RESEARCH ON APPLICATION COMPOSITE ELECTROPLATING TO FABRICATE GRINDING TOOL

TRAN THI VAN NGA
TRUONG HOANH SON
University of Transport and Communications

Summary: *Composite electroplating bases on electroplating technology. The coating layer is created by co-deposition of metal and hard particles. The hard particles have improved properties of coating layer such as increasing durability in corrosive, abrasive, heat stability and hardness... Composite electroplating is also applied to fabricate single-layer grinding tools with superabrasive grains such as diamond and Cubic Boron Nitrite (CBN). This paper presents a study on the application of composite electroplating to manufacture grinding wheel. The experimental results show that it is possible to create a single layer of grain on the metal core and grains are adhesive well with electroplating metal.*

Keywords: *Composite electroplating, electroplated grinding wheel, grinding whell with a grain layer, superabrasive grains, Watts solution.*

I. INTRODUCTION

Grinding wheel is a cutting tool usually used for finished surface machining. Currently, in order to save the quantity of expensive grains as diamonds and CBN, grinding wheels are not only used to manufacture multilayer grinding wheels but also manufacture single-layer ones. The shape of single-layer grinding wheel is based on the profile of the body, therefore, manufacturing single-layer grinding wheel for machining shaped surface is a simple task. One of methods to manufacture single-layer grinding wheels is electroplating. In comparison with sintering method, the electroplating method can achieve higher precision but lower cost (especially for expensive particles). In the electroplated method, the coating abrasive layer is created by composite electroplating. In this paper, the authors present a study on the application of composite electroplating to manufacture grinding wheels as well as some results obtained by experiments.

II. COMPOSITE ELECTROPLATING

Composite electroplating bases on electroplating, however particles will be added into the electroplating solution. The particles in the solution are in state of suspending and highly dispersing. The coating layer is created by co-deposition of metal and hard particles. The hard particles have improved properties of coating layer such as increasing durability in corrosive, abrasive, heat stability and hardness...

2.1. Principles of electroplating

During composite electroplating process, stirring the solution will ensure the suspended state of hard particles. After impinging the cathode surface, these particles will be deposited in the metal precipitation layer. The process of forming composite electroplated layer is divided into the following stages [1],[2]:

Stage 1: The movement of the dispersed phase particles and ions in the solution to the cathode

The convection, sedimentation, diffusion, laminar, and turbulence fluid state will affect the movement of the elements of the second phase to the cathode surface. As the particles move to the surface of the electrode, they will be impacted by some forces which are shown in Figure 1.

The moving forward of the 2nd phase element to the cathode is primarily done by agitation and diffusion of the particles. Due to the agitation, particles and ions move rapidly to the cathode surface.

The viscosity of the fluid, the velocity of the particles and ions, the size of the 2nd phase element, the concentration of solution, the composition of the electrolyte, the relative position between the cathode and the anode are main factors in this stage.

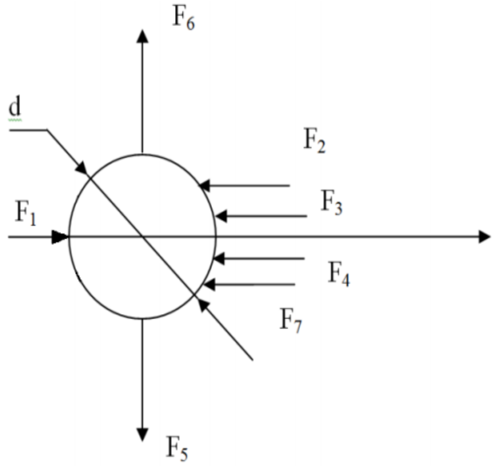

Figure 1. *Diagram of the forces acting on the particles in stage 1*

F1- Inertial forces; F2- Viscous drag; F3- Forces of concentration gradient; F4- External electric power (DC power supply due to the bath); F5- gravity; F6- Archimedes force; F7- Electromotive force (due to friction between the laminar layer); d-the diameter of the particle

Stage 2: The adhesion of the second phase particles (particles) on the surface of the cathode

The element continues moving at distance as the diffusion layer thickness. Absorption capacity depends on the size of the particles, the concentration of electrolyte, cathode shape, the speed, direction and properties of the flow. Based on the laws of Coulomb, electrostatic attraction will cause adhesion process. Cohesive force of the particles onto the surface of the cathode is proportional to the surface tension (also known as surface energy) and determined by experiment.

