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ELECTROLESS NICKEL NEWS

FROM THE EDITOR

As we've often stated, new applications for electroless nickel are meeting with new success all the time. We're pleased to feature case histories of such applications in this issue of EN News.

Robert Jeanmenne of Caterpillar Inc. has been kind enough to provide details on his company's use of electroless nickel for equipment parts, in place of hard chromium plating. While such an application in and of itself is not that new, the success — and the savings — seen by Caterpillar are. Mr. Jeanmenne outlines some of the reasons, along with tips for the success of any EN application.

Electroless nickel was used with similar success on process valves at Air Products Corporation in Louisiana. Wiley Alexander of Encoat, Inc., tells us that story.

A somewhat more unusual, but no less effective, EN application is seen in plating industrial diamonds. Consultant Arthur Wasserman gives hints for success here.

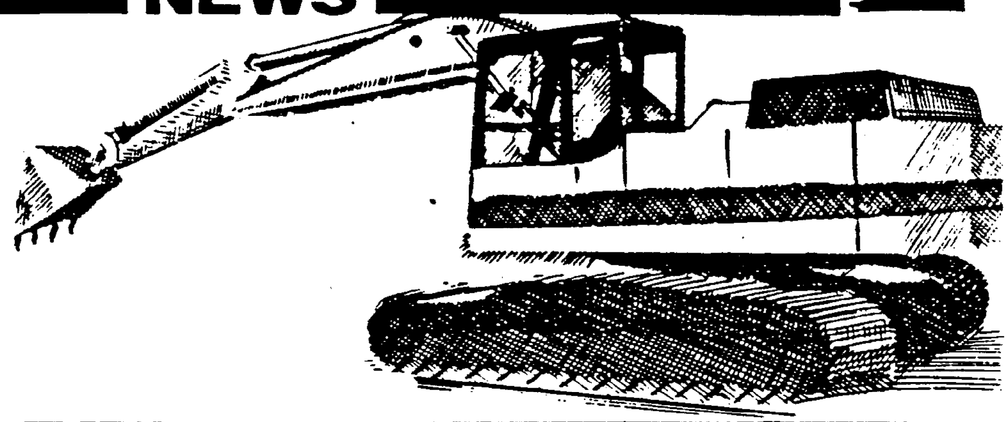
For those of you interested in surface finishing and deburring who weren't able to attend last December's ASME Symposium, Robert Stango of Marquette University has provided us with summaries of the papers presented.

So as you can see, this issue is chock full of reader contributions. And we're always looking for more.

Diane M. Tramontana

Diane M. Tramontana, Editor

P.S. Please help us update our mailing list — if you haven't already done so, send back the reply card. Thanks!



EN for Hard Chromium

Caterpillar has found that it makes "cents" to substitute electroless nickel for hard chromium plating...

By Robert A. Jeanmenne
Caterpillar Inc.
York, Pennsylvania

Since electroless nickel (EN) plating has been on the market it has been touted as a possible substitute for hard chromium plating for many applications. Yet today it is estimated that the EN plating market is probably less than 10 percent of the hard chromium market, the same estimate reported seven years ago.

Hard chromium plating has been a longstanding tradition at Caterpillar Inc., York, Pennsylvania, where an average of more than eight tons of cylindrical piece parts are plated each day. Eight years ago the captive hard chromium market enjoyed 100 percent of the available work and EN plating was a laboratory curiosity. Today, Caterpillar has three full-time EN plating operators working three shifts and is in the process of purchasing a second plating machine dedicated solely to electroless nickel.

Caterpillar now estimates that as much as 40 percent of its hard chromium-plated product could be EN-plated. Today, EN makes up slightly more than 20 percent of the available in-house market. Why has Caterpillar experienced rapid growth in the EN market when it appears that others have remained constant? Primary is Caterpillar's commitment to improving quality and cutting costs.

Customers want the highest quality at a reasonable cost. Platers can work with the design engineers to provide customers with the best available technological information.

