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By Graham Musgrove, product engineer, Arconic Fastening Systems and Rings

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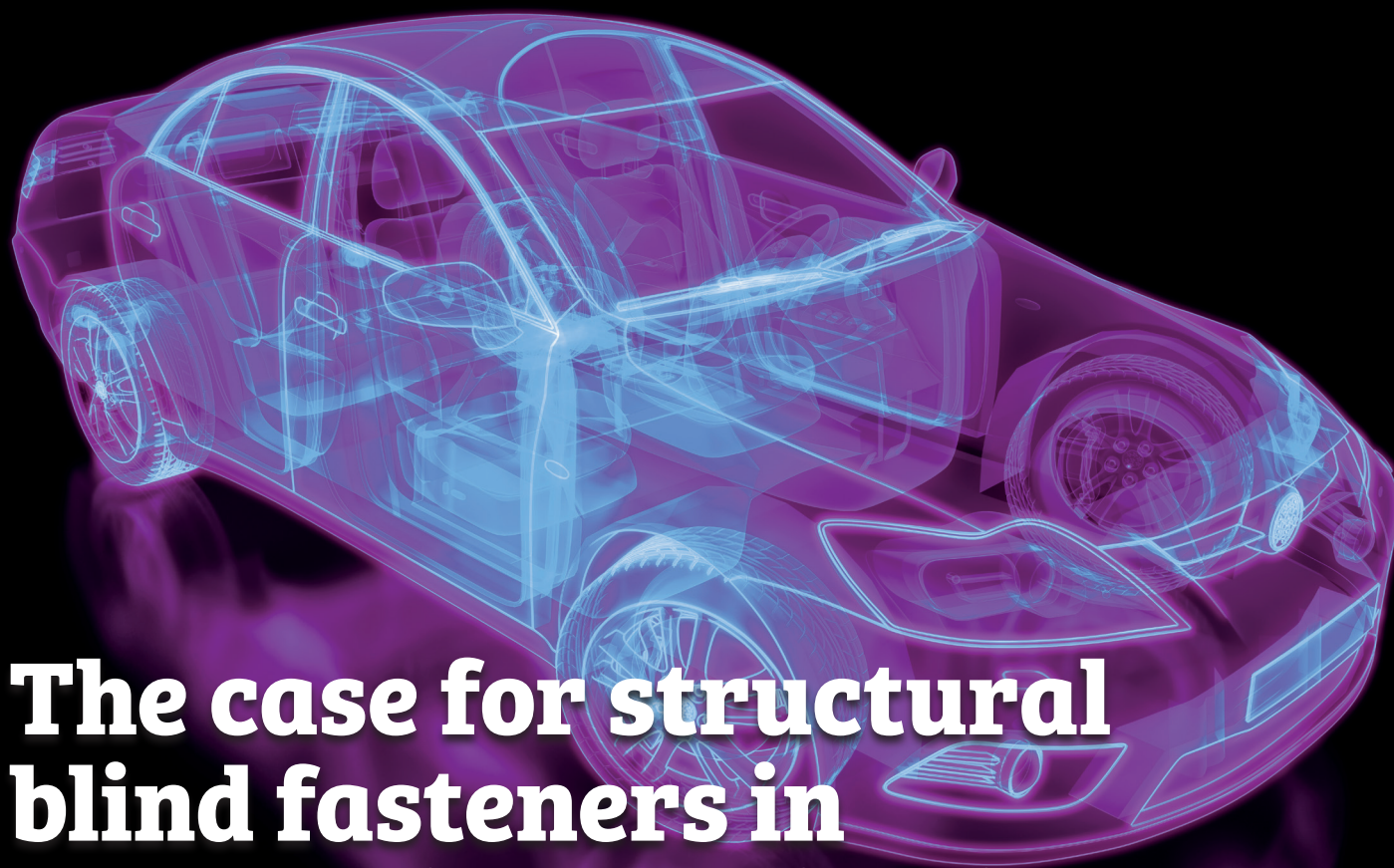
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The case for structural blind fasteners in automotive applications

By Graham Musgrove, product engineer, Arconic Fastening Systems and Rings

The call for lightweighting 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 aluminium usage in vehicles is one example.

While it is widely accepted that aluminium improves fuel economy and agility, it also poses joint design challenges. The lessons learned while fastening steel bodies do not translate to the new aluminium joints, since aluminium behaves differently than steel. Based on this fact, even accepted practices like welding must be rethought. 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, aluminium, and stainless steel variations make structural blind fasteners a viable option for joining a multitude of materials, including aluminium. Also, the 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 – with application 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.

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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 aluminium in the automotive industry has presented two major challenges for welding technology – electrical conductivity and surface preparation. The high thermal conductivity of aluminium means 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 aluminium 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 aluminium alloys, or aluminium to other materials, adds another challenge. Each alloy has its own specific melting point, requiring different levels and speeds of heat application. Welding aluminium can also create complex and unpredictable microstructures in the heat-affected zones.

Where welds on steel show a colour change at the melting point, aluminium does not. In fact, aluminium 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 aluminium welds are another significant challenge. Not only are aluminium 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 aluminium means that it expands two times as much as steel, so if the part is constrained by fastening or part design, this could also lead to cracking at the joint. When aluminium is to be joined, pre-heating and slow cooling parts having different cross-sectional thicknesses, which can help prevent this cracking from occurring.

Surface preparation is another area where the practice for aluminium differs from that of steel. Naturally occurring oxidation in the form of aluminium oxide must be removed from the surface prior to welding. Aluminium 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.

Structural blind fasteners

A third method of joining utilised by automotive manufacturers is blind fasteners. Blind fasteners are used to join dissimilar materials such as aluminium to steel, or aluminium to carbon fibre. 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 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.

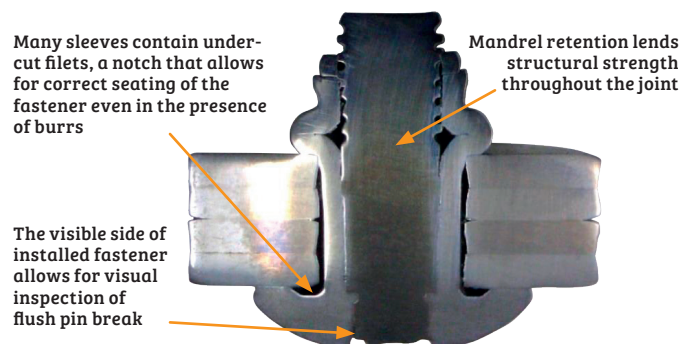


Figure 1: Cutaway of an installed structural blind fastener showing both a retained mandrel and a flush break

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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 pre-treated. 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 they seat properly and require no grinding or deburring 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, labour, and complicated inspection processes – resulting in overall savings and higher output.

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 aluminium 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. +



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