Study on Removal of Copper Rice Paint Film and Copper Recovery Efficiency

Biao Hu* and Kai Yuan*

School of Tianjin University of Technology, Tianjin, China

*Corresponding author e-mail: 18134415371@163.com, 1395263006@qq.com

Abstract. The effects of chromite sand particle size, mixing ratio of sand and copper wire, motor speed and collision friction time on the removal of copper wire paint film and copper recovery efficiency were studied. The results show that the conditions for efficient copper recovery are: chromite sand particle size is 0.40mm, chromite sand and copper wire mixing ratio is 1:1, centrifugal motor speed is 2700r/min, collision friction time is 2min. Under these conditions, the polyester enameled copper wire film was completely removed and the copper recovery rate reached 98.75%.

1. Introduction
Since the polyester enameled copper wire paint film is thin and stable with wire adhesion, removing the enameled wire surface paint film has always been a major problem in recycling polyester enameled copper wire [1-2]. At present, the process of recovering copper from the enameled copper wire is mainly composed of a heat treatment method and a chemical reagent method. The heat treatment method includes a FRHC waste copper smelting process, a Reverberator furnace process, a tilting furnace process, a Cal do furnace process, and an ISA process [3-4], but no matter which heat treatment process is employed, carcinogens such as dioxins are inevitably produced, and During the heating process, copper is easily exposed to air and undergoes a strong oxidation reaction, which has a serious impact on the quality of copper. The chemical reagent method mainly uses NAOH solution as a solvent to remove the surface of the enameled copper wire paint film [5]. Although the film removal is complete, the NAOH waste liquid must be properly treated to be recycled, which indirectly increases the cost of film removal, is not conducive to large-scale use of the factory. This paper intends to adopt a centrifugal self-circulation equipment to make the collision friction effect between the chromite sand mixed with a certain proportion and the polyester enameled copper wire, and then separate the chromite sand, the paint film and the conductor copper, and finally a conductor copper that can be directly recycled is obtained.

2. Research Method

2.1. Test materials and instruments

2.1.1. Test materials. Polyester enameled copper wire, chromite sand. Polyester enameled copper wire (paint film accounts for 2% of the quality of polyester enameled copper wire) and cut into "copper
rice” with a length of 5~10mm. The chromite sand is passed through holes of 0.25mm, 0.30mm, 0.40mm, 0.50mm, and 0.55mm, respectively.

2.1.2. Test instruments. Centrifugal self-circulation equipment (homemade): AC voltage 380V, power 6.5KW, size L350 *Φ400 (mm), controllable speed controller. Magnetic separator: Model CT6018, AC voltage 220V, power 2.2KW, size 60*80 (mm). Balance 500g electronic analytical balance with an accuracy of 0.01g.

2.2. Test plan design

2.2.1. Test method. According to the ratio, 300g of polyester enameled copper wire is weighed every time, and chromite sand with particle size of 0.25~0.55mm is blended according to the ratio, and evenly mixed, centrifugal self-circulation with rotation speed of 1500~300r/min is placed. In the equipment, the chromite sand is separated from the polyester enameled copper wire by a magnetic separator, and then the copper wire is washed, dried, and weighed. Assuming that the paint film is completely removed, the recovery rate of the copper wire during the recovery of the polyester enameled copper wire is:

\[ \% = \left( \frac{W_{\text{Cu}}}{W} \right) \times 100 \]  

(1)

Where: \( K_{\text{Cu}} \) - enameled copper wire recovery, %; \( W_{\text{Cu}} \) - weight of copper wire after drying, g; \( W \) - weight of polyester enameled copper wire before test, g.

2.2.2. Variable selection and control.

1) Selection of particle size of chromite sand
   In order to ensure the rigor of the test, the particle size of the chromite sand selected in this test is: 0.25mm, 0.30mm, 0.40mm, 0.50mm, 0.55mm.

2) Selection of motor speed for centrifugal self-circulating equipment
   According to the structural parameters of the centrifugal self-circulating equipment and the physical relationship between the circular motions, so from 1800~3000 r/ five values were uniformly selected between the control conditions for the motor speed of the test, namely: 1800r/min, 2100r/min, 2400r/min, 2700r/min, and 3000r/min.

3) Selection of mixing ratio of chromite sand and polyester enameled copper wire
   During the test, the chromite sand and the polyester enameled copper wire are thoroughly mixed and added to the centrifugal self-circulating equipment to collide between the chromite sand and the polyester enameled copper wire Collision friction. In this test, the mixing ratio of chromite sand and polyester enameled copper wire was selected to be 0.5:1, 0.75:1, 1:1, 1.5:1, 1.75:1, 2:1.

4) Collision friction time of chromite sand and polyester enameled copper wire
   According to the experience, the collision friction time of chromite sand and polyester enameled copper wire in centrifugal self-circulation equipment is set to 5min, 10min, 15min, 20min, and then the collision friction will be analyzed with the test results. The time of the test was set to a small range.