It may not be surprising to platers that few design engineers consider themselves experts in the field of plating. Since Caterpillar began processing plated parts, it has been approached by engineers who admit they are not knowledgeable on plating technology. The engineer uses what limited information he/she has on the subject and makes a recommendation. A hard chromium plating requirement, for example, may have been added to an existing part to solve a field problem (corrosion or wear) or is added to a new part based on the design of a similar part.

When Caterpillar began investigating EN's possibilities, most engineers were interested. They wanted to learn more about its functional characteristics. If EN was superior to hard chromium and less expensive,

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EN would be specified on the part.

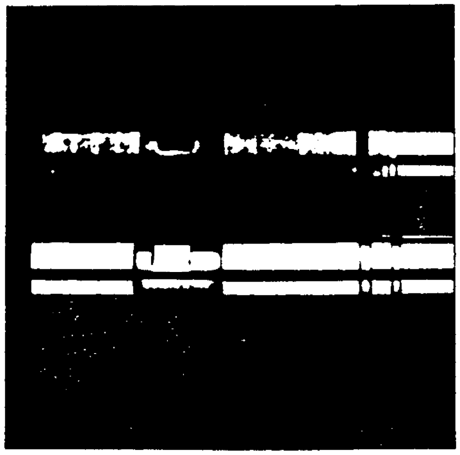
One of EN's problems is its generic name. Electroless nickel describes the deposition of an alloy, primarily nickel and phosphorus, on a substrate. But EN provides various functions, depending on the phosphorus content, the formulation and the preplate conditions.

One company Caterpillar deals with sells more than 30 proprietary formulations. Unfortunately, the industry recognizes each "batch" by the same name: electroless nickel. Add "home brew" to the list of formulations, and those prudent design engineers quickly retreat to the security of a plating procedure (like chromium) with more predictable engineering characteristics.

Engineers expect and demand a coating that will consistently meet specific engineering requirements. This is especially true for specifications calling for the extreme functional requirements that can be obtained from many commercially available EN formulations. Design engineers should not have to be concerned with the unpredictability of any EN coating found in the marketplace. At Caterpillar only one electroless nickel was presented to its design engineering groups.

At Caterpillar, the engineering specification has a designated number assigned. Details of the specification define the required functional characteristics of the plating, and outline performance tests that the coating must pass. If a second type of EN bath is developed for use, then a new specification (with a new number assigned) will have to be written. The specification that details EN for Caterpillar's York plant is the same specification that defines EN for Shin Caterpillar Mitsubishi in Japan. Providing each EN bath with an individual set of specifications ensures design engineers and customers that electroless nickel, as specified, will perform.

If one learns anything while working in industry, it's that a lot of success is not required to make or break a new idea. Sometimes all that is needed is one failure. Once a good reputation has been developed, an occasional failure is normally understood, but an early failure can spell disaster. If quality problems were experienced with EN-plated parts initially, EN would not have grown to its current state because the engineers would have quickly lost confidence in the new process. In my nearly twelve years of plating hard chromium I have seen only one pin returned from the field because of poor plating.



Caterpillar changed from chromium plating a two-inch length of this valve stem to EN plating the entire part. Annual savings: $34,200.

The electroless nickel process required to produce quality plating is difficult. To accomplish this task at Caterpillar, a trained application engineer worked on-line with a plating operator. Together the theoretical and the practical meshed to develop the current process. These two individuals became Caterpillar's EN plating "experts." Any plant considering EN plating should plan on having, or developing, two "experts."

Caterpillar's plating operators have undergone six weeks of training, five weeks on-line and one week in the classroom. They learn to alter their process as needed to properly activate and remove smut from the substrate before EN immersion. They know to process parts through the cleaning operations a second time, if necessary. They also learn to perform numerous process control and maintenance activities.

