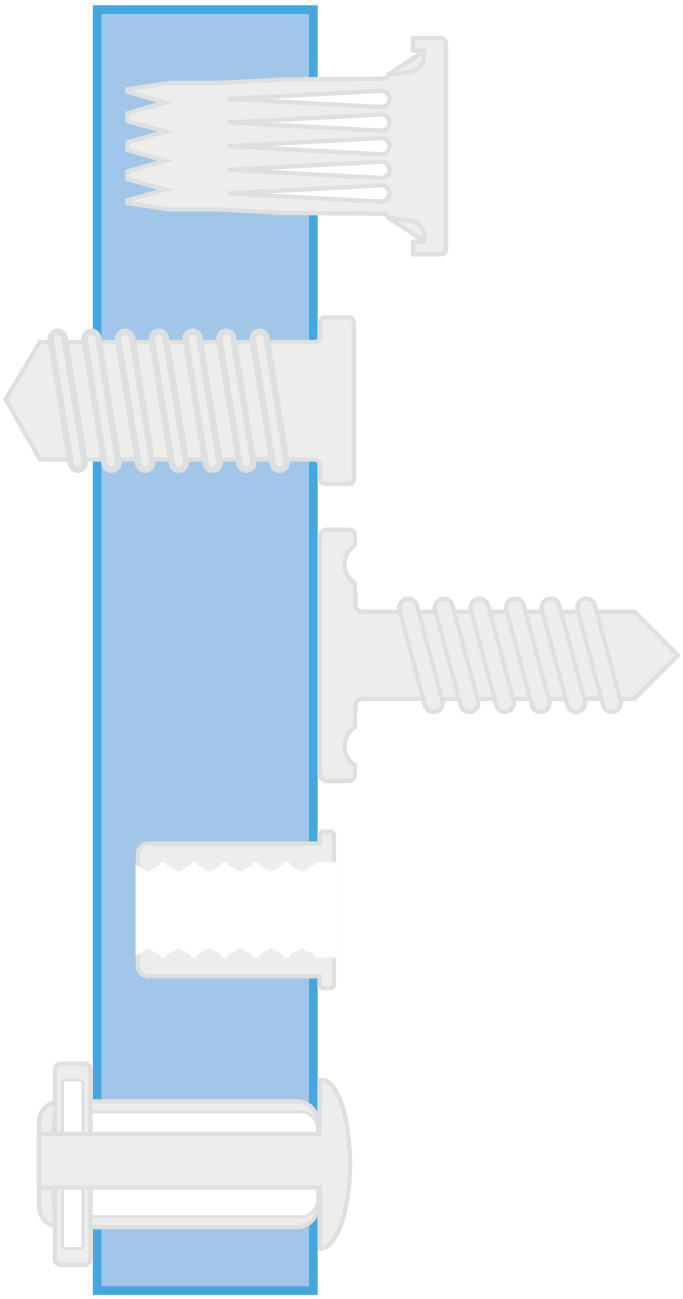
BOSSARD
Proven Productivity



Fastening Solutions for Composite and Plastic Materials

White Paper

Fastening Solutions for Composite and Plastic Materials

by composite and plastic research group

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Contents

FASTENING SOLUTIONS FOR COMPOSITE AND PLASTIC MATERIALS

Introduction

Lightweight design & multi-material construction are no longer trends or hype; they are common principles for Designers and Engineers worldwide today, with great significance in numerous industrial segments, across a huge and increasing range of applications.

It is not only about extensively using carbon-fibre composites; it is the smart combination and optimisation of materials and processes. The right material in the right place. Hence usage of material combinations and multi material joints increases and will continue to do so in the future.

In the lightweighting and multi-material world, processability, reliability, longevity, sustainability and total cost are equally important to weight reduction itself.

What are lightweight materials?

Lightweight materials are not a clearly defined family; the definition generally extends to materials and material combinations that help reduce the weight of a construction. Certain steel alloys, and other novel metallic materials also classify as lightweight materials but are beyond the scope of this document.

Fibre reinforced plastics are ubiquitously thought of as lightweight materials: with fibres taking the load and the polymer matrix holding everything together, it becomes a versatile, formidable combination. Yet plastics, or polymers on their own, can offer lightweighting potential, so are not disregarded herein.

Sandwich materials are another widespread example. Available in almost infinite variations of outer-layer and core configurations, and serving varying applications including automotive load-floors and commercial vehicle sidewalls, aerospace interiors, furniture, and building & construction.

Lightweight material concepts very often present anisotropic material properties. Variations of properties in different directions can heavily influence what the optimum fastening or assembly solution looks like.

The challenges of joining lightweight materials

Joining together lightweight materials and assembling multi-material components to build the macroscopic "end user product" is often beset by uncertainty and limited interdisciplinary expertise.

Increasingly sophisticated materials continue to emerge; manufacturing processes develop, and the range of different material properties expands. This runs parallel to increasing demand for multi-material assemblies and global diversification between OEM´s, Tier suppliers, sub-contractors and design offices.

In conclusion, it was never more important to utilise and design with smart and modern lightweight materials, but at the same time never more complex to do so.

Fasteners and technology systems that bring together individual high-tech parts as an optimised end-product play a significant role; but superior designs and effective configurations are only achievable, when fastening, joining and assembly are considered and understood in a holistic manner.

