

Galling of Stainless Steel Fasteners

INTRODUCTION

Stainless steel is a popular fastener material due to its inherent resistance to corrosion and generally higher tensile strength than commercial low carbon steel. However, during installation users may encounter galling resulting in excessive wear, or in the worst case, seizing of the mating components, **Figure 1**. By identifying the likely causes, designers and assemblers can safeguard against this mischievous, and sometimes misunderstood, phenomenon. While galling can occur between a multitude of mating surfaces, this bulletin focuses on the causes and prevention associated with threaded fasteners.



Figure 1. Galling during installation frequently leads to fastener failures such as seizing, delaminated threads and twisted heads..

EXPLANATION

Galling most commonly occurs between mating fasteners of materials which self-generate a corrosion-resistant oxide surface layer, such as stainless steel, titanium, aluminum and some other alloys. During assembly, contact between the high points on the threads wears away the protective oxide layers exposing the base materials. When the cohesive force between the materials exceeds the strength of either metal, solid-phase welding (galling) occurs. At low pressures or loads, the weld is weak and small amounts of metal transfer to the stronger side or float independently in the joint creating excessive wear and debris. As stresses increase, the high points are deformed enlarging the surface contact areas and forming stronger bonds. The cumulative clogging-shearing action results in increased adhesion and occasional seizing of mating components. Of all galling-prone materials, users experience the most problems with stainless steel due to its modest ability to dissipate heat and higher coefficient of friction.

CAUSES AND PREVENTION

The key factors that contribute to thread galling include friction and heat produced during assembly, use of similar materials, and thread smoothness and cleanliness. Understanding the causes that contribute to these factors is essential in reducing or eliminating galling's effects and incorporating appropriate countermeasures.

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Friction/Heat

Axial misalignment between mating fasteners and/or extraneous loads between clamped components introduced during assembly, either by mistake or design, can increase friction resulting in galling. Examples include holes of clamped components not aligned, installation angle of external thread fasteners beyond perpendicular to the mating surface resulting from operator error, and using the threading action between fasteners to draw resistant components together or compress springs. The optimal design allows the fastener to thread freely up to the mating surface and then go from snug to fully loaded within a 90-degree rotation. The least amount of thread flank-to-flank contact under load, the greater the likelihood the fastener will not gall.

If a fastener requires a locking element to resist loosening due to vibration, a nylon material may be added to the threads to create frictional resistance to rotation between the mating fasteners. However, these elements are commonly applied to one side of the fastener creating eccentric pressure and a high risk of galling. Locking elements that are applied 360-degrees around the thread result in a uniform pressure and reduced chance for galling. Stainless steel nuts with mechanically deformed locking features are almost certain to gall with stainless steel external thread fasteners.

To satisfy the demand for reduced assembly times, high rpm drivers are commonly used to install threaded fasteners. As installation rpm's increase so does the heat during threading and potential for over-tightening – both prime causes of galling. By reducing installation rpm's and closely controlling seating torque, the likelihood of galling can be reduced.

Similar Materials

Many applications constrain the designer into using similar series of stainless steels. In general, 300-series stainless steels are specified for their corrosion resistance. Although they do not have the same level of corrosion protection, fasteners made from 400-series stainless steels have less tendency to gall with 300-series fasteners because the alloys work harden at different rates. Also, 400-series can be heat treated offering additional resistance to galling whereas 300-series cannot. Using dissimilar grades within the same series, 304 and 316 for example, to avoid galling breeds debate between some notable sources within the fastener and stainless steel industries and may not have the desired effect. Advanced raw materials have been developed to reduce galling while maintaining corrosion resistance. Gall-Tough® and Nitronic 60® are two examples of proprietary stainless steels that reduce galling. In general, dictating stainless steel grades and specifying proprietary materials can add complexity and cost to a design and should only be considered when all other preventive measures fail.

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Thread Smoothness/Cleanliness

Fastener threads that appear smooth to the naked eye will manifest roughness, seams, material laps, and burrs when viewed under magnification, **Figure 2**. With carbon steel fasteners, these surface irregularities do not cause any problems but with galling-prone materials they form the high points that can trigger the galling cycle. Most sources claim that cut threads gall more easily than cold-formed threads because the base material's grain lines are severed introducing planes of weakness and cutting tool marks. Conversely, cold-forming threads molds the material's grain flow lines to conform around the thread profile and burnishes the roots and flanks.