Main factors of this stage: the cathode surface, hydrogen gas escaping from the cathode surface, the size of particles, coated hydrophobic surface. The electric field and magnetic permeability are also important because they exert a force on the charges. The longer interaction time between particles and cathode occurs, the better ability of adhering those particles can be achieved. Depends on the position between cathode and anode, the clash of particles might obtain different characteristics.

Stage 3: The deposition of the particles.

This is the most important stage which can determine the quantity of dispersed phase in the coating, sustainable bond and local structural of the particles.

The particles on the surface are deposited along with metal precipitate. When the electroplating process is finished, a composite coating based on deposition of metal and hard particles will be obtained.

The important factors of this stage are listed as follows: the density of particles, the stability of the mixture, the highest state dispersing of particles. If particles are too large, they can be easily sinked and separated from the cathode surface, causing reduction in capacity of adhering. If particles are small, they will experience Archimedes force.

Along with the polarization, high electrical gradient at cathode encourages charged particles speeding up to the surface of the cathode, enabling the co-deposition of metal and hard particles.

Shape and hydrophilic properties of the surface as well as diffusion ability of the electrolyte or viscosity of the solution will result in cathode polarity process, affecting the quality of electroplating.

2.2. Factors affecting the formation of the coating

Factors affecting the coating are: electric current, pH, temperature, composition of solution, stirring speed, preparation of coating, method and device of electroplating [1],[2].

III. RESEARCH ON APPLICATION OF COMPOSITE ELECTROPLATING TO FABRICATE GRINDING TOOL

3.1 . Materials for manufacturing electroplated grinding wheel

The electroplated grinding wheels are generally limited to superabrasive grains because of the economics of wheel life. The term superabrasive is used for two very hard abrasives, either diamond or CBN. Diamond is the hardest known abrasive material and CBN is the second hardest after diamond. [8]

Table 1. *Knoop hardness criteria of diamond, CBN, Silicon carbide, Aluminum oxide [6]*

Grains	Diamond	CBN	Silicon carbide	Aluminum oxide
Knoop Hardness(kg/cm^2)	6500	4500	2500	1370-2260

3.2 Bonds for electroplated grinding wheel

In electroplating, precipitation of nickel is the main factor which creates the bond between particles and plating [7], [8]. The ability to bond abrasive particles to the plating also depends on electroplating technology.

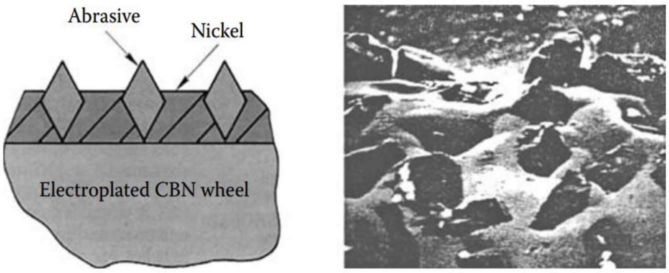

Figure 2. *Schematic of an electroplated cubic boron nitride wheel section and the appearance of the actual surface of such a wheel. [7]*

However, approximately 50-70% abrasive particles are deposited in order to ensure chip evacuation. Depending on the distribution of abrasive particles, large or small chip evacuation might be obtained.

Electroplating is mechanically depositing abrasive particles process. Therefore, plating depth is required to greater than 50% the height of the abrasive particles. Cross section and plating shape of the grind wheel fabricated by electroplated method is shown in Figure 2 and Figure 3. After conducting surveys and analyzing of electroplated layer of electroplated CBN grinding wheel, it shows that nickel is the main factor creating bond in grinding wheel [5].

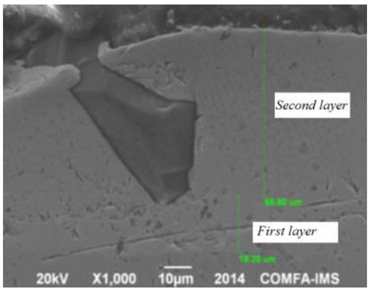

Figure 3. *Cross section of CBN grinding wheel [3]*

3.3. Applying composite electroplating to fabricate grinding wheel

Based on composite electroplating, the coating layer is created by co-deposition of nickel and grains. The purpose of this research is to obtain an evenly distributed and adhesive coating layer. The author has conducted a number of experiments, however, further research is needed since grains distribution were uneven.

Figure 4. *Result of experiment (sample M50)*

In the experiment, in order to obtain nickel coating, material of tool body is C45 (TCVN 1766 - 75) and Watts solution ($NiSO_4.7H_2O$ 250÷300g/l, $NiCl_2.6H_2O$ 25-30g/l, H_3BO_3 25 ÷ 40g/l, sodium laurel sulphate 0.1- 0.15g/l) is used. In the solution, grain size is # 120 (approximately 0.1 mm diameter) with the proportion of 250g/l. Solution temperature, current density, plating time are 50-65^{0}C, 1.2-3.5A/dm^2, 15-30 minutes respectively. Solution was stirred with the purpose of achieving optimal surface distribution. The tool bodys were plated vertically or horizontally in coating process.