FASTENING SOLUTIONS FOR COMPOSITE AND PLASTIC MATERIALS

Introduction

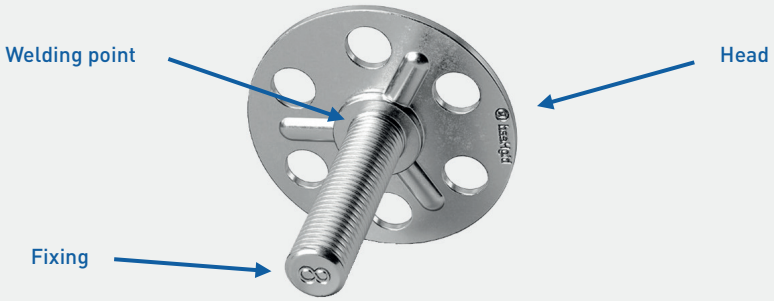
This document helps resolve these challenges: in one place, we introduce a range of different fastening technologies, explain how they offer fastening solutions, and detail the advantages of each.

Together, we create: successful composite and polymer fastening.

FASTENING SOLUTIONS FOR COMPOSITE AND PLASTIC MATERIALS

bigHead® fasteners

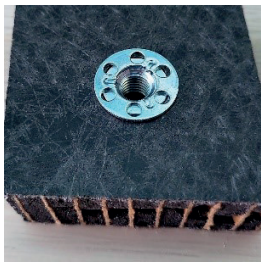
bigHead fasteners consist of two components – a big Head as the base plate component and a fixing component. bigHead weld the two components together on-site, near Bournemouth in South England, where "the original bonding fastener" was developed in 1966.



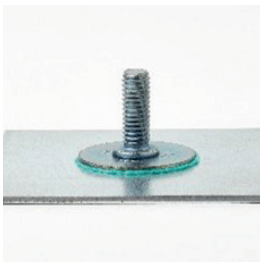
bigHead fasteners are suitable for use with a variety of materials, and there are different bigHead solutions available to suit different lightweight, multi-material fastening applications:

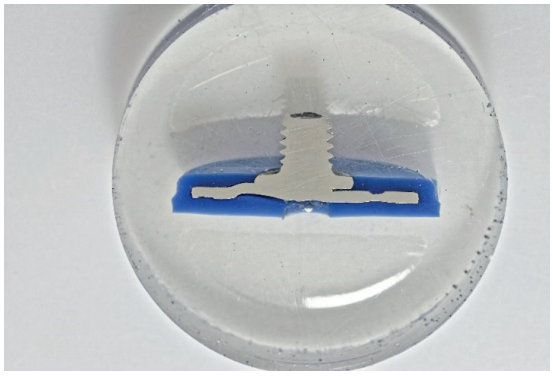
Polymer and fibre reinforced polymer components

Metallic and non metallic sandwich components

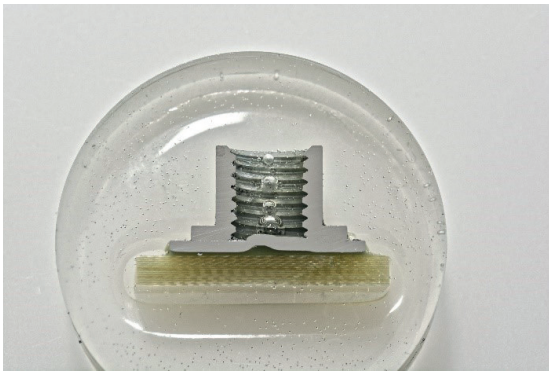


Thin-sheet metallic components





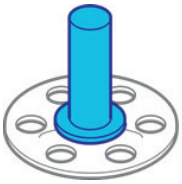
bigHead® Stud fixing – Co-processed

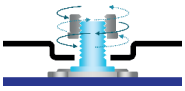
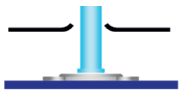
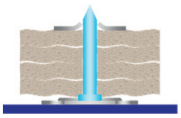


bigHead® Collar fixing – Adhesive bonded

Technology

bigHead fasteners provide a versatile solution for creating fixing points on components or materials. The fixing point provides a fastening function within an assembly, often in combination with a secondary fastening element. Common examples include:


Threaded fixings
for use with nuts or bolts for fastening components

Plain pins
for aligning components during assembly

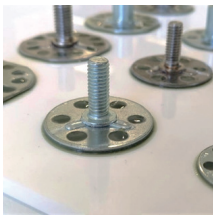
Nail fixings
for use with spring clips for securing soft materials

Tyrap fixings
for use with cable-ties for securing cable bundles

It is possible to install a bigHead after manufacturing the parent component, or the bigHead can integrate into the component manufacturing; we call this "post-process" or "co-process" installation, and there are many different solutions for achieving either.

- Adhesive bonding is one of the most common post-process installation techniques for bigHead products, although some solutions utilise mechanical fixation. Adhesive bonding is suitable for both metallic and non-metallic materials, also including sandwich materials.

- Embedment of the bigHead usually involves including the fastener within the parent component's manufacturing process. Hybrid solutions of pre-embedment and post-process attachment are also possible.

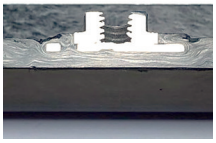


Post-process solution - Adhesive bonding

Post-process solution - Mechanical attachment

Hybrid solution - encapsulation & polymer welding

Co-process solution - embedment into fibre reinforced polymer laminate



Co-process solution - embedment within sheet-moulding compound (SMC)

Co-process solution - embedment within fibre reinforced polymer moulding

Solutions

bigHead has different product and product-system offerings, and they offer design and engineering support to help identify the ideal solution for lightweight materials and processes:

Core range
A pre-defined range of threaded fixing products, supported by comprehensive guidelines and technical information, for use in both post-process and co-process applications.

