Nickel Iron Plating

Anthony J. Varuolo, MacDermid Inc., Waterbury Connecticut, USA

It's not new; it's been around for quite some time; not too many people know much about it. The deposit is extremely bright, with excellent leveling and ductility. The neat thing is, the deposit ratio, 75% nickel and 25% iron. We will reintroduce nickel iron and describe the benefits.

For more information contact:
A.J. Varuolo
245 Freight Street
Waterbury Conn 06795
Phone: 203-575-7912
Fax: 203-575-7990

With the price of nickel metal climbing to $8.00 per pound it was an easy decision to re-introduce a process[1] from the mid 1970's. The nickel iron alloy plating process was dusted-off, improved and re-introduced to a new generation of electroplaters. Fortunately, the original researcher [2] was able to make these process improvements.

The resulting process is considerable better than its predecessor is and the expectation is that most platers will utilize this process to help reduce the effects of the high price of nickel anodes.

NICKEL IRON ALLOY PLATING OFFERS:

Extreme brightness and leveling

Outstanding ductility

Excellent corrosion protection

Consistently high "STEP"

Non pyridine process

Lower use cost

1. NIRON Process Udylite corp., *MFSA Quality Metal Finishing Guide Vol. VII No.2*
2. Robert Tremmel

It is interesting that as we set out to re-introduce this nickel iron alloy process to counteract the high cost of nickel anodes, it was discovered that the brightness and leveling of a low alloy nickel iron deposit well exceeded the deposit of a standard nickel deposit. This is also true of the high iron alloy. Just to qualify the above statement, low nickel iron deposits are deposits that contain less than 10% iron and high nickel iron deposits are deposits that contain 10% to 25% iron. Plating a nickel iron deposit with iron levels above 25% is possible but requires additional control parameter and will not be discussed at this time.

FEATURES	**BENEFITS**
• Extreme brightness and leveling	• Less nickel thickness required- reduced cost
• Non pyridine process	• Less troublesome breakdown products
• Consistent STEP test results	• Excellent corrosion protection
• Outstanding chrome receptivity	• Reduced rejects due to whitewash
• Ductile deposit	• Suitable for bent or crimped parts
• Nickel iron deposit	• Reduced cost

Nickel iron process produces deposits that are brighter and have more leveling ability than a nickel process because of the codeposition of iron. These nickel iron deposits are as bright as nickel deposits from pyridine nickel systems without the troublesome breakdown products.

Chrome receptivity is excellent and whitewash is reduced due to low organics breakdown products.

Ductility is excellent and the deposit is suitable to applications where the parts are bent or crimped after plating.

Corrosion protection and STEP tests results are exceptional and will be illustrated later.

The amount of nickel anodes consumed is reduced proportional to the amount of iron deposit. And in this era of nickel metal selling at approximately $8.00 a pound, any savings in nickel metal should be accepted with opened arms.

The nickel iron process with 10% iron in the deposit has the following composition:

	Component	Optimum	Range
SOLUTION COMPOSITION:	$NiSO_4 \cdot 6H_2O$	263 g/L (35 oz/gal)	225 – 300 g/L (30 – 40 oz/gal)
	$NiCl_2 \cdot 6H_2O$	75 g/L (10 oz/gal)	60 -135 g/L (8 -18 oz/gal)
	Boric Acid (H_3BO_3)	53 g/L (7 oz/gal)	49 - 60 g/L (6.5 - 8.0 oz/gal)
	Total nickel content	75 g/L (10.0 oz/gal)	60 - 90 g/L (8.0 - 12.0 oz/gal)
	Total chloride content	24.8 g/L (3.3 oz/gal)	22 - 45 g/L (3.0 - 6.0 oz/gal)
	Total iron (Fe)	1.8 g/L (0.24 oz/gal)	1.3 – 2.7 g/L (0.17- 0.35 oz/gal)
	% Ferric Iron (Fe^{+3})	Less than 25% of total iron up to a maximum of 0.45 g/l (0.06 oz/gal)	
	Wetter	0.5%	0.1 - 0.8%
	Solubilizer	7.0 g/L (0.9 oz/gal)	4.5-10.0 g/L (0.6 – 1.3 oz/gal)
	Primary	4.0%	3.0 - 5.0%
	Leveling Agent	1.5%	1.0 - 2.5%
	Secondary	0.20%	0.10 - 0.30%
OPERATION DATA:	pH (Electrometric)	3.8	3.5 – 4.0
	Temperature	57°C (135°F)	54 - 60°C (130 - 140°F)

