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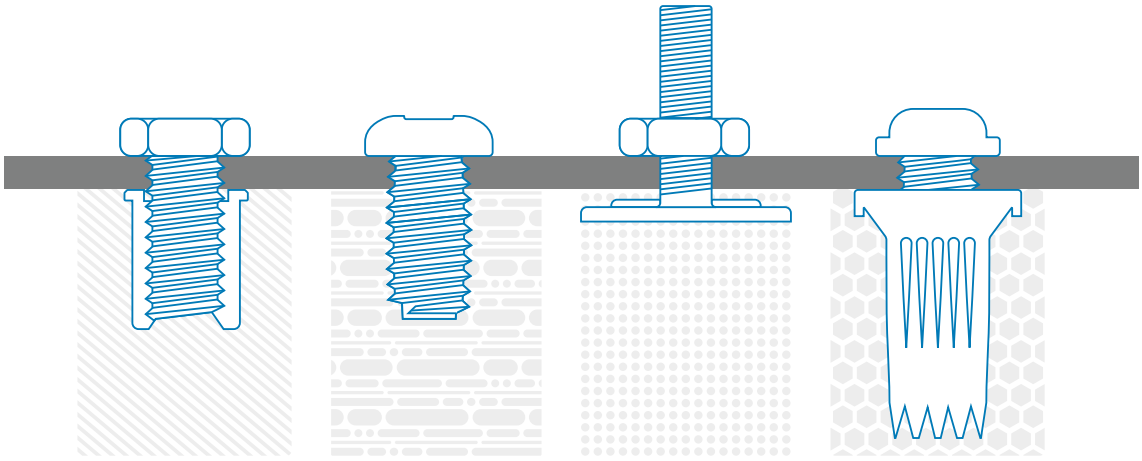

Challenges and solutions for fastening composites

White Paper

Challenges and solutions for fastening composites

by composite team

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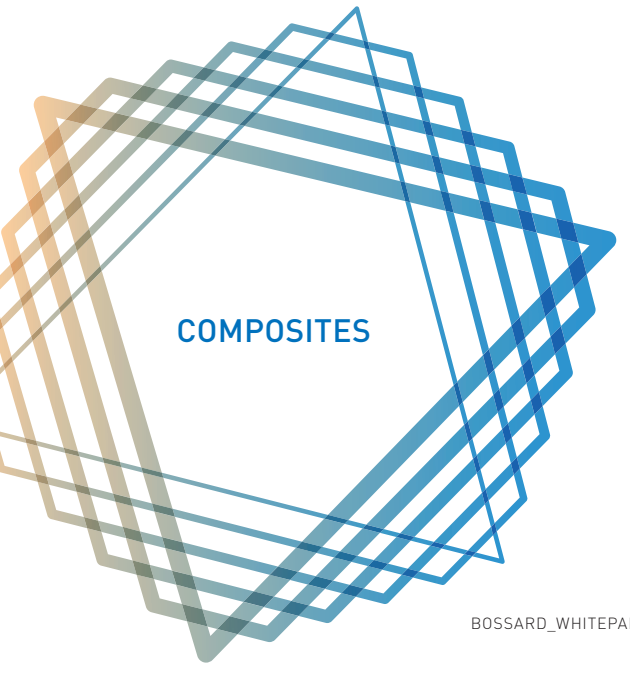
The recommendations and advices mentioned must be adequately checked by the reader in practical use and be approved as suitable for its application. Changes reserved.



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Introduction

Lightweight and composite materials are vital for efficient and cost-effective manufacturing but combining them into multi-material components with state-of-the-art fastening technology can simply be complex. This white paper presents different approaches to solve key challenges faced by designers, manufacturers, and assemblers.

CHALLENGES AND SOLUTIONS FOR FASTENING COMPOSITES

Introduction

It was never more important to utilize and design with smart and modern composites materials, but at the same time never more complex to do so. The combination and optimization of materials and processes are key for weight reduction, processability, reliability, longevity, sustainability, and total cost.

Joining together lightweight materials and assembling multi-material components to build the macroscopic "end user product" is often fragmented, beset by uncertainty and limited interdisciplinary expertise. Fasteners and technology systems play a significant role in bringing high-tech parts together, but superior designs and effective configurations are only achievable when fastening design, production and assembly are considered holistically:

Design

Designers face the challenge of finding the right combination of materials that meet the requirement of strength, durability, and cost-effectiveness while considering the limitations of the manufacturing and assembly process.

Manufacturing

The challenge for manufacturers is to produce high-quality products that meet necessary standards, while also ensuring that the production process is sustainable and cost-effective. To achieve this, manufacturers must optimize throughput by carefully balancing factors such as production speed, efficiency, and quality control.

Assembly

Assemblers face the challenge of bringing together different materials and ensuring that the components are joined correctly and securely. This requires a good understanding of the materials' properties and the appropriate fastening technology to use for each combination of materials. The assembler must also ensure that the final product meets the necessary safety and quality standards.

The Bossard Group is a leading strategic partner for industrial fastening and assembly technology solutions to OEM customers globally with proven expertise in engineering and logistic services.

This document provides a collection of key challenges faced by the key stakeholders mentioned and offers potential solutions following specific fastening technologies and services.

Together, we create successful composite and polymer fastening.

What are lightweight materials?