Extended range
Selected product ranges, in a wider variety of fixing type and size combinations.

Specialisation
Products designed and developed on an engineered to order basis, typically to a customer-specific design.

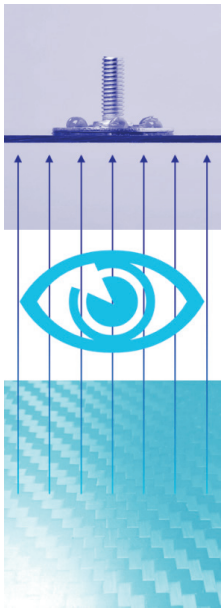
Process solutions
Product systems involving both the fastener product and the fastener installation technique; designed and developed to resolve specific manufacturing process or application challenges.

Design and Engineering partnerships
bigHead work in partnership, from early design to final implementation, to help create the optimum fastening and assembly solution for a given application.

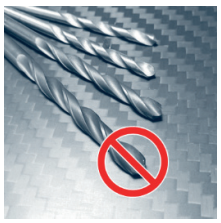
Benefits

What are the key reasons why bigHead could be the best match solution for your application?

Creation of **non-visible** fastening systems:

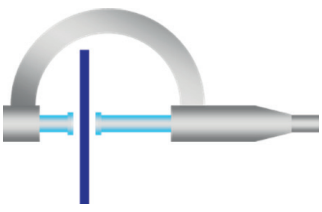


No through-holes
Post-process solutions typically eliminate hole drilling or machining of the parent component material.



Process efficiency:
Co-process installation solutions eliminate secondary processes and avoid one-by-one fastener installation

Solutions for **thin materials** (e.g. less than 3 mm):

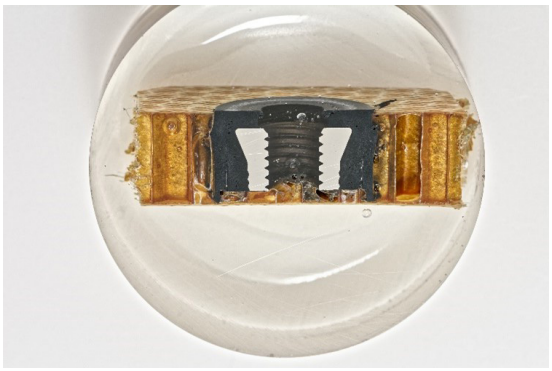


Suitable for creating fastening functions on **component materials that are not suitable for thread load bearing**, or cannot tolerate thread cutting or forming operations:

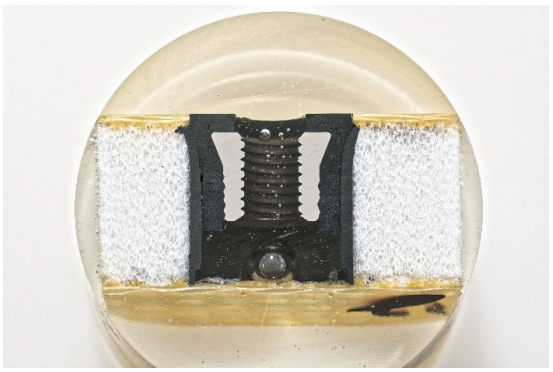
FASTENING SOLUTIONS FOR COMPOSITE AND PLASTIC MATERIALS

MultiMaterial-Welding®

In short MM-Welding® is a range of fastening technologies that use ultrasonic energy to partially melt thermoplastic materials, and create functional, strong, form-lock connections in fractions of a second. The available solutions are suitable for use with a variety of thermoplastic and porous materials, including sandwiches.