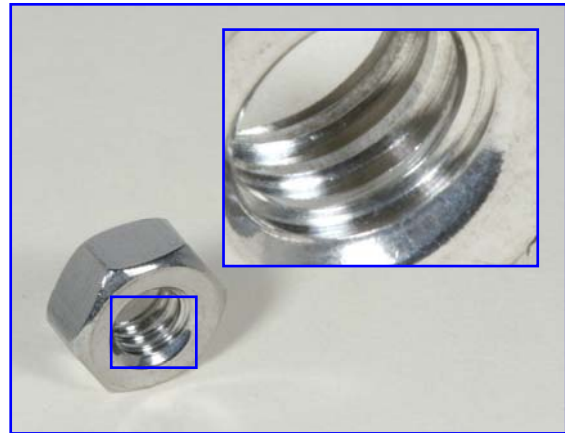


Figure 2. Threads that appear smooth to the naked eye reveal roughness under magnification.

However, a least one reputable source of stainless steel raw material disputes the benefit of cold-forming 300-series stainless steels. Ironically, most users experiencing failure point blame at the external thread fastener because it is generally the first component to show damage. However, the majority of internal thread fasteners have cut threads whereas most external thread fasteners are cold-formed. Externally threaded fasteners should be handled carefully. Poor packaging and haphazardly tossing heavy fasteners in a storage container can nick and dent threads creating a stimulus for galling as well.

Clean threads are less likely to gall. Grit and debris in the threads can increase friction and thread surface contact pressure. While a trace amount of oil left behind from manufacturing may help lubricate threads and prevent galling, this is usually not acceptable for electronic assemblies where cleanliness is paramount. Parts should be inspected, handled and stored to prevent contamination before use.

Countermeasures

Even though precautions may be taken to mitigate the aforementioned conditions, galling may still occur. Lubrication may be one of the best ways to reduce friction between thread flanks and eliminate galling. One of the most common and least expensive lubricants in the fastener industry is a commercial wax. Applied by the supplier, in most cases it is unnoticeable to the user and can be extremely effective when used in conjunction with other anti-galling measures. In more extreme situations, a baked on Teflon® or molybdenum disulfide coating applied to the threads by the supplier significantly reduces friction.

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Lessening the friction between thread flanks lowers the torque necessary to properly load the fastener. Therefore, torque installation specs should be revised according to each application.

CONCLUSION

Galling frequently occurs between stainless steel mating fasteners as a result of excessive friction and heat generated during assembly, use of similar materials, and thread roughness and cleanliness leading to premature wear and possible seizing of components. In Pencom's experience, most galling cases result from faulty joint design and high rpm installation, and can be remedied by applying a commercial wax to the fastener threads and/or revising assembly procedures. **Figure 3** lists the causes of galling and the associated prevention steps.

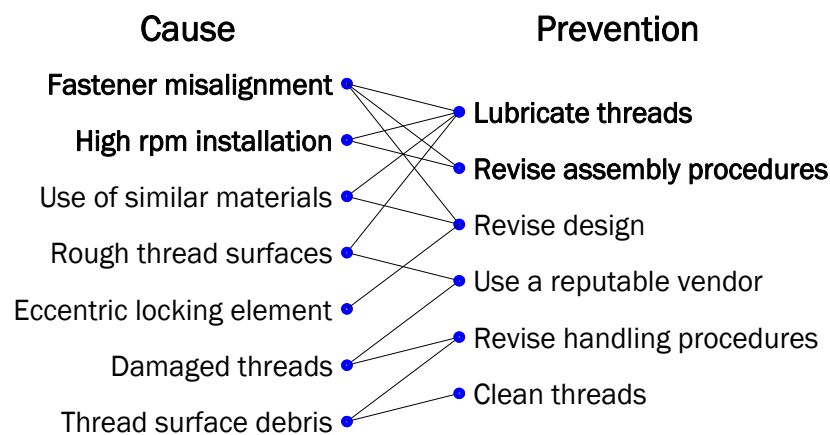


Figure 3. Causes of galling and steps for prevention.

With careful forethought, the advantages of stainless steel fasteners can be fully appreciated without experiencing the detrimental effects of galling. To inquire about gall-resistant coatings on your fasteners or to discuss application concerns contact a Pencom Account Representative.

Gregg V. Summers, M.S.E., P.E.
Director of Product Development

References available by request

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