

The Case for Structural Blind Fasteners in Automotive Applications

The call for light weighting has led to significant advancements in how we design and construct vehicles. Technology gains have resulted in new and exciting possibilities, but they have also created unique problem sets. The move toward increased aluminum usage in vehicles is one example. While it is widely accepted that aluminum improves fuel economy and agility, aluminum also poses joint design challenges. The lessons learned while fastening steel bodies do not translate to the new aluminum joints, since aluminum behaves differently than steel. Based on this fact, even accepted practices like welding must be re-thought. Fortunately, proven technologies already exist to replace, and even improve upon, now incompatible practices.

Enter structural blind fasteners. They have been used in many critical joint applications for decades, including widespread usage in aerospace, proving their reliability. The availability of carbon steel, aluminum, and stainless steel variations make structural blind fasteners a viable option for joining a multitude of materials, including aluminum. Installation of structural blind fasteners does not require the extensive training required for other joining technologies, and their captive subcomponents eliminate the “squeak-and-rattle” caused by other types of fasteners.

You may ask: “Why try something new, when I know and trust adhesives or welding?” This article will explore the benefits and drawbacks of these technologies, and compare them to the benefits of structural blind fastening.

Adhesives

For manufacturers who must join dissimilar materials, adhesives are an attractive option. Application is usually simple and straightforward. These adhesives form consistent bonds between both similar and dissimilar materials, while only nominally adding to the weight of the structure. Additionally, adhesives can be applied along the perimeter of a joint to lend additional strength and provide a measure of protection from contaminants.

One can choose from a broad selection of adhesive products for use in a number of applications. However, these options must be carefully evaluated, as many can be costly. Also, bonding times can be extensive, and if the adhesive is not applied consistently and cured properly, the resulting bond could be unreliable. When adhesives are used, a careful review of each joint must be performed.

Adhesives can also be susceptible to degradation based on atmospheric conditions or contact with corrosive elements, raising long-term durability concerns for many applications. Lastly, the environmental impact of adhesives cannot be ignored. The disposal of residues from the application and cleaning up of adhesives can present problems, as can the recycling of end-of-life vehicles in which adhesives were used.

Welding



Welding is another widely accepted process for joining metals, having been used in various forms since the Bronze Age. The twentieth and twenty-first centuries have seen a growth in new welding technologies, many in response to lightweighting objectives and the introduction of new materials.

The growing use of aluminum in the automotive industry has presented two major challenges for welding technology: electrical conductivity and surface preparation. The high thermal conductivity of aluminum means that heat must be applied four times faster than with steel in order to raise the temperature the same amount. While high current must be used to generate sufficient heat to reach melting temperatures, this heat must be carefully controlled because aluminum exhibits low strength at high temperatures. For this reason, heavy or loaded parts must be supported during and after welding. Even after cooling, these heat-affected zones are often very brittle.

In addition, welding differing aluminum alloys, or aluminum to other materials, adds another challenge. Each alloy has its own specific melting point, requiring different levels and speeds of heat application. Welding aluminum can also create complex and unpredictable microstructures in the heat-affected zones.

Where welds on steel show a color change at the melting point, aluminum does not. In fact, aluminum gives no visual indication that the area next to the weld could melt, which may result in welds that are larger than desired. Cracks in aluminum welds are another significant challenge. Not only are aluminum welds prone to developing cracks at the outset, they will also naturally age-harden over time, further increasing the probability of cracking. The high coefficient of thermal expansion exhibited by aluminum means that it expands two times as much as steel, so if the part is constrained by fixturing or part design, this could also lead to cracking at the joint. When aluminum is to be joined, pre-heating and slow cooling parts having different cross-sectional thicknesses can help prevent this cracking from occurring.

Surface preparation is another area where the practice for aluminum differs from that of steel. Naturally occurring oxidation in the form of aluminum oxide must be removed from the surface prior to welding. Aluminum oxide has a higher melting point than that of the base metal, so if heat is applied when present, the resulting weld could be weaker or wider than expected. Inert gas or flux are typically used to prevent oxidation from forming after the surface has been prepared. However, either of these oxidation treatments could cause weld imperfections. In addition, the presence of flux could also lead to future corrosion issues.¹

Structural blind fasteners

A third method of joining utilized by automotive manufacturers is blind fasteners. Blind fasteners are used to join dissimilar materials such as aluminum to steel, or aluminum to carbon fiber. Current applications for these fasteners include window regulators, door handles, and trim. Blind fasteners are low cost, easy to install, and easy to inspect. There are two major classes of blind fasteners: structural and non-structural. Today, the majority of blind fasteners in use are non-structural “pop” type rivets, which limits their application to light duty-type joints, since non-structural blind rivets are not load bearing.