MM-W LiteWWeight® Double Pin



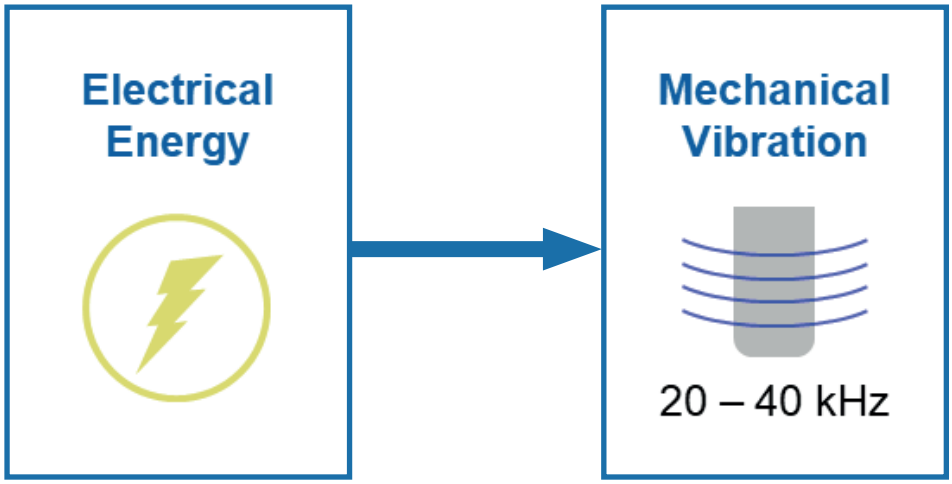
MM-W LiteWWeight® Double Pin

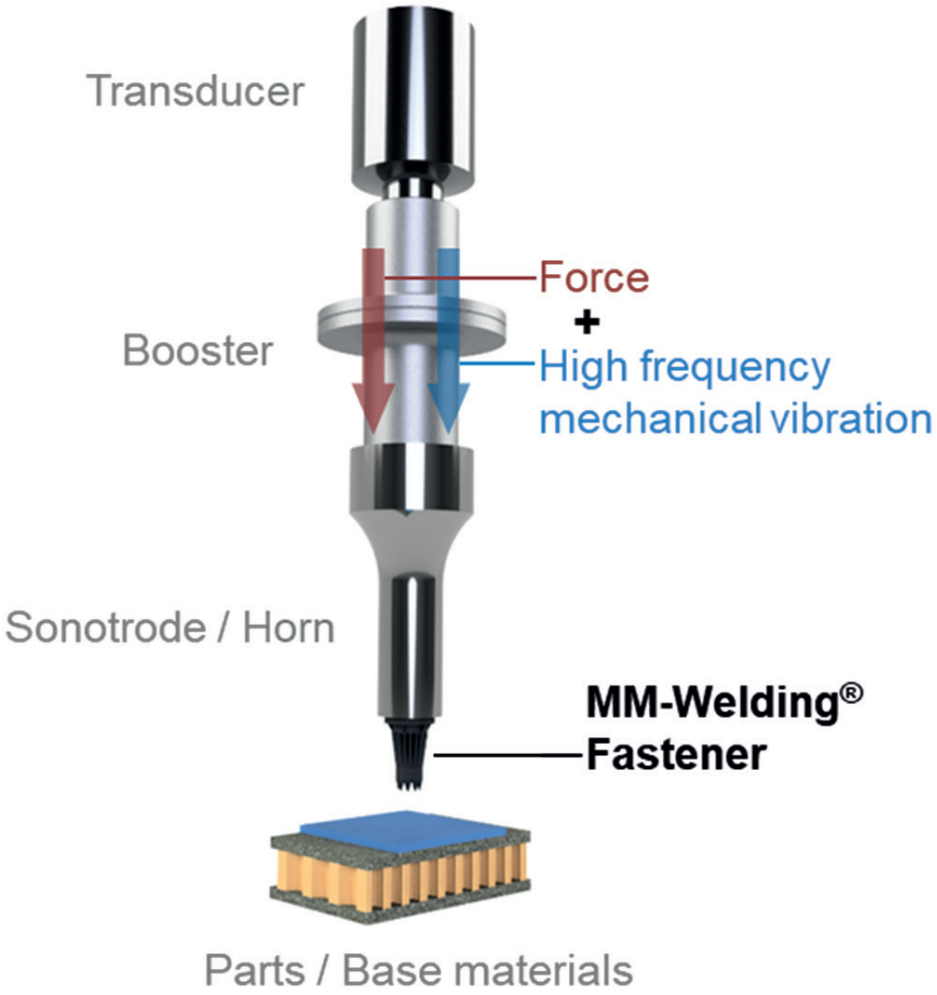
MM-W LiteWWeight® PIN

MM-W LiteWWeight® zEPP

Technology

In order to install MM-Welding® fasteners, it is necessary to use ultrasonic welding equipment, which transforms electrical energy into mechanical energy with a defined frequency, amplitude and direction of the vibration. This mechanical high frequency vibration is then transferred through the tip of the tool, via the ultrasonic stack, to the fasteners together with the necessary force to penetrate the substrate materials.

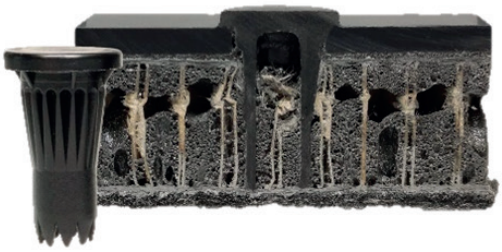

Electrical Energy
Mechanical Vibration
20 – 40 kHz


Transducer
Force
+
Booster
High frequency mechanical vibration
Sonotrode / Horn
MM-Welding®
Fastener
Parts / Base materials

Solutions

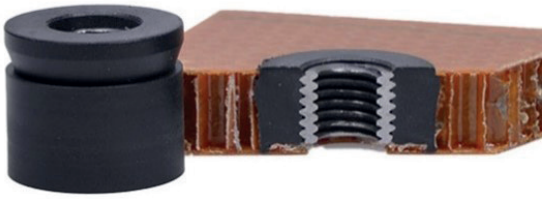
MM-Welding has two main types of fastener families, which are differentiated by the way the mechanical connection is created. Both types of fasteners are installed with standard ultrasonic welding equipment, and only the sonotrode is adapted to the fastener type.

LiteWWeight®
This product family consists of MM-Welding fasteners made of thermoplastic materials, with teeth-like features, that melt into the substrate materials to create the connection. There are several products within the LiteWWeight® fasteners family, and they vary in geometry depending on the type of substrate material.

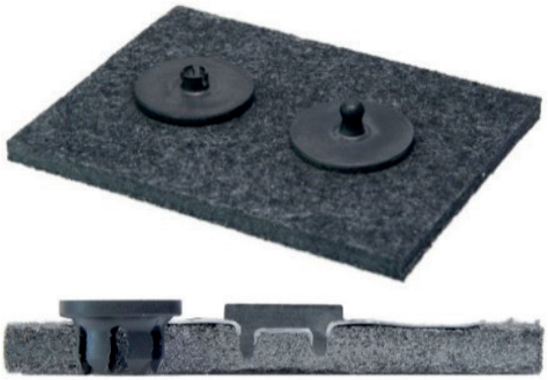


LiteWWeight® Pin
Sandwich materials or materials with dense, porous internal fillings or structures. Various geometries available depending on the type of substrate material.

LiteWWeight® zEPP
EPP and similar foams. Versatile solution for high strength fixation points in EPP and similar foams with different densities.



