Bulletin of Electrochemistry 7 (6) June 1991, pp 266–268

0256-1654/91/$ 3-50

SEMIBRIGHT NICKEL UNDERCOATS ON THE CORROSION PERFORMANCE OF BRIGHT NICKEL-IRON-CHROMIUM DEPOSITS

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[Received: 1990 October; Accepted: 1991 May]

In the pursuit of a suitable substitute for the conventional bright nickel-chromium system, bright nickel-iron-chromium system has been accepted all over the world as a viable alternative especially for indoor applications. Further research on the effect of different undercoats and topcoats with a view to improving their corrosion performance has led to the conclusion that an underlayer of semibright nickel, similar to that in duplex nickel, can substantially improve the corrosion resistance and make it suitable for outdoor use.

Key words: Semi-bright nickel, undercoat, corrosion, Ni-Fe-Cr system

INTRODUCTION

The electrodeposited bright nickel-iron alloy with a flash of chromium has been universally accepted as a substitute for decorative nickel-chromium for indoor applications [1-2]. The cost-effectiveness of this process drives one to pursue further for improving its qualities so that its use for severely corrosive service is also possible.

In the earlier communications, the effects of applying copper undercoats of different thicknesses as well as those of providing a microdiscontinuous chromium overlay for this alloy system have been dealt with [3-5]. A copper undercoat of adequate thickness has been found highly favourable and the corrosion protection offered by a nickel-iron-chromium system incorporating the same appears to be even better than that of copper-nickel-chromium system for longer exposures. The formation of blisters, cracks etc. which degrade the appearance and protection are the main defects observed, and in the case of latter especially after extended periods of exposure. Likewise, the alloy system in presence of a porous chromium is known to have as high a corrosion resistance as the corresponding nickel system. This arose the curiosity of the authors to compare duplex nickel and duplex nickel-iron based systems especially under very severely corrosive conditions.

EXPERIMENTAL

Experiments were carried out for testing 9 μm thick alloy deposits of 25% iron content with 16 μm thick semibright nickel undercoats and with a regular or porous chromium overlay in each case, making use of 7.5 × 3.0 cm mild steel specimens. Severe corrosive tests, namely, Acetic acid Salt Spray (ASS), Copper Accelerated Salt Spray (CASS) and Corrodkote were employed as described earlier [3-5]. The semibright nickel deposits were produced from an electrolyte containing 250 $g.l^{-1}$ nickel sulphate, 20 $g.l^{-1}$ nickel chloride, 40 $g.l^{-1}$ boric acid and 0.4 $g.l^{-1}$ butyne diol and adjusted to a pH of 4.0. The solution was operated at a current density of 4.0 $A.dm^{-2}$ and 333K. All other deposits were produced under conditions described elsewhere [5]. The specimens were masked off at the edges having an effective exposed area of 5.0 × 2.5 cm. The exposed specimens were inspected for formation of corrosion spots, if any, at regular intervals extending up to 240 h in the case of the ASS test, and 3 cycles in the case of the CASS and Corrodkote tests.

In regard to corrosion performance rating, the ASTM method [6] was followed. According to this method, a perfect specimen showing no sign of deterioration is rated 10.0/10.0 and progressive degrees of failure are denoted by lower numbers. A rating below 7.0 for either protection or appearance is generally considered unsatisfactory.

RESULTS AND DISCUSSION

The results of the accelerated tests are shown in Figs. 1-4. In ASS test, the duplex nickel-iron with regular chromium exhibits almost similar or even slightly better performance as compared with duplex nickel-regular chromium systems (Fig. 1) in terms of protection ratings. The deviation is higher only when appearance rating is considered. However, even after 240 hours of testing, which is well above the period stipulated for severe corrosive service, both appearance and protection ratings are well above 8.0 pointing to the suitability of the coating system for use under severe corrosive environments.