Structural blind fasteners offer similar benefits to those of non-structural blind fasteners, while also providing a distinct advantage: quantifiable and predictable shear and tensile strength. Unlike “pop” type rivets, structural blind rivets retain their mandrel after installation. This retention of the mandrel is made possible by the interaction of the mandrel and mandrel sleeve during the installation process. The presence of the mandrel accounts for a 60-80% increase in load-carrying ability in shear and tensile over conventional non-structural blind fasteners. Structural blind fasteners can be differentiated from non-structural not only by their overall increased level of strength, but also by the fact that their published shear values will be higher than their tensile values.

Structural blind fasteners install quickly (often in under one second), by a single operator from one side of the material. Operator training is simple, and does not require any sort of certification. Also, special training is also not a requirement for inspection, since the visual inspection of structural blind fasteners is based solely on the position of the mandrel break location relative to the sleeve.

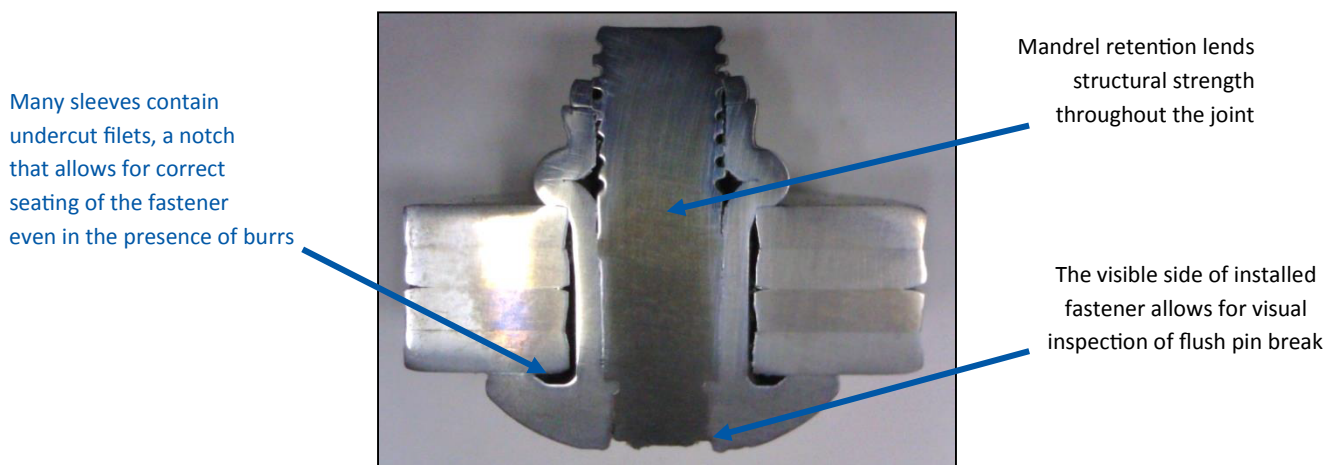


Figure 1: Cutaway of an installed structural blind fastener showing both a retained mandrel and a flush break.

Many attributes make structural blind fasteners ideal for fastening dissimilar materials. These fasteners are available in a variety of materials, diameters, head styles, coatings, and structural strengths. They join material through either hole-fill or surface bearing. Hole-filling blind fasteners ensure holes remain correctly aligned after installation, preventing “sheet creep,” while surface bearing blind fasteners may be used with thin or brittle material or where high tear out loads are required. These surface bearing fasteners may also be used in situations with slotted holes on the blind side of the application.

Installation of structural blind fasteners is both safe and simple. No fumes are emitted in the installation process, no heat is used, and surfaces do not have to be cleaned or pretreated. The availability of material and coating options for structural blind fasteners virtually eliminates concerns about surface oxidation. Some structural blind fasteners even include undercut filets on the sleeves, ensuring that they seat properly and require no grinding or de-burring of the hole surface.

Installed structural blind fasteners remain tight up to their minimum mechanical values, creating tight, vibration-resistant joints that are less susceptible to cracking. These versatile fasteners can also be used in conjunction with adhesives to ensure that a joint remains tight until the adhesives cure while also contributing additional supportive strength to the joint.