EQUIPMENT:	Tank	Koroseal® lined or other approved plastic
	Agitation	Eductor
	Filtration	Continuous filtration through activated carbon is required
	Heating & Cooling Coils	Titanium, tantalum or Teflon®
	Tank Ventilation	Required
	Anodes*	

- Nickel	S-Nickel rounds or electrolytic squares or crowns
- Iron	Mild, cold rolled steel
- Ratio (Ni: Fe metal)	50:1 to 30:1
Anode bags	Any that are suitable for decorative nickel

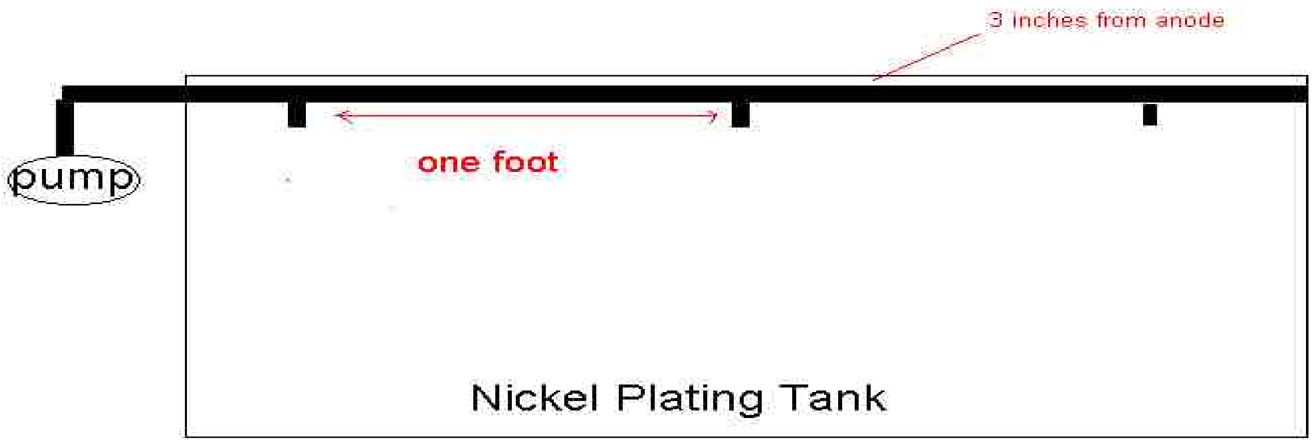
.* Use separate anode baskets for nickel and iron anode chips - never mix both anode chips in the same basket.

It is strongly recommended that potential users of the nickel iron have the following available to ensure successful operation.

- Eductors
- Solution filtration
- Suitable pre-treatment processes
- Low ripple rectification (<5%) with suitable current density control
- Suitably lined tanks
- Analytical control of the solution including AA
- Thermostatic solution control

Agitation
It is recommended that eductors be used to agitate ***Ni/Fe*** solutions to reduce the oxidation of ferrous iron to ferric; as well as eliminate nickel spray. Eductors should be placed at the bottom of the tank, approximately 3 inches in front to the anodes. Eductor discharge nozzles should be placed 1-foot increments and the discharge angle should be adjustable in order to optimise solution agitation. Standard air agitation systems have been used with nickel iron plating baths.

Eductor layout diagram



- Eductors should be placed 3 inches in front of the anodes and spaced in one foot increments
- Eductor discharge angle should be adjustable
- Pump flow rate should be sufficient to provide uniform bath agitation
- More than one row of eductors may be required for deep tanks

Corrosion test data:

The following tests were performed on panels processed with nickel iron alloy.

C.A.S.S. Testing (ASTM B-368):

Copper Accelerated Salt Spray or CASS, is widely employed and is useful for specification acceptance, simulated service evaluation, manufacturing control, and research and development. It was developed specifically for use with decorative electroplated nickel/chromium and copper/nickel/chromium coatings. The apparatus for this test resembles that used in neutral salt spray testing with two important exceptions. The salt solution used in CASS testing contains 0.25 g/l copper chloride, and the pH is lowered to 3.1 to 3.3. This provides a much more corrosive environment than neutral salt spray producing what is considered to be more valuable corrosion resistance information. See test results below.

