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Study on Heat Treatment and Coating of Copper Screw Mother in Friction Pair of Rock Drill

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1. Introduction

Pneumatic rock drill occupies a large share in the market of rock drilling machinery due to its low price. It is widely used in mining, railway and highway construction sites, and its working environment is generally in open air, pit or tunnel, etc. [1].The screw mother is the most critical part of the rotary mechanism in pneumatic rock drill [2]. It is usually made of tin bronze, and its quality directly affects the service life of pneumatic rock drill.According to the field survey, the tin bronze screw mother used by a certain type of pneumatic rock drill has a very low life, with a footage of only about 2000m, causing serious waste of scarce non-ferrous metals.Serious wear of the screw parent is bound to lead to serious wear of the matching screw rod, which will significantly reduce the drilling efficiency of pneumatic rock drill [3-4].Therefore, it is an urgent problem for pneumatic rock drill to improve the service life of screw mother and make it consistent with the service life of screw rod.Mother in this paper, the two manufacturers copper screw parts of contrast research, including material, hardness, microstructure of the thermal spraying technique on the mother rock drill product copper screw parts then explores its formation mechanism research, the drill after heat treatment and thermal spraying of the friction pair copper screw mother on customer site test, to reduce the spiral mother wear, improve its service life provides certain reference basis.

2. Copper screw base material and hardness analysis

The friction pair of copper nut (see Figure 1) is the most important connecting transmission mechanism on pneumatic drill. The quality of copper screw driver directly affects the service life of pneumatic drill. Due to the advantages of high strength, good wear resistance, good corrosion resistance and good cutting performance of tin bronze QSN7-0.2, the copper screw driver is usually made of tin bronze.

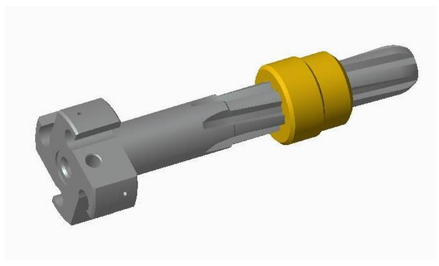
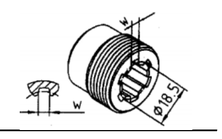


Figure1 Copper nut friction pair

Hardness is an important performance index to measure the degree of hardness of metal materials. It can be understood as the ability of material to resist elastic deformation, plastic deformation or failure, and can also be expressed as the ability of material to resist residual deformation and anti-failure.Under the same conditions (the same friction coefficient, composition, microstructure, environmental conditions, etc.), there is a nonlinear proportional relationship between hardness and wear resistance.

Based on site investigation, company A and company B footage of pneumatic rock drill products and copper screw standards (see table 1), the company A and company B and C company copper screw mother material and hardness testing company A and company B, the spiral mother material choose QSn7 0.2 tin bronze, spiral mother hardness is 195 hb, A company B company spiral mother hardness for 124 hb.

Table 1. Field footage and scrap standard for copper screw mother

Company	Working time	Working life(m)	Mode of action	Scrapping standard	Measuring position	Graphical representation
A	30 shifts	1380	2.5 m drill rod, 20 holes per shift	Spline profile Wear 2 mm	Measure the width w of spline keyway at 18.5mm of large end face, and discard it when w≥ 7.4mm	
B	35 shifts	1610				

3. Research on plasma thermal spraying

Plasma spraying is a thermal spraying processing method in which rigid non-transfer plasma arc is used as heat source to heat the powder material to molten or semi-molten state and spray it to the surface of the pretreated workpiece through high-speed flame flow to form spray coating. Its principle is shown in Figure 2.

