POLISHIN OF NON-FERROUS METALS WITH HIGH EFFICIENCY[①]

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ABSTRACT "Electrolysis-Fixed Abrasive polishing" is a new method used to polish non-ferrous metals such as aluminium, copper, titanium and their alloys. Because this technology has nothing to do with the plasticity, toughness, strength, hardness and other mechanical properties of metals, it solves the problem that non-ferrous metals are difficult to polish due to their high toughness and high plasticity. The polishing mechanism and the polishing results are described.

Key words non-ferrous metals electrolysis polishing abrasive magnetic field

1 INTRODUCTION

Besides steels, non-ferrous metals such as aluminium, copper, titanium and their alloys are very important materials, due to their advantages of high corrosion resistance, high plasticity, high toughness, high specific strength and good low temperature properties. These non-ferrous metals are widely used in navigation, aviation, steam turbine vane, medical component and sports equipment industries. However, some of their mechanical and physical properties cause grinding and polishing difficulties. The reason for this is that they have high toughness, high friction and low thermal conductivity factors which cause burning and blackening of the work surface. The titanium and aluminium alloys exhibit a strong chemical affinity for oxygen, and if we use aluminium oxide abrasives to grind or polish them, a chemically affine reaction takes place between the abrasives and the surface metal, causing the cutting edge of the abrasives to be covered with metal. The result is that the grinding wheel blunts and the grinding ratio reduces.

However, the problem of grinding and polishing non-ferrous metals in a highly efficient manner is easily solved by applying the Electrolysis-Fixed Abrasive Polishing (EFAP) process.

2 PROCESSING CONDITIONS[1-3]

(1) Processing device: The plain lathe with electrolytic D. C. source, cathode, magnetic poles and the clamp of the abrasive slice is used, as shown in Fig. 1. The anode work is connected to the positive pole of the D. C. source, and the

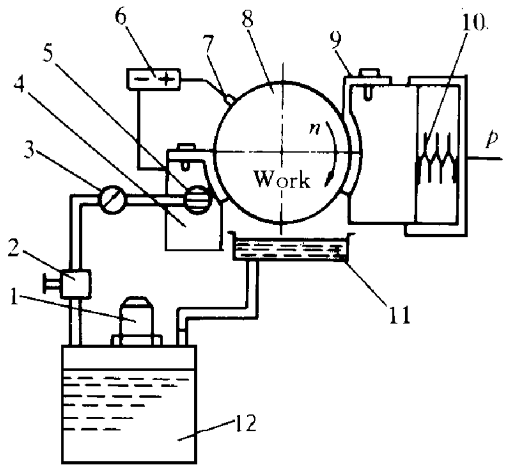

Fig. 1 Schematic diagram of processing device
1—Pump; 2—Valve; 3—Flow gauge; 4—Cathode; 5—Magnetic poles; 6—D. C. source; 7—Brush; 8—Anode; 9—Abrasive slice; 10—Spring; 11—Return cell; 12—Electrolyte cell

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cathode is connected to the negative pole;

(2) Magnetic poles: The N pole and the S poles are respectively fixed at the two sides of the cathode, and the magnetic field of 0.01 T is perpendicular to the electric field;

(3) Electrolyte: The concentration of the neutral Chile nitre solution is 20%;

(4) Abrasive slices: Two kinds of different matrixes are used.

The first kind of abrasive slices, whose abrasives are 240#, 320#, and 1 000# respectively, are made up of macromolecular synthetic fibre, binder, and the Al_2O_3 abrasives on the fibre surface. During rough finishing, using the abrasive slices of 240#, the roughness of the turned work surface can be improved from Ra 4 ~ Ra 5 to Ra 0.2, and using the 320#, the roughness can be improved from Ra 0.2 to Ra 0.1~ Ra 0.05.

During semi-finishing, the abrasive slices of 1 000# are used and the roughness of the work surface can be improved from Ra 0.05 to Ra 0.02.

The matrix of the second kind of abrasive slice is macromolecular cellular parenchymatous mesh, and the size of the Al_2O_3 abrasives are smaller than that of the 1000#. Fig. 2 shows its SEM picture.

Using the second kind of abrasive slice to polish the work, the roughness of the work surface can reach Ra< 0.02.

3 PROCESSING MECHANISM[4-6]

When processing, the work rotates, the abrasive slice and its presser, not only feeds axially, but also vibrate axially at certain frequency and amplitude to improve grinding or polishing evenness.