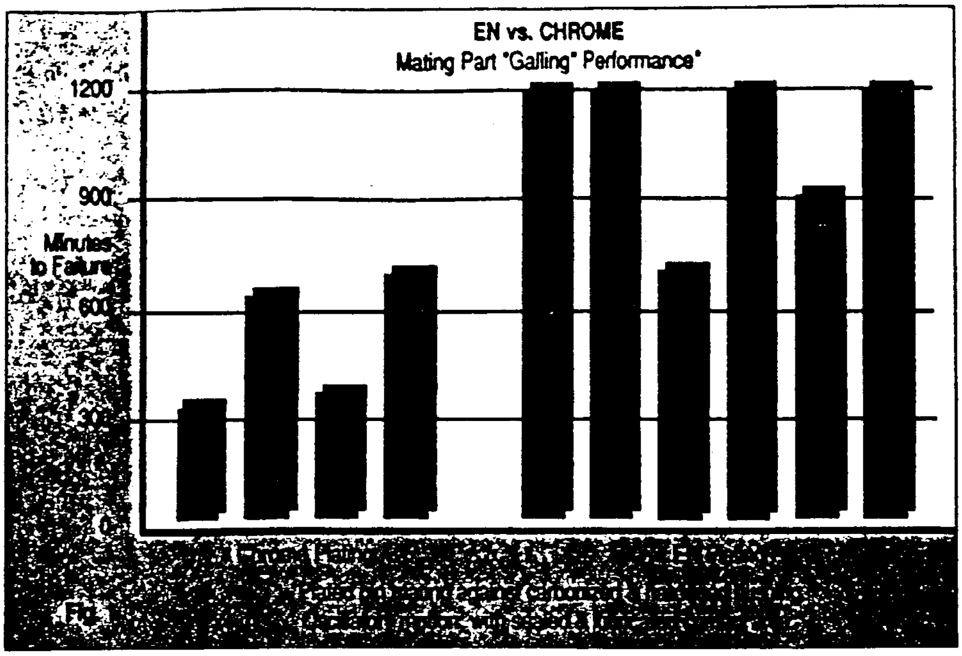
Once the EN bath and process are determined, a blueprint change is required for the plater to go to work. A quality engineer never makes a functional engineering change without justification, usually improved quality or reduced costs. It is not easy to convince a design engineer to develop a trial procedure to run a comparative test. Fortunately, the EN plater who has a process that improves quality and reduces costs should not have a problem. In all cases where EN replaced hard chromium at Caterpillar, quality was improved. At Caterpillar quality, not cost, is the bottom line.

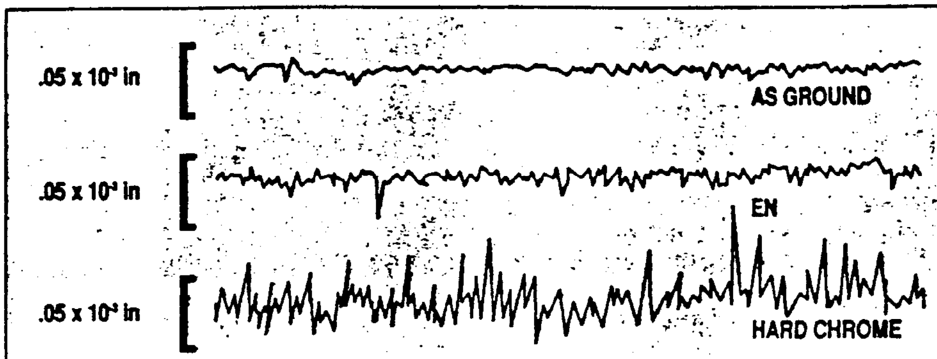
EN improved quality on various parts in a number of ways. In all cases the corrosion resistance of the selected "P" (plating required) is improved. EN plated parts last longer in corrosive environments, because, unlike the chromium-plated part, the entire part is plated and therefore protected from corrosion. Therefore the ends of the parts, which are normally "thieved" for chromium plating, are protected using EN. EN plated parts perform well in wear applications. Caterpillar is working to correct the misconception that the hardest part will always provide the best wear.

Today, Caterpillar investigates the tribological phenomenon that occurs between mating parts. The company is finding that EN parts as plated (HRC 48-50) can match hard chromium (HRC 65-70) in some applications (Figure 1).

Surface finish is more consistent, (Figure 2) resulting in improved performance in joints with phenolic bushings. Some of the joints engineered at Caterpillar require that a plated pin ride inside a bushing made of a phenolic or plastic material. This joint style eliminates the potential for galling and has excellent wear life.

