

Study on SiO₂ Melting Rule Based on Image Analysis

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Abstract. In order to study the melting process of SiO₂ particles, the pure SiO₂ particles and corundum crucible with diameter of 8 mm were used as test materials, the melting rule of SiO₂ particles was studied from the area and volume features. The results show that this method can effectively study the melting process of SiO₂ particles. At the same time, its area and volume decreased with time, and its melting rate gradually slowed down.

Keywords: SiO₂, Center of Mass Trajectory, Edge Profile Index, Melting Rate, Data Fitting.

1. Introduction

The main component of iron tailings is SiO₂, and SiO₂ is the most refractory component of iron tailings. Therefore, the melting behavior of iron tailings can be expressed by the melting behavior of SiO₂. But the temperature of the high-temperature melting pot is above 1500 degrees, and the service life of the conventional testing equipment is very short in the environment. In order to solve this problem, the relevant research group first used a tearing CCD video shooting system with amplification effect for the first time at home and abroad. The dynamic visualization data of SiO₂ in high temperature molten pool were obtained by non-contact method, and the real-time melting rate of SiO₂ in time series was observed by video analysis. It provides guidance for the tailings addition and thermal compensation in the preparation of slag wool, thus indirectly improving the technology of blast furnace slag direct fiber formation [1-5].

In order to analyze the melting behavior of SiO₂, it is necessary to trace the position of the center of mass of SiO₂ particles in the melting process, and its edge contour features. Therefore, in this paper, pure SiO₂ particles and corundum crucible with diameter of 8 mm are used as testing materials. The melting rule of SiO₂ particles is studied from the area and volume features, which can be used as a reference for studying the melting process of different particles.

2. Image Processing and data acquisition

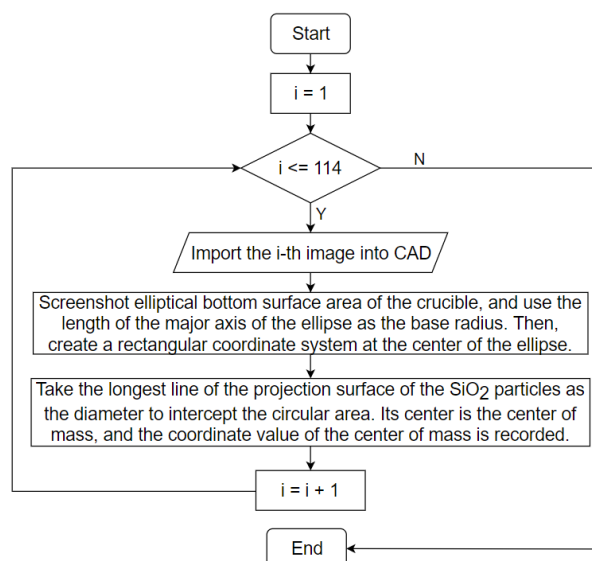


Figure 1. The image processing flowchart

The position of SiO₂ particles is constantly changing in the continuous images collected, so the first step in analyzing the melting behavior of SiO₂ is to track the target. In order to study the trajectory of SiO₂ centroid, 114 images need to be processed and the corresponding data collected. After processing each image, it is found that the bottom of the crucible is not round. This is due to the slanting of the shot which causes the surface of the crucible to appear elliptical. When you examine the data, you can see that the length of the spindle is the diameter of the underside, and the center of the Ellipse is the center of the underside. Similarly, the projected surface particles of SiO₂ are irregular because the image is tilted when captured. Therefore, the longest linear particle on the projection surface of SiO₂ is taken as the diameter of the truncated circular region, the center of which is the center of mass [6, 7]. Specific image processing and data acquisition is shown in Figure 1.

Takes the 54th image (550 seconds) as an example, the AutoCAD image information intercepts the bottom of the crucible and the center of mass particles of SiO₂ as shown in Figure 2.

