

## Computer recognition of slag property diagrams in ternary systems

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**Abstract:** In order to take data information from the slag property diagram in a ternary system automatically and actually, a picture recognition and drawing software has been developed by Visual Basic 6.0 based on the image coding principle of computer system and the graphics programming method of VB. This software can transform the ternary system isopleth diagram from bitmap format to data file and establish a corresponding database which can be applied to rapidly retrieve a mass of data and make correlative thermodynamics or kinetics calculation. Besides, it still has the function of drawing the ternary system diagram which can draw different kinds of property parameters in the same diagram.

**Key words:** slag property; ternary system diagram; recognition

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### 1 Introduction

It is known that slag properties are very important in the iron and steel making process. The selection of the slag property parameters is the key work to metallurgical thermodynamics and kinetics calculations. Those that often be used are the component activity, slag density, slag viscosity *etc.*, which in previous literatures were always given in the format of a ternary system isopleth diagram [1]. The problem is that only by measuring out the proportion of the three components on the specific point can we get corresponding data information. To transform the slag property diagram in a ternary system from bitmap format to data file, or the very reverse, a recognizing and drawing software has been developed based on the image coding principle of computer system and the graphics programming method of VB. It can be applied to rapidly retrieve a mass of data from a ternary system diagram and draw the ternary system isopleth diagram.

### 2 Software descriptions

#### 2.1 Fundamentals

A computer displays a bitmap image on the screen through denoting the location and gray value of each pixel in the image. It can distinguish different colors by estimating RGB (Red, Green, Blue) function. Therefore, adjusting the RGB value of the pixels by

coloring up points or lines in the image with some bitmap tool and designing a corresponding program will make the computer recognize the colored pixels and memorize the corresponding information such as location and gray value.

It is need to say that Microsoft Paint bitmap tool has the functions of modifying single pixel and magnifying the image, so it is feasible to actually distinguish each pixel and color up it according to the information the image shows.

#### 2.2 Image processing

**Figure 1** is a typical component iso-activity diagram in a ternary system [2], which is often used in thermodynamics research on the control of inclusion composition in ultra clean steels. Take it for example, explain the steps of image processing as follows. The sketch map of the processed picture is shown in **figure 2**.

(1) To scan the picture with a scanner and storage it as the format of 24 bit map, which is the standard format under Windows X system.

(2) To color up the three vertexes blue with Microsoft Paint, that is  $RGB=(0,0,225)$ .

(3) To color up the needed isoline red, that is  $RGB=(255,0,0)$ .

(4) To record the represent value of the isoline col-

ored with a text file. For figure 2 it is to record the value of activity. The red line represents 0.002.

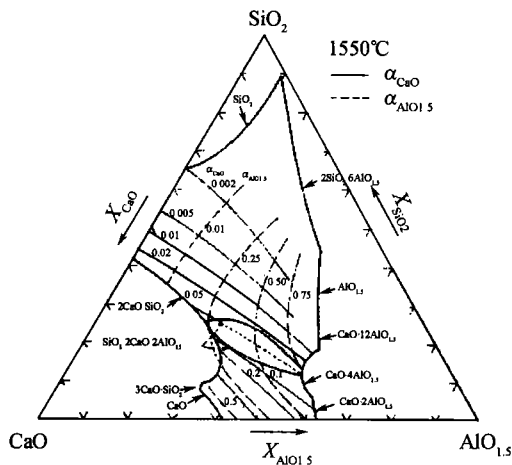


Figure 1 Activity of CaO and  $\text{AlO}_{1.5}$  in  $\text{CaO-SiO}_2\text{-Al}_2\text{O}_3$  system at  $1550^\circ\text{C}$ .

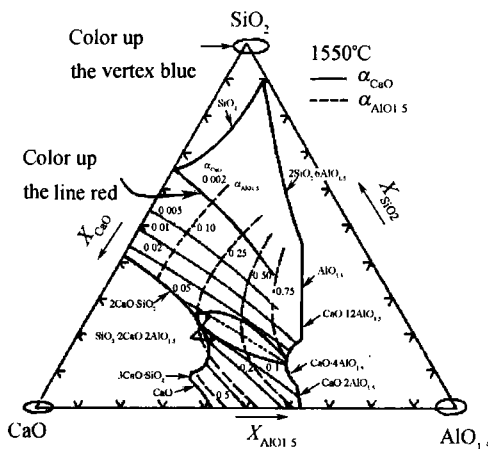


Figure 2 Sketch map of the processed picture.

### 2.3 Software functions

(1) To display the component proportion of the appointed point in the image on the screen.

(2) To recognize the isolines in the ternary system diagram, memorize corresponding coordinates and establish the component proportion database.

(3) To draw the ternary system diagram.

### 2.4 Analysis for program structure

Visual Basic is a kind of object oriented program design language. It provides the most rapid and simple method of program designing and developing. This work selected VB as the developing tool [3]. The flow chart of program structure is shown in figure 3. It includes two parts, picture recognition and picture drawing.

(1) Picture recognition part.

