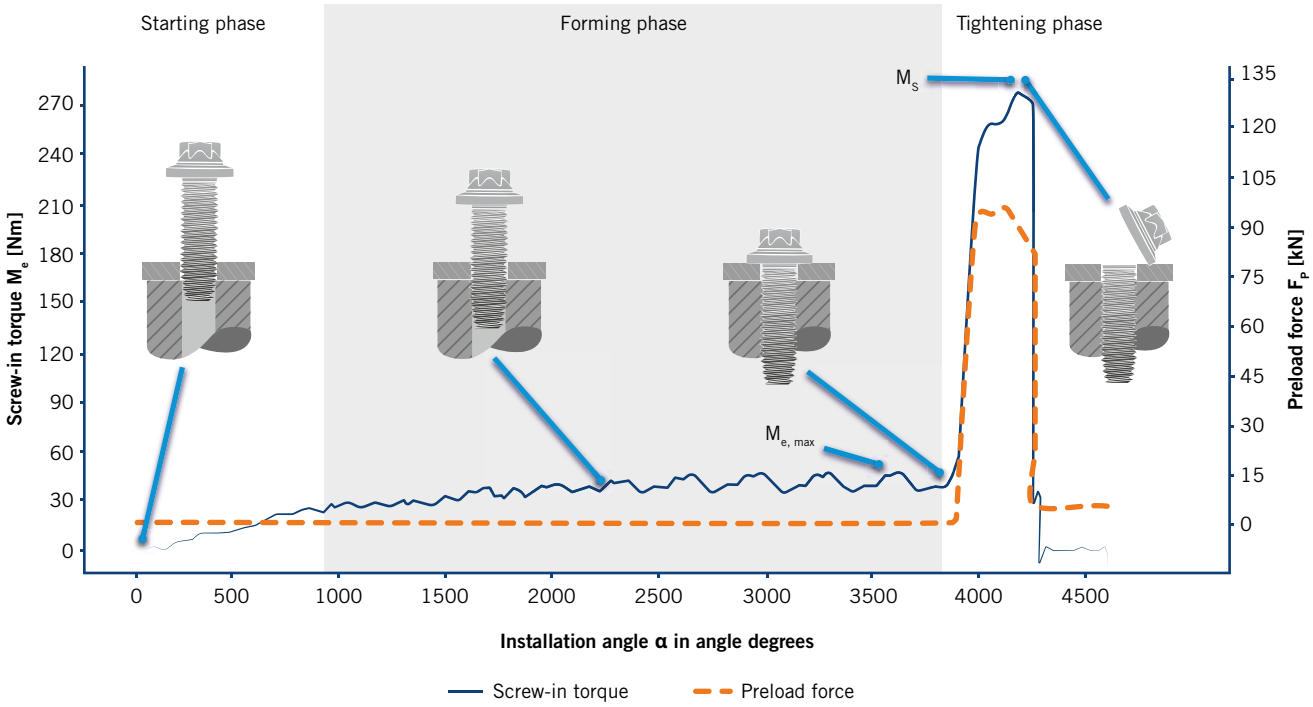

FIGURE 5 The diagram shows the three phases of the screw installation process for a b&m-Tight M14×50 until the stripping torque is reached (© b&m)

diameters from M8 to M14 and lengths between 16 and 140 mm, the screws are used primarily for safety-related and crash-related joints in aluminum and steel. One example is the integral subframe, which provides the transverse connection in the front end of the vehicle. It supports the engine as well as – in conjunction with the side members – the battery pack housing in electric vehicles and various other units, **FIGURE 4**. With additional weight, such as the armoring on the Guard models, the car can weigh around 4.5 t, which is 2 t more than the regular weight of the basic version. This presents a critical situation, because the transverse forces acting on the threaded connection have to be absorbed, which requires extremely high preload forces to prevent the integral subframe from slipping in extreme situations.

DESIGN ACROSS SEVERAL PRODUCT LINES

Another challenge is the design of the vehicle body, which is used across several product lines, referred to as the Modular Rear Architecture (MRA) platform at Mercedes-Benz: Depending on the model, either an aluminum tube or a steel tube is installed. In an aluminum tube, for example, the system favors a large process window for the final tightening when using b&m-Tight M14×50 due to a comparatively low forming torque of <50 Nm and at the same time high failure torque of >270 Nm. This generates reliably achievable preload forces of more than 85 kN – with a load-bearing thread section of only 1.7 × D (D = nominal external thread diameter), **FIGURE 5**.

Seat connections have also proven to be a challenging task: In some cases, conventional direct screwing systems were not able to withstand the crash test specifications. The b&m-Tight on the other hand did. With its circular thread cross section and fully formed thread flanks, it offers maximum flank overlap and therefore high pull-out forces. As the workers install these connections with hand-held screwdriving devices and fasteners are installed in steel on the sill side and in aluminum on the tunnel side, an identical parameter set for both areas is immensely helpful when using just one screwdriver. The b&m-Tight makes this possible and can exclude any potential risk of mix-ups and errors during the assembly process. This also reduces the parts variety, for example for two different screws, and the number of process steps with a view to cost efficiency.

CONCLUSION

Conventional direct screwing systems often run into issues in applications in tough-soft aluminum alloys. With their special forming zone and circular thread cross section, b&m-Tight screws are ideal for exactly this type of material – in particular for large screw-in depths – but also for high-strength steel. The full flank overlap between the screw and the formed female thread allows for the greatest possible transmission of forces in a reliable process. This joining solution is recommended especially for composite aluminum-steel structures. Another advantage: If the core hole is adapted accordingly, the b&m-Tight is self-sealing against gases and liquids.

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