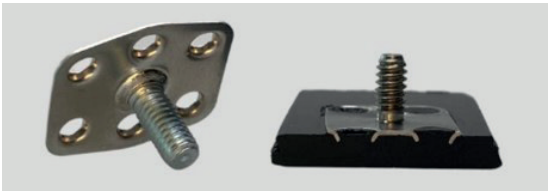
LiteWWeight® Double Pin
Sandwich materials or materials with dense, porous internal fillings or structures.



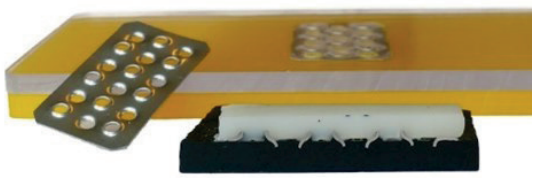
LiteWWeight® Lotus
Fibrous materials, including those with thin layers such as aluminium heatshield / cover foil.

InWWerse
This product family consists of MM-Welding fasteners made of metallic materials, featuring crater-like geometries for installation into thermoplastic materials. The connection is achieved by melting the material together with the fastener geometry. There are several products within the InWWerse fasteners family, which vary in geometry depending on the type of substrate material.

Depending on the type of material, and for thicknesses upwards of 1.5 mm, it is possible to create InWWerse connections without creating marks or witnesses. Within the InWWerse technology, there are also solutions for connecting thermoplastic materials with dissimilar properties.



InWWerse Fastener
Solution for connection to thin polymer parts



InWWerse Disc
Connection between non-compatible polymer parts

Functionally Integrated Parts

Within all product families, it is possible to integrate the MM-Welding connection geometry into the functional parts of interest. This is called Functionally Integrated Part (FIP).

The advantages of Functionally Integrated Parts are the following:

- Costs can be reduced by purchasing only the one part that will be connected, instead of the part plus the fasteners.
- Production effort in the handling and installation of each fastener is reduced
- Quality failure risks are also reduced.
- Parts can be designed to have specific aesthetics, so the visual aspect of the parts is also personalized and therefore improved.

Benefits

MM-Welding® can offer many different advantages, depending on the specific application. In general the following advantages apply:

Very fast

- Welding process time < 1 s.
- Ideal replacement for long-time curing adhesives or other complicated connection processes.

Strong

- High pullout forces are achieved.

Simple

- Very simple installation process.
- No pre-drilling required in most cases.

Clean

- No additional materials / surface pre-treatment required.
- No waste is produced through the process.

Flexible

- Not limited to rotationally symmetric parts.
- High flexibility in geometries and materials of connectors and base parts.
- Production systems can be used for multiple fasteners and also for metal-metal or plastic-plastic welding.

Smart monitoring

- Qauality control for each weld: monitoring, statistical check and remote assistance.

Integrated

- Fasteners and parts can be integrated into 1 part to connect.
- Reduction of parts and therefore weight and costs.

Proven Productivity

- Technology successfully implemented in medicine industry and furniture industry.
- First automotive serial production projects.

FASTENING SOLUTIONS FOR COMPOSITE AND PLASTIC MATERIALS

Threaded Inserts

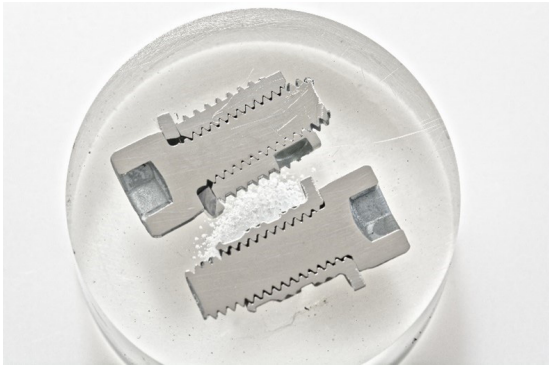
Threaded inserts create precise, durable internal threads in plastics, light metal alloys and other notch-sensitive materials.

Technology

Specifically, threaded inserts are used if a reversible fastening connection is required. Compared to self-tapping screws, threaded inserts withstand higher axial and radial loads in same dimensions in cause of an increased shear area. This allows engineers to use thinner and smaller material sections and designs.

Threaded Insert for mould-in

Self-cutting Threaded Insert



Top: Self-cutting threaded insert
Bottom: Threaded Insert for press-in

Solutions

For creating internal threads in plastic materials, there are four types of threaded inserts:

- Self-cutting
- Press-in
- Press-in with expansion anchoring
- Mould-in

Self-cutting, press-in and press-in with expansion anchoring threaded inserts are installed **after the moulding process** of the material whereas mould-in threaded inserts are installed in the material **during the moulding process** of the material.

After-moulding threaded inserts

After-moulding threaded inserts require a location hole within the parent material. The dimension of the location hole depends on different factors, including the parent material properties and the installation process employed.

Self cutting

Suitable for thermoplastic (glass-filled or unfilled) and thermoset materials

The principle of the self-cutting inserts is quite easy to explain: As the insert is screwed into a location or pilot hole prepared within the parent material, the external thread cuts a thread into and engages with the parent material.

Press-in

Suitable for thermoplastic materials (glass-filled or unfilled)

The different knurling styles and designs are related to different installation methods like press-fit or heat-installation in prepared location holes. The choice of the installation method is dependent on the plastic material type (heat-installation for glass filled thermoplastics / press-fit installation to unfilled thermoplastics) and the application performance requirements.

Press-in with expansion anchoring

Suitable for thermoplastic (glass-filled or unfilled) materials and may be suitable for some thermoset materials.

