Innovative fasteners for high-performance plastics

Optimising weight with direct screw fastenings into plastics

Picture 1: We find direct screw fastening into plastics anywhere where lightweight construction, strong forces and cost optimisation come together. Whether in PCBs, where the installation space is extremely limited and it is not possible to use inserts or in heavily-stressed components such as wing mirrors, pumps, valves and oil filters. (Source: shutterstock-ID: 40618312 | © terekhov igor)

When it comes to fastening plastics there are many different influencing factors at play. The challenge is to find a geometry for the screw fastening that balances out any negative effects such as tolerance fluctuations. Moreover, it is important that the fastening solution is optimally adapted to the material's properties and the type of load it will need to bear.

The strength of the material, the way it is conditioned, the fibre orientation and the type of fibre, the visco-elastic deforming behaviour, the component and screw tolerances such as the diameters of the core hole and the screw, and even the precision of the screw-driving system – are all factors to bear in mind when implementing direct screw fastenings into plastic materials. And to find out whether a particular screw geometry is suitable for the application in question, it is also important to know the quality characteristics required of the direct screw fastening into the plastic material. Quality characteristics are high overturn torque, low insertion torque, and high pre-clamping and pull-out forces.

"Looking at a traditional graph line for a screw connection, the aim is to achieve the highest possible pre-clamping force with a moderate driving torque and an

"In many plastics applications, with strategic design of the fastening points, it is possible to use direct screw fastening into the plastic."

Sinja Strobl, Application Sales Manager,
ARNOLD UMFORMTECHNIK

overturn torque that is as high as possible. At the same time, to ensure a secure fastening it is important to achieve a sufficiently high delta torque between driving and overturn. This prevents the screwdriver from stopping in the event of fluctuation before the head setting has been reached, or from ripping out the formed nut thread. Moreover, the optimum tightening torque is defined by the delta torque", commented Sinja Strobl. She is the Application Sales Manager at ARNOLD UMFORMTECHNIK with responsibility for screw fastening design and expanding applications, as well as for providing technical application advice in the fields of plastics and electrification.

Direct screw fastening into thermoplastics

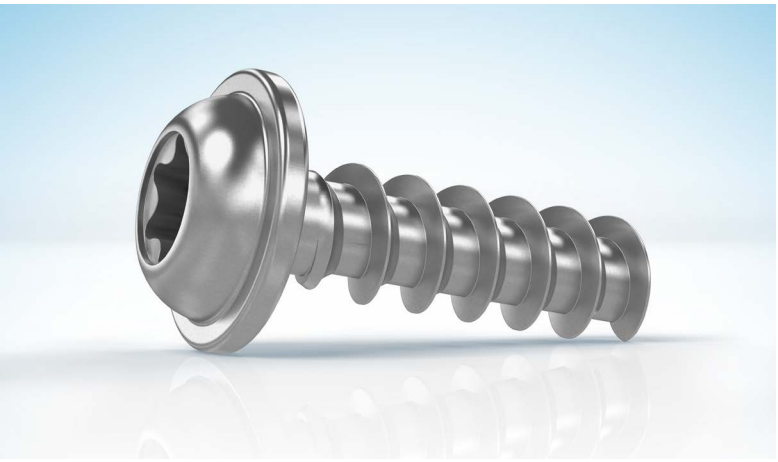
The pre-clamping force is not generally monitored during series production. Which is why the torque is the measure used. In tests carried out at ARNOLD UMFORMTECHNIK the pre-clamping force is determined by connecting a load cell. Using this method a specific force can be assigned to every recorded torque.

Another assessable quality characteristic is the point of failure. Here destructive tests are used to discover how the thread fails. "The optimum point of failure is when the nut thread overtightens due to the repair solution used. And of course, in plastics with a high proportion of glass fibre, the screw could break. However in normal fastening situations the plastic is always the weaker element and is therefore the first to fail", explained Strobl. "We need to prevent what is known as boss cracking. This type of failure is nearly always down to the wrong boss design."

