EXPERIMENTAL RESEARCH ON PRETREATMENT PROCESS OF SURFACE IN ELECTRO-BRUSH PLATING

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Abstract

Electro-brush plating process consists of electrolytic degreasing, activation, under layer plating and working layer plating, in which electrolytic degreasing and activation quality affect the combining strength and performance of layer. By adjusting working voltage and activation time, No.2 and No.3 activation solutions were used to activate $45^{\#}$ steel by connecting anode with work piece, and then the quality of electrolytic degreasing and activation were evaluated by surface topography and metallographic analysis, which laid a foundation for the following process. It shows that for $45^{\#}$ steel, under the relative velocity of 17m/min, appropriate electrolytic degreasing process is 14V voltage and 60s time; using No.2 activation solution, optimal activation process is 14V voltage and 20s time; using No.3 activation solution, optimal activation process is 18V voltage and 80s time.

Keywords: Electro-brush plating; Electrolytic degreasing; Activation; Surface topography; Metallographic analysis

1 Introduction

Electro-brush plating technology is a part of re-manufacture and surface engineering technology which can obtain many kinds of high-quality coat in convenient, flexible, fast and cheap way. Electro-brush plating technology can not only used in part repair but also in part surface strength, erosion resist and decorate. It is used more and more in industry field and becoming a dependent, reliable and utility surface engineering technology. Huge economic and social performance has been obtained by using electro-brush plating technology [1,4,8]. At present, nanotechnology of electro-brush is the priority research area of electro-brush plating technology. Using nanotechnology of electro-brush can obtain compound nanometer cladding of uniform distributed particles, high hardness and high abradability. Nanotechnology of electro-brush is the developing direction of electro-brush plating technology; its use scope is even broader [2,3,6,7,9,10,11,15].

Electro-brush plating process consists of electrolytic degreasing, activation, under layer plating and working layer plating. Before plating under layer and working layer, the clean extent of base surface after pre-treated is one of the key factors who determined the cladding quality [5]. Electrolytic degreasing and activation quality directly affect the bond strength and the performance exerting. Zhang Zhaoguo etc[13,14] researched the optimal activation standard to nodular cast iron, $45^{\#}$ steel and 40Cr based steeling technology using the activate current density and activate duration as factors; they analyzed the effect of activate current density and activate duration on bond strength, and analyzed the activate mechanism on the basis of metallographic and electric mirror experiment. By adjusting working voltage and activation duration, No.2 and No.3 activation solutions were used to activate $45^{\#}$ steel by connecting anode with work piece, and then the quality of electrolytic degreasing and activation were evaluated by surface topography and metallographic analysis, which laid a foundation for the following process.

2 Material and methods2.1 Surface pre-treat solution

Surface pre-treat solution includes oil removing electrolyte (electrolytic degreasing solution) and the activate solution to electrolytic etching surface, the major formulas see table 1[12].

Table 1 Formulas of surface pretreatment solution

Chemical composition			Content /g·L^{-1}
Electrolytic degreasing solution	No. 2 activation solution	No. 3 activation solution	
NaOH			25~40
Na_2CO_3			20~40
Na_3PO_4			50~160
NaCl			2~5
	HCl (36~38%)		20~30
	NaCl		130~150
		$C_6H_8O_7 \cdot H_2O$	90~100
		$Na_3C_6H_5O_7 \cdot 2H_2O$	140~150
		$NiCl_2 \cdot 6H_2O$	2~4

2.2 Electro-brush plating sample

Electro-brush plating samples are rings of φ40×φ16×10(mm) made of $45^{\#}$ steel, outer cylinder is to be brushed with surface roughness of Ra1.6.

2.3 Experiment method

Using the opening of φ16 on the sample, chucking the sample in plain lathe of CA6136 by jig, the sample was brushed by TD-60 electro-brush power, CY40×25 graphite anode and TDB-1 Ⅱ brusher.

