



AUTOMATED IMAGE ANALYSIS OF THE INHOMOGENITIES IN THE MICROSTRUCTURE OF ALUMINUM CASINGS

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Abstract

The fast cooling of the die casted aluminum products can cause an inhomogeneity in the microstructure. An automated image analysis method is developed and introduced to evaluate this inhomogeneity. This is based on the analysis of a tile image taken from the whole cross section of the castings. This article describes the method of analysis.

Keywords: die casting, aluminum, microstructure, image analysis, hypo-eutectic

1. INTRODUCTION

The mechanical properties of the metals and alloys are strongly related to its microstructure. Some cases are easier to examine, evaluate and qualify the microstructure instead of performing mechanical tests. The testing of thin walled castings is a typical example. The most productive technology of this type of products is the die casting. During die casting, the cooling of the melt can be fast. The cooling rate has a great effect to the microstructure. The cooling rate the largest at the surface of the melt, next to the tool, the crystallization starts in the surface region, and fine microstructure develops. In the bulk the cooling rate is smaller due to the finite heat conduction of the solid and melt aluminium. In the bulk coarser structure can be found. The extent of this effect extremely depends on the thickness of the wall. So, in the case of thin walled castings the evaluation of the microstructure is not enough. Evaluation of the mentioned inhomogeneity is also necessary [1]. This means the analysis and evaluation of a large number of images. Image analysis is only one tool which can help in the evaluation of this number of images [2].

Image analysis is extensively developed in the last decade. Several fast algorithm and mathematical method were created to solve simple and complex problems. In materials science, the metallographic examinations use extensively image analysis mainly in the mentioned evaluation and qualification tasks [3]. As it was mentioned above in the case of castings, the comprehensive mechanical testing could be an extremely hard work or impossible. For this reason, there are image analysis systems nearly the all quality control lab of foundries [1].

Mainly hypo-eutectic aluminium-silicon alloys are used in die casting. The microstructure of this alloys contain primary aluminium dendrites and eutectic colonies. The eutectic colonies are built-up by silicon plates in an aluminium matrix. The aluminium and the aluminium matrix are ductile. For this it is necessary to measure the size of the aluminium dendrites and the eutectic colonies too. The dislocation free path is the important parameter which has a strong relation to the strength and the elongation of the material. There are more measures which can describe the size of the dendrites and eutectic colonies [4]. It is necessary to find that geometrical parameter which proportional to the dislocation free path.

Samples were examined which were produced according to [1]. Thin walled samples produced by



die casting with several thicknesses. This article shows the metallographic techniques, the algorithm of image analysis and the evaluation method.

2. METHODS

Samples were cut from the casted parts. The samples were mounted in resin. The cross sections of the samples were examined. The examined surface of the samples was grinded and polished. The polishing was made by 3 μ m diamond paste. The surface of the samples was etched by hydrofluoric acid. The whole cross section of the samples was necessary for the examination therefore tile images were taken by Zeiss AxioImager M1m microscope and Zeiss AxioVision software. The images were analysed.

The tile images were too large for the analysis, therefore 1024x512 pixel sized images were cut out from the tile images. The single images were analysed separately. The images were cut out as a moving window along the thickness of the sample. The longer measurements of the cut images were parallel of the surface of the casting. The windows moved through the thickness with $\frac{1}{4}$ overlap. This proved a stability of the measured results. This analysis was performed in three independent positions. Figure 1 shows an illustrated sample of a 2mm wide sample.

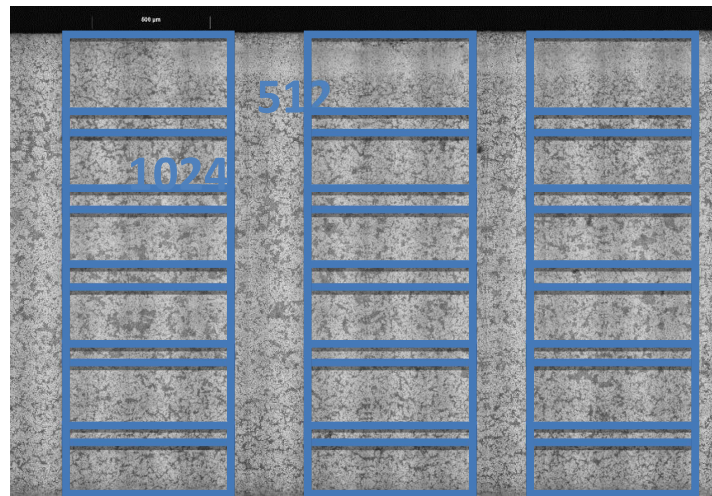


Figure 1 The tile image with the analysed image. Images cut out from the tile image for analysis

The images are prepared for the segmentation. An automatic contrast method was applied. Automatic segmentation technique (moment) was used for distinguishing the eutectic area and the primary dendrites. Binary transformation also used to remove digital noise from the images. This digital noise means small white dots in the eutectic area. Binary open was applied to remove these dots. Figure 2 shows a grayscale image and a binary image.