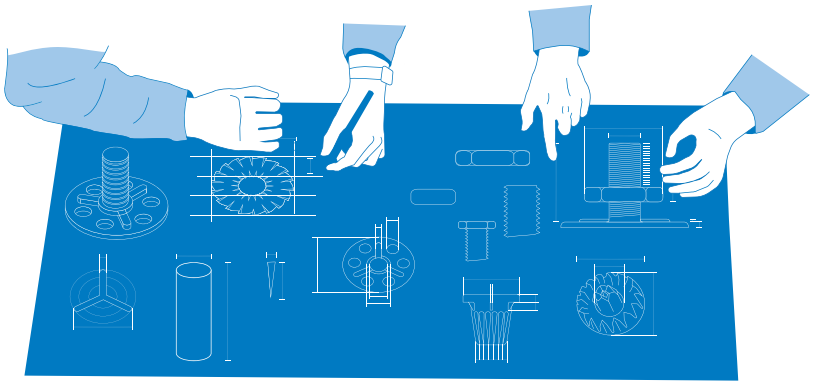
Lightweight materials are not a clearly defined family; the definition generally extends to materials and material combinations that help reduce the weight of a construction. Certain steel alloys, and other novel metallic materials also classify as lightweight materials but are beyond the scope of this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

CHALLENGES AND SOLUTIONS FOR FASTENING COMPOSITES

Design

Challenge 1: Exploring and understanding fastening types

As a Design Engineer your focus is on finding the right solution as fast as possible. However, the language barrier of fastening can be overwhelming for those who are not familiar with the various fastening options available. This is where Bossard comes in to help you explore and understand your best options.

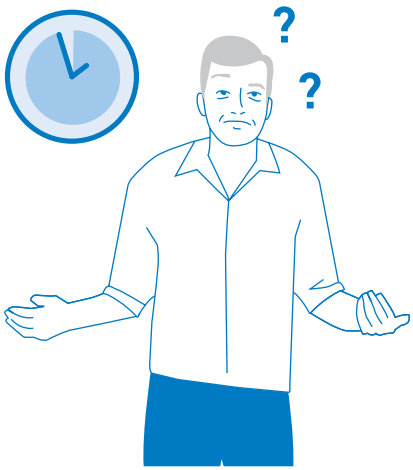


Use Case

Suppose you have a specific goal in mind, such as assembling a component onto a sandwich panel using a machine screw, but you are unsure of which fastening type to use. In that case, Bossard can assist you in finding the appropriate fastening option to achieve your desired outcome.

Without Bossard

After hours of searching, you have found several possibilities, but you are not sure which one fits best your needs. Further investigations needed.



? Solution

With Bossard

After talking with an expert, you learn that you can either use a threaded bushing, or there are specialist solutions from MM-Welding® that have proven performance and productivity benefits.

✓ Solution

Challenge 2: Defining the best option for your application

When it comes to selecting the best fastening option for your application, it is essential to have access to people who understand fastening applications by fastening function, material concepts, manufacturing processes, and end-use market sectors.

Use Case

Suppose you have a specific application in mind, such as fastening components onto a composite wind turbine structure in a way that is serviceable but not visible.

Without Bossard

While researching composite fasteners, you find many aerospace fastener catalogues and learn mostly about the benefits of using quarter-turn fasteners for lightweight composite panels.

- × Blind fastening
- ✓ Composite material
- × Aerospace application
- × Best option defined

With Bossard: comprehensive approach

By sharing your fastening and assembly designs with us and providing information about the materials involved, we can guide you towards applicable options and relevant design guidance. This includes considering the material type, material architecture, and forming/curing process to ensure the fastening solution is the best fit for your application.

- ✓ Blind installation, serviceable fastening functionality, ignore through-material & permanent fixation fastening options
- ✓ Thermoset polymer matrix, ignore solutions specific to thermoplastic
- ✓ 800 GSM biaxial E-glass fabric, ignore solutions that involve incorporation/retention of small fasteners into the preform
- ✓ Vacuum infusion, room temperature curing - consider the labour time/process complexity required to co-process embedding fasteners vs. post-process installation of surface bonding fasteners
- ✓ Best option defined

Challenge 3: Certitude that it will work

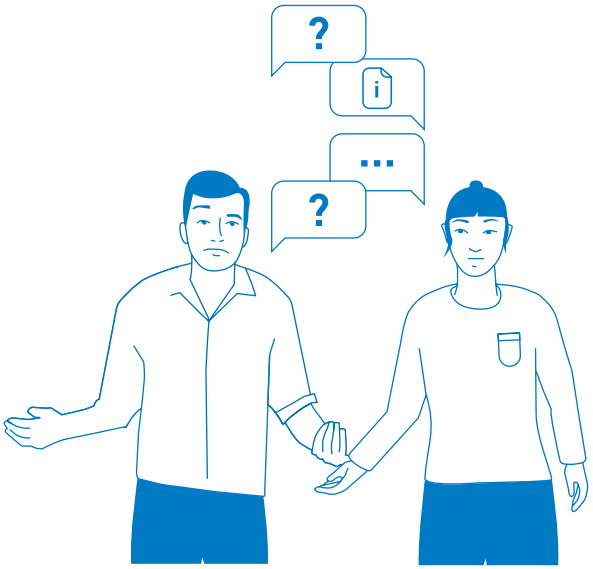
To bring your design to live, it must function effectively in practical settings. It is crucial to have a knowledgeable partner who distinguishes between testing products and application testing and can determine which application tests are relevant to your specific application, as well as which factors might impact performance.

Use Case

Suppose you need to validate the mechanical performance of your fastening design, but you're not sure if the available mechanical performance data is comparable to your design, and you don't know how these fasteners are tested.

