FASTENER +FIXING MAGAZINE

Technical Analysis

Galling of stainless steel fasteners

By Deepak Garg, Bossard expert team

The fasteners most commonly prone to galling when tightened are made of stainless steel, aluminium or titanium. Stainless steel fasteners are available in austenitic, ferritic and martensitic grades, with austenitic grades of stainless steel fasteners usually used in the industry. The stainless steel material has a chrome oxide layer, which protects it from corrosion.

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When two fasteners are tightened together, surface pressure builds between the thread surfaces of the bolt and nut, and the protective oxide layer may break off. The high friction between the interfaces of the joining fasteners, where the base metal has been exposed (due to the shaved oxide layer), can cause interlocking of the surfaces; this phenomenon is known as galling. The higher coefficient of friction increases the risk of galling.

Galling is seizing or abrading of the threads, in which either the joint elements jam during the assembly or threads get damaged. It is also known as local cold welding (frictional bonding) of the thread flanks. It is generally formed when the thread flanks rub against each other for an extended period of time.

Different types of stainless steel materials, with different heat treatment conditions, behave differently in terms of galling. Table 1 compares galling characteristics of seven types of stainless steel. It indicates that the galling time can be from 7 seconds to 58 seconds at a specific load.[1]

Galling and its causes

This section talks about various causes of galling and prevention methods in those conditions.

Torque and galling

VDI 2230 (technical guideline for fasteners) indicates that bolts may only be tightened to 90% of their yield strength. If the tightening torque is too high, the bolt will be overstretched or even break. The screws can also be broken by torsional shear forces – due to thread galling.

The friction coefficient of stainless steel against another stainless steel is relatively high in comparison with the friction coefficient of many other materials in combination. To achieve

Type	Condition	Initial hardness	Surface treatment	Load (lbs)	Time for galling to occur (Seconds)
416	Heat Treated	43 Rc	None	400	12
416	Heat Treated	43 Rc	Tufftrided*	1,000	37
440C	Heat Treated	59 Rc	None	800	17
440C	Heat Treated	59 Rc	Tufftrided*	1,100	41
440A	Annealed	96 Rb	None	650	15
440A	Annealed	96 Rb	Tufftrided*	1,000	47
303	Annealed	85 Rb	None	(only preload)	3
303	Annealed	85 Rb	Tufftrided*	750	25
303MA	Annealed	88 Rb	None	300	2
303MA	Annealed	88 Rb	Tufftrided*	1,350	58
317	Annealed	85 Rb	None	500	7
317	Annealed	85 Rb	Tufftrided*	750	27
347	Annealed	89 Rb	None	600	8
347	Annealed	89 Rb	Tufftrided*	500	22

Table 1: Comparative galling characteristics

the same preload, screws made with austenitic stainless steel material A1-A4 must be tightened with higher torque than regular steel screws with the same strength.

In the case of thread galling the tightening torque goes up and preload is not achieved. Sometimes the operators tend to apply additional torque to visibly seat the fasteners properly without being aware of the occurrence of galling. Such failures may hardly be detected during the tightening operation and can be invisible from outside. It appears during repairs or service that the fasteners can no longer be loosened.

After galling a bolt/nut will certainly not rotate loose or get lost, but joints that are not properly tensioned may fail from fatigue when put under service loads.

Lubricating stainless steel fasteners prior to assembly, as well as solid lubricant coated fasteners, have been demonstrated to be advantageous against galling.

Manufacturing process and galling

The thread surface of different thread profiles may appear smooth when looked at with the naked eye. However, under a microscope the thread profile may show folds in the thread crests. This failure occurs due to an improper rolling die setting. Blunt thread crests decrease the thread forming capability of thread forming screws.

