High Corrosion Resistant
Environmentally Friendly Chrome Plating

Dr. Toru Murakami, C. Uyemura & Co., Uyemura Malaysia, Johor, Malaysia

A high corrosion resistant, environmentally friendly whitish chrome plating process is presented. The corrosion resistance test results on CASS and calcium chloride (anti-freezing agent) + kaolin were superior to conventional hexavalent (Cr6+) chrome plating. The hardness and heat-resistance was also superior to hexavalent (Cr6+) plating. Numerous advantages were also seen with this novel chrome process when it was compared to current conventional trivalent chrome plating technologies.

For more information contact:

Mr. Anthony Revier (president of Uyemura USA); Uyemura USA (UIC)
E-mail: TRevier@uyemura.com

Mr. U.K.Wong(GM of Uyemura International Singapore; UIS)
E-mail: uk-wong@uyemura.co.jp

Dr. Toru Murakami(R&D director, Uyemura Malaysia);Uyemura (Malaysia)
E-mail: toru-murakami@uyemura.co.jp

Mr. Marehiko Doi(president of Sum Hitechs Co.,Ltd), Thailand
E-mail: marehiko-doi@sumhitechs.co.th

Mr. Tsuyoshi Uotani (director of C. Uyemura & Co.); Uyemura Japan
E-mail; tsuyoshi-uotani@uyemura.co.jp

Introduction

The double layer chrome plating process is an industry wide, well established conventional plating process. It is understood that in order to obtain high corrosion resistance and high hardness deposit properties with typical decorative chrome, a crack-free chrome layer must be plated. This paper introduces an environmentally friendly chrome plating solution that consists predominantly of trivalent chromium ions with crack free chrome, single-layer high corrosion resistance features. This new product has advantages compared to conventional hexavalent chrome plating processes. Although decorative plating is the primary application, this product should be strongly considered for new technologies and applications.

Experimental

The tested plating solution contained 78g/L of trivalent chromium ion, 10g/L of hexavalent chromium ion, organic carboxylate and conductivity salt (this solution will be called CF Cr). The plating solution temperature was 48^{o}C, the solution pH was 2.2, the cathodic current density was 10A/dm^{2}, and the plating time was 8 minutes. The test samples plated for corrosion testing, internal stress testing, and hardness measurements were plated for 3hrs.

The sample parts tested on ABS plastic were supplied and plated by a production plating facility. The test parts had been plated with bright copper, semi-bright nickel, bright nickel, micro-porous nickel and hexavalent chrome plating (HV Cr). The CF Cr was plated onto the samples after stripping HV Cr and evaluated for corrosion resistance using the CASS test with calcium chloride (anti-freezing agent). The test solution consists of 5mL of saturated calcium chloride and 3g of kaolin. Samples coated with the solution were left for one week in ambient air before the corrosion resistance comparison was done.

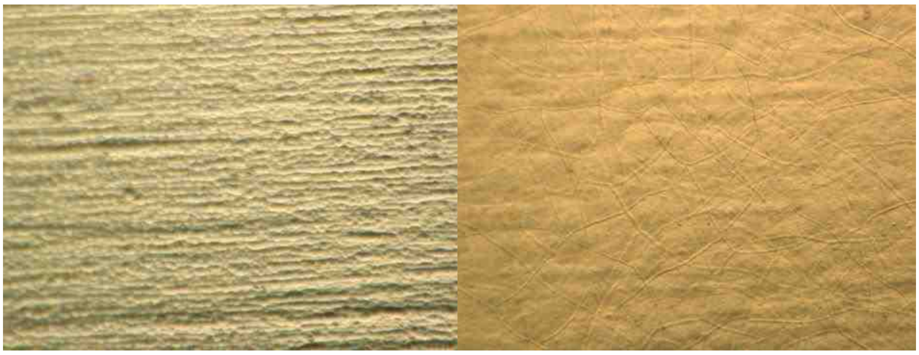
Samples plated on mild steel plates included 15 micrometer of Semi-bright nickel, 1 micrometer of tri-nickel, 10 micrometer of bright nickel, and 0.3 micrometer of chrome plating. The difference of corrosion resistance between HV Cr and CF Cr plating was also compared using the CASS test.

The internal stress was measured using the strip bending method. Hardness was measured using Vickers hardness testing equipment. Direct current was supplied using a Sanrex model HKD-1520F rectifier. The anodes used for plating were Pb-5% Sn. The surface morphology was evaluated using a digital microscope (Keyence).

