Fastener Additions

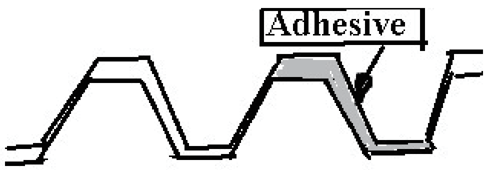
by Thomas Doppke

To produce hose clamps, large coils of wire/steel are fed into machines, where they are formed and cut out into their special shape. They are then "heat treated" where the soft metal is made stronger by conditioning it to "behave" like a spring. A variety of finishes are available for corrosion protection as well as color-coding to meet certain automotive requirements.

Also known as "What's that junk on my fastener?" there are numerous additions made to fasteners to modify their performance and improve their attachment properties. We will present a short overview of what types of post additions are currently being used, what they do and why they are required, and some pros and cons to serve as a rough guide as to what, if any, addition is needed for your fastener. For our discussion, the types have been loosely classified into several classes. These are; finishes, adhesives, sealers, plastic locking patches, oils, waxes, and other fluids and special chemicals for unique applications. Many of these chemicals serve more than one function. While each type can be enough for a separate article, we will limit this discussion to the high points only. Articles on an individual chemical's application may be forthcoming in future issues.

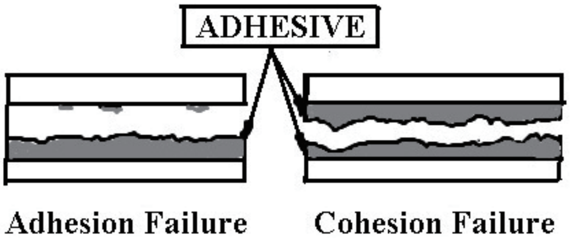
Today, almost every fastener comes with a finish; a coating over the surface which protects the part from corrosion and modifies its performance to some extent. While numerous articles have been written previously about the effects of a fastener finish upon the torque-tension relationship, most users divide up the two fields (finishes and fasteners) with little interchange between them (although lately conversations have become more frequent). Finishing magazines discuss the chemistry but they omit the effects on fastening and most fastener magazines seldom get involved with finishing and its processes. Since the subject of finish and its effects on fastener performance is well covered in past articles in this magazine, just a few points will be reiterated. For increased corrosion protection, modern day finishes have become a great deal thicker. So much so that in many cases the parts have difficulty being assembled, necessitating oversizing/undersizing of nuts and bolts.

As has been mentioned many times, only 10% of the applied torque in a joint goes into pulling up (tensioning) the joint, the rest being lost in friction between various parts of the fasteners. For this reason, the coefficient of friction of the finish plays a very important role in the final joint security. Testing of the joint with the actual parts, finished to specification, is an absolute requirement. Finishes should not be changed without re-valuation, as often happens when engineering responds to field complaints, etc. Determination of the correct coefficient of friction for a fastener with a specific finish is a lengthy process and uncertain as dimensional data also affect the results. While finish friction coefficient tables exist, the information is general in nature. For the best results the actual combination should be tested for the most accurate data.



Looking at another case of specialization; adhesive people are not fastener people and fastener people get very little information about adhesives beyond torque capability. Thread adhesives are used to retard the loosening of installed attachments generally through vibration. Most nut and bolt attachments are free spinning, that is, they mate together with little effort. The reason that they assemble so easily is that they are not line-to-line contact parts; a clearance space exists between the tips of one part and the roots of the other.

There are also back-side flank clearances in the joint. These clearances allow the parts to slip sideways (dilate/contract) during severe vibrations and to move forward and aft when impact loads exceed the clamp force. One way to reduce this problem is to fill the interspaces with a compound that will prevent movement as far as possible. Although given enough force, time and vibration, every joint will loosen. Adhesives are successful, for an increased period, in overcoming these loosening effects. Adhesives function by "filling the gap" and bonding to two surfaces into a solid structure. However, to effectively work, the adhesive strength depends upon two factors. These are the strength of the adhesive to the substrates (adhesion) and the strength of the adhesive internally (cohesion). The ideal adhesive should be balanced between these two forces.



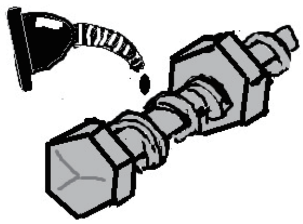
The adhesive effectiveness depends upon how well it bonds to the substrate, the roughness of the substrates, and how well the adhesive 'wets' the surfaces. Adhesives with high surface tensions do not 'wet' the surface of rough substrates and will form gaps which reduce the effectiveness of the bonding. Contaminants such as oils, die lubricants, heat treat scale, and such interfere with the adhesive bonding process. Proper surface preparation is an important and often neglected step. Temperature, aging and external stresses are the most common causes of cohesive failures. There are only a few families of adhesives commonly used with fasteners today. Acrylic adhesives, also known as anaerobic adhesives, are the major type generally used. This material is a one component material which is kept from hardening (curing) by the presence of atmospheric oxygen. When installed on a fastener and threaded onto its mating part the material's the lack of "air" in the joint allows the curing agent in the adhesive to begin to polymerize (cure/harden). This type has high shear strength, hardens rapidly in most applications, is cost effective, is easily pre-applied, and shows good resistance to vibration. While the material is available for modifications to its basic properties, it does form a brittle joint and should not be used in joints subjected to bending. It is generally incompatible with most plastics.