These insert types function as dowels for plastic materials and are installed into a pre-prepared hole. Different styles and forms allow the usage in different plastic material types and different loading directions.

Mould-in threaded inserts

Conversely to the previously described inserts for plastic materials, which require a location hole and post-moulding installation, threaded inserts for **mould-in** directly integrate into the moulding process:

Mould-in

Suitable for thermoplastic (glass-filled or unfilled) and thermoset materials

Mould-in threaded inserts are suitable for both thermoplastic materials (glass- and unfilled) and thermoset materials. The inserts locate onto a pin in the moulding tool and become interlocked within the plastic material during moulding.

So summarise, the following overview will help you to find the ideal threaded insert solution for your application:

Installation process	Self-cutting	Press-in*)	Press-in with expansion anchoring	Mould-in
Location hole	X	x	X	0
Thermoplastic	X	x	X	X
Thermoset	X	0/X	X	X
Foamed comp.	X	0/X	0/X	0/X
Elastomer	X	0	0/X	0/X

X = ideal / required

0 = not ideal / not required

0/X = critical

***) cold press fit installation / heat installation (ultrasonic / thermal / induction)**

Benefits

A known problem with threaded joints in plastic materials is the propensity for creep and stress relaxation. Fastening with threaded inserts provides a reliable and creep resistant connection over the total length of the insert. Typically, the inserts will have twice the diameter of the connecting screw, in order to maximise the engagement/ shear area and increase the maximum axial and radial force resistance.

FASTENING SOLUTIONS FOR COMPOSITE AND PLASTIC MATERIALS

Rivet Technology

Rivet technology is well known in the world of metals. But did you know that rivet technology can also be of interest in the world of plastic and composite materials?

In fact, some blind rivets or blind rivet nuts can be used in composites and plastics too.

Blind rivet nut technology

Blind rivet nuts utilise **permanent** form-fit connections to create load-bearing threads within **thin or thick metal plates/profiles, composites, plastics or even honeycomb materials.** They are used where thread forming is not possible, either because the material is too thick, weak or brittle or because it is too hard for thread forming applications. To fasten with a blind rivet nut, you only need **access** from **one side** of the assembly, which is a huge benefit.

POP® Wellnut®

POP® Jack-Nut®

Ecosyn® BCT

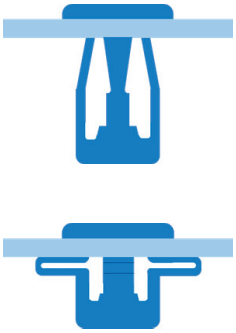
Solutions

With blind rivet nuts you have three different solutions which are designed to fasten or to be fastened into composite and plastic applications.

Bulge Control blind rivet nuts use state of the art technology to engineer the collapse of the rivet nut and the formation of the rivet bulge

Ideal for soft or brittle materials where often the failure mode of the joint is the material itself

Load spreading blind rivet nuts create load bearing threads in thin-walled materials and materials with limited out-of-plane loading capability



Suitable for use in plasterboard, plastic, hardboard, plywood, pressboard, etc.

Rubber blind rivet nuts can absorb vibrations and noise, have excellent electrical insulation properties and ensure against liquid or gas ingress

particularly suitable for low-pressure environments

Benefits

With blind rivet nuts you have three different solutions which are designed to fasten or to be fastened into composite and plastic applications.

Bulge control

- No danger of base material damage
- No stress peaks in the area around the edge of the hole
- No thread misalignment and therefore no stress on the joined components
- No danger of a vertical misalignment of the thread and therefore no stress between the components fastened
- Reliable, resilient threads

Load spreading

- Will not distort or deform soft plastics or thin sheet metals
- Fast, inexpensive, and easy to use
- Not hole-size sensitive
- Fastens securely despite burrs or uneven substrate
- Suitable for a wide grip range
- Removable

Rubber

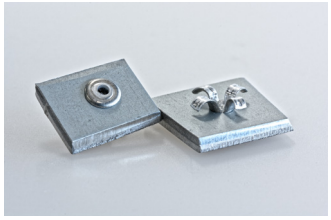
- Blind installation possible (e.g. within profiles, tubes)
- Also suitable for blind holes
- Absorbs shocks, vibrations
- Dielectric (non-conductive)

Blind rivet technology

Blind rivets create permanent, form-fit connections between two elements. With blind riveting, the joining process can be carried out from only one (usually the outer) side of the component (one-sided accessibility).

Solutions

Peel blind rivets



The peeling process allows minimum force to be applied during the setting process, thereby protecting the work piece material

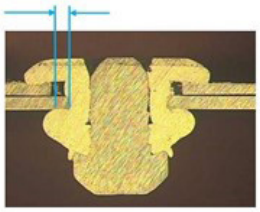
Ideal for joining softer and more brittle materials such as plastics, rubber, wood, GFRP or laminates

Load spreading blind rivets

Features a secondary head that forms large "folds" which provide a larger bearing surface that resist the pull-through or cracking that can occur with a standard rivet

Specifically designed for plastics and other brittle or soft materials

Blind rivets with controlled bearing stress



With standard blind rivets, the rivet sleeve can expand radially to maximize the clamp length range. To limit the radial expansion, blind rivets with controlled bearing stress have additional embossing on the body. The workpieces are pulled together whilst forces against the sides of the holes in the joined components are reduced.

Reduces the bearing/ lateral forces created in holes within the joined materials.