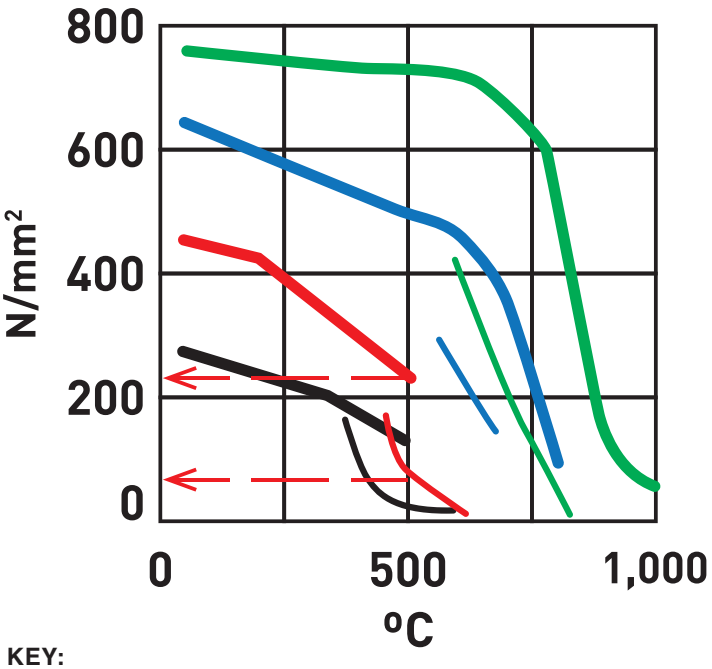
The internal thread of a prevailing torque nut could have similar issues, which lead to seizing of the threads. These types of failures are considered 'invisible' failures. Manufacturers take extra care when producing thread cutting and thread tapping fasteners for the same reasons. Generation of the burrs (Figure 1) during thread rolling is one of the common issues that can cause galling.

Figure 1: Burr on thread

High temperature fasteners and galling

Gas turbines and diesel engines are typical representatives of machines where fasteners are exposed to high temperatures. High temperature can change the physical properties of a material. Due to the high temperature, aggressive gases may create scale on the surface of bolts and nuts. Thermal expansion can lead to permanent distortion. Regardless of such external impacts, the required preload must be maintained in fastened joints. In addition, the fasteners must remain detachable for service and repair works.

Galling can also occur when fasteners and structural elements are made from different materials. The design engineer should take high temperature consequences in consideration when designing a joint.



KEY:
Ck35: Steel
24CrMo5: Low alloy steel
X5 NiCrTi 2615: Austenitic stainless steel
NiCr 20 Co 18 Ti: Nickel-chromium-cobalt alloy with titanium

Figure 2: The yield strength at elevated temperature for some heat resistant bolt materials.

High temperature and relaxation are often a source for thread galling in service and repair works. To prevent threads from galling, threads of heat resistant bolts have an increased thread play.

Prevention of galling

Manufacturing process

During the manufacturing process the wire may be coated with copper for lubricity to prevent galling in the dies. The copper coat acts as a solid lubricant on the wire. It is removed after thread rolling by pickling the finished fasteners.

Top coat

Galling can be minimised or prevented if metal to metal contact of the engaging threads is prevented. There are several methods possible, including:

- Lubrication with 'Molylub': The solid molybdenum disulphide particles prevent metallic contact and thus minimises abrading. Sometimes application of normal oil or lubricants may not be sufficient to prevent galling.
- Similar solid film lubricants containing silver, aluminium or copper particles can also be beneficial. These lubricants help decreasing the coefficient of friction. Most of the anti-seize compounds, those that are applied at the assembly line, contain these metal particles. Lubricants containing graphite are not advisable since there could be dangerous reactions between the carbon and the chromium at high temperatures.

- A thin PTFE sealing tape can offer protection from galling. For large threaded components such as pipes and valves, the threads of these parts could be wrapped with a thin PTFE-sealing tape.

- Coatings such as Polyseal, Xylan, DELTA®-SEAL or wax applied to stainless steel fasteners may also prevent galling.

Tribological coating

Fluoropolymer coatings are a blend of resins and fluoropolymer lubricants. PTFE, PVDF, PFA, and FEP provide low friction, chemical and corrosion resistance, non-wetting, and release or non-stick properties at temperatures up to 550°F.