Through the cathode holes, the electrolyte flows on the work surface, that the work surface is ground and polished in a comprehensive action as follows.

3.1 Electrolytic action

Under the electric field, the electrolyte between the work and the cathode is electrolyzed. The electrolyzing speed of the convex peak on

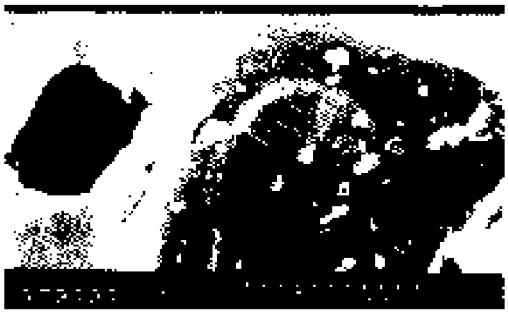

Fig. 2 SEM picture of abrasive slice of macromolecular matrix, ×300

the work surface is faster than that of the concave valley. The reason for this is that the density of the electrolines on the convex peak and the electric field strength is greater, promoting the leveling of the work surface.

3.2 Abrasive slices action

During electrolyzing, a dense passive film of low hardness is formed on the work surface, having nothing to do with the mechanical properties of the work, but being related to its own electrochemical properties. Therefore no matter how high the metal toughness and hardness are, the formation of the passive film is not affected.

Because the hardness of the passive film is low and the stress is concentrated on the convex peak, when the work rotates, the passive film on the convex peak is easily scraped by the abrasive slice, thus the new metal surface is exposed, repeatedly, leveling the work surface on the convex peak quickly.

3.3 Magnetic field action[2, 7, 8]

The charged particles in the electric field will be acted upon by Lorentz force in the magnetic field, and when the electric field is perpendicular to the magnetic field, the action of Lorentz force is the greatest.

The Lorentz force plays an agitating effect on the electrolyte, which accelerates the mobility and spread of ions near the electrodes, reduces the electrochemical polarization and concentration polarization, and accelerates the electrochemical reaction. Fig. 3 shows the comparison of the surface roughness Ra of the pure titanium with magnetic field and without magnetic field, the efficiency with magnetic field is higher than that without.

Fig. 4 shows the effect of magnetic density on toughness of the work surface. The surface roughness decreases as the magnetic density increases. When the magnetic density is 0. 01 T, the optimal dynamic equilibrium under the grinding of the abrasives, the passivation of the electrical chemical reaction and the activation of the magnetic field is obtained. This lowers the work surface Ra to the lowest.

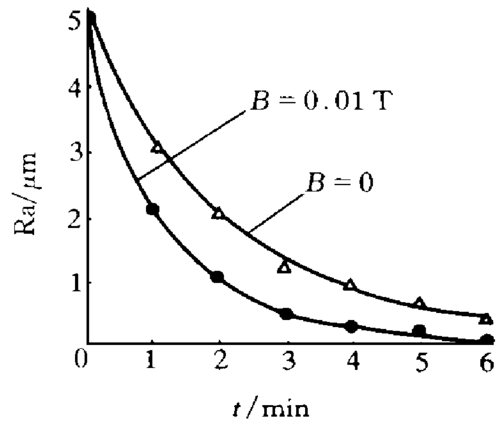

Fig. 3 Comparison of surface roughness Ra of pure titanium with magnetic field and without magnetic field

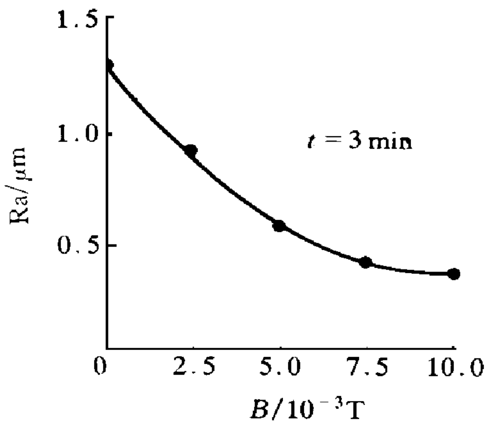

Fig. 4 Effect of magnetic density on Ra

4 INTEGRITY OF WORK SURFACE AFTER ELECTROLYSIS-FIXED ABRASIVE POLISHING

The integrity of the work suface includes two important aspects. The first is the roughness of the work surface, the second the metallographic changes in the surface, which are used to study the special properties of the surface layer, including the mechanical and physical properties.

