Reliable protection for fasteners

Surface coatings for the automotive industry

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Volkswagen and General Motors have recently approved a third generation, high-performance chromium (VI)-free microlayer corrosion-protection system (MKS) that complies with their material specifications TL 245 (VW) and GM 3359 respectively for protecting metric threaded parts made of high-strength steel against corrosion. This non-electrolytically applied zinc-flake coating provides reliable protection where standard methods, such as hot dip galvanizing and electroplating cannot be used for technical reasons.

While electroplating and hot dip galvanizing provide adequate corrosion protection for non-high-strength steels, neither of these methods can be used for high-strength base materials. The hardness of the steel is predominantly achieved through well-defined temperature control (quenching and tempering) when processing the steel. As a rule, the reheating temperature for this process lies between 340 and 425°C. This value has a crucial effect on other heat treatment processes. However, the temperature of hot dip galvanizing is higher than that used for the heat treatment because the melting point of pure zinc is 420°C. During the galvanizing process, the hardness of the steel changes uncontrollably. Electroplating cannot be used for coating high-strength steels.

Since the component is used as the cathode, atomic hydrogen is generated on the surface when it is immersed in the electrolyte. The hydrogen diffuses into the substrate and some of it then remains in the form of dissolved hydrogen in the interstitial sites of the metal's crystal lattice. This leads to hydrogen embrittlement - a term used for a series of failure mechanisms. The most important of these mechanisms is hydrogen-induced stress corrosion since this results in immediate failure of the component without showing any preliminary signs of damage. However depending on the structure of the electroplated layer, the effusion of the hydrogen is possible by means of tempering. This process is costly, both in time and money, and the method never eliminates the problem altogether.

Zinc flake as an alternative

Primarily, zinc flake coatings are used for high-strength materials. These coatings contain flat zinc plates about 10 µm across which are bonded to the component with a binder system. The technique used for this “painting process” varies and is mainly determined by the shape of the component:

- Dip-spin systems for medium sized mass produced small parts (such as bolts and screws),
- Spraying for large bolts and stamped parts and
- Dip-drain for tubes or larger panels with simple geometries.

After the coating has been applied, it is cured at relatively low temperatures (›Delta-Tone‹ at 180 to 200 °C, ›Delta-Protekt KL 100‹ at 200 to 230 °C, competitor's product at 300 to 360 °C).

When finished, the cured coating contains about 85 % metal, most of which is zinc. Because of the high metal content, the flakes overlap one another, touch one another and therefore form a conductive coating.

Zinc provides sacrificial protection

During corrosion, the individual zinc flake is converted to $Zn(OH)_2$. This produces what we call white rust. The oxidation process (according to the model) releases electrons on this lamella and all other parts that are in conductive contact, including the steel substrate. Since, according to the electrochemical series, zinc is less noble (at –0.7 V) than iron (at –0.44 V), the zinc flake layer also corrodes in preference to the steel when mechanically damaged (scratches). These electrons are of course constantly consumed by the corrosion process. The reduction of oxygen is the most probable reaction to take place in the presence of moisture.

The properties of zinc-flake materials described above can be extended even further. A supplementary coating with a topcoat can be used to optimise properties selectively such as colour, friction values, wear resistance and chemical resistance. There is a fundamental difference between organic topcoats that are usually epoxy based and inorganic topcoats that are usually silicate based. As a rule, the organic topcoats (such as ›Delta-Seal‹) provide better protection against chemicals (Figure 1), while the inorganic topcoats (such as ›Delta-Protekt VH 300‹) can be applied in much thinner layers – and therefore with tighter tolerances (Figure 2). Common to all topcoats, however, is that the desired friction value can be obtained with the addition of an integrated lubricant.

Topcoats increase protection

Of course, a topcoat also increases the corrosion protection of the substrate by sealing the cathodically active surface of the zinc flake basecoat. Thus, the combined use of an approximately 8 µm basecoat and a 3 µm inorganic topcoat will provide a service life during a salt-spray test according to DIN 50021 SS of more than 1000 hours and up to three cycles in the “Daimler Chrysler” test, (condensate test), where one cycle corresponds to 14 days.

There are clear advantages associated with the use of third-generation MKS materials. Using the same coating thickness as, for example, Delta-Tone 9000, which has been proven for years, the corrosion protection can be significantly improved, which can also considerably extend the service life of the finished component. Alternatively, by optimising the coating, it is also possible to reduce the coating thickness and therefore the material consumption when the stresses on the coating are not expected to be too high. The material price of the new Delta-Protekt KL 100 zinc flake systems is thoroughly comparable with that of the established system mentioned above.

Figure 1. Corrosion protection using ›Delta-Protekt KL 100‹ and the coloured ›Delta Seal‹ topcoats

Figure 2. High-performance corrosion protection ›Delta-Protekt‹: Test-bolts, coated with ›Delta-Protekt KL 100‹ and ›Delta-Protekt VH 300‹ after 1000 hours of testing according to SST DIN 50021

For the coater, therefore, there is no difference in the material costs.

Significantly thinner layers

The new siliceous topcoats are also associated with a great range of advantages. In contrast to conventional, epoxy-resin based organic topcoats, for example, the lubrication of these topcoats is not diminished even following long exposure to thermal stress (up to 100 hours at 180 °C). Since these coats are applied in significantly thinner layers of around 2 to 3 µm, they offer significant corrosion protection even where tolerances are low. This not only creates the added benefit of very high yields associated with these inorganic topcoats, but the layers of organic topcoats required are generally thicker by as much as 8 µm.

■**Literature:**

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