Effect of Nano-TiN Particles on Ni-TiN Composite Coatings

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Abstract. Through the research on the performance of the Ni-TiN composite coatings prepared by ultrasound-electrodeposition technology and several experiments exploring the effect of nano TiN particles on the hardness, wear resistance, corrosion resistance and components of the composite coating. The result shows: Ni-TiN composite coating containing appropriate amount of nano TiN particles has good hardness, corrosion resistance and wear resistance, greatly reduced wear extent and better performance.

Introduction

The development of nanotechnology and electro-deposition technology promotes the development of nanotechnology. Nano materials have started to display its unique charm. The performance and preparation of nano-composite coating have made great breakthroughs. In the preparation of composite coating, ultrasound-electro-deposition technology has become the major technology and the principle of this technology is: by stirring and a weak electric field force, the particles are absorbed on the surface of cathode, and then gradually covered by deposited matrix metal grain. When the cover of deposited metal crystal particles exceeds the radius of the particles, the "chimeric effect" will occur between particles and matrix metal, thereby forming a composite coating. Studies show that: In terms of wear resistance, corrosion resistance and antioxidation, composite coating has excellent performance, and the composite coating prepared by the ultrasound-electro-deposition technology has good appearance and internal performance. The nano composite coating has an incomparable advantage which organically integrates the superiority of the traditional composite coating materials and that of the modern nano materials, therefore, it has become the focus of attention and research for scholars at home and abroad.

Use Ultrasound-Electro-deposition Technology to Prepare Ni-TiN Composite Coating

Use appropriate amount of distilled water to mix up the nano TiN particles and surfactant, stir them evenly and apply ultrasonic pressure on them. The ultrasonic power is 200W, disperse the TiN particles gradually, after 15min, mix the TiN suspension with the plating solution prepared by the technology and components listed in table 1, then use the ultrasound instrument of 200W power to apply ultrasound on the mixture for 5 min, then prepare the nano Ni-TiN composite coating according to the technology listed in table 1.

Table 1 Technology and Components

Technology Conditions and Components	Parameters
$NiSO_4 \cdot 6H_2O$ （g/l）	200–400
$NiCl_2 \cdot H_2O$ （g/l）	30–50
H_3BO_3 （g/l）	30–40
Nano TiN C(g/l)	1–8
Plating Solution Temperature （℃）	30–50
Currency Density I（A/dm²）	2–6
PH	4–5
Ultrasonic Power （W）	0–300
Surfactant(mg/l)	Trace

Experiment

Detect the components of the Ni-TiN composite coating by using the JSM-5600LV scanning electron microscope manufactured by UK Oxford Microanalysis Group. Measure the hardness of the composite coating by using HXD-1000 fiber durometer, when measuring the hardness, the load weight is 100g, the load time is 15s, collect 5 data and take the average value. When measuring the wear extent, use the PM-1 flat grinding machine, with a load weight of 1000g, flat grind for 500 times, then use a electronic scale to measure the wear extent. When measuring the corrosion resistance, use full-immersion weight loss experiment method which first put the sample in 5% NaCl solution to immerse for 180h, maintain the solution at 28℃, finally, use the electronic scale to measure the mass loss after long-time corrosion, and calculate the corrosion rate.

Effect of Nano-TiN particles on the Performance of Composite Coating

Effect on the Hardness of the Coating

When the nano-TiN particle content in the composite coating is 0, the coating is an ordinary nickel coating, after adding the nano-TiN particles, the composite coating grains become finer, that is because the ultrasonic dispersion effect has great impact on the composite coating prepared by applying the ultrasound-electro-deposition technology. The ultrasound makes the nano-TiN particles disperse in the plating solution so that the nano-TiN particles can uniformly distribute in the composite plating solution. Moreover, the strong impact energy of ultrasound can scour the electrode surface, ensuring no serious pinholes, buildup and other quality defects. The smaller the buildup is, the smaller the crystal particles are, and the coating will be smoother. In addition, the nano-TiN particles embedded in the plating solution will reduce the cathode overpotential to facilitate the generation of new crystal nucleus and suppress the formation of crystal particles and thereby forming a relatively smooth coating surface.

