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METAL FINISHING SOLUTIONS BEYOND THE SURFACE

THE TOTAL EN SOLUTION

The Total EN Solution:
Recommending the Best EN Process for the Application

Abstract
This paper discusses the importance of understanding the needs of your customer before quoting or recommending an Electroless Nickel (EN) process. All too often, the basic questions are never asked, leaving the success of the application to chance. The importance of improved communication between the metal finisher and the manufacturer will also be addressed. Particular emphasis will be placed on pretreatment tecniques, EN chemistry formulations, post-plate processes, and testing options. EN applications will be discussed as a total process, rather than as individual elements.

The Total EN Solution:
Choosing the Best EN Process for the Application

Anybody who has spent any amount of time in or around the metal finishing industry has probably seen plating requirements on prints that leave a lot to be desired. One of my personal favorites is the classic callout for “Nickel Plating” on an engineering drawing or purchase order. That’s it, nothing else. Just “Nickel Plating”. It’s kind of like walking into a Baskin-Robbins 31 Flavors and ordering “ice cream”! “Excuse me, but could you be a little more specific? Electroless? Electrolytic? Sulfamate? Watts? High-phos? Mid-phos?” (You get the picture). Such a poorly defined requirement is likely to spark a heated debate over the actual type of nickel plating the engineer had intended, and in the hands of a “less-than-reputable” metal finisher, can completely undermine the intent of the application. For certain applications, more than one Electroless Nickel (EN) process may provide adequate results, but in most instances there is clearly a “best option”.

Most part drawings have the plating requirements defined in the note section or through the use of a specification callout. And unless the requirement seems outdated or inappropriate, the plating requirements are typically non-negotiable. However, when the requirements are not clearly defined or perhaps are not the best available option, we as metal finishers have an obligation to help the customer resolve any inconsistencies. Many loosely specified plating requirements still exist, either because of changes in technology, as an oversight, or out of a lack of knowledge regarding all of the available choices. As an industry, we need to help educate and actively promote the most current information regarding EN to the industries we serve. Although those of us who provide EN services may “hold these truths to be self-evident”, apparently we still have a lot of work to do in the educational arena. Therein lies the opportunity!

In today's business climate, we hear the buzzwords such as “partnering” and “strategic alignment” so often they become almost second nature. But what do they really mean? As corporations strive towards vendor-base reduction, the need for improved communication between the design engineer and the metal finisher becomes even more critical. Suppliers are expected to provide more than just commodity services at the cheapest price. Although this greater level of communication places a bigger responsibility upon the metal finisher, it can also lead to greater rewards. Long term relationships and/or contracts, input on finishing requirements at the design stage, preferential vendor status (approved supplier, etc.), and additional opportunities for vendors who consistently perform well, are just a few examples.

Although it sounds amazingly simple, there are many instances where the right questions are never asked, and the result is a less-than-satisfied customer. Determining the best EN process can only be accomplished by asking the right questions up-front. Fully understanding the specific requirements will undoubtedly lead you down the right path towards recommending the best EN process to the customer. What are the customer's expectations of the EN plating? What are the primary and secondary functions of the coating? What service environment is the plated component going to be used in? What properties does the application require, and in what order of priority? Is a specification or specific process appropriate, or is a lesser degree of detail sufficient? The answer to these and similar questions are essential to the success of the application.

Gathering Information

One of the best methods of gathering all of the pertinent information is through the use of a checklist. By using a checklist, nothing about the specifics of the application will be overlooked. Most often, it can be completed directly by the customer or prompted along by any member of your staff, even non-technical personnel. Usually prototype and other R & D projects do not include prints or other written plating requirements. For these situations, it is especially important to gather as much information as possible about the part and the application. Some of the key information most frequently requested is included in the following sample:

Part Information
Part #
Material:
Hardness:
Est. Annual Volume:
Masking Req'd? Y / N
Barrel vs. Rack:

Application Information
Main objective of EN plating: (rate in order of importance)
___Corrosion Resistance
___Hardness / Wear
___Solder / Braze Application
___Uniform Dimensional Buildup
___Release Properties / Low Co-efficient of Friction
___Cosmetic Appearance
___Other: ______________________________________

Current plating requirements:
Other coatings used / tested:
EN thickness requirements:
Part Function:
Service Environment Conditions:
Process Requested by Customer:
Testing requirements / methods:
Additional application information:

The Total EN Process

A plating process is more than just dunking the parts into a plating solution. In fact, the EN plating solution is only one component in a sequence of processing steps. Although the bath chemistry and composition are very important elements of the EN plating process, there are other considerations that can be equally important to the success of the application. The best plating process is one that, after careful evaluation of all of the available application information, translates into a well-thought-out, clearly defined sequence of pre-plating, plating, post-plating, and/or testing processes. If done correctly, the result will be highly consistent EN plated components that perform to expectations, at a cost-effective price. Once the process has been proven to be successful, the specifics should be captured either on the drawing or in a procedure to ensure future success.