Bossard ecosyn®-lubric coating is a tribological dry coating system for mechanically stressed fastening elements and components (such as screws, nuts, washers). The coating is a thin layer coating, applied non-electrolytically, with built-in lubricating properties and additional corrosion protection.

The coating comprises a composition containing fluoropolymers and organic solid lubricant particles, which are dispersed in specifically selected synthetic resins and solvents. It is referred to as an AFC coating (anti-friction coating), which forms a smooth film to even out all irregularities in the surface and thus optimises friction even under extreme loads and working conditions. The synthetic resin also ensures improved corrosion protection.

A thin, dry film of lubricant, which adheres firmly to the substrate, forms after the lubricating varnish has hardened. This film acts as a separating and lubricating layer reducing the friction and wear between friction bodies that are in contact with each other.

Bossard ecosyn-lubric tribological coating offers an excellent solution for the applications which require controlled coefficient of friction and protection against wear. The tribological properties of Bossard ecosyn-lubric minimise galling with fastening elements. ecosyn-lubric coating also helps maintain pre-defined torque to achieve the correct clamp load.

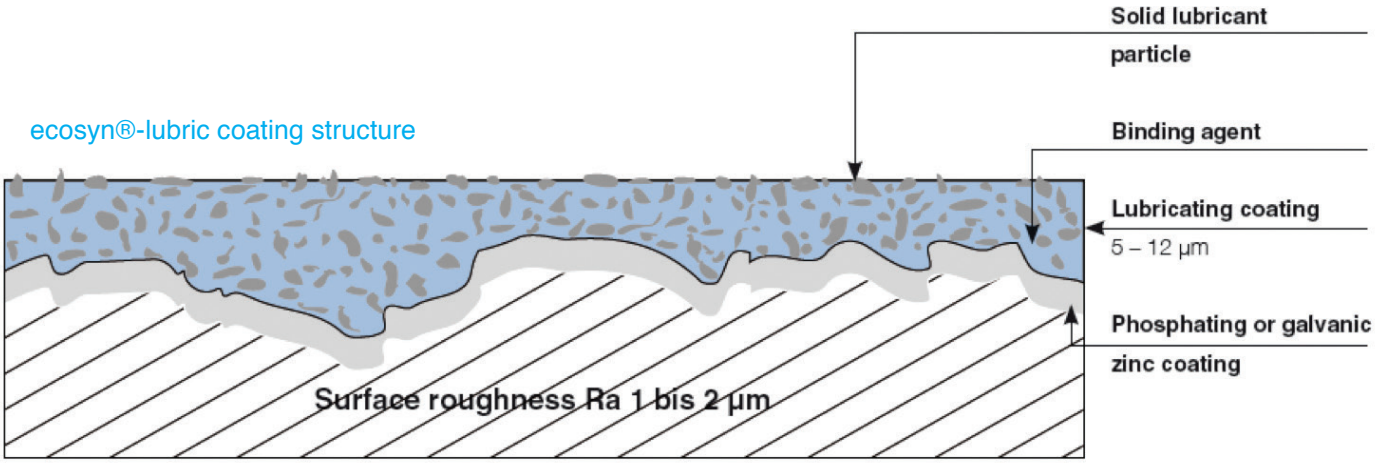
Bossard ecosyn®-lubric coated fastener

Summary

Stainless steel fasteners are frequently prone to galling when assembled. The excessive friction and generated heat during tightening create plastic deformation of the surface(s) that leads to seizing of the mating members. Use of lubricants and intelligent coating such as Bossard ecosyn-lubric; extra care during thread forming; appropriate RPM of the installation tool; cleanliness; and proper design practices can help reduce or eliminate the galling.

With careful attention on prevention of galling, stainless steel can be a very useful fastener material due to its inherent resistance to corrosion and generally higher tensile strength than commercial low carbon steel. ■

ecosyn®-lubric coating structure



Bibliography

Budinski, K.G. (1991). Tribological Properties of Titanium Alloys. International Conference on Wear of Materials.

[1] Producers, C.O. (1978). Review of the Wear and Galling Characteristics of Stainless Steel. American Iron and Steel Institute, 2-19.