RESEARCH NOTE

PRETREATMENT OF GRAY CAST IRON FOR HARD CHROMIUM ELECTROPLATING

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Abstract From the standpoint of processing, hard chromium layer plate may be applied to steels, cast iron, aluminum and nickel base alloys. Cast iron can be plated provided that the surface is capable of conducting the required current and is reasonably free of voids, pits, gross silicate inclusions, and massive segregation. There are many difficulties arising from graphite phase and deposition of hydrogen on the surface of gray cast iron (G.C.I). To obtain desired hard chromium coating with acceptable adhesion, special pretreatments should be used. In this paper the surfaces of G.C.I. were prepared in sulphuric acid, chromic acid + SO_4^{--} by anodic etching phosphoric acid + sulphuric acid solution by electropolishing and sulphuric acid + fluoridric solution by dipping in the different conditions. The best results for removal of graphite from the surface of specimens are obtained after anodic etching in 60% H_2SO_4 solution.

Key Words Gray Cast Iron, Chromium Plating, Electroplating, Hard Chromium

چکیده جهت بهبود سطوح قطعات فولادی، آلومینیومی، چدنی و نیکلی و آلیاژهای آنها می‌توان از پوشش‌های کرم سخت استفاده نمود: سطح قطعات چدنی باید فاقد هرگونه حفره، ناخالصی‌های سیلیکاتی و رسوبات حجیم باشند. پوشش دادن سطوح قطعات چدن خاکستری بدلیل وجود گرافیت و آزاد شدن هیدروژن بسیار دشوار می‌باشد. لذا برای ایجاد پوشش کرم سخت با چسبندگی مناسب، عملیات آماده سازی سطح ویژه‌ای را باید انجام داد. در این تحقیقات آماده سازی سطوح قطعات چدن خاکستری توسط محلول‌های: اسید سولفوریک، اسید کرمیک + SO_4^{--} با استفاده از روش اچ آندی، اسید فسفریک + اسید سولفوریک با استفاده از روش پولیش الکترولیتی و اسید سولفوریک + اسید فلئوریدریک با استفاده از روش غوطه‌وری در شرایط مختلف صورت گرفته است. نتایج حاصل نشان می‌دهد که بهترین روش جهت برطرف کردن گرافیت‌های سطحی، استفاده از روش اچ اندی در محلول اسید سولفوریک ۶۰ درصد می‌باشد.

INTRODUCTION

Hard chromium coatings are intended primarily to increase service life of functional parts by increasing their resistance to (a) wear, (b) abrasion, (c) heat, (d) corrosion, (e) hardness or (f) crack density. Most hard chromium deposits are applied to parts made of ferrous alloys. Cast irons can be plated provided that the surface is capable of conducting the required current and it is reasonably free of voids, pits, gross silicat inclusions, and massive segregation [1,2]. Many difficulties arise from graphite phase in the gray cast iron structure. For example, although hydrogen overvoltage on this phase is low which makes it easy to deposit hydrogen, it makes the reduction of chromium ions difficult [3,4]. In addition, when chromium deposition proceeds, without applying a suitable pretreatment for removing the graphite from the surface, this phase remains in the deposit and causes the damage. To obtain desired hard chromium coating on the surface of G.C.I. with acceptable adhesion, special pretreatments should be used. Anodic etching in sulphuric acid solutions is the best method for preparing G.C.I before coating [5,6,7]. Other chemical and electrochemical methods

such as electropolishing in H_3PO_4 and dipping in H_2SO_4 + HF have also been suggested [8,9].

EXPERIMENTAL PROCEDURES

for preparing required specimens, gray cast iron with the thickness of about 12*mm* was cast in the sand molds. Chemical composition was set so that the microstructure of the specimens to be the same as that of industrial cases. After machining and grinding the specimens with 30×30×8*mm* dimensions were cut. For investigating the influence of various chemical and electrochemical processes on the gray cast iron surfaces, experiments under the conditions mentioned in Table 1, were performed. Specimens, after cleaning in hot alkaline solutions and rinsing, were processed under these predetermined conditions followed by rinsing and then nickel electroplated. Ni-coating acts as a suitable backup for protecting the specification of the surface Just after surface treatment and also for removing "rounding effect" in microscopic examination of the surface.