The next largest family of fastener utilized adhesives is the epoxy based compounds. Epoxy adhesives consist of a two-part system, a resin and a curing agent. The two compounds are kept separate from each other until they are "mixed" by the act of installation. Obtaining the right balance of agent to resin is important as too little catalyst and the adhesive bond is not effective, too much of the costly agent and the economics make usage of the adhesive prohibitive. Most epoxy adhesives used today use microencapsulation compounding. The catalyst is distributed throughout the resin base and is not reactive until the installation act crushes and mixes the two compounds. Epoxy adhesives have great adhesion and are resistant to many chemicals. However, they cure slowly and may require as much as 24 hours to affect ahardened, cured bond.

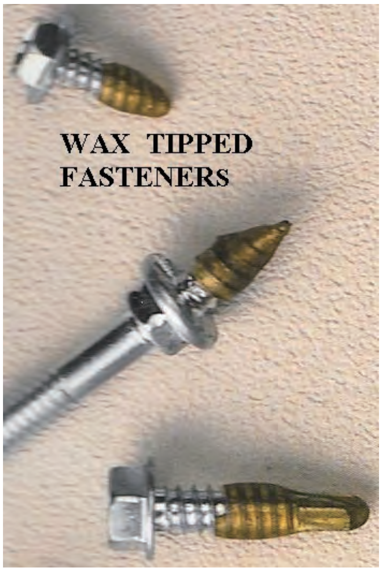
Among the advantages of adhesives in fastened joints is that the parts may be assembled without a significant increase in prevailing on torque. Another advantage is that the bonded joint, once hardened, cannot be easily broken. Many other locking element features, such as deflected locking threads, require an increase in prevailing torque to install but have a lower value in the break loose direction. While this may be enough for many joints, adhesives excel in high break loose requirement joints.

Disadvantages-For one, once the adhesive bond is broken there is not much resistance to further loosening. Adhesives are not reusable. There may be a slight hardening when an adhesive coated fastener is re-used, mainly due to the incomplete mixing of the compounds during the first installation. The value is generally very low if measurable at all. Most adhesives are sensitive to heat and many to humidity as well. Shelf life is a factor as many parts are left in the warehouse for weeks to months before use.

A quick summary is that adhesives are useful where a low installation torque is required. A very high break loose value is needed to prevent loosening of the assembly and the joint is a one-time assembly. No extra height or change to part dimensions occurs when the part is adhesive coated.



Fasteners are oiled sometimes intentionally and sometimes as the result of other processes. While chemists will object to my classifications, I call any liquid substance an "oil", a semi-liquid a "grease" and a soft solid a "wax".



These compounds first come in contact with the fastener when it is still in a wire coil form. It is covered with a rust preventive for shipping and later as a die draw lubrication to assist in dimensioning the wire to proper heading diameter. Oil-grease-wax is a part of the fastener throughout its manufacture. Heat treated parts are quenched in oil and finally as a finished protective coating, oil is the topping the parts live with. Greases, per se, have little use on fasteners except in the heading process, as mentioned above. Waxes appear on fasteners generally in three ways. They are added to parts as performance enhancers to reduce torque and galling, often used as an inexpensive solution to sealing and occasionally as a protective coating. Water and solvent based waxes have been a staple of deflected all metal locknuts for years, although the exact formulas are trade secrets of the nut companies. And thread forming bolts (for example, seat belt bolts) are waxed to reduce driving effort to meet ergonomic concerns. Small screws are often "tipped" with a glob of wax so that, when installed in sheet metal, the wax forms an effective seal against the intrusion of gases and liquids into passenger compartments.

While oil has the advantage of being viscous and flows into every cavity, this is also a disadvantage as it makes effective removal difficult. Oil left on parts from drawing, machining, and heading can prevent plating from being correctly applied. Oil inadequately cleaned from parts before heat treatment can form a 'burnt' surface, like the spoiled meal left too long on the stove. This burnt surface will restrict the formation of the phosphate coating necessary for phosphate and oil coating to successfully coat the parts. This leads, of course, to little or poor corrosion resistance. Oil from parts on sheet metal before painting causes 'fish eyes' on the painted surface, a major reason from sheet metal rejections.

While phosphate and oil coatings are used extensively they tend to have low corrosion resistance. Part of the reason from this is that there is no specification for the oil to be used in this process. A quick review of the coating-the phosphating process converts the surface of the steel to iron phosphate. This is a porous compound. The oil then soaks into this 'sponge' and increases the corrosion resistance from a few hours to several weeks or months. Whereas formerly there were few coaters which produced a consistent product, now the process is done by everyone and anyone who wishes the coating applied. To save costs and whatever other reasons the operators use any oil available, from used motor oils to, in none case, leftover deep fryer vegetable oils. Some of the synthetic oils are not very cleanable and carryover oiled surfaces are a problem causing many of the problems mentioned above. With no specific oil specified in most phosphate and oil specifications you'll get whatever torque value and corrosion resistance you happen to get, and probably not the same thing twice in a row.