The existed theory and experiment showed that the factors such as working voltage, electrode relative speed and treat duration etc. all affect the quality of surface pre-treating. Electrolytic degreasing solution is oil removing electrolyte, which is strong alkaline, has excellent oil moving function and has slight ability of rusty removal. This experiment didn't consider effect of the electrolytic degreasing process on surface pre-treat, and primary studies the effect of activate process on surface pre-treat. Electrolytic degreasing working voltage is 14V; electrode relative speed is 17m/min, treat duration is 60s. The activate experiment was performed in room temperature and electrode relative speed is17m/min. the working voltage and activate duration were selected as research factors, and different levels were selected.

Factor one: working voltage. 6V, 10V and 14V were selected as three levels of activate voltage of No. 2 activate solution; the voltages of No. 3 activate solution were 17V, 20V and 22V.

Factor two: activate duration. 10s, 20s, 30s, 60s and 90s were selected as five levels of activate duration of No. 2 activate solution; and the six levels of No. 3 activate solution were 20s, 40s, 60s, 80s, 100s and 120s.

3 Results and analysis

3.1 Surface topography after electrolytic degreasing

The surface topography of electrolytic degreased 45# steel with electrolytic degreasing solution positive was shown in figure 1. From the metallographic photo, we can see that electrolytic degreasing can only clean the oil film on part surface, the constitution hasn't been changed and the process fringe has no obvious change.

Figure 1 Surface topography after electrolytic degreasing at 14 volt

3.2 Surface topography after activated by No. 2 solution when connect anode to work piece

3.2.1 6V working voltage

When working voltage is 6V, Surface topography after using No. 2 activating solution by connecting anode with work piece were shown in figure 2.

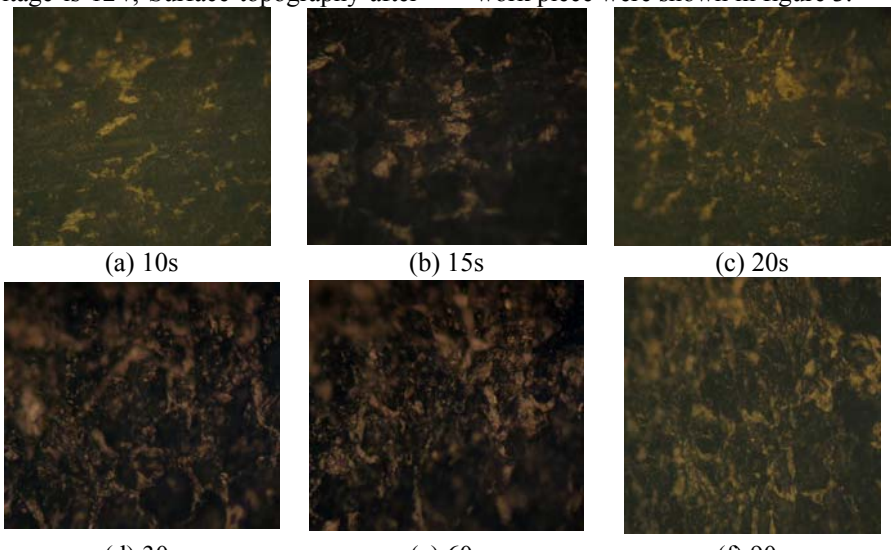
From figure 2, we can see after activated 10s, 20s, 30s on 45# steel, the process fringes on sample surface turn blurred in turn, and after activated 60s the oxide film and machining process fringes on sample surface were corroded entirely.

(a) 10s (b) 20s (c) 30s (d) 60s

Figure 2 Surface topography after activating using No. 2 solution at 6 volt

3.2.2 12V work voltage

When working voltage is 12V, Surface topography after using No. 2 activating solution by connecting anode with work piece were shown in figure 3.