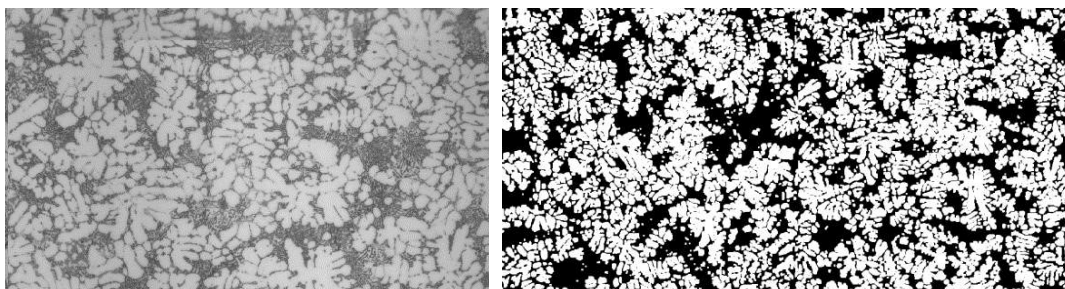




Figure 2 One grayscale image cut out from tile image and a binary image before measurement
The white areas are the primary dendrites, the black areas are the eutectic colonies. Both have complex shape. Simple parameters are necessary to measure which characterize the microstructures. The trivial choice is the specific surface of the dendrites, but this value has not a direct relation to the dislocation free path. The area fraction of the dendrites and the eutectics can be easily measured. The horizontal and vertical projected diameters also can be measured easily. A parameter was constructed based on these values according to (1).

$$WAPD = X_{dendrite} \overline{Proj}_{dendrite} + X_{eutectic} \overline{Proj}_{eutectic} \quad (1)$$

In the equation WAPD is the mentioned parameter. $X_{dendrite}$ is the area fraction of the primary dendrites, $X_{eutectic}$ is the area fraction of eutectic colonies. $Proj_{dendrite}$ and $Proj_{eutectic}$ are the average of the horizontal and vertical projected diameters. This parameter has a direct correlation of dislocation free path because of both volumes, the eutectic and primary dendritic, can be deformed in some extent. These parameters were measured on the images. All image means a position so it is possible to plot the results according to the wall thickness.

3. RESULTS

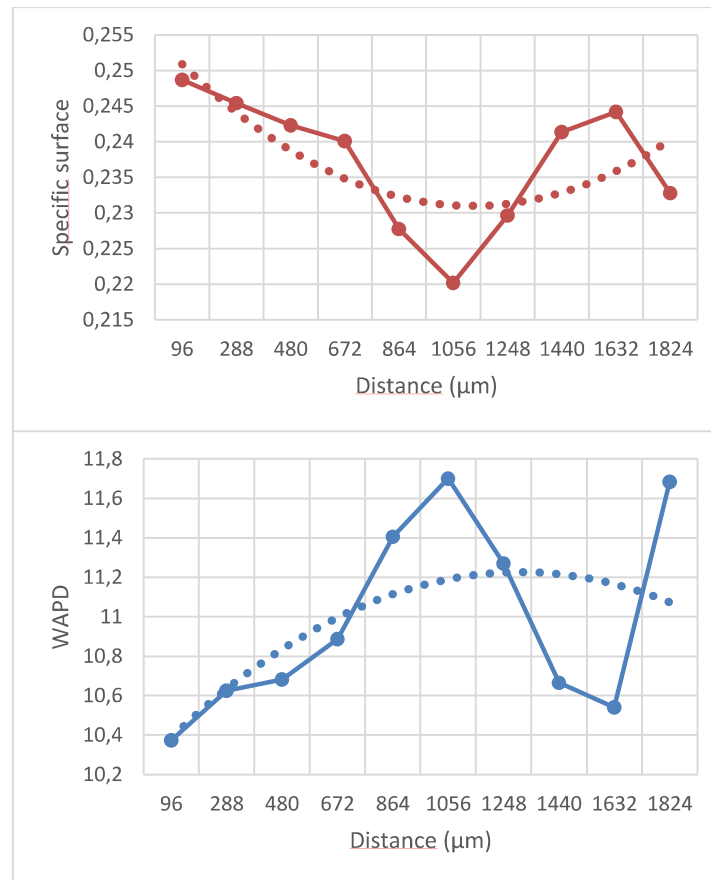


Figure 3 The results of the analysis of Figure 1. The upper graph shows the changes of the specific volume, the lower graph shows the changes of WAPD parameter along the thickness of the sample



Figure 3 shows the measured results of the 2mm wide sample. It can be seen on the graphs that the structure of the dendritic area and the eutectic colonies are finer in the surface of the sample than the middle. The fits with the prior observation. The graphs show a difference between the two sides of the sample. Probably this originated to the supply of the tool. In the warm side the microstructure is coarser.