Figure 1 show the relation curve between nano-TiN particles content and the coating hardness, when the content is 0, the coating hardness is 181HVO.1, as the content increases, the coating hardness increases. When the nano-TiN particle content is 0-2g/l, the coating hardness increases rapidly, as the nano-TiN particles content increases, the increase of coating hardness slows. If the nano-TiN particles content in the composite coating is higher and the dispersion is more even, the strengthening effect on the coating is more obvious. In addition, in the process of measuring the hardness, the average value is calculated for randomly picking 5 data, therefore, the increase of the hardness measured is not obvious, if more data is collected, a more accurate measurement can be made and the increase value of the hardness will be higher.

Figure 1 Hardness and Nano-TiN Particles Content Relation Curve
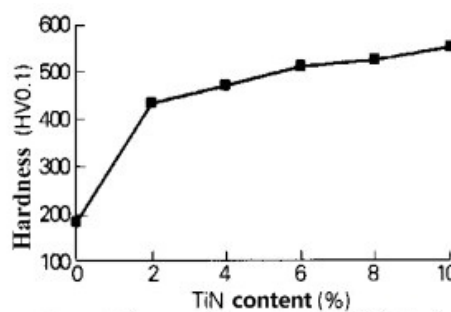
Effect on the Coating Wear Resistance Performance

To explore the wear resistance of the composite coating and its mechanism, we conduct a wear resistance test on the composite coating prepared by applying ultrasound-electro-deposition technology. Under the same technology, there is great difference between ordinary nickel coating and composite coating in terms of wear resistance. The wear extent of the ordinary nickel coating is 5 times that of the composite coating, proving that the composite coating has better wear resistance. Of course, when the nano-TiN content in the composite coating is different, the wear resistance of the composite coating is different. The higher the content, the less the wear extent and better wear

resistance. Mechanism of the nano-TiN particles' strengthening effect on the wear resistance of composite coating: Nano-TiN particles uniformly distribute in the coating leading to the increase of dislocation, twin crystal and other defects in the coating, while the partial deformation resistance strength is enhanced, the nickel dislocation and deformation movement are hindered, thus improve the hardness and strength of the composite coating. Meanwhile, the nano-TiN particles have great strength and hardness, the dispersion effect of its uniform distribution further enhances the wear resistance of the coating. In the process of preparing composite coating, in the electro-deposition stage, there are some differences between matrix metal lattice, and the electrocrystallization enhances such imbalance, thus the metal crystal particles are inhibited and produce good effect of grain refinement. The smaller the grain, the greater the hardness and toughness, and therefore, it is conducive to improve the wear resistance of the composite coating.

Different preparation process will produce different wear resistance. The experiment shows that the composite coating prepared by ultrasound-electro-deposition technology has the best wear resistance and the least wear extent, however, the composite coating prepared by DC deposition technology has more than a double wear extent than the composite coating prepared by ultrasound-electro-deposition technology. This is because ultrasound can effectively suppress the agglomeration of nano-TiN particles, accelerate the growth rate of grain and promote its nucleation.

Effect on the Corrosion Resistance of the Coating

Figure 2 shows the relation curve of different composite coatings, among which the corrosion of Ni-TiN composite coating is the slowest with few changes on its corrosion rate, while the corrosion rate of the ordinary nickel coating is faster, about three times that of the Ni-TiN composite coating. The corrosion rate of matrix 20 steel has great fluctuations and its corrosion rate is higher than that of the other two coatings.

Figure 2 Corrosion Rate Curve
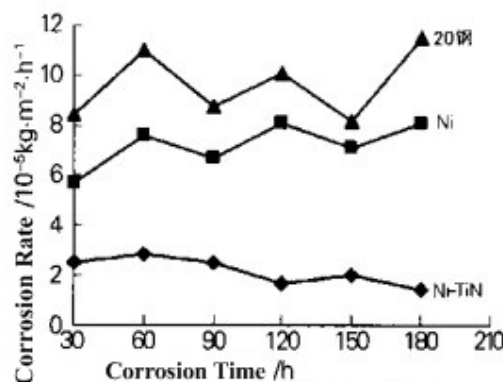
The nano-TiN particles in the Ni-TiN composite coating are distributed uniformly between the grains and grain boundaries, which can reduce the pore size and enhance the density of the coating. After the pore size is reduced, the corrosive liquid cannot invade the micropores in the coating so that the corrosion resistance of the coating can be improved.