For the joint to work properly the surface finish of the pin is critical. A rough or corroded pin will prematurely wear the bushing. A chromium-plated pin can develop two problems with this style of joint. Hard chromium plating may produce tiny surface nodules that prematurely wear on phenolic bushing material. Also, joints of this type are designed with seals on the ends. Moisture trapped within the joint can produce corrosion products that wear on the bushing. Surface finish cannot be improved as a result of EN plating, but properly plated EN parts have a consistent surface finish without nodules and provide dramatic improvements in corrosion protection.





Finished ground pins were checked with a surface analyzer and subsequently plated with EN and chrome. A second profile was taken to determine changes in the surface finish after plating. A significant increase in the surface roughness is shown for the hard chrome plated pins.

Fig. 2

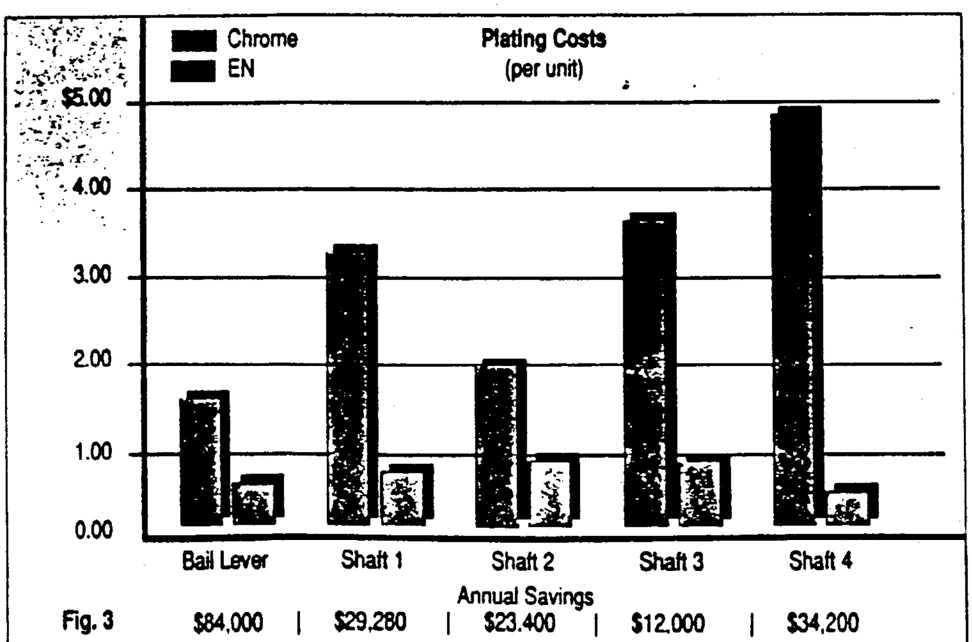


Fig. 3

EN-plated parts can function between in service, but for parts to function properly they must fit. If a part requires chromium plating, the engineers will normally allow the chromium plater sufficient tolerance to compensate for the size variation (dog-bone effect) that occurs with an electroplated product. If the engineer specifies EN as a replacement he can also reduce the allowable tolerance. Parts plated with EN have a more consistent finish size than parts plated with chromium. EN-plated parts work better because they fit better.

EN-plated parts do not require post-plated grinding, whereas chromium plated parts often do. When chromium is ground improperly it can produce cracks in the chromium surface that can propagate into the substrate, causing failures. EN-plated parts cannot fail from grinder-induced cracks since they never require a post-plated grinding.

Common "Cents." EN costs more than chromium plating; this statement is both true and false. EN costs more per mil per square foot, but actually EN can be substituted for hard chromium at a savings. A few years ago when Caterpillar was reducing its work force worldwide, a project was written to expand the EN plating line. The EN plating operation was able to grow because it offered a lower cost and quality improvement to many parts that were hard chromium-plated.

Cost is not just price per mil per square foot, when making a cost comparison. Cost includes materials, energy, manpower, and time to produce a product by one method vs. another method. The EN process can reduce costs in four specific ways.