Without Bossard

Technical inquiry responses often default to data sheets; but they sometimes omit your specific material or only cite product specification data instead of design relevant application data.



- ✓ Generic material & property class information
- × Composite/plastic relevant design data
- × Composite/plastic relevant design guidance

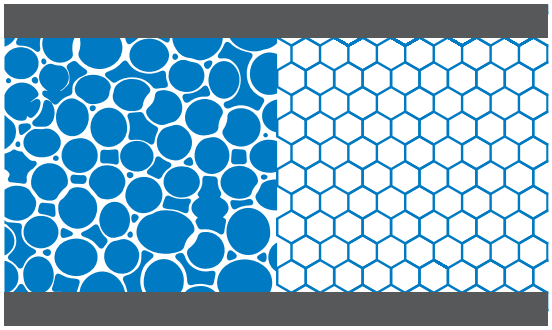
With Bossard: Support for R&D, application engineering and composite specific testing

We discuss your application performance requirements, share relevant applications testing data where available, and help you define a valid test program if required.

- ✓ Minimum material thickness, installation hole size guidance
- ✓ Product performance data, e.g., applicable ISO 898 mechanical strength tests
- ✓ Composite/plastic design data, e.g., ASTM D7332 fastener pull through strength/equivalent comparisons for different materials

Exploration A: Material suitability considerations – what is being fastened?

Fastening with sandwich materials

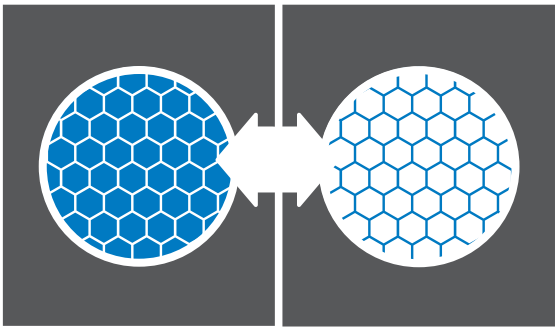


If you are using sandwich materials and need to attach or create fastening points within them, traditional fasteners like screws, threaded inserts, and nuts and bolts may have limitations. Depending on your fastening needs, there are solutions available.

When working with sandwich constructions that have core and/or skin materials, creating and retaining threaded connections can be difficult. Conventional assembly screws and threaded inserts may not perform well if installed directly into these materials. Instead, consider technologies that create connection points to facilitate the installation of conventional fasteners while ensuring optimum performance.

Thin skin materials in sandwich constructions with limited flexural strength or flatwise tensile strength can be damaged or disbonded with high localized loading. For attaching or connecting to such materials, you can use e.g. bigHead® load-spreading surface bonding fasteners or specialist solutions from MM-Welding® that interlock with the core material. If the assembly requires a through-bolted connection, a compression limiter or suitable bushing within the sandwich can prevent core crush during assembly tightening.

Fastening of dissimilar thermoplastic materials



Fastening is a suitable method for joining dissimilar materials, including when both materials are thermoplastic. With proper assembly design, issues related to preload sensitivity and creep relaxation can be addressed. Although welding and adhesive bonding can also be effective in certain cases, there are still reasons to consider fastening.

Traditionally, fastening is only considered when serviceability or disassembly requirements necessitate a non-permanent connection. However, the associated manufacturing process complexity of alternative joining techniques should also be taken into account.

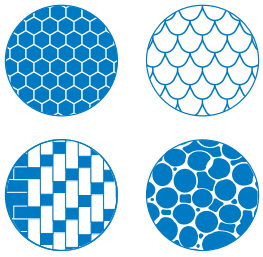
- Rivet fastening and thermoplastic screws offer instant fixation and assured mechanical interlock, with smart fastener installation tools validating the installation. The mechanical performance of the assembly is less reliant on complex process variability. In contrast, other joining techniques may require a more complex process for performance assurance. Additionally, the capital investment for fastener installation tools is typically lower than specialized welding or adhesive bonding techniques for thermoplastics.
- In cases where equipment investment is less of a concern, welding or adhesive bonding may be considered. However, these methods can be sensitive to any variability in the substrate materials, such as moisture content or surface energy.
- With e.g. MM-Welding's® InWWerse® disc technology, it is possible to instantly create invisible, mechanically interlocked connections between dissimilar thermoplastic materials without requiring exacting pre-conditioning of the materials or pernickety surface preparation methods. This technology offers a reliable and efficient alternative to traditional welding or adhesive bonding techniques.

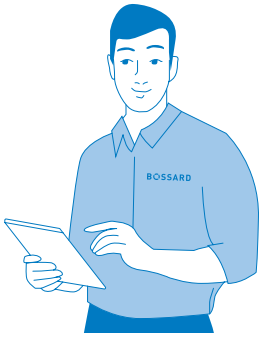
CHALLENGES AND SOLUTIONS FOR FASTENING COMPOSITES

Manufacturing

Challenge 1: Working with novel or unprecedented material concepts

Working with composite materials can be challenging, especially when it comes to integrating fasteners into the manufacturing process. You need to understand your application requirements and figure out, which process leads to the desired result.





Use Case

Suppose you're following the designer's choice for a new application. Now you need to develop a new way to make sandwich materials using a combination of liquid resin, natural fibers, paper honeycomb, and compression molding and wondering how to integrate fasteners into this process.

Without Bossard

You may have to use in-house R&D and production resources to develop the fastener design, demonstrate the processing techniques, and then try to find a full-scale manufacturer for a one-off, very specialist fastener product. This process can be time-consuming, expensive, and may not yield the desired result.