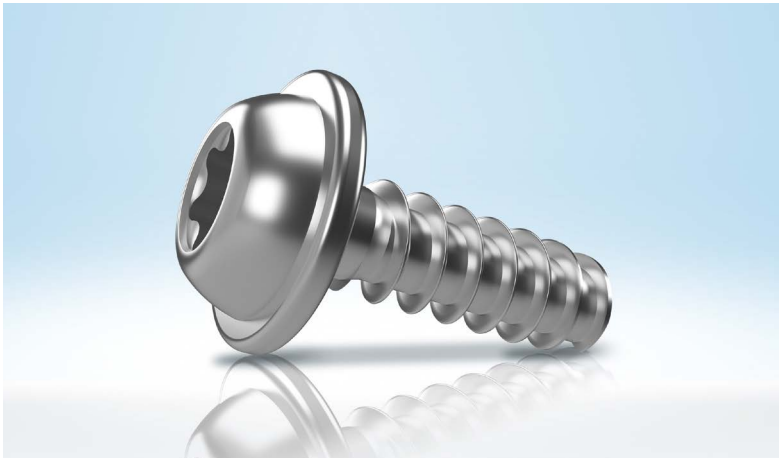
Thread-tapping screws with asymmetric thread profile.

Direct screw fastenings into plastics are appropriate for fastening plastic components as a reliable and cost-optimised solution. REMFORM® screws from ARNOLD UMFORMTECHNIK – thread-forming screws with an asymmetrical thread profile – offer a number of advantages over conventional screws for plastics with a 30° flank. The optimised thread core greatly increases resistance to vibration as well as the screw's breaking torque. This results in a more stable join, but in the case of high-strength plastics it also allows for a higher assembly torque without the risk of the screw breaking.

A further improvement to the 30° flank is represented by the radial profile of the thread flanks. Since a comparatively high speed is used when making a direct screw fastening into plastics, the material heats up and softens locally during the screw-driving process. Due to the radius profile of the REMFORM®



Picture 2: The optimised thread core of **REMFORM®** screws greatly increases resistance to vibration as well as their breaking torque, resulting in a more stable join.
(Source: ARNOLD UMFORMTECHNIK)



Picture 3: For particularly demanding applications ARNOLD UMFORMTECHNIK manufactures the **REMFORM® II™ HS.** This is used in cases where there is a requirement for fasteners with a high load-bearing capacity, demonstrating high pre-clamping force and a high degree of detach-security, for example in the case of harder, fibre-reinforced plastics.
(Source: ARNOLD UMFORMTECHNIK)

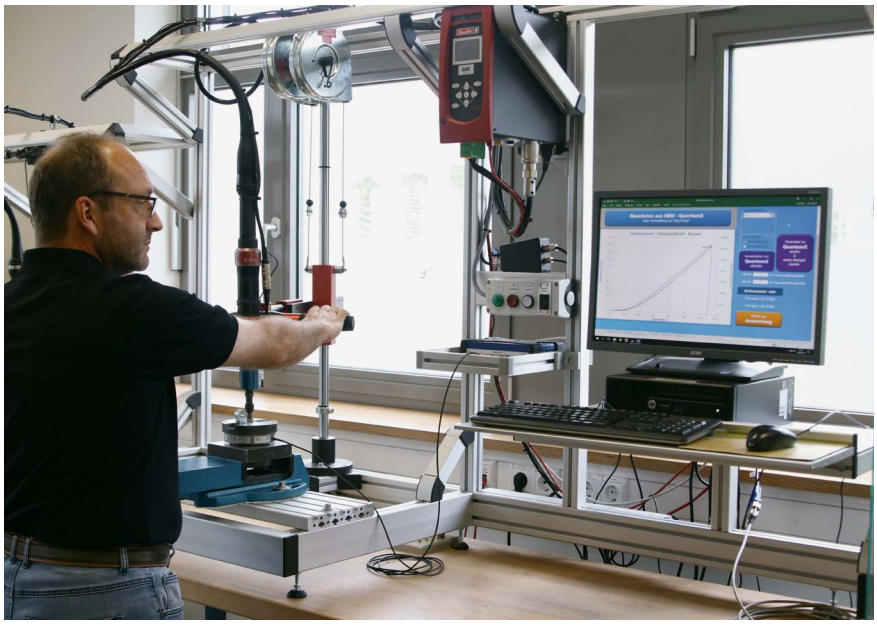
screw thread flank, the flow behaviour of the plastic is fully utilised and, with the greater volume of material, the plastic is compressed towards the load-bearing flank without creating any pronounced stress peaks. The steep 12° load flank has the task of generating the necessary pre-clamping load, while at the same time providing a high degree of assembly reliability. The plastic must therefore be able to accept the pre-load force applied evenly, without risking a boss break caused by too much radial stress.