Increase productivity. Chromium plating operations have cells that establish an allowable space for piece parts. Parts are normally positioned on a rack to make sure they fit into each cell. This special location within the anode cell produces a more concentric part. The positioning requirement for the large-diameter parts is the same as for small-diameter parts. However, this positioning requirement does not exist with the EN process. Parts can be spaced much closer together in the EN tank.

Consequently, more parts can be plated per tank volume.

Eliminate masking. In some cases parts are engineered with plating on only one section of the part. It is important for the plater to know this area so he can properly plate the part. Unfortunately, some engineers may not be aware that it often costs more to plate a section of the part rather than the entire part. In one case an engineer felt he was saving money by asking for a partially plated part. "Why waste all that chromium?"

Today, engineers are asked to define a "P-Permitted" area that defines the entire length of the part when possible. We also have tried to establish a standard that EN-specified parts cannot be masked. The purpose is to develop procedures that reduce plating costs. Painting, dipping, or taping to save surface area at the expense of production is not recommended.

Masking and unmasking is slow. Parts with holes, keyways or threads must be sized to allow for the uniform EN coating. They must, in effect, be plated up to blueprint size. When the engineers design parts with EN plating in mind, they will specify full length coverage and size the entire part to permit complete and total coverage.

Eliminate grinding after plating. Chromium-plated parts with tight tolerances often require a grind operation to remove the uneven plating as a result of the dog-bone effect. Furthermore, high production through-feed grinders usually need a little extra chromium stock to properly clean-up. Therefore, additional bath time is required to add the extra chromium. After grinding, a final wash operation is required. When specifying EN as a substitute for hard chromium, the extra plating, grind and wash operation are eliminated.

Associated material handling costs are also saved. Figure 3 charts cost comparisons.

Growth of the electroless nickel industry is dependent on several factors. The metal products finishing industry cannot continue to call every EN formulation "electroless nickel." The numerous and varied electroless nickel baths on the market need to be defined and organized so that each proprietary bath is recognized for its own specifications. Platers need to take the time to develop EN experts and empirically evaluate the various proprietary baths.

An impartial organization such as ASTM should work with the chemical suppliers to develop a generic naming system that would functionally separate the various baths. An industry standard for EN plating baths would better define to customers what they are buying.

Suppliers of electroless nickel must do a better job of marketing the best pre-plate process available. They cannot allow the plater to use the traditional processes that have worked for conventional electroplates. Conversely, platers must work with the chemical suppliers to develop pre-plate processes that will produce a quality deposit every time.

Platers must communicate directly with the engineers who design the parts and work with the accountants who can determine actual costs. The engineers alternate methods of design and manufacture that can improve quality and reduce costs.

Finally, if you are looking to expand your EN market, look to the hard chromium market. The part examples shown illustrate that EN can be successfully substituted for hard chromium. Small parts that require masking and a finish grind operation can potentially produce the greatest savings. In most cases, when the EN method is compared with the hard chromium method, EN will be the most economical method to produce a quality part.

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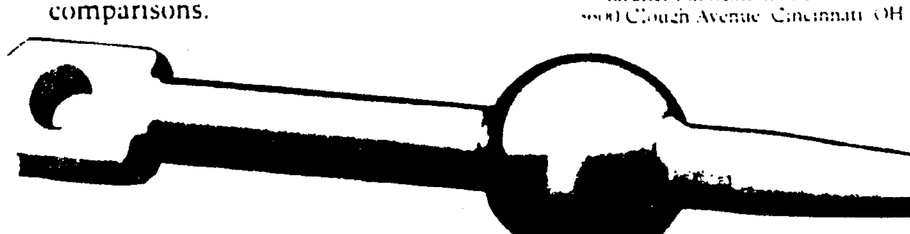

EN plating this ball lever improved roundness and prevented corrosion. Annual savings: $84,000.

TwinCityPlating

Roger W. Plath
President, CEO

641 Hoover Street N
Minneapolis, MN 55413-29

Phone: 612-331-8895 Ext. 1227
Fax: 612-331-3926

e-mail: roger@twincityplating.c
www.twincityplating.c