- ✓ Trial & error
- ✓ Time-consuming
- × Saving resources

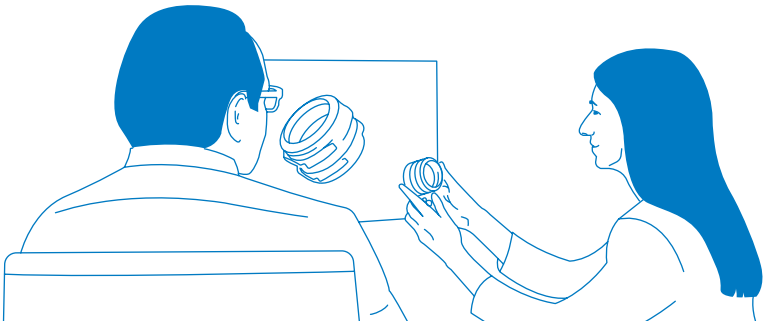
With Bossard

We can explore whether post-process solutions e.g. from MM-Welding® could achieve the desired result, or we can use our capabilities and expertise to explore and demonstrate co-processible options without tying up valuable in-house R&D and production resources.

- ✓ Expertise in co-processing and post-processing
- ✓ Meet design, productivity goals and quality standards
- ✓ Saving resources

Challenge 2: Getting the manufacturing right first time

In the highly competitive manufacturing industry, getting it right the first time can make the difference between success and failure. This is why manufacturers need to pay attention to every detail in their production process, from design to delivery. One critical aspect of achieving this is knowing what to check, when, and who to ask.

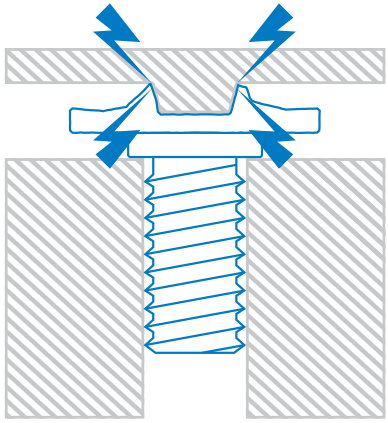


Use Case

Suppose you are planning to co-process an embedding fastener within an injection moulding, you are designing the tooling to +/- 0.1 mm Z-direction tolerances and we need the embedding fasteners to have the same tolerance. In situations like this, you can attempt to specify a tighter tolerance on the fastener manufacturing. However, it's crucial to take the time to ask questions about the tooling configuration, how the fastener is retained inside, and the tooling design's sensitivity to fastener geometry tolerances. The consequences of overlooking these critical details can be costly.

Without Bossard

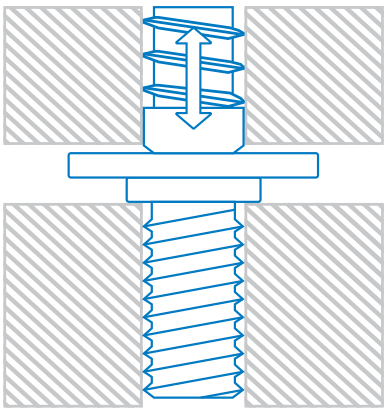
The tooling is designed with a fixed retainer pin, to be created during machining of the main tool surface – during production the fasteners that are on the upper dimensional tolerance limit may repeatedly clash into the retention pin during moulding, causing damage that results in 2 days lost production time and €10,000 of repair work.



✓ Moderate to high risk of damage and maintenance tasks

With Bossard

Together with you, we review the CAD of the component tooling, highlight and discuss the sensitivity of a fixed-pin design to fastener geometry tolerance, and review the financial implications of tool damage. As a result, we suggest to spend an extra €5,000 to equip the tool with a floating pin device, reducing the chances of stopping production and implementing repairs. Additionally, the floating pin could be removed and replaced if needed, minimizing disruption to the production process.



✓ Minimal risk of process interruption

Challenge 3: Increasing capacity to meet demand

Increasing capacity to meet demand is a common challenge for many businesses, especially those involved in manufacturing. Efficient fastening solutions can help to maximize throughput and increase production capacity, enabling businesses to meet growing demand.

Use Case

Suppose you're producing polyurethane moldings with 15 to 20 embedded threaded fasteners each. At the moment you are hand-preparing co-processed fasteners with sealing devices to keep the threads clear. This process involves screwing the sealing caps on before molding and unscrewing them afterwards, which takes too much time and slows down production and limit your capacity to take on more work.

Without Bossard

The tooling engineers might implement a push-fit solution in some areas, but they would not be able to use the same solution across all fastener types. As a result, the small increase in efficiency would not lead to a noticeable overall production capacity uplift.

- ✓ Small increase in productivity
- × Significant production capacity uplift
- × Declining staff cost

