Got Fastener Training?

Fastening Aluminum

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I recently took a request for technical help from a supplier who was asked by his customer, a manufacturer and installer of after-market truck accessories, how to choose fasteners when installing accessories for the new **Ford** F150 aluminum truck bodies.

Aluminum is a very popular and versatile material that is used in a wide variety of equipment and structures. It is universally popular in aerospace, consumer products, sporting goods, automotive components, engines, motorcycles, boats and now F150 truck bodies. The list could go on and on. Aluminum provides opportunities and challenges in the areas of weight reduction, strength-to-weight ratio, overall corrosion resistance, ease of fabrication, availability, marketing and of course, fastening and assembly.

Strength & Corrosion Issues

When fastening aluminum components to each other, or to other materials, special consideration is needed. There are two major reasons for this. First, aluminum is not generally as strong or as hard as other materials such as steel and alloy steel. Second, aluminum components, when used with most common fastener materials, can raise the prospect of galvanic corrosion.

There are some other considerations as well, but for the sake of this article we will consider strength and corrosion as our issues to study. We won't go into the merits and limitations of various aluminum alloys and coatings. The principles presented here apply to most aluminum alloy assembly components whether made from castings, forgings, extrusions, formed sheets, weldments or machined from billet. They also apply to other soft assembly component metals such as magnesium, zinc, brass and even some plastics.

Let's look at the strength issue first. In most fastened assemblies, the assembly components are stronger than the fasteners that hold them together. That is to say, the fastener is more likely to fail than the component if overloaded. This is because the components are in compression and the fasteners are in tension. The designer need only consider the service loads and then specify the size, strength and number of fasteners needed to hold that load if tightened to the maximum safe load the fasteners can deliver. When aluminum is one or more of the assembly component base materials the reverse can happen. The fasteners are now stronger than the components and the components will fail on overload. The designer must consider the loads the assembly will bear in service as well as the load the fasteners will place on the components in the assembly.

In a typical aluminum component assembly, the steel fastener is harder and stronger than the base material. The designer needs to consider how the loads will affect the components in terms of surface pressure limits and strength.

Soft surfaces compress more easily when met with the tremendous forces applied from a fully loaded steel cap screw or nut. Compression of the base materials anywhere in the joint can lead to inaccurate tightening and loss of clamp load. These surfaces also gall and abrade from torsional forces of the turning fastener bearing surfaces against the aluminum surface during tightening. This is damaging to the components and has an adverse effect on the torque-tension relationship. This issue is easily addressed with the proper use of a hardened steel flat washer, or even an aluminum flat washer in some cases. Lubricants can also be of great help, but must be carefully specified and taken into consideration when selecting a torque value. The general principle is: *Do not tighten a steel cap screw or nut directly against a soft metal surface.*

Strength, or the lack of, is inherent in the design of the aluminum component. Castings tend to be more prone to cracking than machined parts and forgings. Aluminum components tend to have mounting features such as feet, lugs and flanges with thin sections. It is important for these features to seat equally onto the mounting surface to prevent any bending or uneven loading of the mounting features. In most cases, cap screws or studs and nuts made of steel or alloy can be used at full clamp load. Flange nuts and flange bolts are recommended. Good tightening strategy is critical when fastening aluminum components. If torque control is the method of choice, testing is recommended using the actual assembly components, fasteners and tooling to be used in the assembly.

Another important consideration when fastening aluminum components is thread strength when using tapped holes in the aluminum base materials. Aluminum lends itself well to the advantages of ease of manufacturing and the use of thread forming screws. It is critical that hole sizes be correct and tightening strategies be well worked out. When tightening cap screws or thread forming screws into aluminum, there must be sufficient material surrounding the hole to support the radial forces on the threads.

Over-tightening in aluminum can strip the threads versus breaking the bolt, especially with bolts that are medium or high strength such as Grade 5 or Grade 8 and PC 8.8 and 10.9. This is a very dangerous condition because it can easily go undetected. The general principle is: *Component strength and thread strength need careful consideration in the tightening strategy when working with aluminum. Testing is needed to be sure the strategy is effective and safe.*

One way to overcome the limitations of thread strength in aluminum components is to use threaded inserts. These come in a variety of types, materials and costs. Careful consideration must be given to material compatibility and installation processes. Training is essential for installers of threaded inserts. Inserts are also an ideal way to repair a stripped thread

in aluminum components and can easily be made part of the standard maintenance instructions, thus saving an expensive component such as a pump housing or an engine block from the scrap heap. The general principle is: *Inserts can solve a lot of problems when working with aluminum, but do it right.* This is a topic for a future *FTI* technical article.