Finally, the installed cost of structural blind fasteners tends to be lower than that of other joining options, with savings on time, labor, and complicated inspection processes resulting in overall savings and higher output.

Automation Capabilities

In recent years, automated fastening systems have become more refined and readily available to manufacturers. These solutions provide intelligent control methods and repeatable mechanical movements to quickly and efficiently perform the blind fastening process. With blind fasteners becoming more prevalent on high-throughput production lines, there is ever increasing pressure to provide the highest levels of quality assurance and process control in fastener placement. Automated fastening systems provide monitoring for the blind fastening process, as well as path optimization between fastener locations. These advantages decrease the fastening cycle time, which offsets the automation and consumable expenses by reducing the overall cost of the joint.

When automated drilling is performed, hole alignment and tolerance become constants, limiting the potential of “sheet creep” due to repetitive fastening of the part. Matched drilling also allows parts to be presented to the manufacturing line without pre-punched or pre-machined holes. This is valuable for critical part assemblies that require tight tolerances and/or for non-critical parts that cannot be precisely placed into fixtures prior to the fastening process.

Structural lightweight components are designed in complex geometries for added rigidity, which typically limits the available space for joining hardware. The confined spaces on these parts require that the fasteners be located in areas that are difficult or impossible to access by an operator at a single work cell. Robots have the capability to quickly and precisely maneuver around intricate part designs, as well as fixtures, to reach the fastener locations.

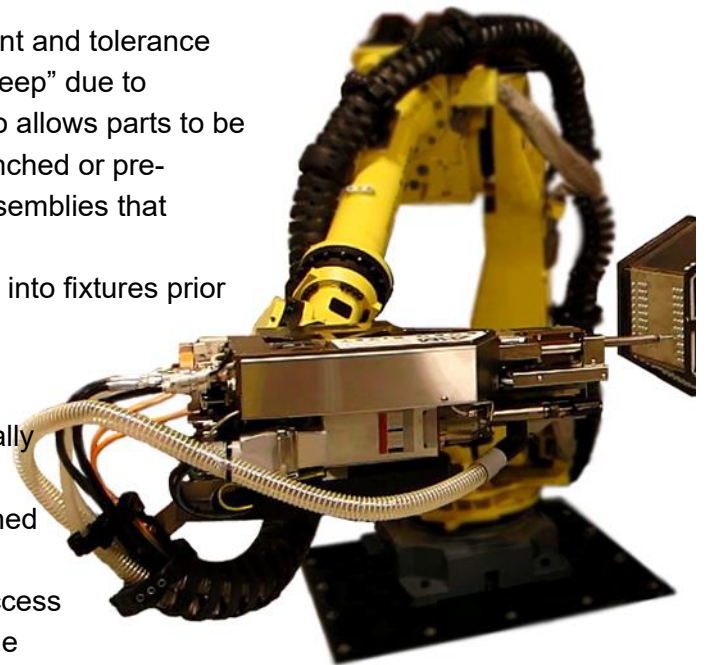


Image courtesy of ARM Automation, Inc./Robo-Rivet

Automation presents additional opportunities for design engineers by enhancing the technical benefits of blind fasteners. This design flexibility allows for fasteners to be accurately located on the part. The benefits of automation are also passed through to production engineers, assuring the quality of the joining process while maintaining a high level of manufacturing throughput.

Moving Forward



The automotive industry is under continued pressure to do more with less: less weight, less cost, and less time. The growing usage of aluminum and other exotic materials presents unique challenges in joint design. Understanding how different joining technologies function from the perspective of weight, cost, productivity, and reliability is crucial. While adhesives and welding are often the joining technologies of choice when trying to address weight concerns, structural blind fasteners should also be given strong consideration.

Structural blind fasteners may add minimal weight to the system when compared to adhesives or welds, but despite this, structural blind fasteners offer a viable, if not superior, alternative to other technologies. Structural blind fasteners create strong, tight joints between various materials, and the wide selection of fastener options offers unique characteristics and performance, allowing joint designers to zero in on the solution that works best for each application. Easy installation procedures make it easier to secure and train operators, while quick visual inspection guidelines help ensure that each joint is fastened properly, every time.

A number of resources are available to help determine which structural blind fastener is a viable option for your next design. To find the blind fastener that will make your product stronger, safer, and easier to assemble, please contact Star Fasteners.