Written by Robert A. Valitsky, Loctite Corp.
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It's been said that man's invention of nails, rivets, screws, and other basic fasteners helped pave the road from the Stone Age to the Space Age. If that is true, then fastener loosening has provided quite a few of the speed bumps and pot holes on that road.

Keeping fasteners tight, particularly threaded fasteners, seems like a simple task, but the moving nature of the machinery they are used on is what makes them so troublesome. How nails and rivets work is fairly well known. But because the physics of the threaded fastener is not as well understood, it tends to cause the most problems.

Causes of loosening

Threaded fasteners are employed primarily to clamp objects together using tension. Rotary force or torque imposed on the fastener provides that tension. Problems occur when this clamping load deteriorates.

About 85 percent of the torque and effort of tightening a bolt is absorbed by the friction in the threads and under the head. Only 15 percent produces clamping load. Therefore, high torque may be absorbed by high friction and not produce tension. Torque is not the most precise method of controlling clamping load, although it is the most common. When bolt and nut manufacturing is closely controlled, the tension produced in a bolt for a given torque varies up or down by 15 percent.

Although it is always the first suspect in any case of lost clamp, vibration, as commonly perceived and observed, is not capable of bolt loosening by itself. If vibration is violent enough to cause shifting of the threads, then it will cause loosening, and in only 50 to 100 cycles. However, vibration that violent is usually perceived as shock, shudder, or impact. Toward the end of the loosening cycle, common vibration can and will rattle the fastener loose. This is why it often takes full blame for loosening.

The actual cause of loosening is side-sliding or shifting of the threads. The empty space between the threads of a nut and bolt leaves room for movement that leads to self-loosening and loss of clamping force. The friction in the threads and under the head of the bolt is reduced to zero when the clamped parts and threads slide sideways to the bolt axis.

Each time this happens, the bolt can unwind by itself. The loosening process of a non-locking fastener starts with the first motion. It normally takes less than 100 side motions to completely loosen a bolt.

This shifting can occur any time the side force exceeds the friction between surfaces, as produced by the clamping load. There are three common causes of shifting:

- Bending. Bending of parts causes stress on the friction surface. If slip occurs, the threads and head also will slip. Each slip causes a partial downhill or unwinding slip in the threads. After 50 to 100 of these, the bolt is completely loose.
- Thermal expansion. Differences in temperature or in clamped materials can cause the same effect as bending. If the effect is strong enough to cause side-slip, then downhill slip also will occur and loosening will result.
- Applied loads. The impact of loads applied directly to the fastening point can cause side-slip as well.

Any one or combination of these conditions can occur from shipping trauma, extreme heat or cold, or just plain abuse. The effects are cumulative and self-accelerating. As these affect clamping load, there is increased probability that side-sliding will occur.

Threadlocking

Various methods and devices have been employed over the years to reduce or prevent loss of clamping load in threaded fasteners.

The earliest attempts involved the use of lock wires and split pins in conjunction with nuts and bolts with holes drilled in them. Although effective, these measures had some serious drawbacks. Each fastener had to be the correct length, and the holes had to be aligned on each individual bolt. Consider the difficulty and time required using this method to assemble numerous parts requiring many threaded fasteners.

As fastener manufacturing skills improved, more complex methods of threadlocking were developed. Two of the most common mechanical methods of threadlocking are thread distortion and the use of washers. Although these methods can be effective for short-term threadlocking, anaerobic threadlockers can provide short-term, long-term, and even permanent tightening when necessary.

Liquid threadlockers

The first chemical threadlockers, developed by Loctite, eliminated many of the design faults and shortcomings of threaded fasteners. Chemical threadlockers are anaerobic liquids that cure to a tough, solid state when activated by a combination of contact with metal, and a lack of air. The resulting cured material is a thermoset plastic that cannot be liquefied by heating, and resists most solvents.

The purpose of threadlockers is to lock and sometimes seal threaded components without changing fastener characteristics or altering torque-tension relationships. In addition, chemical fasteners offer a number of other advantages over mechanical tightening methods:

- Breakloose and prevailing torque. Liquid threadlockers find their way into tiny imperfections of threads. As they cure, these imperfections serve as molds for thousands of tiny keys that resist fastener movement in any dimension.
- Anti-corrosion. Because threadlockers fill the voids between threads, they block the entry of moisture, preventing corrosion and subsequent seizure.
- Strength control. Most threadlockers are graded by their various strengths and characteristics into distinct classifications. The different formulations of Loctite threadlockers, for instance, are distinguished by the color of the threadlocking material: low-strength is purple, removable is blue, permanent is red, and the penetrating formula is green.
- One size fits all. Because they are liquids, threadlockers do not come in different sizes. The same bottle that locks in a tiny screw also can be used on a large bolt. Stocks of various size mechanical threadlockers are no longer necessary.

Selecting the right threadlocker There are several key factors to consider when choosing a threadlocking compound:

1. Shear strength. If all threaded fasteners were designed never to be removed, then only one type of threadlocking compound would be necessary, the strongest available. Most assemblies that are held together with threaded fasteners will, with varying frequency, need to be dismantled for repairs, maintenance, or adjustments. Consequently, threadlockers of various shear strengths are available.
2. Cure speed. The cure speed of threadlockers can vary, depending on several

factors, including temperature, base metal, surface treatments, clearance between parts, and surface cleanliness. The use of chemical primers can speed cure and result in higher ultimate strength.

3. Gap filling requirements. Most threaded fasteners are designed with some clearance between their mating surfaces. Larger clearances between mating surfaces require more product to fill them. Thixotropic liquid threadlockers will easily fill clearances in threaded fasteners, without migrating to other areas of the assembly. Where a higher shear strength product is required, and product migration is considered a potential problem, a higher viscosity compound is recommended.
4. Operating environment. Both chemical resistance and operating temperature should be considered when selecting a liquid threadlocker.

The chemical resistance properties of threadlocking compounds vary between different grades. The most popular anaerobic products will generally resist water, natural or synthetic lubricating oils, fuels, organic solvents, and refrigerants.

Like most organic materials, threadlockers lose strength at elevated temperatures. Most show significant strength retention at temperatures up to 300 F (150 C). Hot-strength formulations can increase this working temperature to 450 F (230 C) for those applications where it is considered necessary.

Removability

The most common myth about liquid threadlockers is that once they are cured, they cannot be removed. In fact, all threadlocked fasteners can be removed. Different grades of threadlocker can be used depending on the task. Fasteners secured with low- and medium-strength grades can be removed with common hand tools. Those secured with high-strength grades can be removed by applying heat for a specified time.

Threadlockers are not just for specialized uses, either. They perform effectively on fasteners and threaded assemblies of any type and size, in any kind of equipment. **MT**

Information supplied by Robert A. Valitsky, a manager of technical communications at Loctite Corp.'s North American Engineering Center, 1001 Trout Brook Crossing, Rocky Hill, CT 06067; (860) 571-5416; Internet www.loctite.com