3. Results Analysis

3.1. Effect of particle size of chromite sand on stripping
   Weigh 300g of polyester enameled copper wire and chromite sand and mix it according to 1:1, then add it to the centrifugal self-circulating equipment for collision friction for 10min, the motor speed is set to 2700r/min, after 10min, two magnetic separation is performed, and the copper wire is washed, dried, and weighed. The particle size of the chromite sand was changed and the above operation was repeated. The mass change of the polyester enameled copper wire was measured as shown in Table 1.
According to Table 1, the copper recovery rate as a function of the particle size of the chromite sand was as shown in Fig. 1. It can be seen from Table 1 and Figure 2 that the change of particle size of chromite sand is not significant for the stripping effect of polyester enameled copper wire, indicating that the particle size of chromite sand is not the main factor affecting the stripping of polyester enameled. When the particle size of chromite sand is close to the diameter of polyester enameled copper wire, the collision friction effect is better.

**Table 1. Paint removal of polyester enameled copper wires with different particle sizes.**

| Chromite size /mm | Enameled copper wire /g | copper/g 0.98W | Copper wire after stripping /g | Copper recovery \( K_{Cu} \) /% \( (K_{Cu} = W_{Cu}/0.98W) \) |
|-------------------|-------------------------|----------------|-----------------------------|-------------------------------|
| 0.25              | 300                     | 294            | 292.95                      | 99.64                         |
| 0.30              | 300                     | 294            | 289.62                      | 98.51                         |
| 0.40              | 300                     | 294            | 290.01                      | 98.64                         |
| 0.50              | 300                     | 294            | 292.77                      | 99.58                         |
| 0.55              | 300                     | 294            | 293.43                      | 99.81                         |

**Figure 1.** Copper recovery rate of different chromite sand.

### 3.2. Effect of motor speed on stripping of centrifugal self-circulating equipment

The experimental scheme was designed, specifically: chromite sand particle size 0.40mm, collision friction 10min, chromite sand and polyester enameled copper wire is mixed 1:1, and the motor speed of the centrifugal self-circulating equipment is set to 1800r/min, 2100r/min, 2400r/min, 2700r/min, 3000r/min, respectively, and the collision friction test is performed. The result is shown in Fig.2. As the rotational speed increases, the copper recovery rate decreases gradually, but the magnitude of the decrease is gradually reduced. When colliding friction between chromite sand and polyester enameled copper wire, the decrease of copper recovery rate indicates that the motor speed of centrifugal self-circulating equipment has obvious effect on the removal of polyester enameled copper wire paint film, and the lower copper recovery rate also indicates that a large amount of copper is also removed from the enameled copper wire during the collisional friction.
3.3. Effect of mixing ratio of chromite sand and polyester enameled copper wire and collision friction time on stripping

It can be seen from Table 2 and Figure 3 that under the mixing ratio of the same chromite sand and polyester enameled copper wire, the collision friction time is extended from 5min and the copper recovery rate is lowered, and the decrease is big with time increase. Which indicates that the collision friction time is the main factors affecting the stripping of the enameled copper wire. Under the same collision friction time, the copper recovery rate did not change much with the mixing ratio, indicating that the mixing ratio of chromite sand and polyester enameled copper wire is not the main factors of the enameled copper wire stripping.

Table 2. Copper recovery rate under with different mixing ratios and friction times.

| mixing ratio | 5min  | 10min | 15min | 20min |
|--------------|-------|-------|-------|-------|
|              | K Cu% | K Cu% | K Cu% | K Cu% |
| 0.5:1        | 97.11 | 93.77 | 90.88 | 89.57 |
| 0.75:1       | 96.75 | 93.87 | 91.13 | 89.09 |
| 1:1          | 96.83 | 93.45 | 91.05 | 89.40 |
| 1.25:1       | 96.76 | 93.59 | 91.06 | 89.59 |
| 1.5:1        | 97.32 | 93.15 | 90.79 | 89.46 |
| 1.75:1       | 97.28 | 93.68 | 91.44 | 89.58 |
| 2:1          | 96.38 | 93.17 | 91.45 | 89.53 |

Figure 2. Recovery rate of copper under different rotating speed.

Figure 3. Recovery rate of copper under different mixing ratios and friction times.
4. Conclusions and Suggestions
The chromite sand and the polyester enameled copper wire are used for collision and friction stripping. Under the premise that all the paint films are completely removed, the copper recovery rate decreases with the increase of the motor speed and collision friction time of the centrifugal self-circulating equipment. In order to meet the industrial production, ensure the ability of stripping and reduce the collision friction time, the selected process conditions are: chromite sand particle size is 0.40mm, chromite sand and polyester enameled copper wire mixture ratio is 1:1. The collision friction time is 2 min, and the centrifugal self-circulation equipment motor speed is 2700r/min. Under this test condition, the polyester enameled copper wire paint film is completely removed, and the copper recovery rate is above 98%.

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