



THE thread THAT binds

The causes and cures of self-clinching fastener thread galling

By Ron Dise

Thread-binding issues sometimes may arise when assembling with self-clinching fasteners made from stainless steel. One such issue is galling, which is the seizing or abrading of threads caused by adhesion between the sliding surfaces of a fastener's mating threads.

Although thread galling is not typically a widespread problem with threaded fasteners, it can cause significant fastener damage, and even fastener failures. Even more vexing, sometimes galling of mating threads will go undetected at assembly until it's too late, when screws break during removal for service or other reasons.

With most loose hardware, failed fasteners can be replaced easily with new fasteners, and seldom does the galling damage extend to the attached parts. However, a failed self-clinching fastener may require that the panel into which it is installed be scrapped, since self-clinching fasteners become permanent parts of an assembly. Interrupted production and added costs then follow.

Knowing the mechanics of thread galling, the factors that will increase its likelihood, and methods to reduce or eliminate galling problems can help optimize fastener performance in service.

Mechanics of Thread Galling

The surface of a thread flank is not flat but, instead, composed of high and low spots. The high spots are

called *asperities*. When a thread flank is loaded in straight tension with a tensile testing machine, the asperities yield, compress in height, and increase in size until the total contact area can support the load without further yielding.

When a threaded joint is tightened, the asperities are crushed as load increases, but there also is sliding motion between the thread flanks. This sliding motion can cause the tips of asperities to shear off. On metals such as stainless steel and aluminum



This installed self-clinching, flush-head stud with galled threads creates attachment difficulties with mating hardware (the nut at top).

that readily form oxides on their surface, the shearing away of the oxide layer exposes bare metal.

With adequate heat from friction and pressure from the induced load, these bare spots can weld together. Welds of this type have been found to be stronger than either base metal. Therefore, with increased torque as the tightening continues, the welds themselves will not break, but instead chunks of base metal will be pulled out of the weaker base metal.

This initiates galling. As more tightening torque is applied, the contact area increases to support the higher induced load. This creates larger, stronger welds, which pull out even larger chunks of the weaker base metal. In extreme cases, the torque necessary to continue relative rotation of the mating threads can exceed the torsional strength of the external thread and cause it to fail in torsion. Even in less extreme cases, galling significantly increases the coefficient of friction on the galled surface; with common torque-controlled tightening (that is, all fasteners are tightened to the same torque), preload may be significantly less than required for a reliable joint.

Although the role of heat input in galling has not been fully explored, high heat input is known to increase the chance of galling. The source of heat during tightening of a threaded assembly is friction. Screw threads are very inefficient, with only 10 to 15 percent of the tightening torque used to induce load, and the rest used to overcome friction.

Factors Contributing to Galling

A variety of factors can increase the likelihood that some percentage of mating threads will gall when assembled.

Soft Connection Elements. Soft elements require more rotation during tightening. This increases the area under the torque-angle curve, which causes more heat energy input from friction. In engineering terms, an element is softer when it has lower stiffness, and a threaded connection may contain one or more soft elements. While fastener stiffness is generally fixed for a given thread size and material, the stiffness will vary with grip length, or the space between the nut face and the underside of the screw head. The longer the grip, the lower the stiffness.

High-speed Tightening. This action can generate very high temperatures on the thread flanks before the heat can be dissipated by the rest of the fastener mass. Slower speed will allow more time for heat dissipation.

Material and Finish Combinations. Decades of experience have shown that, in most thread galling cases, both threaded components have been made from 300 series stainless steel.

Materials that form natural protective oxides (such as stainless steel, aluminum, and titanium) have been found to be more prone to galling. This is because the protective film provides corrosion

resistance without any plating or other additive finish. These oxides tend to give the surface a higher friction coefficient than plating materials typically used on steel fasteners. This means higher torque is required for a given clamp load, which means more area under the torque-angle curve and more heat energy input.

If the oxide is very thin, it will follow the surface roughness on the thread flank and be completely removed when the tip of an asperity is sheared. This action exposes pure base metal with excellent welding characteristics. This is especially true for stainless steel, where the chromium oxide layer is only several angstroms thick. The abrasive nature of the sheared-off oxides also may contribute to thread galling.

Materials of the same type generally are more prone to galling, possibly because they are more easily welded than dissimilar materials. Materials of the same hardness also will generally be more prone to galling, since the breaking down of asperity tips is happening to nearly the same degree on both materials. In turn, plated materials will generally be less prone to galling.

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Fine Threads. Fine threads tend to gall more than coarse threads. This is because fine threads are more prone to nicks or other damage from handling, and thread nicks can contribute to galling. Fine threads further require more rotation and higher torque for the same stress on the larger tensile stress area during tightening, resulting in more area under the torque angle curve and more heat energy input.

Thread Damage. Threads with significant nicks or other damage can gall. If there is interference between the mating threads, there will be some level of prevailing torque during the entire tightening process. In some cases, the geometry of the damaged area may be such that it initiates galling in the immediate vicinity of the damage.

Excessive Tightening Torque. Proper tightening torque is essential to develop the needed preload in a fastener, and preload is critical to prevent vibration loosening. Tightening torque should never be reduced below the proper value for the sake of galling prevention. However, tightening torque can contribute to galling.

Mating Part Alignment. Mating parts should be lined up as well as possible before final assembly

to reduce the amount that a fastener has to be turned during tightening. Otherwise, thread galling can occur.

Tightening Sequence Issues. If a fastener is tightened with enough clamp load to keep the pieces from moving before all the other fasteners are started, some clearance holes may not be in the proper position. This can cause screws to enter on an angle.

In some cases, tightening on one side causes components to gap on the opposite side. The fasteners on the gapped side will need to draw the gapped components together, forming a soft joint. A better approach is to start in the middle of the workpiece and progressively tighten fasteners on alternating sides of the center, finishing at the far ends.

Low-quality and Inconsistent-quality Fasteners. Threads not perpendicular to the bearing face of nuts can create the same galling issues as screws entering on an angle, because of hole size or position problems. And fasteners with inconsistent yield strength can yield from excessive tightening torque.

Methods to Reduce Galling

Sometimes, fastener design features prone to galling simply cannot be eliminated. The next line of defense against galling is the assembly technique, but even with the best assembly practices, some galling can occur. When this happens, one of the following additive methods might help:

- **Add lubricant at assembly.** Many different lubricants and anti-seize compounds are available. Some, such as USP-grade castor oil, are very safe and still provide excellent lubrication. An antiseize compound is recommended for stainless threads.
- **Specify fasteners with a lubricant.** It is common to specify dry film lubricants on all-metal, prevailing torque locknuts, but these same dry film lubricants can be applied to nonlocking fasteners, too. Typically, only one of the mating threads needs to have a lubricant to prevent galling. When possible, it is preferable to apply the dry film lubricant to the external threads for complete coverage.
- **Specify fasteners with antigalling plating.** Some metals deposited by electroplating have inherent lubrication properties. And as with lubricants, typically only one of the mating threads needs to have a plating to prevent galling. Note that most stainless steel and aluminum fastener threads are not produced with an allowance to accommodate the plating thickness. This usually means that a fastener manufacturer can't simply take existing parts from stock and have them plated. Instead, parts need to be specially made with the needed thread allowance.
- **Specify fasteners made from antigalling materials.** While this option typically may require that fasteners be made to order, it is especially viable for high-volume, long-product-life applications.

Address Galling Early

While these guidelines can help prevent thread galling, particular applications may present particular challenges. Regardless, resolving galling issues at the outset can make all the difference on the road to optimized fastener performance. **FAB**

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