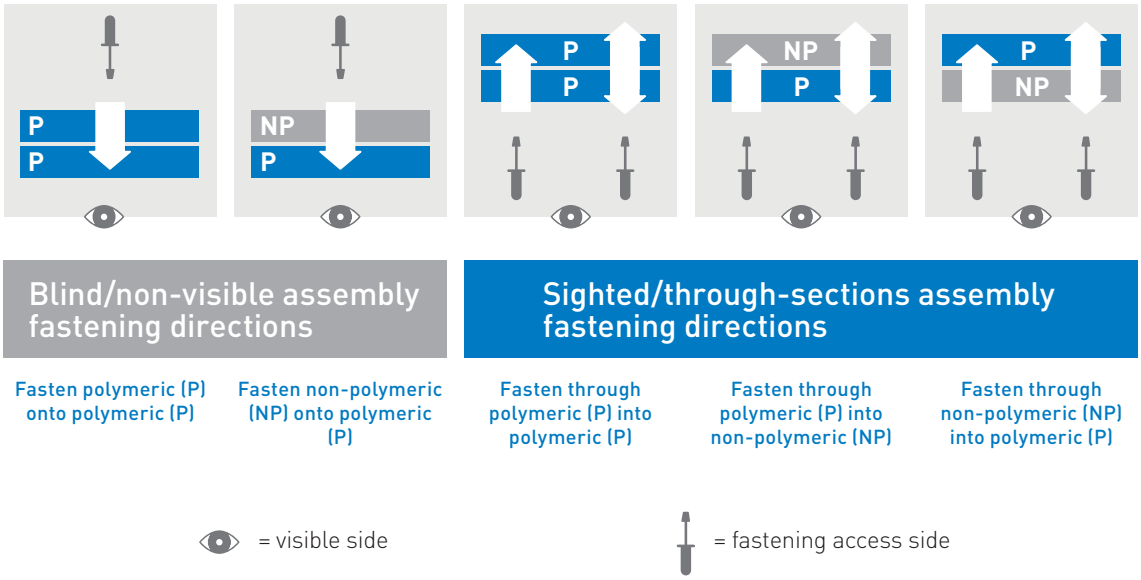
With Bossard

To overcome this challenge, we at Bossard would consider available co-processible fasteners and develop push-fit tooling retainers/sealing devices together with specialist fastener designs where required. This approach would help reduce tooling turnaround time and increase daily production capacity. This approach would result in a 20-minute reduction in tool setup and demolding time for each molding, leading to a 50% uplift in the production rate. This increase in productivity would enable the same-sized production team to take on more work and grow the business.

- ✓ Reduction of tooling turnaround time
- ✓ Significant production capacity uplift

Exploration B: Fastening direction – when & where are the fasteners installed?

Fastening direction is an important consideration that goes beyond component design. During sub-assembly or final assembly, it's essential to determine whether there can be holes in the fastened components, in what direction the fasteners should be installed, and the order in which they should pass through different materials.



For instance, self-drilling screws work well for metallic materials but not for polymeric ones. They can pass through polymeric materials and connect to metallic ones, but it's not advisable to reverse this process. In such cases, fastening must occur through polymeric material, into metallic material.

To ensure successful fastening, several factors need to be considered. These include:

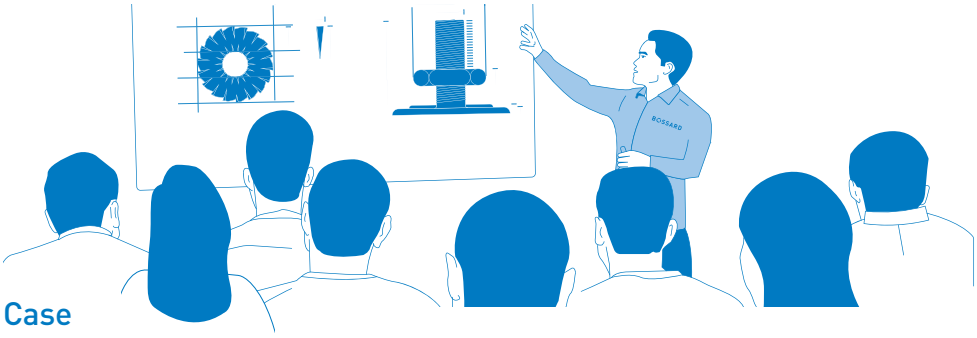
- Blind or sighted fastening: Do you need the fastening to be visible, or should it be invisible? Will making a hole through one of the materials cause performance or manufacturing issues? Can you use fastening systems that pass through both components, or do you need to avoid making a hole in one of the components?
- Material presentation order: Does the fastening technique require the materials to be presented in a specific order? Is it possible to present the materials in this required order, and is there clear access to the required fastener entry/installation side?
- Access restrictions: Does the fastener installation/assembly require large tools or heavyweight equipment? Are there access or space restrictions on either side of the fastened joint? The ability (or requirement) to access the fastening only from one side may determine which fastening techniques or products are suitable.

CHALLENGES AND SOLUTIONS FOR FASTENING COMPOSITES

Assembly

Challenge 1: Using the right fastening technology in your assembly

When it comes to assembly, using the right fastening technology can make all the difference. It is crucial to ensure that the fastening system chosen is not only appropriate for the application but also for the environment in which it will be used. To avoid unforeseen issues that may result in loss of time and money, it is essential to obtain verified data, advice, or undergo testing and training to ensure the use of proper assembly techniques.

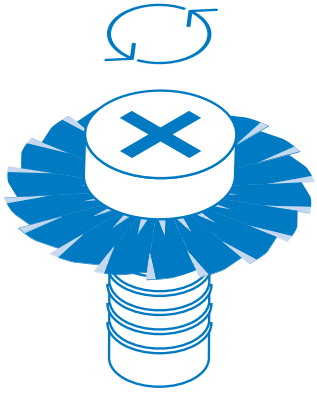


Use Case

Let's consider the scenario where we are fastening two composite mouldings together. The end-use application involves a lot of vibration, and it is critical that we keep the seal between the two components tightly clamped. In this instance, anti-loosening is a critical requirement for the application. To achieve this, we must look at specialist fastening systems designed explicitly for this purpose. However, with so many options available, it can be challenging to know which system will work best.