Benefits

Peel blind rivets

- Load spreading for porous, brittle and honeycomb materials
- Exceptional pull-up properties
- Blind hole, one-sided installation capability

Load spreading blind rivets

- Clamping loads spread over wide area, avoiding damage to vulnerable materials
- Accommodates oversized holes
- Corrosion-resistant
- Limited number of lengths needed because of wide grip range
- Blind hole, one-sided installation capability

Blind rivets with controlled bearing stress

- Bearing/ lateral forces within soft and fragile components are minimised
- Soft and fragile materials can be securely joined
- Noise generation during the rivet setting process is reduced

FASTENING SOLUTIONS FOR COMPOSITE AND PLASTIC MATERIALS

Bolting and screw-fastening

Bolting and screw-fastening are relatively well-known reversible techniques, typically used for fixing materials or components in position, or for fastening components onto other components or structures.

Often simplistically referred to as either "nuts and bolts" or "screws", there are in fact a wide variety of different product types for achieving different fastening techniques. Some products work in combination to create assembly fastening systems, others work on their own to directly fasten materials/ components.

Direct screwing in a Polymer

Technology

Through-bolting

With through-bolting, the bolt/ screw passes through both fastened materials and combines with a nut or suitable device to retain and/ or clamp the assembly.

In bolted joints, the fastening system usually creates axial pre-load or clamping forces to restrict the planar movement of the fastened components by increasing the friction between them.
In certain specialist joints, the bolt or screw restricts planar movement of the fastened components principally through bearing, or lateral forces.

Installation typically requires access to both sides of the fastened joint, although specialist designs/ solutions may facilitate fastening/ final tightening from a single side.

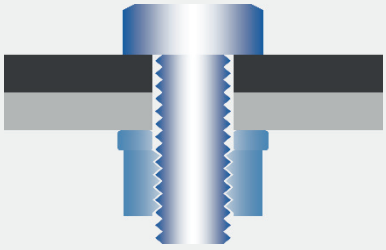


Figure 1 - Through-bolted joint comprising threaded bolt, nut & washer

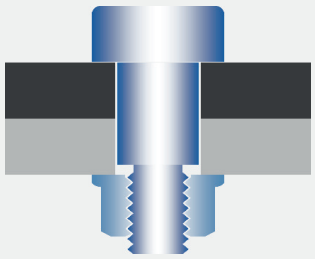


Figure 2 - Through-bolted joint comprising shoulder-bolt and locking nut

Direct assembly screwing

With direct assembly screwing, the fastener passes through one component and directly engages with the material of the second component.

Depending on the material suitability, self-tapping and self-drilling technologies can eliminate the requirement for separate hole drilling and thread-forming operations.

Unlike through-bolting, many direct assembly screwing concepts require only a single fastening element instead of a system of two or more fastening items, and the fastening operation usually only requires access from a single side.

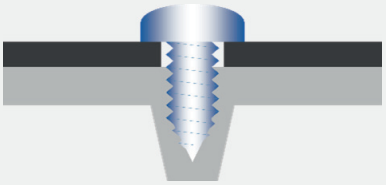


Figure 3 - self-tapping screw fastened assembly

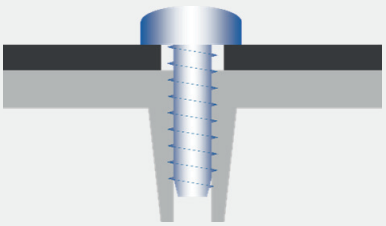


Figure 4 - Thermoplastic screw fastened assembly

Materials suitability considerations

Through-bolting

- Viability of hole drilling/ machining with chosen materials/ manufacturing processes.
- High pre-load forces: may not be suitable for materials that are sensitive to out-of-plane compressive loading.
- Bearing/ shear-out response of materials if considering pin-loading of bolt.

Direct assembly screwing

- Viability of pre-hole/ through-hole preparation with chosen materials or within manufacturing operations.
- Sensitivity of material(s) to thread forming/ cutting operations (notch sensitivity).
- Ability of material(s) to support thread loading during assembly tightening/ final usage.

Both types

- Creep relaxation of polymer materials, and reduction in pre-load
- Potential galvanic corrosion/ electrical issues with conductive or semi-conductive fibres/ pigments

Solutions

Bolts, screws and associated offerings

Standard parts

Bossard offer a variety of catalogue parts for creating through bolted fastening systems, including:

Socket, hex and flange type bolts/ screws:

Shoulder or semi-finished bolts/ screws:

Washers, spring washers, lock washers and retention devices

Nuts, locking nuts and other types of nuts

Specialist materials

For applications where standard steel construction may be unsuitable, for example due to corrosion, electrical continuity, magnetic, or x-ray considerations, Bossard also offer certain products in the following materials:

Aluminium

Brass

Plastic

Stainless steel

Product selections and ecosyn® ranges

Bossard offers a range of multifunctional product selections that enhance performance and productivity. The product selections are unique to Bossard, and bring together products that provide solutions for:

- Creating vibration resistant/ anti-loosening fastening without using additional fastener items/ elements.
- Simplifying the assembly/ fastening operation and improving assembly efficiency and reliability.

Bossard ecosyn® offerings provide economical fastening multifunctionality within a single product type: reducing the need for separate items, increasing assembly simplicity, and improving productivity. The offerings include:

ecosyn®-fix
These screw products provide shake and vibration proof fastening, whilst eliminating the requirement for secondary washers - they are especially suited to electrical appliances and technical equipment.

ecosyn®-grip
A range of internal drive screw products that minimise visual impact, safeguard against loosening without using additional fastener elements, and offer improved load-bearing capacity over other low-head screws.

ecosyn®-lubric
A coating offering for bolts/ screws that offers integral lubrication, consistent friction coefficient, and additional anti-corrosion performance. These dry-to-touch coatings simplify assembly operations and in-service maintenance requirements, whilst eliminating the need for separate lubricants and lubrication regimes.