(a) 10s (b) 15s (c) 20s

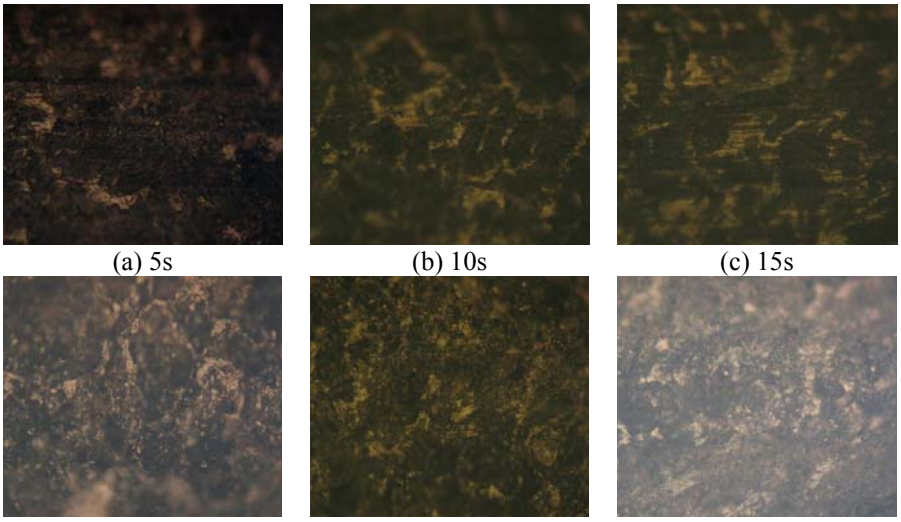
(d) 30s (e) 60s (f) 90s

Figure 3 Surface topography after activating using No. 2 solution at 12 volt

From figure 3, we can see after activated 10s, 15s, 20s on $45^{\#}$ steel, the process fringes on sample surface turn blurred in turn, and after activated 30s the oxide film and machining process fringes on sample surface were corroded entirely.

3.2.3 14V work voltage

When working voltage is 14V, Surface topography after using No. 2 activating solution by connecting anode with work piece were shown in figure 4.



(a) 5s (b) 10s (c) 15s

(d) 20s (e) 30s (f) 60s

Figure 4 Surface topography after activating using No. 2 solution at 14 volt

From figure 4, we can see after activated 5s, 10s, 15s on $45^{\#}$ steel, the process fringes on sample surface turn blurred in turn, and after activated 20s the oxide film and machining process fringes on sample surface were corroded entirely. When the activate duration exceed 20s, the change of activate effect is not obvious.

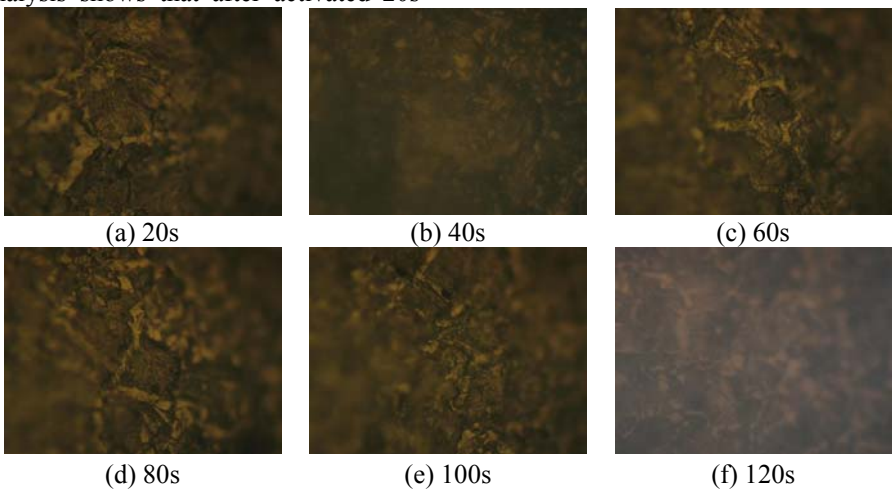
Above research shows that for No. 2 activating solution when at the same working voltage, the activate affect become well with the increase of the activate duration. But the activate effect changes little when activate duration reaches a certain degree; the activate time needed become shorter when the working voltage increase; when the activate duration is same, the activate effect will be more obvious as the working voltage become higher. The optimal activate process of No. 2 activating solution on $45^{\#}$ steel was determined, the working voltage is 14V and activate duration is 20s, concerned of working efficiency and high working voltage of following No. 3 activating solution.

