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Study on linear segregation of ZL205A alloy

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Introduction

ZL205A is a high-strength casting alloy of Al-Cu series, suitable for sand mold and investment casting. Castings with simple geometry can also be cast by metal mold, which is used to bearhigh-load parts, such as frames, hubs, ribs, arms, impellers, rudder and some high-strength parts onaircrafts. Segregation is one of the defects that occur frequently in ZL205A alloy castings.Segregation will seriously deteriorate the casting performance and cause the casting to be scrapped. These segregation defects in castings can be detected by X-ray. As segregation structures are generated by segregation of major elements, white stripes are usually displayed on X-ray films. So it is also called linear segregation or white segregation. In this work, the discarded ZL205A alloy castings with segregation produced in the factory were preliminarily analyzed, the microstructure and formation mechanism of segregation defects were studied, and the preventive measures were put forward.

Experimental methods

The locations where linear segregation appeared on the x-ray flaw detection and the corresponding casting were shown in Fig.1, and cracks were also observed at the locations where the linear segregation occurred at the transition of the wall thickness of the casting. Sampling, polishing and corrosion are carried out on segregation positions, and then microscopic observation and composition analysis are carried out. The corrosive liquid used for corrosion is 0.5% HF aqueous solution.

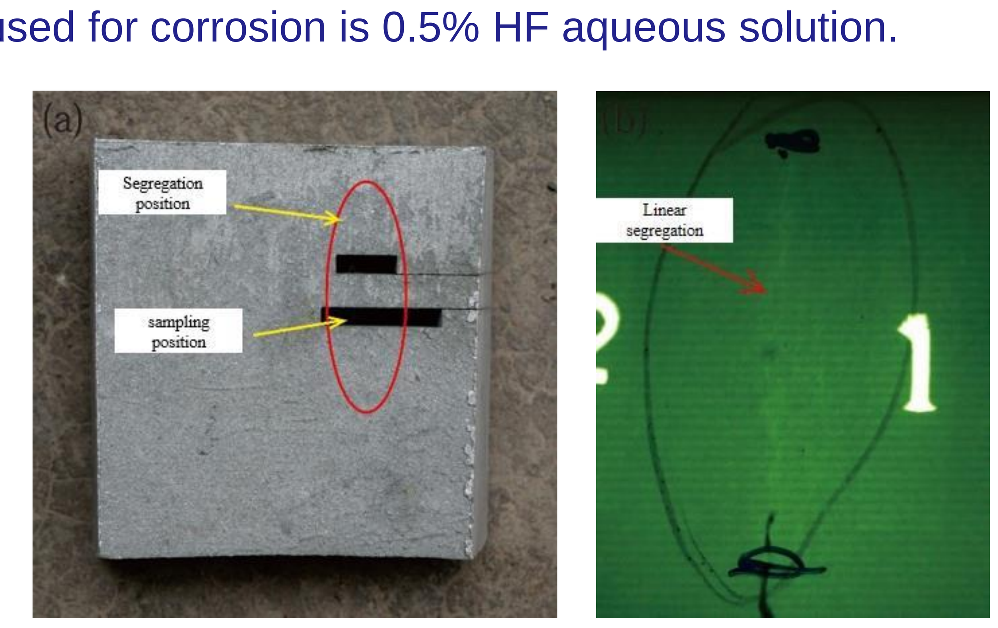

Fig. 1. Linear segregation of castings
(a) segregation position and sampling position of castings;
(b) X-ray flaw detection negatives at segregation of castings

Segregation morphology

The metallographic picture at the segregation position is shown in Fig. 2. it can be seen from Fig. 2(a) that the linear segregation structure is dendritic along the grain boundary, and the linear segregation in Fig.2(b) shows that cracks also appear at the segregation position. The comparison between Fig. 2(a) and 2(b) show that when cracks appear in the casting, the segregation of the casting increases.