Pre-plating Considerations

Stress Relief

Always consider the necessity for pre-plate stress relief on hardened steel components. Depending upon the alloy, hardness (ultimate tensile strength), manufacturing practices, and the end use of certain components, pre-plate stress relief may be recommended to reduce and/or redistribute localized residual stresses left behind from machining, forming, welding, heat treatment, or other manufacturing processes. All of the major EN specifications make reference to stress relief treatments prior to EN plating. Although you may not be plating to a specification, it is usually prudent to incorporate stress relief into the EN process for hardened steel components. Specific time and temperature guidelines can be obtained from industry specifications such as AMS 2404, AMS 2405, MIL-C-26074, and ASTM B-733.

Mechanical Finishing Techniques

Mechanical finishing operations are frequently performed to obtain an acceptable surface finish or to remove gross surface contamination, such as mill scale or weld slag. Vibratory deburring, blasting, and tumble finishing techniques improve the surface condition of the unplated component and can significantly enhance the performance of the EN plating. Shot-peening techniques are frequently used to redistribute localized stresses resulting from machining and fabricating processes.

Chemical Pretreatment

Know your strengths and weaknesses! Are the components made from unusual or difficult to plate alloys? If so, highly specialized pretreatments may be necessary to ensure adequate initiation, adhesion, and overall deposit quality of the EN. Often times special activation processes, electrolytic strikes, or immersion pre-plate deposits may be required to obtain acceptable results. Without the most appropriate pre-treatment capabilities and the expertise to utilize them properly, there is a good chance that the results may fall well short of your customer's expectations. You are doing your customer and the EN industry a disservice if you use inadequate or questionable processes to pre-treat difficult alloys. Usually, short-term gains are far outweighed by the negative effects of questionable processing practices. Most often, it is better to refer those jobs to vendors that have adequate capabilities and experience. Unfortunately, even a single bad experience may unjustifiably lead to a negative opinion of Electroless Nickel coatings, even though the true problem is often a vendor-related incident.

EN Plating Chemistry

Entire volumes of information and related data have been published regarding the properties and applications of Electroless Nickel. Rather than embark upon a deep discussion of the specific EN bath and deposit properties, this paper is intended to emphasize the importance of becoming technically familiar with these topics. All of the major proprietary EN chemistry manufacturers have "hybrid" chemistry formulations that produce deposits possessing unique properties. Furthermore, EN chemistry manufacturers supply product information and technical advice that should help determine the best EN chemistry for each individual application.

Most EN chemistry manufacturers have a few all-purpose "workhorse" platin chemistries that can be used to adequately accomplish the primary and secondary EN plating objectives. For example, in many situations mid-phosphorus plating chemistries produce EN deposits that provide adequate hardness and corrosion resistance, along with the trademark uniformity that EN is famous for. For other applications, however, "adequate" may not meet the intent of the design engineer. This one-size-fits-all approach to EN plating may overlook some of the better options that are available.

Some metal finishers offer only one or two EN processes, and many only plate certain types of alloys. While there is nothing inherently wrong with this approach to EN plating, it limits the choices available to the customer. To become a full service EN provider, more options must be available for consideration and testing. Although it is impractical to offer dozens of different EN processes, a carefully selected handful of hybrid EN formulations, used in conjunction with the most appropriate pretreatment processes will equip you for almost any requirement that you may encounter.

Post-Plating Considerations

Hydrogen Embrittlement Relief

Hydrogen embrittlement relief after EN plating should be considered for all hardened ferrous alloys. As is the case with stress relief, all of the major specifications make reference to hydrogen embrittlement relief, especially for highly hardened steel components. Following good metal finishing practice, hardened steel components should be properly baked to remove the potentially detrimental effects of hydrogen absorbed during the pretreatment and EN plating process. Possible exceptions to this rule of thumb could include parts that are not subject to extreme service conditions, or parts that would be adversely affected by the temperatures attained during hydrogen embrittlement relief.

Baking to Improve Adhesion

Some applications may benefit from a post-plate baking process to improve the adhesion of the EN deposit. Certain aluminum alloys, high carbon steels, and other alloys demonstrate substantial improvements in adhesion when baked after plating. Baking reduces EN deposit stresses, which can be detrimental to the success of the application. In some instances, the as-plated EN deposit is unstable and prone to localized blistering or other failure if tested before baking. The same parts exhibit excellent adhesion after the bake operation has been performed. Time and temperature guidelines for baking to improve adhesion can be found in the previously mentioned EN industry specifications.