Metallographic analysis shows that after activated 20s the oxide film and machining process fringes on sample surface were corroded entirely and the ferrite in pearlite has corroded deeply. Cementite and graphite band come to the surface, so that the entire body surface appears black-gray and takes on uneven. Black carbon can't be cleaned with water, if electro-brush plating is implemented on such surface the bonding strength between electro-brush plating layer and body will be build down. No. 3 activating solution of organic acidity can remove black carbon and expose the atom crystal lattice of body metal, so that the cladding and base body can be bonded firmly.

3.3 Surface topography activated by No. 3 solution when connect anode to work piece

3.3.1 17V working voltage

When working voltage is 17V, Surface topography after using No. 3 activating solution by connecting anode with work piece were shown in figure 5.



(a) 20s (b) 40s (c) 60s

(d) 80s (e) 100s (f) 120s

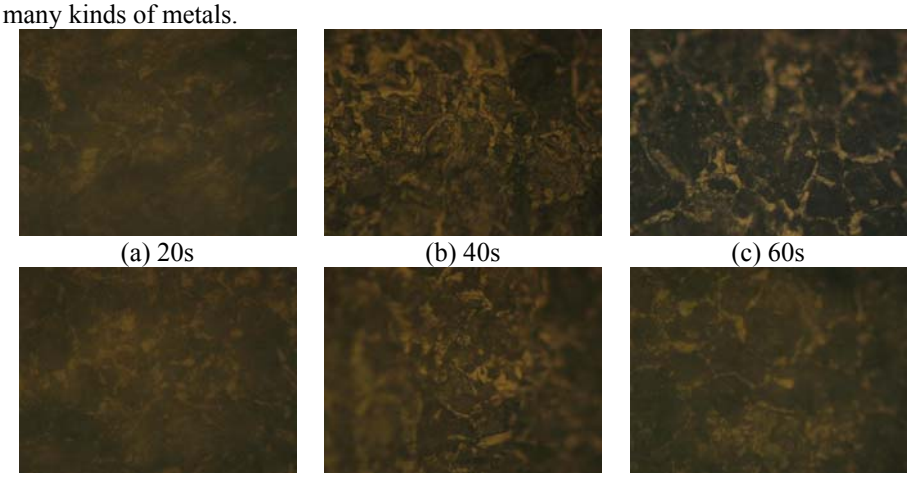
Figure 5 Surface topography after activating using No. 3 solution at 17 volt

From figure 5, we can see after activated 20s, 40s on $45^{\#}$ steel, the black on sample surface become faded

gradually, and silver gray surface appears once more. After activated 100s, 120s, black turns out in sample surface again which means there is low-grade corrode in body, it is because there is coordinate oxidative between organic acid and many kinds of metals.

3.3.2 20Vworking voltage

When working voltage is 20V, Surface topography after using No. 3 activating solution by connecting anode with work piece were shown in figure 6.