Salt spray testing (ASTM B-117)

Salt Spray testing is less common in the analysis of nickel chrome plated parts. While it is more of a measure of substrate porosity than actual corrosion protection, it does provide useful information. Salt spray testing showed the nickel iron process to be equivalent to bright nickel in porosity. See test results below.

STEP testing (ASTM B-764)

Simultaneous Thickness and Electrochemical Potential or STEP, closely estimates the thickness of individual layers of a multilayer nickel deposit and the electrochemical potential differences between the individual layers. The ability of a multilayer nickel deposit to enhance corrosion resistance is a function of the electrochemical potential differences between the layers, as well the thickness of each layer. The potential differences must be sufficient to cause the bright nickel to corrode sacrificially with respect to the semi-bright nickel underneath. Most applications that specify STEP testing require a 120-140 mv potential difference between the bright and semi-bright nickel layers. Parts tested with sulfur free nickel and bright nickel consistently produced a STEP of 140 millivolts.

Nickel Iron corrosion test details

1. Control Panels(4 per set):

Set 1	1.0 mils Semi-bright nickel 0.5 mils bright nickel 0.05(90 sec) microporous 0.01 mils Chromium
Set 2	0.05 mils nickel or cyanide copper strike 0.8 mils bright acid copper 0.8 mils Semi-bright nickel 0.4 mils bright nickel 0.05 mils microporous 0.01 mils Chromium

2. Test Panels(4 per set):

Set 1	1.0 mils Semi-bright nickel 0.5 mils nickel iron 0.05 mils microporous nickel 0.01 mils Chromium
Set 2	0.05 mils nickel or cyanide copper strike 0.8 mils bright acid copper 0.8 mils semi-bright nickel 0.4 mils nickel iron 0.05 mils MP nickel 0.01 mils Chromium

CORROSION TEST RESULTS

Panels were evaluated in Copper Accelerated Salt Spray (CASS). All panels were first cleaned to water break free surface with MgO before placing in the box. Panels were checked and recorded every 22 hrs until first obvious sign of red rust or 88Hr, whichever came first.   Panels were removed once rusting occurred.

When the nickel iron was run through cycle 2 (set 2) which is a typical automotive type finish they were exposed to 96 hours CASS which is a little more then 4 cycles (one cycle is 22 hours). The test was continued for a total of 7 cycles or 154 hours before any signs of red rust.

Salt spray, which is a test only for porosity, showed that nickel iron was equal to nickel plated under the same conditions. Both panels showed first sign of substrate corrosion at 48 hours, when plated to commercial thickness.

Currently an independent testing laboratory in Detroit is repeating these tests.

COST ANALYSIS

Because this nickel iron process is a nickel-iron alloy, there is a significant cost savings associated with its operation. Currently, nickel metal sells for about $7.50 a pound, where iron costs approximately 20 cents per pound. If we assume that nickel iron produces at a minimum 90% Ni 10% Fe alloy, the typical nickel iron user can save about 8% per pound of nickel plated. Or at the high end of the scale of 25% iron in the deposit, the user will save 20% of the present cost of nickel anodes purchased.

If we assume the current on the tank is 1 amp/gallon, which is fairly typical, a 1000 gallon tank will deposit about 2.2 # of nickel metal per hour or 17.6 #/eight hour shift. At the current price of $7.50/pound for nickel metal, at 8% iron, the savings is about $.60/pound of nickel plated. That adds up to $52.80/week for a one-shift operation per 1000 gallons of plating solution.

At the high iron levels, 25% Fe, this savings becomes $1.50/lb of nickel plated or $132.00 savings per week. One must keep in mind that these savings are for only a 1000 gallon tank drawing one amp/gal and operating for only one shift. A 10,000 gallon tank will save ten times the listed amounts. And two shifts is will double the savings.

Since this new process has excellent brightness and leveling ability, I would state that a hidden saving could be the reduction in the total nickel thickness by 10% without any loss in deposit quality. This of course assumes that a minimum thickness specification is not compromised.

Summary: Nickel iron process can be operated as true nickel iron process with 25% iron in the deposit in order to save the maximum amount of money in nickel anodes or the process can be operated at 10% iron in the deposit. In both cases the brightness and leveling will be as good as or better than a pyridine based bright nickel without the harmful breakdown products of a pyridine system.

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