By using the rigid grinding wheel to grind or polish the surface, the roughness is not easily reduced, and the residual stress and metamorphic layer are easily formed on the work surface. For example, when grinding or polishing the titanium alloys, the surface is easily burned, forming a superhot white layer; and the residual stress will lead to work deformation. In the traditional electrochemical grinding or polishing, when the processing parameters such as electric current are improperly selected, the selective corrosion and intercrystalline corrosion appear. The changes on the work surface will affect the fatigue and stress corrosion properties.

Applying the electrolysis-fixed abrasive polishing technique, the integrity of the work surface is good. The reasons for this are:

(1) Reducing the roughness of the work surface is a comprehensive result of electrolyzing, grinding and polishing of the abrasive slice, and magnetic field action which causes the surface roughness of the non-ferrous metal to improve from Ra 5 to Ra 0. 01 in a short time.

(2) There is no residual stress in the work surface layer, since the elastic abrasive slice makes contact non-rigid.

(3) There is no intercrystalline corrosion on the work surface, as Fig. 5 shows, for the electric current density used is smaller. Fig. 5 shows the comparison of the surface layer of the titanium alloy rolling pipe before and after polishing.

(4) Before and after the work surface is processed, measuring its HV hardness, there is no work hardening on the work surface.

(5) Because titanium alloys are sensitive materials, after they are conventionally ground, either at high or low temperatures, their fatigue strength will reduce greatly. According to Ref. [8], when they are ground, low stress grinding must be used to replace conventional grinding. What is called low stress grinding is using a lower hardness grinding wheel, lower grinding speed, and lower feed rate. The electrolysisfixed abrasive grinding conforms to the demand of the low stress grinding and, therefore, the fatigue strength doesn't change significantly.

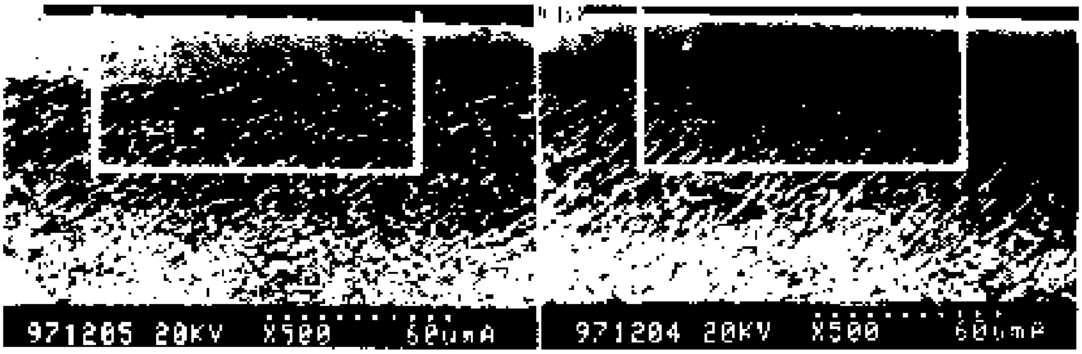

Fig. 5 SEM picture of surface layer of titanium alloy rolling pipe
(a) —Before polishing; (b) —After polishing

5 CONCLUSIONS

The electrolysis-fixed abrasive polishing process is not only of high efficiency, but also of good surface quality without surface defects and the process provides a new effective method for the grinding and polishing of non-ferrous metals.

REFERENCES

1 Zhao Xiaolin *et al*. The Chinese Journal of Nonferrous Metals, (in Chinese), 1995, 5(4): 145.

2 Ma Wei *et al*. The Chinese Journal of Nonferrous Metals, (in Chinese), 1995, 5(4): 59.

3 Takazawa K *et al*. In: Takazawa K *et al* eds, Precision Surface Finishing and Burr Technology, 3rd International Conference on Precision Surface Finishing and Burr Technology, Korea, 1994: 246.

4 Seimiya K. Iron & Steel, 1986, (8): 16.

5 Kimoto Y *et al*. JSPE 1988, (54): 353.

6 Kim J D *et al*. In: Praylenk K ed, Precision Surface Finishing and Burr Technology, 4th International Conference Precision Surface Finishing and Burr Technology, Germany, 1996: 133.

7 Chen Yuquan *et al*. In: Praylenk K ed, Precision Surface Finishing and Burr Technology, 4th International Conference Precision Surface Finishing and Burr Technology, Germany, 1996: 52.

8 Han Rongdi *et al*. Machining of Difficult-to-Cut Material, (in Chinese). Beijing: Mechanical Industry Press, 1996: 87- 94.

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