

Optimizing Lubricity in Plated Fasteners

Q. We currently plate fasteners for an automotive OEM, and we are looking to expand our capacity. When it comes to torque tension modifiers, I am wondering why I can't use a single torque modifier for all applications? Can't I just dilute the solution to adjust the coefficient of friction (CoF) value?

A. This is an understandable question, and it would certainly make things easier if one torque modifier could be used for all applications. From the standpoint of electroplated fasteners, torque tension modifiers are oftentimes the final piece of the puzzle. They are typically applied following passivation of the electroplated deposit. These coatings provide a number of different features including enhanced gloss, better durability, greater corrosion resistance and a more uniform finish. The most important property of these topcoats is their ability to provide the proper amount of lubricity (or slip) for fastener installation.

When fasteners are tightened, a certain amount of torque (rotational force) is applied to them. As torque is applied and the assembly is being tightened, the bolt is being stretched. The amount that the bolt is stretched is a function of the friction that is being generated. If the friction within the coating is exceedingly high, then a lot of the input torque is being used to overcome that friction. This leaves only a very small portion of torque to induce actual assembly tightening. As a result, the fastener has the potential to self-loosen. On the other hand, if the coating is too lubricious, or slippery, and the friction is very low between the fastener and the nut/bearing surface, this can lead to excessive fastener stretching and even fracturing (tensile overload). Torque tension modifiers are *specifically designed* to provide a defined amount of lubricity to ensure the bolted joint is adequately tightened. This will vary by substrate, which is why, to answer your question, one torque tension modifier will not work for all scenarios.

Different electroplated finishes possess different material properties, which impact torque tension performance. For the purposes of this article, we will be focusing on zinc and zinc alloy finishes. It's often not appropriate to use the same torque-modifying topcoat for zinc and zinc-nickel (Zn-Ni) due to their need for differing levels of final lubricity to meet many OEM requirements. All else being equal, when treated with the same topcoat, Zn-Ni (12-15% Ni) will possess a higher CoF than zinc. This is primarily due to the differing levels of hardness between zinc and Zn-Ni. Relative to zinc, the inclusion of a harder metal (nickel) in Zn-Ni alloys will lead to a higher CoF for a given topcoat.

All major OEMs have published exact specifications that include CoF requirements. Within these specifications, the fastener type, bearing surface and test nut that are mandatory



for testing are also listed. This helps standardize the assessment of topcoats and their ability to achieve a specific CoF. Maintaining that tight CoF range ensures the bolted assembly is optimized for a given torque value.

While we've discussed factors such as topcoat choice and deposit type playing a part in your eventual CoF, there are other factors as well:

Topcoat concentration. During dip spin applications, coating retention and viscosity are affected by the topcoat concentration. Low concentrations can cause a wider statistical spread or high CoF as the coating is too diluted to adhere well to the fastener during basket spinning. High concentrations can cause thread fill and other noncompliant finishes.

Spin speed. During the dip spin process, your basket rotation will impart a specific amount of rotational force on the fasteners. High RPM may shear off too much of the coating, leading to higher-than-anticipated CoF and inconsistent spread, while low RPM has the danger of causing buildup within the threads and fasteners adhering to each other during curing.

Passivate. Surprisingly, your passivation choice can affect your CoF as well. The thicker passivates tend to have enhanced porosity and greater hydration, which can lead



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to better topcoat uptake. Likewise, this may contribute to a lower CoF relative to a thinner passivate. This is the case for black Zn-Ni passivates compared to clear/blue Zn-Ni passivates as well as iridescent zinc passivates compared to blue-bright zinc passivates. Certainly not all passivates are created equal. One supplier's black Zn-Ni passivate may be thicker than another. Yet, all else being equal, the thicker passivates can result in lower CoF.

Heat treatment. Electroplated fasteners are commonly subjected to heat treatment (baking) for the purposes of preventing the detrimental effects of absorbed hydrogen within the coating structure. In many instances, this baking procedure is often performed following electroplating and passivation of the fasteners. This protocol often leads to increased CoF, especially for thicker passivates compared to fasteners that are not heat-treated. This is likely due to the chemical and physical changes that high-temperature baking induces such as dehydration, changes in passivate porosity, increased hydrophobicity and so on.

Bearing surface and test nut. Lastly, recall that different OEMs have different testing protocols for torque-tension modifier assessment. This includes the use of different bearing surfaces and test nuts, as well as different fastener types. The interaction of these test surfaces all impact the eventual CoF. For example, the use of a hardened steel washer will physically abrade and shear off portions of the zinc fastener. Furthermore, passivate differences are

magnified in these cases as well. Where one might not see a large CoF difference for thick- and thin-film zinc passivates when using zinc-plated test washers and nuts, the CoF difference will be magnified when using hardened steel test washers and nuts. Similarly, the use of softer metals like aluminum leads to significantly higher CoF values when testing Zn-Ni fasteners due to contributions from ploughing friction.

As referenced above, OEMs designate what material and physical properties need to be achieved for a specified finish type. This includes everything from corrosion resistance, appearance, coating thickness, galvanic compatibility and of course coefficient of friction requirements (which will vary by substrate).

To reiterate, the most critical property of torque modifiers is their ability to provide the proper amount of lubricity (or slip) for fastener installation. Torque tension modifiers more or less have the final say on what CoF you attain on your plated deposit, but they aren't the only important variable. As we reviewed, a number of different factors affect that final friction value including passivate choice, testing nut/washer, topcoat concentration, dip spin rotational speed and basket size, high-temperature baking and your plated deposit of choice. Your chemical supplier should have ample knowledge of these conditions and how they affect your CoF. It's important to consult their expertise concerning process variables to ensure you are consistently meeting OEM requirements. ■■

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