After finding the best pretreatment methods, the treated specimens electroplated in a PVC cell (28×10×10*cm*) by a proper hard chromium bath with 250*g/l* chromic acid a 2.5*g/l* SO_4^- with 30*A/dm*^{2} current density at temperature of 40°C. Two rolled anodes (93%Pb-7% Sn) were used on both sides of the central cathod. In the final step, for adhesion assessment, specimens were tested by "heat and quench" method.

RESULTS AND DISCUSSION

Among the 42 cases mentioned in Table 1, the best results for graphite removal from the surface of specimens are obtained after anodic etching in 60% H_2SO_4 solution. In Figures 1 and 2, differences between an untreated specimen and the one which is treated by anodic etching in 60% H_2SO_4 solution (case 19-Table 1) have been shown.

It is considered that the method is successful in

Figure 1. Presence of graphite in the nickel coating of untreated specimen.

Figure 2. Desired graghite removal from the surface (Electron microscope image).

graphite removing from the surface and there is no graphite in deposited nickel. In addition, even electron microscope shows desired adherence of the coating to the metallic matrix. But deposition of chromium on the specimens pretreated in a way mentioned above was impossible even with varying the main parameters of hard chromium electroplating bath in a wide range. Although steel and copper specimens were chromium plated in this bath easily.

All of the above mentioned results show that electrochemical pretreatment causes the surface of

TABLE 1. Predetermined Condition for Surface Treatment

No.	Applied method	Electrolyte	Current Density (A/dm^2)	Time (sec)	Temp. (°C)
1	Anodic etch	30% H_2SO_4	20	5	25
2	"	"	"	10	"
3	"	"	"	30	"
4	"	"	"	60	"
5	"	"	"	120	"
6	"	"	25	5	"
7	"	"	"	10	"
8	"	"	"	30	"
9	"	"	"	60	"
10	"	"	"	120	"
11	"	"	30	5	"
12	"	"	"	10	"
13	"	"	"	30	"
14	"	"	"	60	"
15	"	"	"	120	"
16	"	60%H_2SO_4	8	30	"
17	"	"	"	60	"
18	"	"	"	120	"
19	"	"	10	30	"
20	"	"	"	60	"
21	"	"	"	120	"
22	"	"	15	30	"
23	Anodic etch	60%H_2SO_4	15	60	25
24	"	"	"	120	"
25	"	250g/l CrO_3 & 2.5g/l	20	5	55
26	"	"	"	15	"
27	"	"	"	30	"
28	"	"	25	5	"
29	"	"	"	15	"
30	"	"	"	30	"
31	"	"	30	5	"
32	"	"	"	15	"
33	"	"	"	30	"
34	Electro polishing	63%H_3PO_4 15%H_2SO_4 & rem. water	20	30	"
35	"	"	"	60	"
36	"	"	"	120	"
37	"	"	25	30	"
38	"	"	"	60	"
39	"	"	"	120	"
40	dipping	5% H_2SO_4 5% HF	"	30	25
41	"	"	"	60	"
42	"	"	"	120	"

gray cast iron to become a suitable place for hydrogen deposition due to decrease in surface hydrogen overvoltage. For removing these areas caused by anodic etching, many methods were tested, applying anodic current to the etched specimen in a solution containing NaOH and NaCN in ambient temperature showed a potent effect. The specimens prepared in these two steps could be coated in hard chromium bath, the successful effect of concentrated sulphuric acid solutions (60%) for surface preparation of gray cast iron can be attributed to their less corroding effect on the metallic matrix of the microstructure. So less carbon-riched low hydrogen overvoltage sites will be produced which can be removed by applying anodic current in an alkaline-cyanide solution.

It should be noted that presence of the coarser qraphite phase in the microstructure of gray cast iron will magnify the difficulties for obtaining a suitable surface for hard chromium electroplating. So it would be advantageous to have finer graphite by adapting suitable procedures in the casting stage to have a uniform structure without any massive graphite.

The results of "heat and quench" tests show that milky and semi-bright deposits have good adhesion to the metal but adherence of burnt deposits with powdery structure is not acceptable which is in accordance with references [3].

In Figure 3 desired adherence of a semi-bright chromium deposit to the base metal has been shown by electronmicroscope.

CONCLUSION

1. Electrochemical pretretment can be used successfully for removing lossed graphite phase from the surface of gray cast iron an providing desired adherence between chromium coating and the base metal.

Figure 3. Desired adherence of a semi-bright hard chromium coating to the base metal.

2. Hard chromium electroplating of gray cast iron have its own difficulties and for the sake of desired adhesion and principally chromiom deposition, special pretreatments should be used.

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