As the screw is inserted, the heat created makes the plastic malleable. To keep the stresses as low as possible, particular attention needs to be paid to the flank angle. "The comparatively flat incline on the load-bearing flank makes it possible to have a steeper orientation of the force vector in the axial direction. This means that the tube is impinged with less load during the screw-driving process and the risk of the boss breaking is minimised," explained Sinja Strobl. In addition, the radius profile produces a torque that steers the plastic directly to the steep flank during the screw-in process. The asymmetrical geometry thus reduces the radial force and increases the axial force. Compared to a symmetrical profile this signifies a much higher thread engagement and higher pull-off force. The high thread engagement also ensures that the cutting surface is bigger. This increases the fastening's overtorque. The lower load on the nut material also allows higher pre-clamping forces, creating a long-lasting connection at maximum residual pre-clamping force. To be able to meet these high requirements for direct screw fastenings into plastic, a material of strength class 10 is used.

The advantages of direct screw fastenings into plastics and the applications

Besides the high level of assembly reliability and the high assembly pre-clamping force, the geometric and material characteristics of REMFORM® also mean that it is possible to achieve reliable repeat screw fastenings. This means that end customers can repair components containing screw fastenings made directly into the plastic. As opposed to conventional plastic screw fastenings which use a sleeve, a screw, and a nut, these screw fastenings can be screwed into the plastic from one side, thus reducing the complexity of the component as well as the number of small parts.

And last but not least, the process involved for direct screw fastenings into plastics is much slimmer than for con-



Picture 4: A comprehensive range of the latest testing equipment and screw fastening technology at the **Fastener Testing Center.** Every investigation is recorded in a detailed test report.
(Source: ARNOLD UMFORMTECHNIK)

ventional screw fastenings for plastics. The component can be injection moulded directly with optimally designed core holes and then assembled with the plastics screw. This eliminates cost and time drivers such as handling different small parts, higher tool costs and processing times for the insert process. "We find direct screw fastenings into plastics anywhere where lightweight construction, high forces and cost optimisation come together. Whether in PCBs, where the installation space is extremely limited and it is not possible to use inserts or in heavily-stressed components such as wing mirrors, vacuum cleaners and oil filters. Using strategic design of the fastening points, it is possible to use direct screw fastening in many plastics applications," commented Sinja Strobl as she described some of the application areas.

Fastenings for harder, fibre-reinforced plastics

For particularly demanding applications ARNOLD UMFORMTECHNIK manufactures the REMFORM® II™ HS (high-strength) on a highly accurate production plant, based on the relevant test data. This is used in particular in cases where there is a requirement for fasteners with a high load-bearing capacity, demonstrating high pre-clamping force and a high degree of detach-security. It is distinctive for its optimised, enlarged thread core, which in addition to its vibration resistance, also considerably increases the breaking torque of the screw. This results in a more stable join, but in the case of high-strength plastics it also allows for a higher assembly torque without the risk of the screw breaking.

A further improvement is represented by the rounded radial profile of the thread flanks. This means that there is no deformation of the thread flanks when screw-fastening fibre-reinforced plastic, thus generating a secure screw connection with high load-bearing capacity. The steep load flank has the task of generating the necessary pre-clamping load while at the same time providing a high degree of assembly reliability. The reduced pitch on the load-bearing flank and the higher proportion of plastic resulting from the radial profile on the contact surface makes it possible to have a steeper orientation of the force vector in the axial direction. This reduces the risk of a boss breakage by minimising the radial stress, while at the same time increasing the transferable force. "This innovative geometry is what makes the REMFORM® II™ HS the ideal product for use in high-performance plastics", commented Strobl.

Testing, predictions, and calculation

ARNOLD UMFORMTECHNIK's customers can make use of the firm's laboratory to examine whether the fastening solution they have chosen is appropriate for the application in question. A comprehensive range of the latest testing equipment and screw fastening technology is available at the Fastener Testing Center. The techniques used meet IATF 16949 requirements. When necessary, we can also provide access to other internal and external laboratories, for example for testing materials or to generate a micrograph. Every investigation is recorded in a detailed test report, tailored to the client's requirements.

And if the actual component is not yet available, customers can make use of the Fast Designer Plastics prediction tool to predict the assembly process and the assembly pre-clamping forces as early as the design stage. This can considerably reduce the scope of testing, which can be expensive. "With the Fast Designer Plastics facility, we can determine the driving torque, the optimum tightening torque and the predicted pre-clamping force. This should be followed by a validation process using tests on the original component," said Strobl, as she pointed out some further options for developing a perfectly tuned fastening solution.

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