Effect on the Coating Components

Different nano-TiN particles content in the Ni-TiN composite coating will produce different effects on the appearance and intrinsic performance. In this regard, we measure the coating components by changing the nano-TiN particle content in the composite coating. We divide the nano-TiN particles into four groups according to its content, 2g/l, 4g/l, 6g/l and 8g/l , prepare four Ni-TiN composite coatings and analyze the effect of nano-TiN particles on the components of Ni-TiN composite coating components.

When the nano-TiN particles content added to the composite coating ＜6g/l, the nano-TiN particles content in the composite coating will increase as the added amount increases, the reason for this is that more nano-TiN particles added, more nano-TiN particles precipitated into the composite coating. When the added amount ＞ 6g/l, as the added nano-TiN particles increase, the nano-TiN particles content in the composite coating decreases, at this time, the viscosity coefficient

of the plating solution will increases as the added amount increases, it becomes more and more difficult for the nano-TiN particles to precipitate towards the cathode surface, therefore the nano-TiN particles in the composite coating will gradually decrease.

Effect on the Friction Performance of the Coating

The wear of metal will cause the consumption of materials. The reason for wear is the interacted movement on the metal surfaces in contact with each other, which generates friction, thus causes wear. Making use of the friction performance in the mechanical motion and power transmission can achieve some effects, for example, the mechanical motion is generally set with a friction pair which has excellent friction performance, wear resistance and corrosion resistance, and all these performances are closely linked to the materials of friction pair. To improve the friction performance of the materials has become a focus in the material industry, The following will discuss the effect of nano-TiN particles on the friction performance of Ni-TiN composite coating. After the friction coefficient detection experiment, it is found that the friction coefficient between composite coating and the steel is less than that between steels, when the pressure is between 400 to 1400N, as the pressure increases, the friction coefficient gradually increases, when the pressure exceeds 1400N, the friction coefficient starts to gradually decrease.

In the process of preparing composite coating, nano-TiN particles integrate with the plating solution, forming a unit cell and the unit cell constitute the coating. The surface becomes more flat and smooth so that the friction coefficient of the coating will naturally become low.

Effect of Ultrasound on the Composite Coating

Different technologies may produce composite coating with different performances. The article mainly discusses about the composite coating prepared by ultrasound-electro-deposition. Here, ultrasound plays a very crucial role. In the process of preparing composite coating, we change the power of ultrasound and analyze the relationship between the ultrasound power and the particle content in the coating. The experiment results show that: when the ultrasound power is within the range of 0-200W, as the ultrasound power increases, the nano-TiN particle content in the composite coating gradually increases. The particle content reaches its maximum value when the power is 200W, and afterwards, the nano-TiN particle content gradually decreases as the ultrasound power increases. The reason for this result is that the ultrasound can promote the co-deposition of nano-TiN particles and metal ions in the plating solution, but in the actual preparation process, to promote the co-deposition, trace of surfactant is usually added to promote the electrification of neutral particles after adsorption of the active agent, thus the neutral particles can be absorbed and precipitated by the motor more easily. The cavitation effect of ultrasound can clear away the impurities and gas on the surface of nano-TiN particles and improve the moist between the particles and plating solution, thus making the particles be absorbed to the molecules of the active agent to improve the co-deposition effect of particles and metal ions. However, when the ultrasound power ＞300W, it will produce excessive stirring action resulting in fierce collision between nano-TiN particles to promote the re-agglomeration of nano particles and making the nano-TiN particles that have been absorbed to the electrode surface wash into the plating solution. Therefore, too much ultrasound power may produce negative effect. That is why the ultrasound power is set between 1-300W in table 1 mentioned above.

Conclusion

With the development of nano technology, Ni-TiN composite coating will develop and become more and more advanced with better wear resistance, corrosion resistance, high hardness and other excellent features. In addition, it plays an important role in promoting the social economic development. The technology of preparing Ni-TiN composite coating has been developed. There is a simpler technology process and more convenient preparation tools. In this article, we take the Ni-TiN composite coating prepared by ultrasound-eletro-deposition technology as an example, we explore the effect of nano-TiN particles on the performances of composite coating, and finally we

simply illustrate the effect of ultrasound on the composite coating for the peer reference.

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