Direct assembly screwing offerings

Self-tapping screws
Self-tapping screws have different shapes: pointed (like a pencil), blunt, or flat, and come in three types: thread-forming, thread-cutting, or thread rolling. For many polymeric materials, self-tapping screws avoid the requirement for pilot hole drilling prior to screwing into the engagement material. Suitability and selection depend significantly on the characteristics of the fastened materials.

Self-drilling screws
Unlike self-tapping screws, self-drilling screws do not require a pilot hole to cut and fasten metallic materials; they can drill, tap, and fasten in one go, which eliminates the extra step of drilling prior to fastening. Although primarily a "metallic" fastening product, they may provide an alternative when pilot hole preparation is undesirable/ impractical, and the materials do not tolerate use of self-tapping products without a pilot or pre-hole.

Screws for thermoplastics
Bossard offer a range of screw products specifically designed for use with thermoplastic materials, which includes the **ecosyn®-plast** range. These products feature specialist thread forms and geometric features to optimise productivity, performance and durability when used to fasten thermoplastic materials/ components.

Benefits

Through-bolting

- Failsafe fastening concepts, especially when combined with anti-loosening offerings.
- Wide range of products makes it possible to easily create systems to suit specific application needs.
- Many products available in different materials to suit specific technical requirements.

Direct assembly screwing

- Requires minimal preparation, and many solutions eliminate hole/ thread preparation operations.
- Minimal part count/ additional weight; fastening often achievable with a single fastener item.
- Simplistic fastening operation requiring minimal equipment.

FASTENING SOLUTIONS FOR COMPOSITE AND PLASTIC MATERIALS

Summary

We present here several technologies that support today's need for effective composites and plastics utilisation. Whether the application is high-strength and thin-walled fibre reinforced composites or high duty-cycle honeycomb panels, each involves specific considerations when determining the best possible fastening solution. Are cycle time optimization or cost reduction in the foreground or are there requirements for tightness, strength and processability? Each requirement has its own solution.

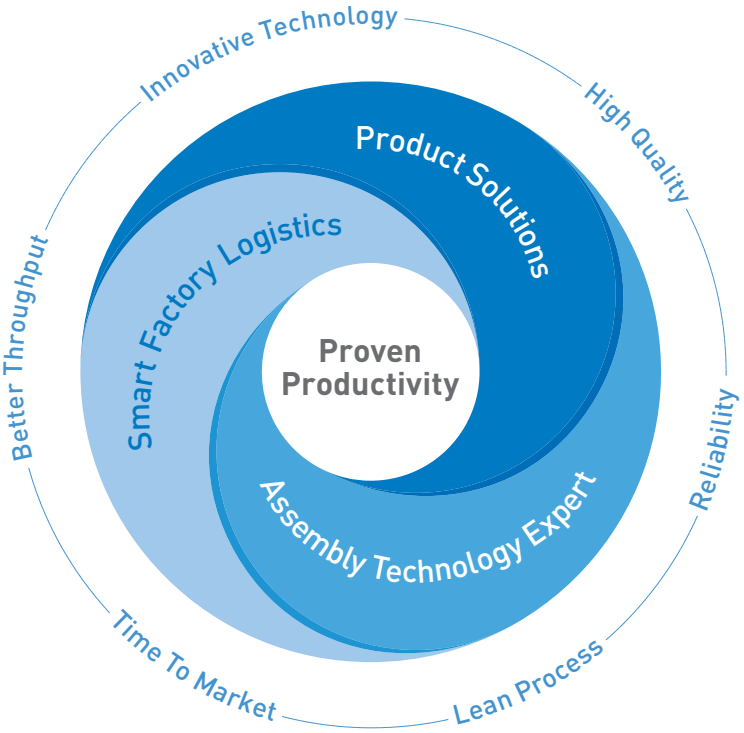
Using ideal, optimised fastening/joining technologies and solutions supports market leadership and competitive advantages through cost optimisation, functionalisation, design optimisation, and lastly, but not least, weight reduction.

However, as lightweight materials continue to develop, so too do fastening technologies and solutions. Keeping abreast of these developments requires professional attention and support.

With ATE (Assembly Technology Expert) the engineers from Bossard can help provide the necessary expertise and insight: either right at the beginning of the design process, or during an ongoing production series. Their know-how can support from product design activities through to process optimization.

PROVEN PRODUCTIVITY – A PROMISE TO OUR CUSTOMERS

The strategy for success



From years of cooperation with our customers we know what achieves proven and sustainable impact. We have identified what it takes to strengthen the competitiveness of our customers. Therefore we support our customers in three strategic core areas.

Firstly, when finding optimal **Product Solutions**, that is in the evaluation and use of the best fastening part for the particular function intended in our customers' products.

Second, our **Assembly Technology Expert** services deliver the smartest solutions for all possible fastening challenges. Our services cover from the moment our customers developing a new product, to assembly process optimization as well as fastening technology education for our customers' employees.

And thirdly, optimising our clients' productions in a smart and lean way with **Smart Factory Logistics**, our methodology, with intelligent logistics systems and tailor-made solutions.

Understood as a promise to our customers, "Proven Productivity" contains two elements: Firstly, that it demonstrably works. And secondly, that it sustainably and measurably improves the productivity and competitiveness of our customers.

And this for us is a philosophy which motivates us every day to always be one step ahead.

If you need further assistance or have special requirements, please check out our contact page at **www.bossard.com** and talk to your nearest Bossard customer service representative.