Small assembly fasteners such as rivets, sheet metal screws, set screws, pins and clinch nuts need only be analyzed to be sure they provide the needed clamp load or stability. Be aware that sometimes a pin or sheet metal screw has limited reusability, not because of the fastener, but because of the aluminum. For example, a dowel pin once installed and removed in an aluminum component may not hold with the same force on re-installation. Sheet metal screws will strip more easily, especially in thin sheets. The general principle is: *Aluminum distorts easily. Press fit fasteners and small screws need a light hand when used with aluminum.*

Now let's look at the galvanic corrosion issue. The second major consideration when fastening aluminum is galvanic corrosion, although aluminum has very good corrosion resistance even when not coated. Aluminum bare surfaces form a microscopically thin coating of aluminum oxide immediately upon exposure to air. This coating prevents further oxidation (corrosion) in most environments and also self-heals. If the surface layer is scratched or damaged, a new layer forms on the bare metal. This is why many aluminum assembly components can be used with no supplemental coatings.

Fasteners add another dimension to the aluminum corrosion resistance equation. This is because dissimilar metals in close contact along with the addition of an electrolyte such as moisture or dirt can cause galvanic corrosion. In most cases, the aluminum will corrode out from around the fastener. This is especially true when fastening aluminum with stainless steel fasteners.

Fortunately, some of the most popular fastener coatings provide protection from galvanic corrosion in aluminum assemblies. Zinc plating in accordance with *ASTM F1941* is adequate for most indoor and dry environments as well as many automotive applications. On the down side, should the zinc coating become corroded, the underlying steel will contribute to an aggressive electrolytic environment that will rapidly cause the joint to corrode. If better corrosion resistance is needed, there are excellent dip-spin coatings that contain aluminum and zinc. These are covered in *ASTM F1136* and are available in products such as Dacromet®, Magni® and Geomet®. For outdoor environments, zinc hot-dip galvanized fasteners are a good solution when fastening aluminum. The general principle is: *Aluminum is a very corrosion-resistant material, however it is also a lightning rod for galvanic corrosion. Protect accordingly.*

There are some other weapons in the war against galvanic corrosion when assembling aluminum. One of the more obvious solutions is to use aluminum fasteners to fasten aluminum components. Rivets, screws, bolts, nuts and most fastener types are readily available in aluminum. Consider cost and strength, as aluminum threaded fasteners cost more than steel fasteners, and they are not as strong for a given size.

Another solution is to isolate the aluminum from the dissimilar metal fasteners. This can be done with aluminum washers, plastic washers and spacers, shoulder washers, paint, tapes, sealants and some standard aluminum coatings such as anodizing and chemical films. A very important consideration when anodizing aluminum components with tapped holes is to be aware that anodizing is a very hard and dimensionally significant surface. Tapped holes should be plugged prior to anodizing.

When fasteners offer no practical solution to an aluminum assembly problem, spot welding and adhesives have proven to be very effective. These are highly engineered solutions and require significant testing in any application.

When using steel or stainless steel threaded inserts with aluminum components, isolate the insert external surface from the aluminum by installing it wet—that is with a paint or primer. This not only provides an electrolytic barrier, but fills any spaces where water or other corrosion causing products can collect. The general principal is: *Isolate dissimilar metal surfaces from each other and give corrosion causing products no place to collect.*

The impetus for this article came from an inquiry regarding fasteners for the new Ford F150 aluminum truck bodies. When I got the inquiry, my first thought was, "What does Ford have to say about it?" The following technical bulletin will be particularly useful to anyone working on the new Ford F150s, but the ideas are applicable to any assembly involving aluminum components. It can also be used by suppliers to help their customers know how to properly fasten aluminum. The bulletin can be downloaded at:

https://www.fleet.ford.com/truckbbas/non-html/Q-222.pdf

Aluminum is one of the most common and versatile materials we have. Expect to see its use continue to increase at a rapid rate. Knowing how to fasten aluminum properly and avoiding the strength and corrosion issues that can arise will make you a better user of aluminum and a better fastener supplier to those who use it.

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