Choosing Plating Coatings for Best Performance

Q. I know there is much to be considered when choosing a coating for various substrates and that zinc-nickel seems to be a desirable choice. Will you provide an overview of the functionality of plated coatings on various substrates?

A. Plated coatings are essential for enhancing the performance and longevity of fasteners and automotive and industrial components. The appropriate choice of coating depends on several factors, including the substrate material, environmental exposure and specific application requirements.

To determine the best coating for a plated component, several critical factors must be evaluated:

- **Corrosion resistance:** How well can the part withstand environmental exposure?
- **Durability:** Will the coating endure mechanical stress and/or abrasion?
- **Temperature:** What are the operating temperature conditions?
- **Torque-tension needs (for fasteners):** How does the coating influence fastening performance?

Corrosion resistance and the galvanic series. A key foundation for selecting metallic coatings begins with understanding the galvanic series seawater table. This tool compares metals based on their electro-potential volts in seawater. Metals farther apart on the chart have a higher galvanic corrosion potential when paired. For example: Anodic coatings such as aluminum, zinc, cadmium and zinc-nickel are considered sacrificial coatings that protect steel substrates. Cathodic coatings such as nickel, tin and copper are non-sacrificial coatings that do not provide sacrificial protection to steel. Zinc-nickel coatings exhibit a lower potential difference with steel (0.1 volt compared to 0.31 volt for zinc), reducing galvanic corrosion rates. As a result, this electro-potential difference makes zinc-nickel an excellent choice for high-corrosion environments.

Durability and temperature resistance. Durability and temperature tolerance are critical considerations when selecting coatings. For instance, zinc-nickel has a Vickers hardness of 400-500 HV, significantly higher than the 100 HV of pure zinc, which makes it far more resistant to abrasion and handling damage. Additionally, zinc-nickel coatings can perform better in under-the-hood temperatures, maintaining better corrosion resistance, and can achieve more than 1,000 hours of neutral salt spray protection before red rust forms. These characteristics make zinc-nickel a preferred choice for high-performance and high-temperature applications.

Torque-tension additives and requirements. There are different types of torque-tension additives used for various alloys and substrates. A modifier designed for zinc will not perform or provide the same coefficient of friction for zinc-nickel or tin-zinc. Each additive can perform differently in areas of lubricity, corrosion protection, porosity and coefficient of friction. It is critical to use a torque-tension modifier designed specifically for the coating being applied to ensure the requirements of the specification are met.

The coefficient of friction needs can vary based on the coating, substrate, end use and OEM specifications. Proper selection and application of torque-tension modifiers are essential to achieving consistent performance and meeting design parameters. Improper tightening can result in loose or broken bolts, jeopardizing joint integrity. Torque-tension testing equipment evaluates critical parameters such as clamping force, friction and yield point, providing manufacturers and OEMs with data to optimize safety and performance.

Passivates and torque-tension relationships. Conversion coatings, such as trivalent passivates, enhance corrosion resistance and influence the appearance of fasteners. These passivates, available in various colors, extend the time to white corrosion and improve base metal protection. Sealers can be added on top to enhance salt spray resistance, gloss and lubricity.

Torque-tension requirements are another essential consideration. Lubricants applied over passivated fasteners ensure proper torque-tension relationships. Specialized testing equipment enables detailed analysis of these relationships, ensuring fasteners meet the specified tightening characteristics without breakage or vibration.

Advantages of zinc-nickel coatings. Zinc-nickel has emerged as a preferred electroplated coating for many industries due to properties like corrosion resistance (high protection levels in harsh environments), hardness (resistance to mechanical damage during assembly), thermal stability (excellent performance in high-temperature conditions) and hydrogen embrittlement mitigation (microcracked structure can enable hydrogen escape).

Practical applications. Electroplated coatings such as zinc-nickel are widely used in automotive, aerospace and industrial sectors for fasteners and components. They are particularly suitable for barrel applications (fasteners and small parts) and rack applications (brake components and larger assemblies).

Alkaline and acid zinc-nickel processes offer specific benefits tailored to application needs. Collaboration with knowledgeable suppliers ensures the right process is selected to meet performance criteria.

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