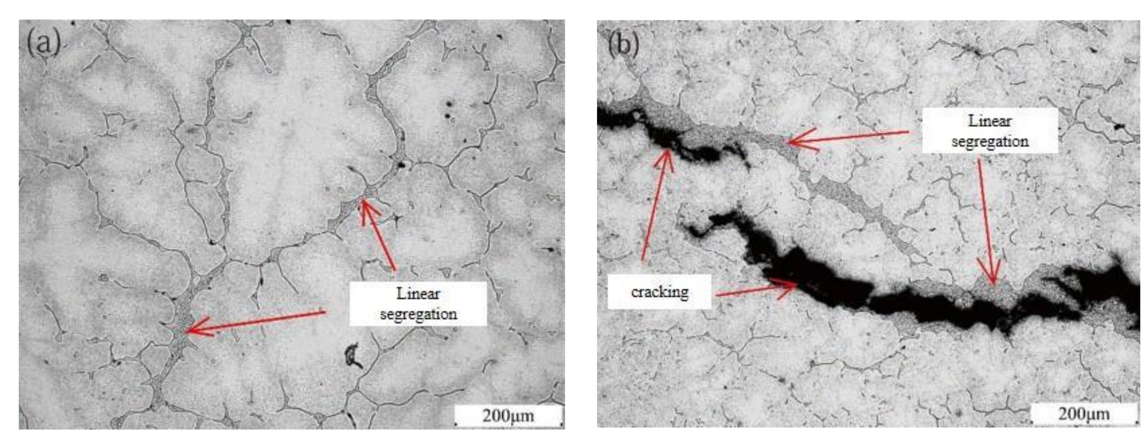

Fig. 2. Morphology of Linear Segregation
(a) Segregated structure at large wall thickness;
(b) Segregated structure at wall thickness transition

Scanning electron microscope observation of segregation structure shows that coral white and bright structure is linear segregation structure at grain boundary as shown in Fig.3. EDX analysis was carried out at points 1, 2 and 3 in the Fig.3, and the analysis results are shown in Table 1.

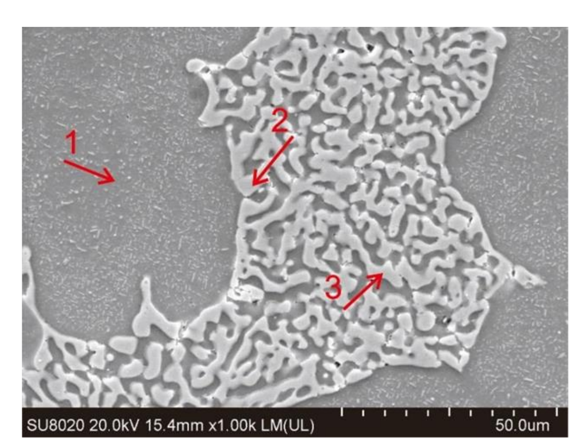

Fig. 3. SEM picture of linear segregation structure in ZL205A alloy

Table. 1. EDX analysis of linear segregation in ZL205A alloy

Element	Matrix		Segregation region					
	1		2		3		Average	
	wt%	at%	wt%	at%	wt%	at%	wt%	at%
Al	94.88	96.87	49.84	69.12	49.91	69.23	49.88	69.18
Cu	3.99	1.73	49.39	29.08	49.37	29.08	49.38	29.08
Mn	0.44	0.22	-	-	-	-	-	-
O	0.68	1.18	0.77	1.80	0.72	1.69	0.75	1.75

In order to further confirm the distribution of Cu elements in the linear segregation structure, the linear scanning and surface scanning of Al and Cu elements were carried out on the sample segregation structure and nearby areas, and the scanning results are shown in Fig. 4.