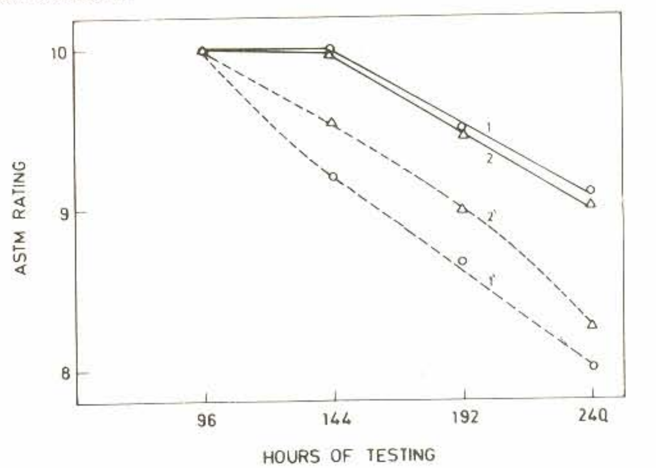

Fig. 1: Effect of semibright nickel undercoats in Ni/Ni-Fe systems with regular chromium topcoats in ASS test
1,2 = Protection, 1',2' = Appearance
1,1'= Nickel-iron, 2,2' = Nickel

When the quality and not the cost is of major concern, the corrosion performance of the alloy system can be further enhanced by finally applying a porous chromium overlay. The

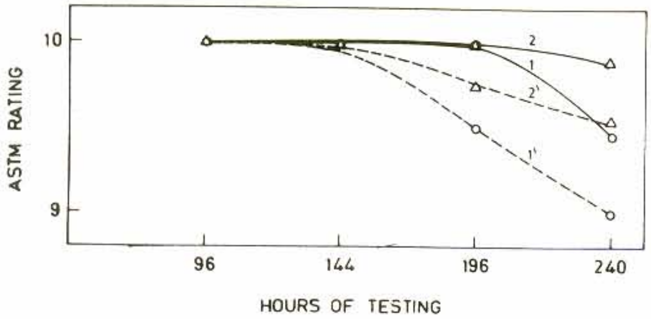

Fig. 2: Effect of semibright nickel undercoats in Ni/Ni-Fe systems with microporous chromium topcoats in ASS test
1,2 = Protection, 1',2' = Appearance
1,1' = Nickel-iron, 2,2' = Nickel

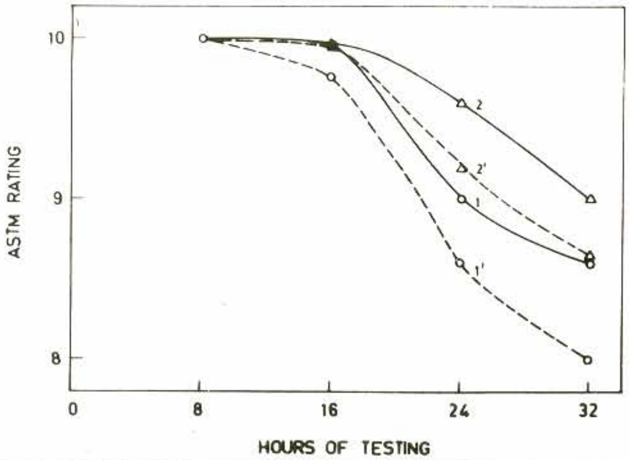

Fig. 3: Effect of semibright nickel undercoats in Ni/Ni-Fe systems with regular chromium topcoats in CASS test
1,2 = Protection, 1',2' = Appearance
1,1' = Nickel-iron, 2,2' = Nickel

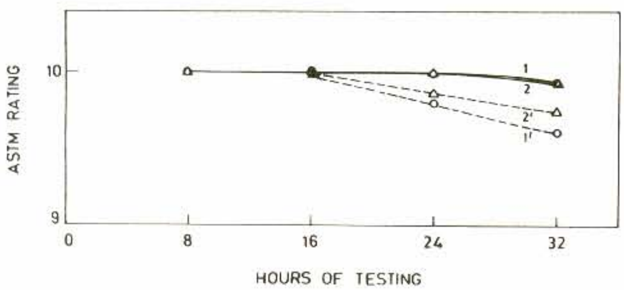

Fig. 4: Effect of semibright nickel undercoats in Ni/Ni-Fe systems with microporous chromium topcoats in CASS test
1,2 = Protection, 1',2' = Appearance
1,1' = Nickel-iron, 2,2' = Nickel

protection and appearance ratings are 9.5 and 9.8 respectively with very insignificant difference from the duplex nickel-porous chromium system. Upto 144 h of testing, the period stipulated for recommendations to service condition,there is the least variation in performance, at least with respect to protection between the two systems.

