Improving friction control coatings

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Ref: FFM731201/120

Originally published in Fastener + Fixing Magazine Issue 73, January 2012.

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An improvement to leach and seal was to incorporate dry film lubricants in the coating to lower the coefficient of friction (CoF) of a fastener. With the introduction of high performance trivalent chromium passivates in 2000, the technology evolved into processes applied at room temperature. These were more sympathetic to the underlying passivates, giving high quality black finishes without the use of thick film paints.

One major global automotive OEM followed this evolution, moving from hexavalent passivates with leach and seal, to trivalent passivates with a thin film topcoat and lubricant combination. The following outlines these technologies and the decision making process for change.

Leach and seal

Arguably the best-known leach and seal process is the MacDermid JS500 system. Used alone, it reduces the CoF range of pure zinc from >0.4 to 0.22 +/- 0.08. Combined with an integral lubricant it reduces the CoF to 0.12 (+/- 0.02). This integrated process (known as JS600) provided the required protection, improvement and lubrication for the majority of their fasteners.

Change instigates higher performance requirements

Around the year 2000, the ELV directive drove many automotive companies to upgrade their existing plated fastener finishes requirements. Typically this was the new specification:

- Higher corrosion resistance.
- Compatibility with trivalent passivation.
- CoF 0.15 with a deviation of +/- 0.02.
- New CoF requirements for different fastener innovation.
- Identification with an integral UV tracer.

The answer was a new breed of topcoats. These mixed inorganic and organic compounds and gave thin topcoats which adhered to and respected the underlying passivate, presenting significant improvements in neutral salt spray (corrosion) resistance and a very predictable CoF of the desired 0.15. As the topcoat is so thin and transparent, its application can be verified by the presence of tracers, which maybe seen under a UV lamp.

Let us review how these new topcoats achieve these performance enhancements.

Higher corrosion resistance

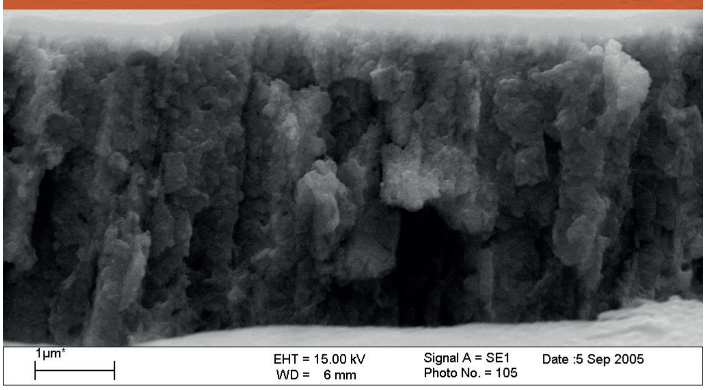
Three effects are taking place to increase the overall protection: (i) water resistance (ii) corrosion inhibition (iii) adhesion to the passivate layer.

The first line of defence is that the coating performs as a barrier layer. The topcoat prevents water reaching the surface by providing a strong hydrophobic layer. The homogeneity of the coating also prevents premature swelling of the coating by water absorption. The second defence is the presence of corrosion inhibitors throughout the coating. These help to seal the coating in any areas where minute discontinuities in the film might occur. Thirdly the adhesion to the passivate layer is so strong that any 'undercutting' of the film is prevented. This is particularly important on sharp profiles (where the coating will typically be thinner).

Compatibility with trivalent chromium passivates

The original leach and seal coatings were designed around hexavalent chromium passivates. The leach process ensured exceptional adhesion by combining the passivate with topcoat layer. Trivalent passivates are homogenous layers and not so easy to leach. So the new products had to adhere to a smooth and pore/crack free coating. They also had to be compatible with various types including thin film (typically blue) and thick film (iridescent or black) passivates.

The homogeneous trivalent chromium passivate layer



Narrow range coefficient of friction

All fasteners have a designed maximum proof load. Creating the correct torque-tension relationship achieves maximum joint security without exceeding the proof load of the fastener.

Zinc and zinc alloys have a relatively high and variable coefficient of friction. This can adversely affect the torque-tension properties of fasteners. Additionally, passivates offer different levels of CoF. For example, it was noted that hexavalent passivates have an average CoF of 0.4, whereas a high build trivalent could be as high as 0.5.

If fasteners are used without a friction control fluid, the increase in friction results in lower bolt tension for a given torque, resulting in a joint weakness, which leads to poor clamping, insecure joints and, possibly premature bolt fatigue failure. Conversely too much can lead to bolt fracture and thread stripping. This factor becomes even more crucial in safety critical applications, such as wheels, seat belts, steering and suspension component systems.

Therefore lubricated topcoats provide both a lower friction coating than simply metal to metal joints; and also makes the relationship more predictable, avoiding too low or too high clamping forces.

Returning to our OEM, they changed to the newer topcoats in order to consistently achieve this predictable surface CoF. Another consideration was to ensure that all applicators, across an increasingly global supply chain, conformed to the same standard. Incorporation of the UV tracer permits verification that the right topcoat has been applied.

New range coefficient of friction requirements

As new fastener technology is introduced, new CoF ranges are demanded, whilst still maintaining the corrosion resistance and compatibility with trivalent passivates. The most current dry film lubricant systems can be tailored to meet these new CoF demands, while still returning low variability.

Summary

Dry film lubricants have evolved from leach and seal processes, designed primarily for hexavalent chromium passivates, to non-leach systems compatible with trivalent chromium passivates. Coupled with outstanding corrosion resistance, the non-leach technology delivers exceptionally predictable torque-tension relationships without interfering with the dimensional tolerances. Additionally they can be modified to meet newer demands for friction ranges. This technology allowed a major global automotive OEM to improve the effectiveness of the fastener assembly operations by consistently returning desired corrosion and coefficient of friction on zinc and zinc alloy plate and trivalent passivation systems. ■

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