Result

1. Physical properties
   a) Appearance and surface morphology of deposits:
   The appearance evaluation of the CF Cr process concluded that the deposit was a bright whitish color as with the HV Cr process except for the HV CR having a slight bluish color. The CF Cr had no crack and granular morphology, the HV Cr had cracks and a flatter, smoother morphology than CF Cr (*Photo.1*).
   b) Hardness and internal stress of deposit:
   Hardness of CF Cr deposit as plated is harder than that of HV Cr. Although the as plated CF Cr hardness increases with heat treatment the HV Cr hardness decreases (Table 1). Internal tensile stress of the CF Cr deposit is about half of HV Cr (Table 1).
2. Corrosion resistance of the plastic plated parts (CASS and Calcium chloride test):
   There was a difference in corrosion resistance between the CF Cr and HV Cr after 6 or 7 cycle of the CASS test. Corrosion resistance of CF Cr was superior to that of the HV Cr. In each case whether the micro-porous nickel was plated or not the chrome plating was scratched with a knife (*Photo 2,3*). There were many pit marks from the nickel corrosion in the case of the HV Cr when the micro-porous plated nickel was used. When the non micro-porous plated nickel was used an increase in localized corrosion was experienced. In the case of HV Cr, the role that micro-porous nickel played included dispersing the corrosion. The corrosion resistance of CF Cr was superior to HV Cr with or without the micro-porous nickel plated. The CF Cr also produces superior corrosion resistance results on the knife scratch test which simulates outdoor automotive activity.
   Corrosion resistance of CF Cr was also superior to that of HV Cr utilizing the calcium chloride + kaolin test (*Photo. 4*). There was also the difference between the Cr deposits after one week. Excessive corrosion was experienced in the case of HV Cr, but there was no corrosion in the case of CF Cr.

3. Corrosion resistance of chrome plating on tri-nickel plated on iron :
   Corrosion resistance of CF Cr with tri-nickel plated on iron was also superior to that of HV Cr (*Photo. 5*). There were many pit marks from nickel corrosion and rust from iron in the case of HV Cr.



Novel crack- free chrome plating (CF Cr) Conventional hexavalent chrome plating (HV Cr)

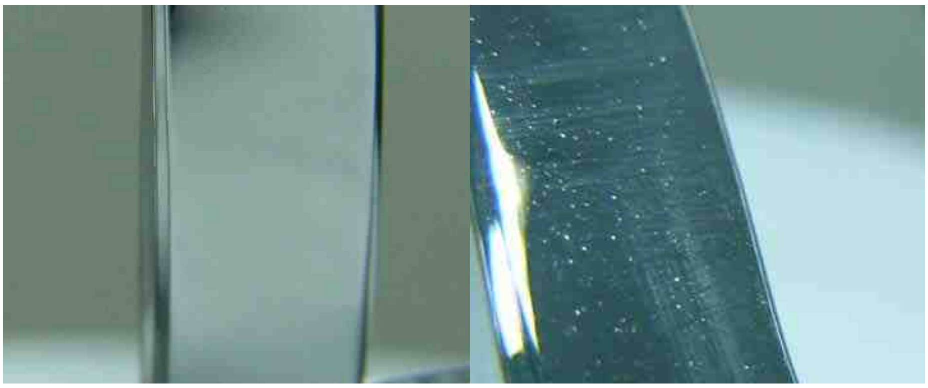
Photo 1: Surface morphology of chrome deposits (2000x)

Table 1 Vickers Hardness and internal stress of chrome deposit

Temperature (degree C)	Hardness after heating for 1hr (Hmv)					Stress Kgf/mm2
	as plate	200	400	600	800	
CF Cr	1,150	1,620	1,820	1,810	1,820	12
HV Cr	1,025	900	760	430	430	30

* CF Cr ; novel crack-free chrome , HV Cr ; conventional hexavalent chrome

Cr deposit thickness; about 13micrometer on copper plate. Load; 25gf, 10sec.



CF Cr *HV Cr*

Photo.2 Result of CASS test (Plastic plating with micro-porous nickel plating; after 7 cycles)

CF Cr (with scratches) *HV Cr (with scratches)*

Photo 3 Result of CASS test (plastic parts plated without micro-porous nickel; after 6 cycles)

CF Cr *HV Cr*

Photo.4 Calcium chloride + kaolin corrosion test (plastic parts plated with micro-porous nickel ; after one week)

CF Cr *HV Cr*

Photo 5 Result of CASS test (Tri-nickel plating on iron; after 4.5 cycles)

Discussion

A crack in the chrome deposit can be considered a deposit defect. There were no cracks with the CF Cr plating and the internal stress was about half of the conventional hexavalent chrome plating (HV Cr).

Amorphous deposits would be obtained by carbon inclusions in the CF Cr deposit, and internal stress of the deposit is decreased, because the plating solution is mainly composed of trivalent chromium and organic carboxylate. The hardness increases, because it changes to a crystalline structure with heat treatment.

A novel functional use of the plating would be expected, because the plating has excellent functional properties that current conventional hexavalent chromes do not have. Micro-porous nickel plating is not necessary for CF Cr plating, because the corrosion resistance of the plating with no micro-porous nickel is better than that of hexavalent chrome plating with micro-porous nickel. The calcium chloride (anti-freezing agent) + kaolin corrosion test results are also superior to conventional hexavalent chrome plating. Therefore, further treatment to increase corrosion performance which is reported in the case of trivalent chrome plating[1] is not required after CF Cr plating.

Conclusion

1. The crack-free chrome deposit (absent of crack defects) on the deposit where the corrosion resistance is superior to conventional hexavalent chrome plating.
2. The appearance of deposit is whitish color which is similar as conventional hexavalent chrome plating.
3. Due to the high hardness property, the deposit will not be easily damaged. The CF Cr deposit has improved properties where hardness will not decrease even after heat treatment. The internal stress of the deposit is about half of the conventional hexavalent chrome deposit.
4. The main composition is trivalent chromium ion which is environmental friendly and can meet requirements of global environmental issue.

Reference

1. Sakai, Hyoumen Gizyutu, **57**,869(2006).