Without Bossard

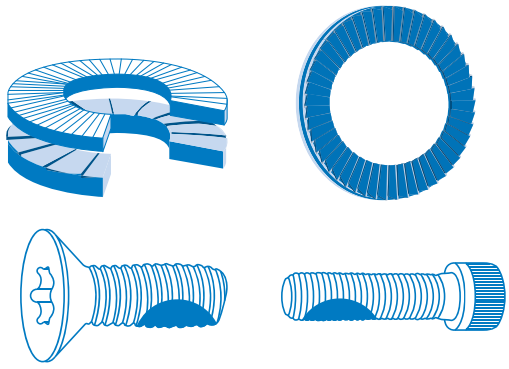
Designers may specify a low-cost toothed washer, believing it will safeguard against loosening and keep the purchasing team happy. However, during prototype testing, it may become apparent that the toothed lock-washers do not work at all. This means more time and money must be spent finding an alternative solution and testing it.



✓ Awareness of need for anti-loosening
? Safe assembly
× Saving time and resources

With Bossard

We know toothed lock-washers have certain shortcomings: In 1990 a NASA engineer went so far as to say that "a lockwasher of this type is useless for locking"![1] Bossard engineers can use their expert assembly knowledge to proactively raise awareness of the issues with toothed lock-washers. They can explore securing and anti-loosening options such as thread locking adhesives and coatings, specialist nuts and washers, or even specialist anti-loosening screws.

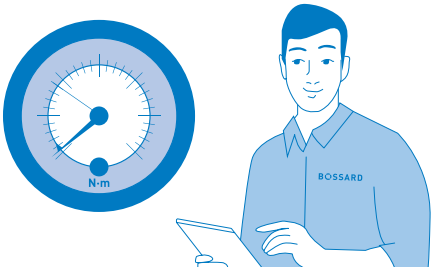


✓ Variety of anti-loosening solutions
✓ Safe assembly
✓ Saving time and resources

[1] NASA Reference Publication 1228, "Fastener Design Manual", Barrett, R. T., National Aeronautics and Space Administration, Lewis Research Center, Cleveland OH, 1990

Challenge 2: Assure adequate quality and safety in the application

Various composite and plastic materials can react differently to assembly parameters. Some may collapse with low preloading, while others may creep or delaminate under compressive or edge loading. Safeguarding against these issues is crucial for durable assembly connections. However, training an assembly workforce to address these challenges can be difficult.

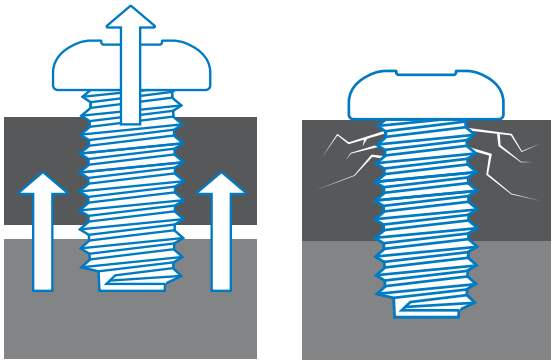


Use Case

As an example, you are using a combination of thermoplastic screws and threaded inserts with screws to fasten your components. You need to achieve the right amount of preload to hold the parts together, but you're concerned about overtightening the screws and causing damage during installation. To address this, you require information about the appropriate assembly parameters for your thermoplastic material and must demonstrate that each fastener is installed correctly.

Without Bossard

The assembly team uses manual torque wrenches and low tightening torques to prevent overtightening damage. However, this approach results in complaints about vibration noises and component wear due to improperly fastened parts. Increasing the tightening torques to achieve greater preload seems like a possible solution, but it leads to mixed results, as some operatives overtighten the screws, resulting in an increased scrap/rework rate. On the other hand, returning to lower tightening torques would mean a lack of confidence in the assembly reliability.



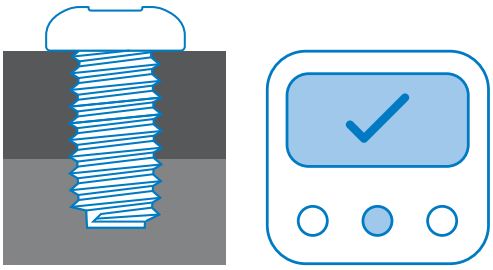
? Safe assembly
? Meeting quality standards
× Reduce scrappage

With Bossard

We work together to determine the right tightening parameters for fastener installation, considering material properties and fastening type.

- For threaded inserts, we assess the material's ability to retain the insert and how assembly preload affects it.
- With thermoplastic screws, we consider the required preload and the impact of creep relaxation over time.
- Once we establish the appropriate torque and speed, we train operatives to use smart assembly tools that control and record these parameters, ensuring consistent installation and verifying data for each fastener.

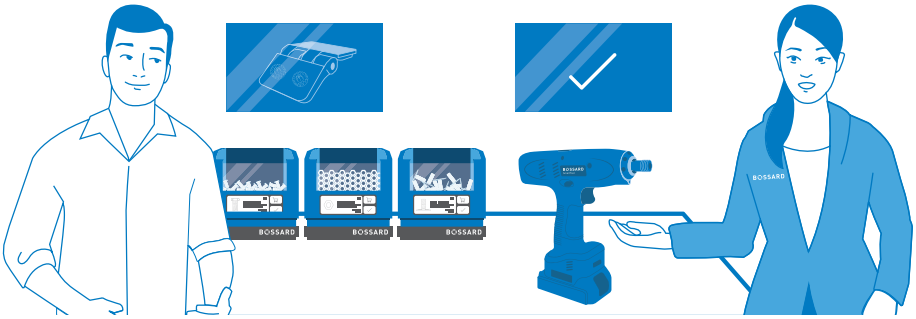
This approach guarantees secure and undamaged assembly connections, giving the assembly team confidence in delivering reliable results.