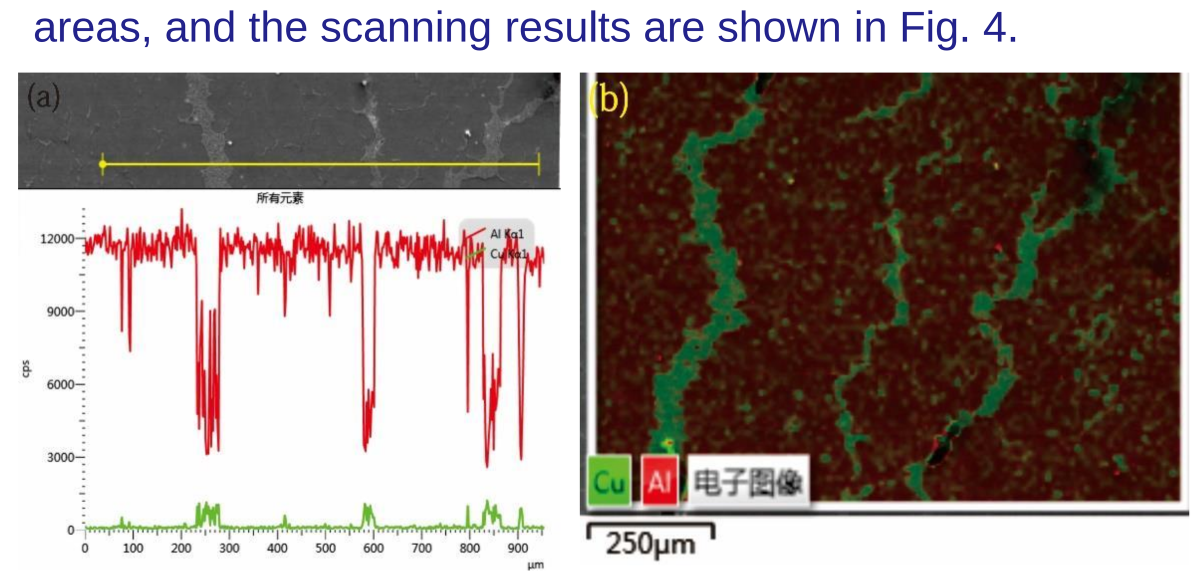

Fig. 4. Line and surface scanning analysis of linear segregation in ZL205A alloy
(a) line scan of Cu and Al elements; (b) surface scan of Cu and Al elements

Results and Analysis

- **Grain Boundary Segregation.**

From the solute distribution in the solidification process, with the decreasing of temperature, the alloy grows in a dendritic form……

- **Relationship between linear segregation and hot crack.**

The generation of linear segregation is caused by the flow of Cu-rich solution. Therefore, it is believed that there is a certain correlation between cracks occurring during solidification and the formation of linear segregation. The cracks produced during solidification are called thermal cracks……

- **Measures to eliminate linear segregation in ZL205A alloy castings.**

From the above analysis, it can be seen that the generation of linear segregation is related to the flow of Cu-rich melt, while the generation of thermal cracks promotes the formation of linear segregation. Therefore, to eliminate the occurrence of linear segregation, the flow of Cu-rich melt should be prevented. To prevent the flow ofCu-rich melt, we should start from avoiding hot cracking of the casting, such as reasonably designing the casting structure and gating system, avoiding hot spots as much as possible, and adopting cold iron measures for the hot spots……

Conclusions

(1) Linear segregation structure in ZL205A alloy castings is dendritic or similar to crack morphology along grain boundaries, and shrinkage cavity and crack also appear at segregation.

(2) During solidification of ZL205A alloy castings, Cu atoms tend to segregate spontaneously to the crystal boundary. The segregation element is Cu element and exists in the form of θ(Al 2 Cu) phase, while the linear segregation structure consists of θ(Al 2 Cu) and α-Al eutectic phase.

(3) The formation of linear segregation is related to the flow of Cu-rich melt in the late solidification period, while the occurrence of thermal cracks promotes the formation of linear segregation.

(4) The elimination of linear segregation should start with preventing the flow of Cu-rich melt and increasing the distribution area of Cu-rich melt at grain boundaries, such as eliminating hot spots of castings and refining grains.

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