Statistical Process Control Method Based on Weight Percent of Al-Si Alloy for Melting and Holding Process in Die Casting

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Abstract. We proposed a conceptual method of how to control liquid state of Al-Sialloys in holding process of the die casting. Given that, we determine the characteristic of the holding furnace based on weight percent (wt %) of the certain alloys and their elements. An Experimental case study deals with the application of the proposed method in company that produces castings by the die-casting technology.

Keywords: die casting, chemical analysis, alloy, weight percent, SPC.

1 Introduction

The die casting technology is the widest technique for producing castings from aluminum alloys. High cadency of casting production by this technology causes high intensity of melting and replenishment of molten metal into melting holding furnaces [1]. The critical parameters include quality of liquid alloy, which means their chemical composition, etc. [2] and [3]. These parameters impact the final properties of castings produced in pressure die-casting process. The cold chamber die-casting machine employs holding furnace that has to hold molten metal preparatory to casting [4]. The melting and holding process of non-ferrous metals is carried out in the induction stationary crucible furnaces [5]. Our objective is to present method to control melting and holding process in holding furnace. Subsequently in Section 3, we applied our method in the specific condition. The last part gives an overall assessment and possible future direction to extend this method in a practical sense.

2 Proposal of Statistical Process Control Method

We assume that with proposed method, the company will be able to measure the process more effective in quality way on the basis of determining the characteristics of the holding furnace. We can also determine the ideal balanced weight percent of given elements in every layer. The particular steps of the given method are as follows:

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1. Ensure degassing and the removal of oxide layers that is emerging at the surface of the liquid alloy.
2. Determine the number of the samples, referred as *n*, where the first sample is carried out before the casting process. (*n*=10).
3. Determine the interval between sampling (see Eq. 1), referred as *i*, based on capacity, *q,* and utilization, *u*, of the furnace.

$$i = \frac{u \times q}{n-1} \tag{1}$$

4. Carry out sampling from the layer that is in the range of 50 to 70 mm below the surface of the molten metal.
5. Perform the visual control of the samples. If it is found that sample was contaminated by surface layer of the liquid alloy, the sample must be excluded. If there are 3 or more excluded samples in a row or more than 4 in total, it is necessary to repeat the sampling from the start.
6. Adjust the surface of the sample after solidification by grinding to analyze.
7. Carry out the chemical analysis using spectrophotometer.
8. Process the measured values to determine variation trend index of element content, denoted as *k* (see Eq. 2), where *m* stands for weight percent of certain element.

$$k = \frac{m_n - m_1}{u \times q} \quad \begin{cases} k > 0; \text{increasing trend in wt\%} \\ k < 0; \text{decreasing trend in wt\%} \end{cases} \tag{2}$$

9. Create charts for each element where x-axis presents number of castings and y-axis stands for weight percent of the certain element. From the charts we can determine the optimal number of cast parts with quality required.

3 Experimental Case Study for Demonstrating Proposed Method

We used our method to investigate variations of chemical composition in specific layers of liquid alloy vertically during the die casting process. In our three-experiment study, we observed the variations of liquid alloy composition, and also investigated a time span of estimated variations of selected elements in alloy that are defined by standards (EN 1706). The furnace uses an induction heating with capacity of 150 kg of the liquid alloy. The utilization of the furnace is 70 %, which stands for approximately 80 cast parts. The chemical analysis was performed for each sample by spectrophotometer SPECTROLAB JR.CCD 2000. We also analyzed volume of Al, Si, Fe, and Mn expressed in weight percent.The calculated values of *k* for Si (-0.0084), Fe (-0.0011) and Mn (-0.0024) point at decreasing trends of all three elements, which means the gradual deterioration of casting parts. In the Fig. 1 depicts charts with variation of the content for each element that is expressed by weight percent. We can assume the decreasing trend of the weight percent for silicon, ferrite, and manganese.

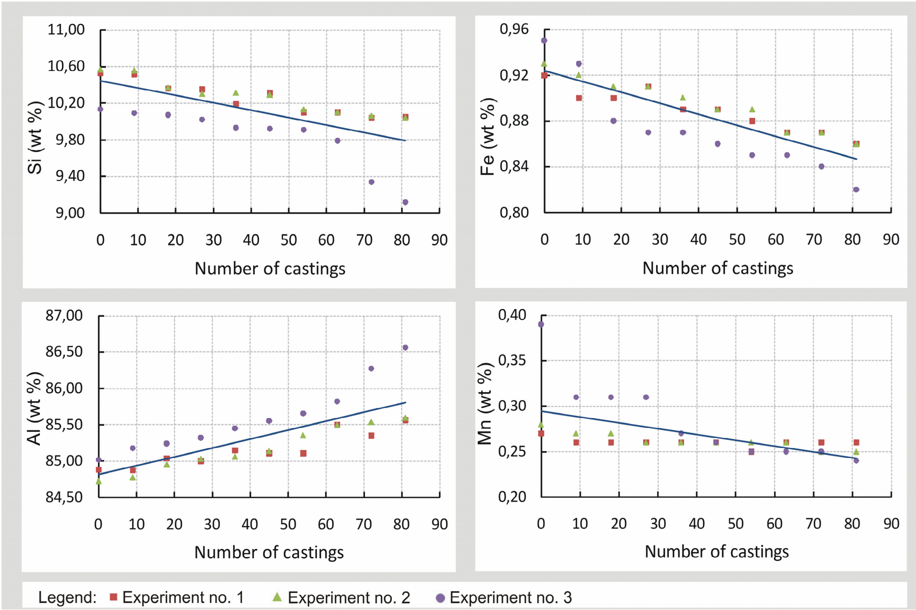

Fig. 1. Weight percent of Si, Fe, Mn, and Al in Al-Si alloy depending on the casted parts

4 Conclusions

The experimental case study demonstrated the application of the method in the company that produces casting parts by die-casting technology. It is recommended to use the proposed method in combination with standards that can lead to an increase in quality of casting parts. Future research work will be focused on monitoring the impact of the changes for selected mechanical properties such as: permanent deformation, ductility and hardness of the casting. It extends the experimental study on others types of Al-based alloys.

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