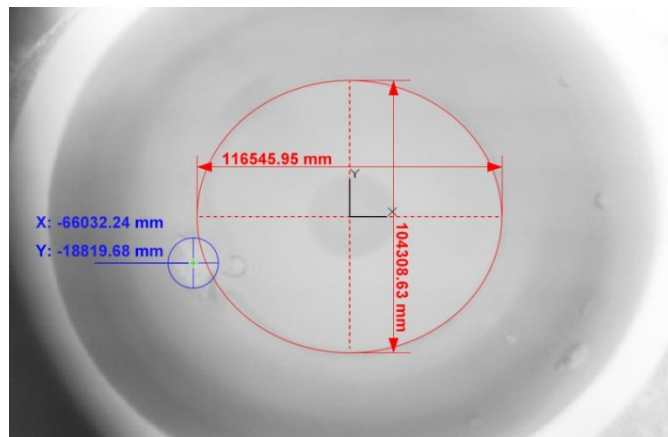


Figure 2. 254th (550s) image set processing renderings

According to the image set processing data, it was found that the particles in the 112th, 113th and 114th images of SiO₂ were no longer visible. It could be considered that the particles in these three images had melted, therefore, the three-point image is not taken into account when processing this center of mass. The area data representing the SiO₂ EDGE profile characteristic index can be obtained, and the scatter plot of area and time can be plotted, as shown in Figure 3 [8].

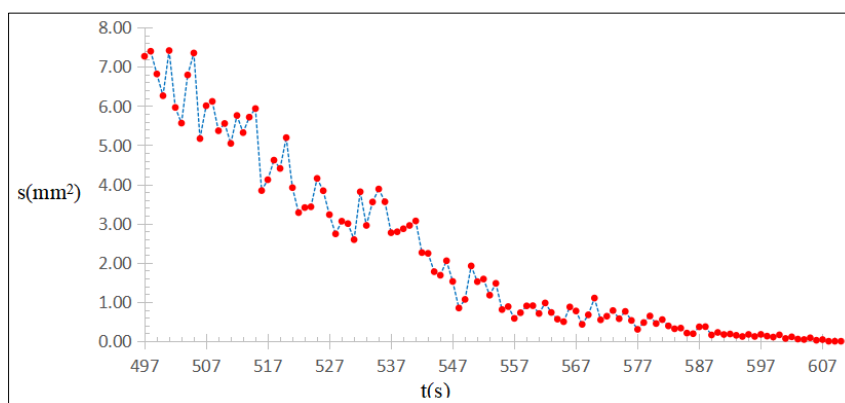


Figure 3. A scatter plot of the area of Edge Profile Index with time

As can be seen from Figure 3, the SiO₂ melting process is decreasing with time, decreasing to zero. The front is falling faster than the back. There are also some up-and-down fluctuations. This is due to the non-uniform melting caused by the rolling and tilting of SiO₂ particles. This is an out-of-control factor, but it's normal.

3. Simulation Experiment

3.1. Area rule of SiO₂ melting process

The functional model of SiO₂ melting process is established according to the scattered point law of area and time. The calculation formula is shown in Formula (1) [9].

$$S = 9.247e^{-\left(\frac{t-464.1}{64.59}\right)^2} \quad (1)$$

The melting process of pure SiO₂ particles and corundum crucible with diameter of 8 mm were simulated, and the results of functional fitting of the melting process of SiO₂ particles were shown in Table 1. Plot the fitting curve for both area and time, as shown in Figure 4.

Table 1. Function fitting results of SiO₂ particle melting process

Results	s vs. t
SSE	18.98
R-square	0.9647
RMSE	0.4192

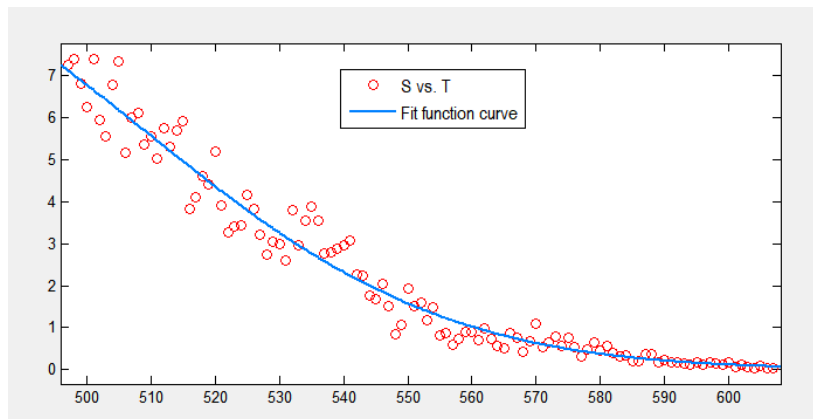


Figure 4. The fitting curve of the melting process of SiO₂

Particles can be seen from Table 1 and Figure 4. The fitting effect is good, which can reflect the melting process of SiO₂ particles. In the whole melting process, the particles decrease gradually and the fitting curve is concave, which shows that the melting speed is first fast and then slow.