✓ Safe assembly
✓ Meeting quality standards
✓ Reducing TCO

Challenge 3: Having the right products, in the right place, at the right time

Selecting the appropriate fastener and assembly procedure is important, but it's also crucial to ensure that the necessary fasteners are available at the installation or assembly location. Without a resilient supply chain, even the most carefully designed assembly could face delays or disruptions. So, how can you be confident that your specified fasteners are available in different locations, and who can you trust to provide the parts you need, when you need them?

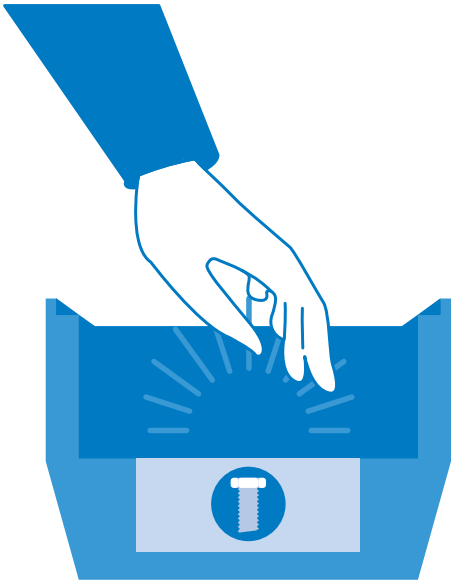


Use Case

You have specified a mix of fasteners in the designs, and your components are produced by different suppliers in two locations. You need to ensure that both suppliers can obtain the necessary fastening products without any disruptions.

Without Bossard

Your suppliers spend valuable time and effort sourcing fasteners from multiple distributors, managing inventories, and scheduling orders. Sometimes, delays occur due to stock shortages or price instability, which makes cost management difficult. This is a drain on resources and greatly reduces overall productivity for businesses focusing on molding and sub-assembly of composite and plastic components.

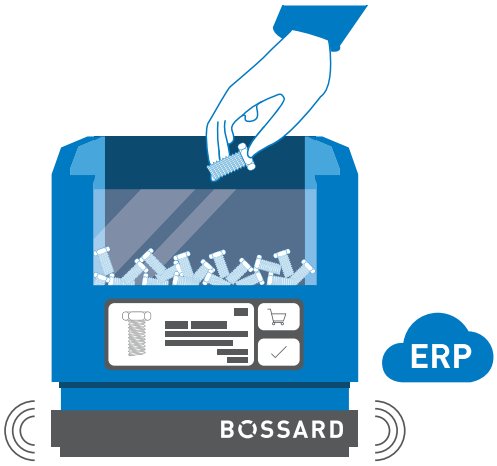


✓ Supply chain
× Stock shortage can cause cost and delays in delivery

With Bossard

As a leading fastener distributor with over 190 years of experience, Bossard can help you source the fastening products you need, regardless of world events or market fluctuations. With access to a wide range of composite and plastic fastening technologies, we can fulfill a variety of fastening requirements for our customers.

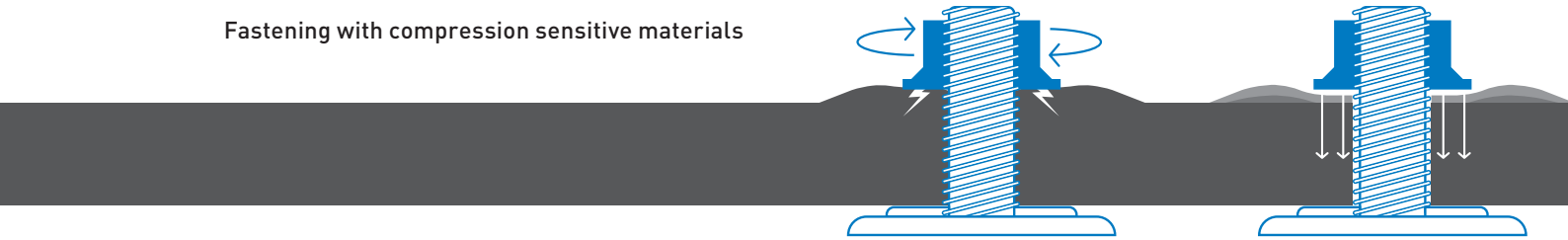
With Bossard Smart Factory Logistics, we can eliminate the hassle of fastener supply disruptions and inventory management. Our smart bins provide real-time stock information, and our software systems help ensure timely ordering. When it comes to fastening supply and logistics in the world of composites and plastics, we take care of it.



✓ Resilient supply chain
✓ On time delivery

Exploration C: Assembly design consideration – where are the known issues?