Heat Treatments to Harden EN Deposits

EN deposits have the unique ability to be age-hardened when heat treated at elevated temperatures (490°F.+). Hardness values in excess of 68 Rc can be obtained as a result of carefully specified heat treatment processes. The downside to heat treatment is a reduction in the corrosion resistance of the plating, especially on high phosphorus deposits. Heat treatment of EN deposits facilitates the conversion of the nickel-phosphorus alloy from an amorphous structure to a crystalline structure. Caution must be exercised when specifying a heat treatment process, so as not to soften the substrate while hardening the EN deposit. Many hardness applications have converted to low or low-mid phosphorus chemistries, which can attain similar hardness values right out of the plating bath, eliminating the need for heat treatment.

Chromating and Other Treatments

Chromate treatments are sometimes used to improve the corrosion resistance of certain EN plated components. Aluminum and iron castings, powdered metal parts, and other porous components are frequently immersed in dilute chromic acid solutions after EN plating to help “passivate” the EN deposit and seal exposed pores in the coating. Other post-plate rinse solutions contain surfactants and wetting agents that aid drying and reduce staining in cosmetic applications.

Testing for Results

Did the EN process achieve the anticipated results? Meaningful testing and validation methods are key to ensuring deposit quality and performance standards. Testing of EN deposits is typically divided into two categories, as follows:

Acceptance Tests:
Visual Appearance
Thickness
Adhesion
Porosity
Hydrogen Embrittlement Uniformity

Qualification Tests:
Alloy Composition
Corrosion Resistance
Wear Resistance
Microhardness
Internal Stress

Acceptance tests are used to validate conformance of the EN deposit on an actual group of plated components. Acceptability is determined using some or all of the elements listed above, based on which criteria is deemed necessary to the success of the application. For example, for a soft, mild steel component the hydrogen embrittlement test would probably not be recommended.

Qualification tests are used to validate a particular EN process. Again, acceptability is determined using some or all of the elements listed above. Qualification tests are geared towards theoretical capability of the EN process, whereas acceptance tests are geared towards workmanship and actual deposit characteristics.

All of the major EN industry specifications provide guidance on testing methods, and most of the basic acceptance tests do not add cost to the process. In contrast, the qualification tests can, and most often do, add additional cost to the EN process. Meaningful qualification tests are indicators of EN process capability and should be performed at the onset of a new program. However, to avoid additional expense, only tests relevant to the success of the application should be specified. After the initial qualification, testing should be performed periodically at a frequency that ensures continuous process conformance.

Prototyping and Other R & D

Plating and testing actual parts is extremely important to validating the success of the EN process. After gathering all of the application information and prescribing a carefully selected EN process, there is no better way to determine success than by prototyping on actual production parts. The proof is in the pudding! Simulating service conditions can be accomplished by various means, including Falex wear resistance testing, Taber abrasion resistance testing, accelerated corrosion resistance testing, and others. Whenever possible, actual in-the-field testing is recommended. Theory is great, but data is better! Modifications in chemistry or thickness can be made after testing to “fine-tune” the process and deliver the best possible EN process.

Conclusions

None of the topics presented in this paper are brand new, cutting-edge technology. The information discussed has been around for quite some time, and in all likelihood you have had some exposure to most of the elements presented herein. Successful EN plating requires more than just dipping parts in any old EN plating solution. Industry demands have placed a bigger burden upon the metal finishing community to provide high performance EN coatings that consistently meet the expectations of the customer…the first time and every time. This can only be accomplished by gathering the basic information, reviewing the application, and matching up the requirements with the best pre-treatment, plating, and post-plating options. By taking a more “holistic” approach towards the entire EN process, the chances for success increase greatly. Ultimately, everyone wins when the result is “The Best EN Process for the Application”!

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ASTM Committee on Standards
100 Barr Harbor Drive
West Conshohocken, PA 19428

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About Imagineering Enterprises:

Imagineering Enterprises, Inc. is a specialty metal finishing firm located in South Bend, Indiana. Imagineering is an ISO 9002 / QS-9000 certified company founded in 1959, and is globally recognized Electroless Nickel plating expert source. Imagineering is an active member of the National Association of Metal Finishers (NAMF) and the Indiana Association of Metal Finishers (IAMF). The company is an active participant in the EPA's Strategic Goals Initiative program, and they recently achieved ISO-14001 registration for environmental compliance.