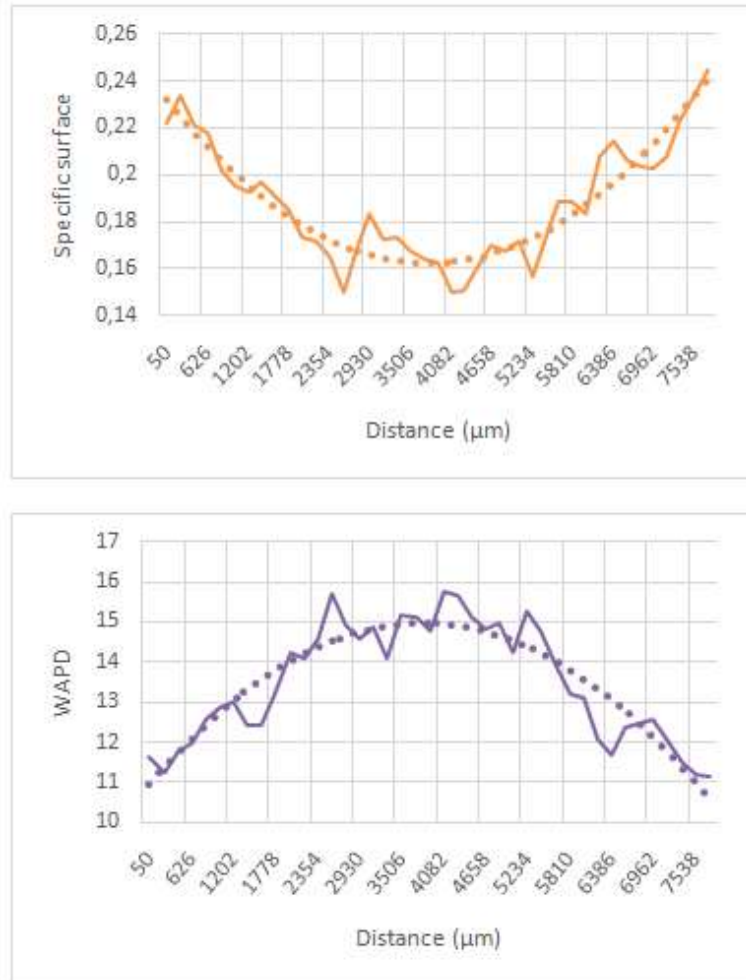


Figure 4 The results of the analysis of the 8mm wide sample. The upper graph shows the changes of the specific volume, the lower graph shows the changes of WAPD parameter along the thickness of the sample. The micrograph shows the tile image.

Figure 4 shows the results of the measurement of 8mm wide sample. It can be seen that much more images build up the tile image. It means a really large amount image to analyse. This only can perform by the introduced automated method. The results show the same. The structure finer next to the wall, and coarser in the middle. The comparison of the two samples shows that the difference between the surface and the bulk is larger in this case. The thickness of the sample is larger so the difference in the cooling rate is also larger. The larger difference in cooling rate causes larger inhomogeneity in the microstructure. Both examples show that the developed method is suitable for characterizing the inhomogeneity of the microstructure in hypo-eutectic castings. it can be seen in the graphs that the specific surface and WAPD parameter show the same and comparable. The specific surface can be measured easier and shorter computation time than WAPD parameter.



CONCLUSIONS

Plates were casted from aluminum alloy in different thickness in a previous research. The microstructure, mainly the inhomogeneity in the microstructure was measured by image analysis method. A tile image was taken from the cross section of the image. Image sequence was cut out from the tile image along the wall thickness. Specific surface of the dendritic area, and a complex parameter (WAPD) were used to describe the whole image. All images indicate a position along the thickness of the wall. The mentioned measurements were plotted as a function of thickness. Both parameters clearly describe the inhomogeneity in the microstructure. But the measurement of the specific surface a fast method, and smoothly shows the differences. Based on the results the introduced method and the specific surface are suggested to characterise the inhomogeneity in thin walled castings.

References

- [1] Léránth G., Barkóczy P.: Nyomásos öntvények vizsgálata, Miskolci Egyetem Közleményei: Anyagmérnöki Tudományok, Vol 37., pp 277-284, 2012
- [2] Leszek Wojnar: Image Analysis applications in materials engineering, CRC Press, 1999.
- [3] Qiang Wu, Fatima Merchant, Kenneth R. Castleman: Microscope Image Processing, Elsevier, 2008.
- [4] Gácsi Z., Barkóczy P.: Számítógépi képelemzés, www.tankonyvtar.hu