Fastening with compression sensitive materials

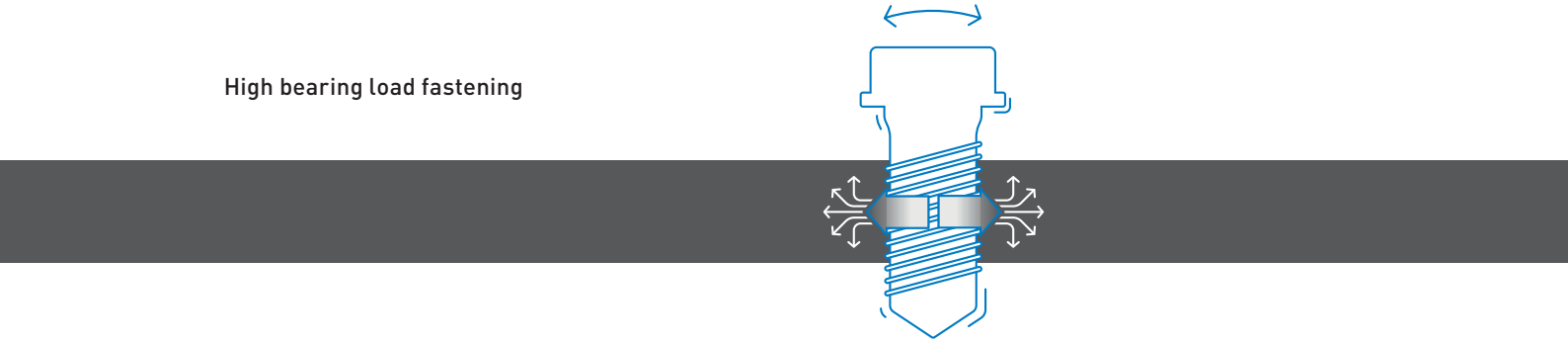


Fastening with compression-sensitive materials involves the challenge of tightly clamping fastened components without imposing excessive compressive forces on the materials. Some fastening technologies, e.g. such as threaded inserts and bigHead® fasteners, allow for the preload to act directly on the fastener's surface, avoiding the transfer of preload forces to the surrounding material.

What to consider:

- Do you need to create threaded connection points through or within polymeric materials?
- Do you need to fasten these materials tightly, but also avoid high clamping forces or crushing of the surrounding material?
- Is the polymeric material surrounding the fastener susceptible to deformation under continuous compressive loading (creep)?
- Would a reduction in assembly preload (creep relaxation) result in failure or performance impairment?
- If you answered yes to any of these questions, we can assist you in designing an assembly that achieves high preloading into the fasteners rather than the surrounding material.

High bearing load fastening



In some cases, a pinned joint design may be necessary for certain applications. However, this can create a significant amount of loading demand on the edges of the hole, especially if the bearing forces are the only thing retaining the parts, without any clamping or preload between the components.

Polymeric materials can be particularly sensitive to edgewise bearing loads, which can result in bearing or shear-out failures. To prevent such failures, it may be necessary to use compression limiters and anti-loosening fastening elements when using pinned joints with polymeric materials.

When considering using pinned joints with polymeric materials, it is important to

- assess whether the material can tolerate high levels of edgewise loading
- consider the implications of a bearing or shear-out failure within the material section
- secure the assembled components to ensure that a bearing load condition never occurs
- use compression limiters or specialist bushings to transfer assembly preloads into the polymeric material section in a desirable manner
- use anti-loosening fastening elements to safeguard against preload relaxation.

CHALLENGES AND SOLUTIONS FOR FASTENING COMPOSITES

Summary

Bossard is a provider of fastening solutions that can address the challenges in fastening composites encountered by design engineers, manufacturers, and assemblers across various industries.

In terms of design, Bossard's focus is on facilitating the exploration and comprehension of fastening options, identifying the most suitable option for your specific application, and ensuring that the design performs as intended in practical environments.

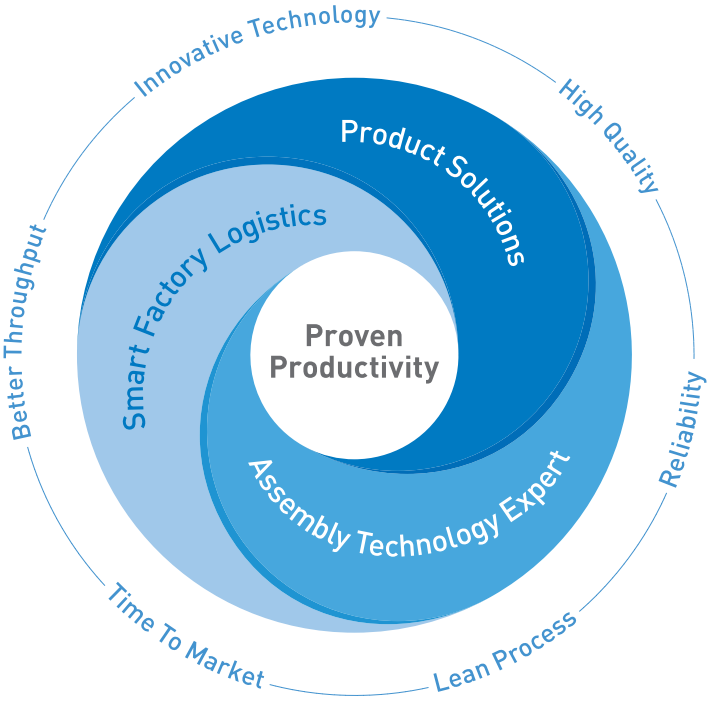
When it comes to manufacturing, Bossard can assist in overcoming the difficulties in working with new materials and ensuring that production is executed correctly from the outset, with meticulous attention paid to every aspect of the manufacturing process.

In the area of assembly, the critical factor is ensuring that the fasteners are integrated accurately, and that the final product is delivered punctually.

Bossard is an expert partner who can provide guidance in all of these domains, ensuring that the fastening solution is the best possible match for your end-user application.

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.

Please do not hesitate to contact us if you have any further questions. We are pleased about your request.
Our contact details: **www.bossard.com**.