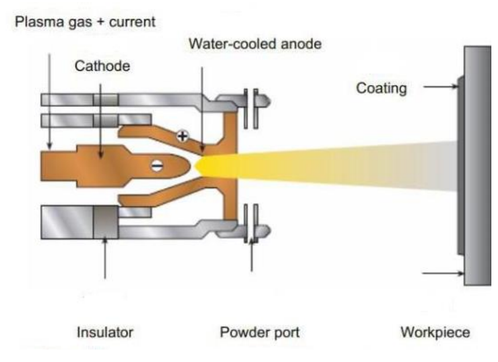


Figure2 Diagram of plasma spraying

The spray gun is actually a non-transfer arc generator, which is the most critical component. It concentrates the electricity, gas, powder and water of the whole system on the spray gun.The spray gun can be supplied with direct current by connecting to the power supply, which is usually a full-wave silicon rectifier.Spray gun can be replaced by nozzle and other parts to meet the requirements of spraying different materials.The spray gun is shown in Figure 3. The top end of the spray gun is the powder conveying conduit, and the bottom end is the pipeline of cooling water and working gas.The powder feeder used is shown in Figure 4.

Figure3 Plasma gun

Figure4 Plasma spraying powder feeder diagram

4. Copper spiral mother heat treatment and coating

Tin bronze alloy is mainly composed of copper, tin, nickel, lead and other elements. The diffusion process of tin in solid state in copper is very slow, and it is easy to form in-grain segregation and a small amount of 8-phase in as-cast state, and it can be eliminated only after homogenizing annealing at high temperature.Both nickel and copper are plane-centered cubic structures, and the difference in atomic radius is very small. Therefore, nickel can dissolve in unbounded solid, but nickel diffuses slowly in copper, and it is easy to form significant dendritic structure.Lead does not dissolve in copper and is generally distributed in a free phase between the crystal branches.By analyzing the main components of the alloy, combining with the phase diagram, changing the distribution of the eutectoid between the dendritic crystals and the dendrites by means of heat treatment can obviously change the properties of the alloy.Through the comparison of the above test results, it can be seen that the peak performance index of the alloy between 350~450℃ appears, indicating that the conductivity, hardness and tensile strength of the alloy have been effectively improved at this time.The test data after heat treatment annealing are shown in Table 2.The metallographic structure after annealing is shown in FIG. 5. The grain size and microstructure are uniformly distributed, and a large number of equiaxial twins can be seen. This is because static recrystallization occurs in tin bronze with the increase of annealing temperature.

Table 2 Annealing heat treatment data sheet.

company (HB)	Annealing temperature(℃)	annealing time(min)	external hardness (HB)	internal hardness (HB)	tooth root hardness
A	370	30	179	177	172

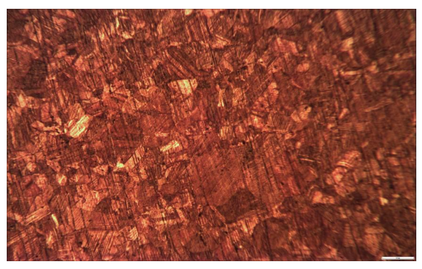


Figure5 Spiral mother QSN7-0.2 annealed metallographic structure

Figure6 Copper screw after thermal spraying

Hard alloy is an excellent tool material and structural material. At present, its production raw material is mainly nano-tungsten-Cobalt (WC-CO) composite powder. Tungsten carbide (WC) is a kind of hard alloy material with high hardness, thermal stability and good wear resistance.Tungsten carbide insoluble in water, hydrochloric acid and sulfuric acid, easy to dissolve in nitric acid - hydrofluoric acid mixed acid.Pure tungsten carbide is brittle and can reduce brittleness if a small amount of metals such as titanium and cobalt are added.Tungsten carbide used as steel cutting tools is often added with titanium carbide, tantalum carbide or a mixture of them to improve the anti-explosion ability, and its chemical properties are stable. Copper screw mother after thermal spraying is shown in Figure 6.

5. Conclusion

After dealing with the annealing and thermal plasma spraying of copper screw mother, with untreated copper screw mother field test in some iron mine, test data as shown in table 3, as can be seen from the table, after annealing and plasma thermal spraying, the copper screw mother longevity by about 22.5%, the study can be extended to other friction pair of pneumatic rock drill products.

Table 3 Improved field test data table of copper screw parent.

company	mode of action	working time	working life(m)	remarks
A	2.5 m drill rod,	31 shifts	1426	before improvement
A	20 holes per shift	38 shifts	1748	after improvement

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