(a) 20s (b) 40s (c) 60s

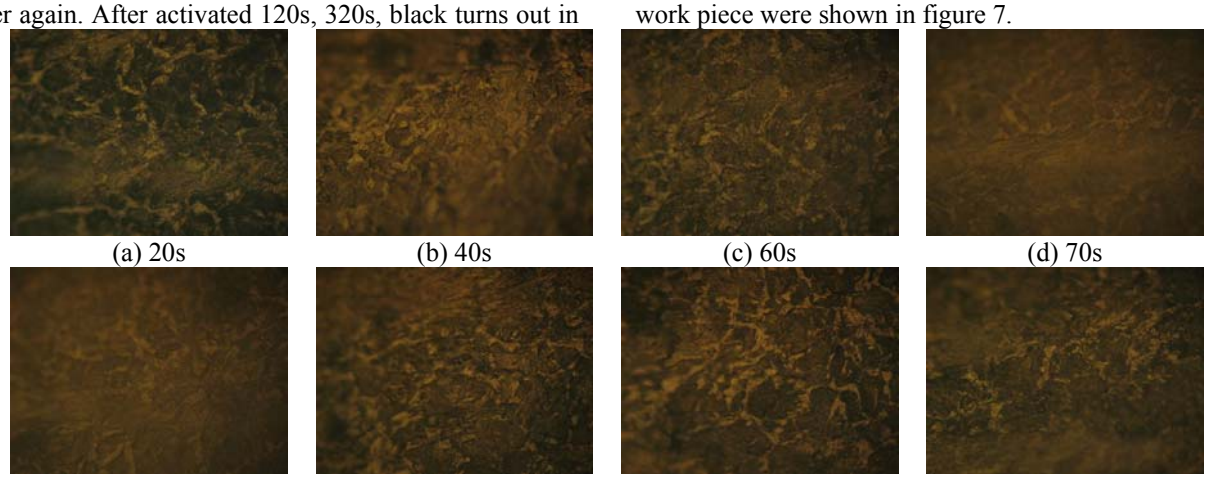
(d) 80s (e) 120s (f) 320s

Figure 6 Surface topography after activating using No. 3 solution at 20 volt

From figure 6, we can see after activated 20~40s on $45^{\#}$ steel, the black on sample surface become faded gradually, and silver gray surface appears once more. After activated 80s, black carbon on part surface was removed entirely; the surface of black-gray body appears over again. After activated 120s, 320s, black turns out in sample surface again which means there is low-grade corrode in body.

3.3.3 22V work voltage

When working voltage is 22V, Surface topography after using No. 3 activating solution by connecting anode with work piece were shown in figure 7.



(a) 20s (b) 40s (c) 60s (d) 70s

(e) 80s (f) 90s (j) 100s (h) 120s

Figure 7 Surface topography after activating using No. 3 solution at 22 volt

From figure 7, we can see after activated 20~70s on $45^{\#}$ steel, the black on sample surface become faded gradually, and silver gray surface appears once more. After activated 80~90s, black carbon on part surface was removed entirely, the surface of black-gray body appears over again. After activated 100s, 120s, black turns out in sample surface again which means there is low-grade corrode in body.

After activated by No. 3 solution, loose graphite and foliate carbide of $45^{\#}$ steel are oxidized to carbon monoxide or carbon dioxide by anode in high temperature, and will be removed; then the new metallurgical structure break upon. From macro point, when $45^{\#}$ steel is activated by No. 3 solution, the black on sample surface will be removed, and silver gray surface appears again. Excellent bonding strength can only ensured by plate metal on such surface. When at the same working voltage, in certain time scope of 80~90s, the activate effect will be more obvious as the time prolong. When time exceeds this scope, body will be corrode slightly and become dark. Concerned to subsequent impact plate process to bottom by special nickel plate at voltage of 18V, the optimal activate process of No. 3 solution are determined such as working voltage 18V and activate time 80s.

4 Conclusions

(1)The proper electrolytic degreasing process to $45^{\#}$ steel are: Working voltage is 14V and electrolytic degreasing time is 60s.

(2)When No. 2 activate solution is at same working voltage, the activate effect becomes better as the activate time increase, but when activate time rises to certain value the change of activate effect is not obvious; when

activate time rises the activate time needed becomes shorter; when the activate time is same, the higher the working voltage is the more obvious the activate effect is. The optimal activate process to No. 2 activate solution is: Working voltage is 14V and activating time is 20s.

(3)When No. 3 activate solution is at same working voltage, at certain time scope of 80~90s, the activate effect is obvious as the activate time increase, but when activate time exceeds this scope the body will be corrode slightly and becomes dark. The optimal activate process to No. 3 activate solution is: Working voltage is 18V and activating time is 80s.

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