3.2. Volume Law of SiO₂ melting process

Mass is the key parameter representing the melting rate of SiO₂. The mass of SiO₂ particles is proportional to its three-dimensional volume. Because the shape of SiO₂ is regular, and the image in this paper melts completely between 497 seconds and 610 seconds, the corner contour melts first in the melting process, so the SiO₂ particles can be considered as spheres. The radius and area of silicon edge profile are normalized by using the SiO₂ particles at different time, and the volume formula of SiO₂ is shown as Formula (2) [10].

$$v_i = \frac{4}{3}\pi l_i^3 \quad (2)$$

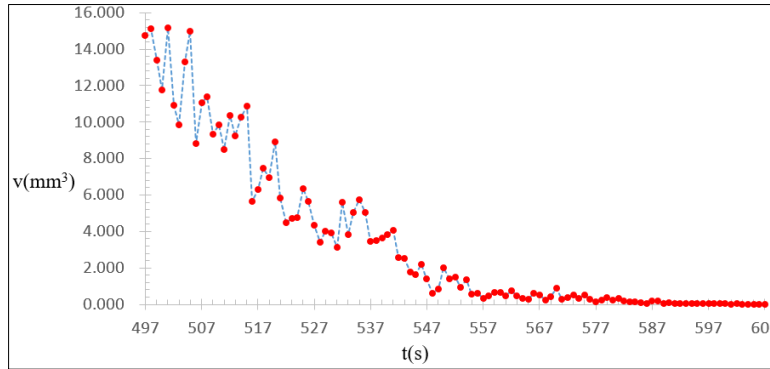


Figure 5. Volume and time scatter plot of SiO₂ Particles

Figure 5 volume and time scatter plot of SiO₂ particles. It can be seen that the melting process of SiO₂ decreases with time until the volume is 0, the speed decreases rapidly from 497 seconds to 547 seconds, and the gradient slows slowly from 547 seconds. Individual volume data seem to fluctuate, which is caused by many factors.

According to the volume and time scattering law, the functional model of SiO₂ melting process is established as shown in Formula (3).

$$v = 24.09e^{-\left(\frac{t-456.8}{56.41}\right)^2} \quad (3)$$

After analyzing the SiO₂ particle data, the deviation can be calculated as shown in Table 2. At the same time, the volume curve of SiO₂ particles is drawn, as shown in Figure 6.

Table 2. Analysis of fitting degree

Results	V vs. T
SSE	95.42
R-square	0.9531
RMSE	0.9399

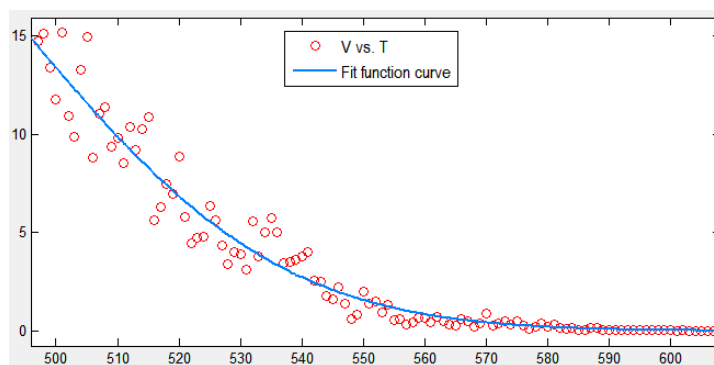


Figure 6. The volume curve of SiO₂

Particles can be seen from Table 2 and Figure 6. The fitting effect is good, which can reflect the volume rule of the melting process of SiO₂ particles, during the whole melting process, the volume number of particles decreased gradually, and the volume curve was concave, which showed that the melting speed was first fast and then slow.

4. Conclusion

In this paper, the collection of continuous image processing technology. Because the image is magnified and the image is tilted, the particles on the projection surface of the crucible and SiO₂ are biased. Therefore, in order to make the data more accurate, data standardization. Secondly, in the process of processing silicon edge profile, the SiO₂ particle is regarded as a sphere, and the melting

rule of SiO₂ particle is studied from the angle of area and volume. It was found that the area and volume decreased with time, and the melting rate decreased gradually.

References

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