The ASS test is somewhat mild and considering the long durations involved, many industries prefer CASS and Corrodkote tests which are considered nearly 4 times more corrosive than the ASS test. Exposure for 16 h constitutes 1 cycle and corresponds to 1 year exposure under severe conditions. As shown in Fig. 3, the alloy coatings, with regular chromium topcoats show ratings above 8.0, even after exposure for 2 cycles, with, of course, a slightly higher extent of difference in their appearance and protection compared to the results of ASS test. Deposits with porous chromium top coats are found to perform almost equally upto 2 cycles(Fig. 4).

The results of the Corrodkote test, Figs. 5-6, are in accordance with those earlier discussed. Even after 2 cycles, the specimens are found to show a better performance than in the CASS test, though the general trend is retained in presence of both regular and porous chromium topcoats.

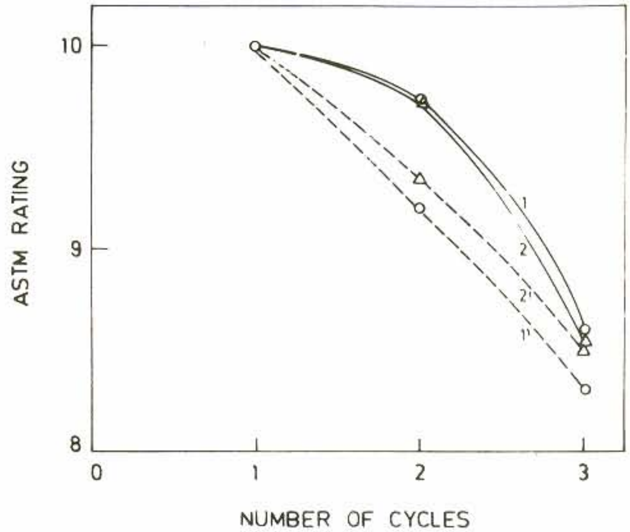

Fig. 5: Effect of semibright nickel undercoats in Ni/Ni-Fe systems with regular chromium topcoats in Corrodkote test
1,2 = Protection, 1',2' = Appearance
1,1' = Nickel-iron, 2,2' = Nickel

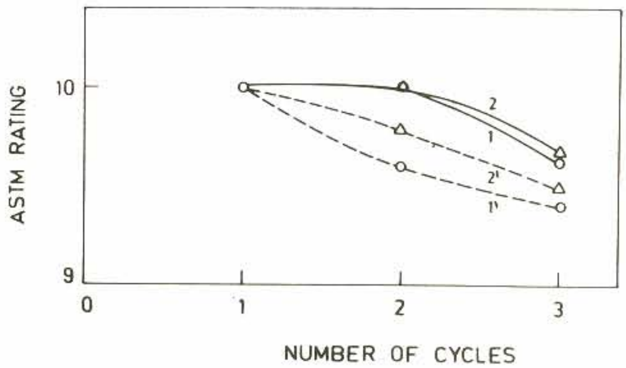

Fig. 6: Effect of semibright nickel undercoat in Ni/Ni-Fe systems with microporous chromium topcoats in Corrodkote test
1,2 = Protection, 1',2' = Appearance
1,1' = Nickel-iron, 2,2' = Nickel

The excellent behaviour of both the systems in presence of a semibright nickel undercoat is well explained by their open circuit potentials (Table I). The factors responsible for the excellent performance of the semibright nickel undercoat for bright nickel-iron alloy or nickel deposits are: (1) the higher difference in open circuit potential and hence the higher galvanic current prevailing in presence of a semibright nickel underlayer than when a copper underlayer is used for bright nickel or nickel-iron alloy deposits and (2) the change in polarity of copper undercoat with varying undercoat to deposit thickness ratios. The higher rate of dissolution of nickel-iron compared to nickel offers more protection to semibright nickel, although a reduction in appearance rating is observed. This can perhaps be overcome to a certain extent by applying the alloy as double-layer coating wherein the upper layer of the alloy consists of only 10% iron without, of course, the

TABLE-I: Open circuit potentials of copper semibright nickel, bright nickel-iron and bright nickel in test solutions

	Potential (mV vs SCE)		
Deposit	ASS	CASS	Corrodkote
Copper	−275	−172	−120
Semibright nickel	−220	− 87	− 44
Bright nickel-iron (25 % Fe)	−340	−186	−153
Bright nickel	−290	−178	−125

exclusion of semibright nickel.

CONCLUSION

The presence of a semibright nickel undercoat for bright nickel-iron alloy deposit and of either a regular or porous chromium overlay leads to almost as much corrosion resistance as with the conventional duplex nickel-chromium system under severe corrosive environments.

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