When the computer ran the recognizing command, the picture was loaded and was divided into a matrix

according to the screen resolution ratio. First, the computer needed to fix the location of the picture, that is, to fix the coordinates of the three vertexes. So it began to check each pixel in the matrix, if  $\text{RGB}=(0,0,255)$ , the computer recorded this point's coordinate. When the three vertex coordinates  $(X_0, Y_0)$ ,  $(X_1, Y_1)$  and  $(X_2, Y_2)$  were all recorded, the picture was fixed successfully. After that, the computer began to recognize the lines. It checked each pixel again, and if  $\text{RGB}=(255,0,0)$ , recorded the point's coordinate  $(X, Y)$  and transformed it from  $(X, Y)$  to  $(a, b, c)$  based on equations (1)-(3), memorized the component proportion and the isoline represent value into a data file at the same time shown in table 1, which is part of the recognition results for the red line marked in figure 2.

$$a = 1 - X + X_0 + \frac{1}{2}Y - \frac{\sqrt{3}}{3}Y_0 \quad (1)$$

$$b = X - X_0 + \frac{1}{2}Y - \frac{\sqrt{3}}{3}Y_0 \quad (2)$$

$$c = 2\frac{\sqrt{3}}{3}Y_0 - Y \quad (3)$$

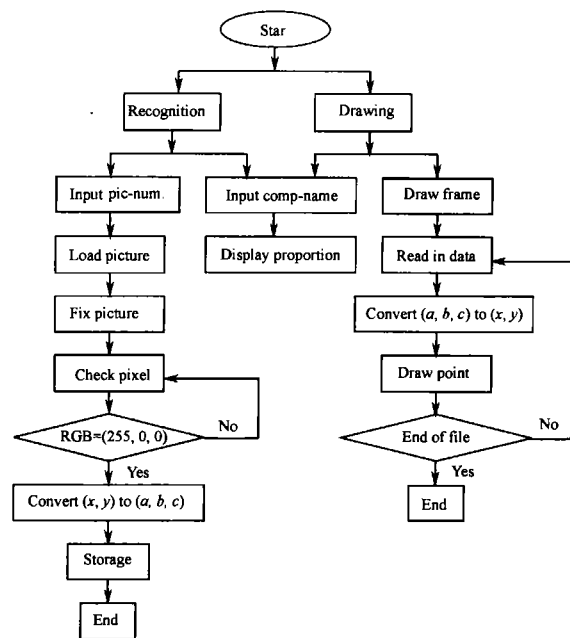


Figure 3 Flow chart of program structure.

(2) Picture drawing part.

This part was designed to draw the ternary system diagram like figure 1 on the operation interface of the screen based on the graphics programming method of VB.

While running drawing command, the computer firstly fixed the location of  $(X_0, Y_0)$ ,  $(X_1, Y_1)$  and  $(X_2, Y_2)$  on the operation interface; secondly, read in the data of component proportion like table 1 and transformed

it from (a,b,c) to (X,Y) based on equations (4) and (5), and then drew the points one by one. The picture was drawn according to the data from recognizing the results for figure 1 is shown in figure 4.

Table 1 Data file

CaO-activity	Component proportion		
	a(CaO)	b(SiO <sub>2</sub> )	c(Al <sub>2</sub> O <sub>3</sub> )
0.002	0.342	0.652	0.006
0.002	0.343	0.650	0.007
0.002	0.341	0.650	0.009
0.002	0.342	0.647	0.010
0.002	0.340	0.647	0.013
0.002	0.341	0.645	0.014
0.002	0.339	0.645	0.016
0.002	0.340	0.642	0.018
0.002	0.338	0.642	0.020
0.002	0.336	0.642	0.022

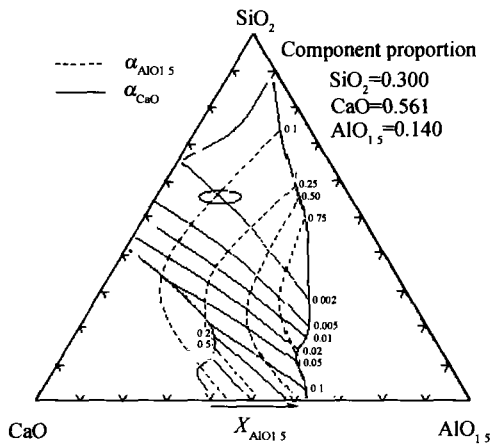


Figure 4 Activity of CaO and AlO<sub>1.5</sub> in CaO-SiO<sub>2</sub>-Al<sub>2</sub>O<sub>3</sub> system at 1550°C drawn by computer.

$$X = X_0 + \frac{1}{2}b + c \tag{4}$$

$$Y = Y_0 - \frac{\sqrt{3}}{2}b \tag{5}$$

2.5 Analysis for results

This software can recognize many pictures at one time according to the picture number input and establish the corresponding database for the service of searching and calculating.

Since the computer takes single pixel as unit to display pictures, each pixel on the isoline could be recognized and recorded. We can get very precise and complete the coordinate data by this software.

For figure 2, there are 93 pixels got in all by recognizing for the red line marked. Only the front ten pixels are shown in table 1 in which a, b, c represents CaO, SiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub> respectively.

From the view of the recognizing results, each number has three significant digits in the given condition which could be adjusted to get much more significant digits if needed. It is obvious that the attainable precision is higher than manual work.

Figure 4 shows all the isolines in figure 1 drawn by computer. The computer can display the component proportion of the appointed point in the ternary system diagram on the operation interface while moving the mouse. The component proportion of the red point marked in figure 4 is shown on the text frame as hinted.

The accuracy of drawing depends on the data got by recognizing or other experiments. As above mentioned, bitmap tools take pixel as unit and can magnify the picture till it is distinct enough to distinguish single pixel. So the key work is image processing.

3 Conclusions

Any reaction happened in iron and steel making process has close relationship to the slag used in practice. Only by totally comprehending slag properties can we estimate the various reactions exactly and find out the optimum control-method. To obtain the correlative slag property parameter and establishing the corresponding database is necessary for researching. This software provides a foundation for it.

(1) This software which can convert bitmap format to data file could be applied to recognize the ternary system isopleth diagrams of the component activity, slag density, viscosity, conductivity, surface tension, interfacial tension and sulfide capacity, etc.

(2) It not only replaced hand-work, but also greatly increased the velocity and veracity of data searching which will be a great help to make correlative thermodynamics or kinetics calculations.

References

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