One final caution about oil. Oils and petrochemical compounds are known to cause crazing and cracking of certain plastics. Although only certain plastics are prone to this, they happen to be the ones most used in trim and interior design on vehicles (ABS, polycarbonates, etc).

In summary, the section of an oil or wax to be used on/with a fastener or in a fastener application should take into consideration the following points. The environment that the material will exist in should not be one in which the petro-chemical promote corrosion, degradation of the material, stress cracking and that it will not offer much protection in severe atmospheres. It will penetrate services and small areas well which will also present problems when such areas are required to be cleaned for further processes. Often oils are blended with further additives such as anti-bacterial inhibitors, drying agents, stabilizers and such. While specifying a specific composition over a general industrial specification would be ideal, the designer will find that there will be great resistance from vendors and your company's superiors.

The following table shows the effects of a few different oils on torque. The sample used was a 3/8-16 hex nut, plain finish, soft, washed and degreased with benzene and ketone, mated with a SAE grade 8 bolt, stock phosphate and oil plated but from same lot manufacture. Nut was lubricated. 10 samples each condition.

Sample	Average Torque	Change
Plain, dry	19.75 lb.ft.	0
SAE 30 wt. oil	16.5	16.5% lower
MoS2 (Molybdenum Disulfide)	15.75	20.3% lower
Light Door Grease	16.15	18.2% lower

Variations with other oils and with samples from other sources and lots showed values from 9% to as much as 35% lower torques. (Unfortunately we did not get samples of the used deep fryer oils. It would have been interesting to see what French Fries do to our torque !) Sealers were mentioned briefly previously. They are generally of two types; adhesive sealers function as both an adhesive and as a sealer. They are usually pre-applied to the fastener to save time, mess, and handling. They affect the torque-tension relationship and testing should be done to determine variation from standard parts.

The other type, called mastic, is made of a soft, malleable compound, which is compressed during installation, sealing off the crevices of adjacent areas it is in contact with. Preventing the intrusion of gases and liquids into, around, and through the fastened joint at the bolt shank to washer clearance joint, the underhead bolt surface to substrate, and the thread spiral, it is an addition used in many underhood automotive areas. The composition can be varied to fit the application with foams, rubber, plastic, and a family of organic tar-like chemicals occuring. Guidelines when using mastic sealers include: keeping the clearance hole as small as possible; use as soft a compound as practical to allow excess to be squeezed out during installation; use closed cellular mastic to prevent "sponging"; and if possible, design an undercut section on the fastener to allow inwards flow for maximum sealing. A handy formula for OD calculation of mastic applied to washers is:

OD = 2D-d + 1/32"

Where D = maximum diameter of clearance hole to be sealed

And d = minimum diameter of bolt.

With every collection of fastener ideas there is always that group called "Others" or Miscellaneous". These items are occasionally encountered, function well in their particular situation, and do affect the joint integrity. In many installations, a fastener is placed in a hole but not immediately tightened. To prevent its loss until its installation a drop of a rubbery "goo" is applied on the threads. This acts to prevent it from falling out down the line. The effects of the dollop on torque-tension is generally unknown. The solution is expensive and requires, as could be expected, extra handling to avoid mix-ups, cost, volume considerations, and all the expenses usually incurred with a "special" part. But it does solve a special problem.

In the 1980's the OEM automotive companies went to a high build primer paint to reduce the steps in painting sheet metal and to improve corrosion. This paint caused big problems with the fasteners that were present on the sheet metal during painting. Weld nuts, pierce nuts, miscellaneous studs and clips, body mount bolts, all would jam up, have erratic torques and uncertain tensions, not even assemble in some cases. The solution was to apply a PTFE compound to the thread areas only which insulates the threads from the electrostatic high build paint. Although the compound was removed by the later installation of the mating fastener, concerns about the effect of the compound upon the T-T relationship are still present. This compound is also used to protect threads from weld splatter (on weld nuts and studs) effectively.

One additive of fasteners which we will not discuss is the plastic locking patch. Starting out originally as a strip or dot of plastic, milled into the thread area, later versions were sprayed on to save cost. There are numerous articles on this addition to fasteners which can be accessed from literature by any interested reader.

Dyes and colorants are used to identify them in certain applications. Close diameter metric sizes are often colored yellow, blue, green, etc. in the small ranges (M1-M4). Metric M6 parts were colored blue to distinguish them from inch ¼" parts when the United Stars began to convert seriously to metric products in the 1960's.

There are many other things added to a part on its journey from manufacturer to the user's site. Some may have a major impact on the attachment's reliability and some may not even be noticed but all will sneak up on the unsuspecting engineer unless they are aware of them, hiding out there, specified or unbidden.