

The Benefits of Electroless Nickel Plating

Q. We have a well-established customer offering us an opportunity to get into electroless nickel work with an available line we have. Can you provide an overview of the benefits of electroless nickel plating, including the different categories, and the differences and applications of each?

A. Electroless nickel plating is a coating process that deposits a nickel-phosphorus alloy onto a substrate without the use of an external current source. This barrier coating process adheres to a variety of substrates and protects the substrate by sealing it off from the environment, rather than by traditional galvanic or sacrificial action. It is worth noting that electroless nickel plating can also deposit a nickel-boron alloy onto the substrate, but for the purposes of this article, we will limit our focus to the nickel-phosphorus alloy, which is more commonly used throughout the plating industry.

Key benefits of electroless nickel plating include uniform coating, durability and corrosion resistance. Electroless nickel's coating capability is well known for depositing an even layer across complex geometries. From a durability standpoint, high hardness and wear resistance are important considerations for industry applications, with the coating having an ability to achieve up to 1,100 Vickers (HV) when properly heat-treated. Finally, the amount of nickel-phosphorus alloy in the EN coating has the ability to provide superior corrosion resistance and hold up well in harsh environments. Lubricity is an additional benefit of electroless nickel coatings, and is especially applicable for hydraulic applications, valves and other moving parts where friction reduction is necessary.

From an overall industry perspective, electroless nickel is commonly used in the oil and gas field for drilling equipment, valves and pumps as it offers excellent durability, wear resistance and protection against harsh environmental conditions. In the automotive industry, it is used for engines, fuel systems and additional components that require high wear resistance. A similar workhorse environment where it can be found is in the aerospace industry where electroless nickel's durability and protection is needed for the extreme conditions to which engines, turbine blades and landing gears are subjected. The process is also used in the medical and electronics industries.

Electroless nickel is broken down into three categories of high, medium and low phosphorus-containing deposits. The varying amounts of the phosphorus contained in the deposits dictate the specific wear resistance, hardness and corrosion protection properties of each, which can help determine the suitability for various applications.

Low phosphorus electroless nickel plating falls into the range of 2-5% phosphorus and offers the highest wear resistance and hardness. Performance-wise, it has lower corrosion resistance and contains magnetic properties. It is often suitable for hydraulic cylinders, pistons and other parts that routinely endure abrasive conditions. The hardness of



Source: Getty Images

this coating typically ranges from 600-700 Vickers (HV) as deposited, which can increase to approximately 850-1,100 Vickers (HV) after a post-plate heat treatment.*

Medium-phosphorus electroless nickel plating contains a range of 6-9% phosphorus and is the most popular choice. It is commonly selected by engineers and applicators as it is the most well balanced and versatile of the three, providing both excellent hardness and corrosion resistance for a variety of industry applications, such as oil and gas equipment, automotive engine components, industrial machinery and tools, aerospace landing gear and more. The hardness of this coating typically ranges from 500 to 600 Vickers (HV) as deposited. A post-plating heat treatment can increase it to approximately 800-1,000 Vickers (HV). Medium-phosphorus electroless nickel offers strong performance benefits and is more cost effective than high-phosphorus coatings. It is widely used and known to be easy to implement and control for various industrial settings.

High-phosphorus electroless nickel contains a range of 10-12% phosphorus. Its primary performance feature is its superior corrosion resistance in highly acidic or corrosive (such as marine and chemical processing) environments. It has a lower hardness value (only 450-525 Vickers HV as deposited), but can be heat-treated after plating to improve hardness properties (to 850-950 Vickers HV).



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**The heat treatment process is performed in a controlled atmosphere and typically involves heating the plated components to temperatures between 300°C and 400°C (572°F to 752°F) for 1-2 hours. The exact temperature and duration can be adjusted based on the desired hardness and the specific application. The choice of substrate can influence the effectiveness of heat treatment.*

When looking at the three categories of electroless nickel, it is also helpful to consider the end-use environment of your application from an acidic versus alkaline standpoint to further determine the phosphorus content needed. For highly acidic environments, high phosphorus electroless nickel is the preferred choice based on its corrosion-resistant properties. For alkaline or mildly acidic environments, medium phosphorus electroless nickel is a good and versatile choice, offering the right balance of corrosion resistance, hardness and cost-effectiveness. Medium-phosphorus is suitable for a broad range of industrial applications where exposure to alkaline substances is common. Low-phosphorus coatings offer good performance in alkaline conditions, but are less effective in acidic environments.

As you consider the option of putting in an electroless nickel line, know that applicators often appreciate electroless nickel for its fast deposition rate, excellent bath stability and long solution life. After setup, operation

of the electroless nickel process is not overly complex. Pretreatment cleaning and activation prior to plating are critical steps to ensure proper adhesion. As previously mentioned, heat treatment can be applied after plating to increase hardness and wear resistance. Good filtration, routine bath analysis and replenishment are also important components of managing the process. Some electroless nickel systems contain cadmium and lead while others on the market are cadmium and lead free. RoHS compliance can also be a determining factor for applicators. Be sure to work with a knowledgeable chemistry supplier who can help you select the proper type and optimize your line for maximum efficiency.

To summarize, electroless nickel plating provides a uniform barrier coating which can offer strong wear resistance, excellent corrosion resistance and enhanced hardness, all of which make it a highly desirable choice in various industrial applications. These performance attributes will vary based on the amount of phosphorus in the coating, and heat treatment can be used to further enhance the hardness of electroless nickel coatings. Reviewing the performance requirements, applications and environmental factors the coating will be subject to, as well as selecting the phosphorus content that will meet those specific needs will help you ensure the protection and longevity of your finished components. ■■

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