



Don Baudrand, Don Baudrand Consulting, e-mail: donwb@tscnet.com

Electroless Nickel and Hard Chrome And Hard Chrome vs. Electroless Nickel

Introduction

There has been a large amount of literature reporting the wear characteristics of hard chrome. Corrosion protection and wear resistance are two of the main reasons to select hard chrome for many applications. Likewise electroless nickel deposits have good corrosion resistance and good wear resistance. Some of the several wear test procedures are used to compare the two very different deposits. Also there is some advantage to using both electroless nickel and hard chrome particularly when the basis metal is high strength steel subject to embrittlement.

I Electroless nickel (EN) and hard chrome

Chromium electrodeposits have produced protection against wear and corrosion with good lubricity and chemical resistance. When Chromium is deposited onto high strength steels such as AISI 4340 steel, loss of fatigue strength results. Chromium deposits are not ductile and are plated with very high intrinsic (internal) stress. The stress cracking is well known for hard chromium deposits from conventional plating solution. The cracks are numerous, but many of the cracks are filled with subsequent plating. There is evidence that some cracks continue to the basis metal, and others left not filled in resulting in crack propagation into the high strength steel. Cracks cause fatigue failure.

Corrosion protection is sometimes compromised. A study using AISI 4340 high strength steel coated with electroless nickel and not coated with electroless nickel but both coated with hard chromium plate showed a difference in fatigue strength. The electroless nickel + hard chrome showed a 30% better fatigue strength compared with hard chrome alone.

Studies using AISI 4340 high strength steel showed marked improvement in both salt spray resistance and better fatigue strength. Electroless nickel was plated to thickness of 10, 20 and 30 micrometers under layer and a chromium thickness of 50 micrometers. At 10 micrometers of electroless nickel deposit, 144 hours salt spray resulted in 10% of the coupons area had corrosion.

At 20 and 30 micrometers of EN with 50 micrometers of hard chromium there was no corrosion after 312 hours salt spray. The test was discontinued at that point. At 49 micrometers of hard chrome alone there was 100% failure at 48 hours salt spray.⁽¹⁾

II Electroless Nickel vs. Hard Chrome

Robert Jeanmenne of Caterpillar, Inc.⁽²⁾ presented a paper at an EN conference, where he told of substituting electroless nickel for hard chromium in many applications at Caterpillar that had been traditionally hard chrome plated. He stated: "satisfied customers are looking for value." They are interested in the highest quality at a reasonable cost." He also reported that in all cases where EN replaced hard chrome corrosion resistance improved. "En plated parts last longer in corrosive environments." In some cases hard chrome offered no protection in blind holes, whereas En plated in the holes providing protection. In Galling tests EN plated parts lasted twice as long as hard chrome plated parts. The uniform coating thickness of electroless nickel provided better dimensional tolerance characteristics than for hard chrome.

What about costs? EN costs more per mil sq ft than hard chromium. However the benefits of EN resulted in lower costs for many of the parts with no sacrifice in quality. Better quality resulted from EN plating. Cost comparisons included total materials, energy, manpower and time to produce the same functional part by one method vs. another. Grinder induced cracks were eliminated when EN was used. Most EN parts did not require grinding at all. Additional ways En reduced costs. 1. Increasing the productivity. 2. Eliminating the need to mask parts. 3. Eliminating the need to grind after plating. The total cost savings were very significant.

Dave Crotty of MacDermid⁽³⁾ studied Electroless nickel vs. Hard chrome. He reported hard chrome characteristics such as stress vs. thickness, Vickers hardness vs. plating parameters. And he reported EN stress vs. Phosphorus content, micro hardness vs. heat-treat temperature, tabor abrasion wear test of EN vs. hard chrome and Falex wear tests of EN vs. hard chrome.

The results of these various tests are interesting. For example Internal stress of hard chrome deposits depends on current density and thickness. For example at low thickness the stress can reach as high as 140 thousand psi. And as thickness increases the stress drops, due to cracking of the deposit. The stress levels off after about 2 mils of deposit, again depending on current density, to about 20 thousand psi, and at 3 mils thickness using 3 Amps/sq in. to about 17 thousand psi tensile stress. The lower the Current density the higher the stress.

Another interesting phenomenon about hard chrome plating solutions is that the hardness of the deposit is dependent on operating temperature and current density. Under some conditions hard chrome is softer than electroless nickel. For example at 250 ASF and 145 degrees F the

hardness is 450 Vickers. At 300 ASF and 100F the hardness is 1200 Vickers. Where do you operate your hard chrome solutions?

The internal stress of electroless nickel deposits depends on phosphorus content and to some degree the choice of stabilizers in the solutions. At 7 to 9% phosphorus, typical internal stress is about 6,600 psi tensile for a new solution going up to about 8,000 psi after 8 regenerations. At 4% phosphorus the internal stress is about 2,000 psi tensile going down to 1,700 after 8 regenerations? At 11% phosphorus the stress is about 1000 psi compressive going up to about 2,000 psi tensile after 8 regenerations. Note, internal stress of below 4,000 psi is considered low stress.

The micro hardness of electroless nickel deposits depends on the phosphorus content and the heat treat temperature. As deposited (without heat-treat) 6-9% phosphorus is about 550 Knoop hardness number at 100 gram load. After heat-treatment the hardness can reach as high as 1000 Knoop when heat-treated at about 385C. The 4% P deposits follow the 6-9% curve when heat-treated, but start as plated at about 700 Knoop.

Wear resistance comparison is interesting. Using a taber wear test, Chromium shows better wear resistance. However if the Falix wear tester is used electroless nickel shows significantly better wear characteristics than that of chromium.

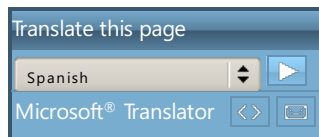
The bottom line is, that for some applications, electroless nickel is better than hard chromium, and in other situations Hard chrome performs better than EN with respect to wear properties.

Considering corrosion resistance there is no contest, EN is superior to hard chromium.

For plating of high strength steels the combination of Electroless nickel followed by hard chromium is best for good fatigue strength if chromium plated finish is mandated.

References

1. " Evaluation of an electroless nickel plating enterlayer on the fatigue and corrosion strength of chromium electroplated chromium AISI 4340 steel"
By Marcellino P. Nascimento, et al state University of Sao Paulo-DMT-UNESP/FEG
2. Robert A Jeanmenne, Caterpillar, Inc. York Pennsylvania
- 3, Dr David Crotty, MacDermid Inc. New Hudson MI



You may download this article FREE in .pdf form, save it or share it with a colleague. [Click here.](#)