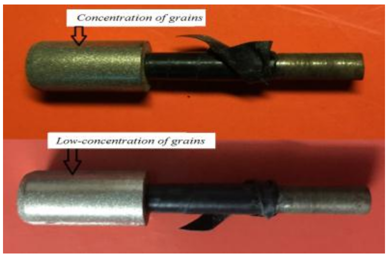

Figure 5. *Result of experiment*

Results received after plating a sample are shown in Figures 4 and 5, while surface SEM are presented as figure 6 and 7.

3.4. Discussion on experimental results

The purpose of stirring was to allow particles to float in plating solution. When stirring speed was high, particles hardly adhere to surface due to high kinetic energy. If stirring speed was too low, particles were not evenly distributed. Only few particles adhere to vertical surface due to high mass. Most of particles were on horizontal surface. Plating surface, therefore, should be in horizontal position.

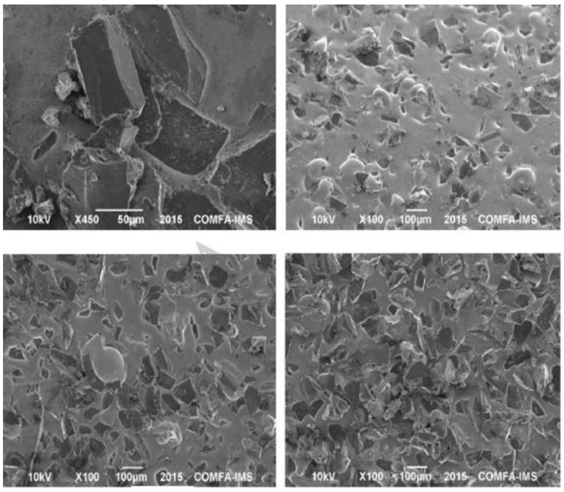

Figure 6. *SEM micrographs of surface of the electroplated sample M50 [4]*

Electroplating current density also affects on the plating layer. With too high density (7-9 A/dm^2), the plating layer was unstable, but with too low density, it can not be created.

- Plating layer is not glossy at low temperature. Most suitable range of temperature for plating is from 55 to 65^0C

IV. CONCLUSION

Studying composite technology and result of experiments shows that:

- It is possible to fabricate single-layer grinding tool by applying composite electroplating.

- By stirring, hard particles on surface are unevenly distributed. Further researches are required to allow hard particles to be evenly distributed in order to create strong bond between particles and surface, thus ensure sharpness of grinding tool.

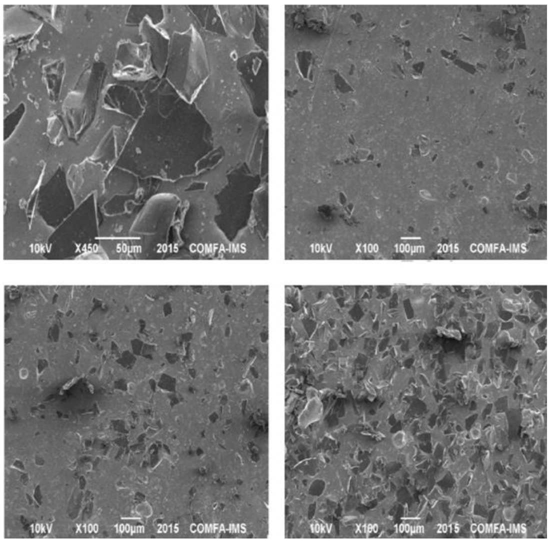

Figure 7. *SEM micrographs of surface of the electroplated sample M54 [4]*

V. CONCLUSION

In this study, the reliable and efficient FE models for the analysis of flexural behavior of strengthened RC beam have been developed. It has been shown that the proposed model is capable of accurately predicting the load-carrying capacities and load-deflection relationships for the RC beam and the RC beam strengthened with TRC layer. The results are clearly demonstrated the accepted beneficial effects of TRC. Both the stiffness and strength of the strengthened beam can be substantially increased.

While the objectives of this research study are achieved, much more work is still needed to fully characterize the behavior of TRC strengthening RC beam. The main concern regarding flexural application is preventing the debonding from the composite to concrete. Future experimental research should concentrate on the bonding mechanisms.

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