DC-Casting of Rolling Ingots with High Level of Magnesium

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Abstract

The direct-chill casting of aluminium alloys is one of the main processes used in the aluminium industry to produce flat rolling products. The quality and final properties of flat rolled products are to a greater or lesser extent related to the quality of the cast ingots. It is well known that all cast products are characterized by a non-uniform distribution of alloying elements in the cross section of the cast product. This non-uniform distribution of alloying elements is called macrosegregation. The work is aimed at developing practical recommendations for casting flat ingots from the AlMg6 alloy with a minimal non-uniform distribution of magnesium in the cross section of ingots.

Keywords: DC casting, AlMg6, Rolling ingots, Magnesium segregation.

1. Introduction

It is known that due to macrosegregation, the concentrations of alloying elements can vary significantly in the cross section of the ingot [1, 2]. In particular, the difference in the cross-section of an ingot in the values of a particular element can reach more than 20 % [3]. In this case, the chemical composition in certain sections of the ingot may go beyond the regulated range of alloying elements and the established content of impurities. The consequences of segregation can be hot cracks during casting of ingots, non-uniform of deformation, significant variation in mechanical properties and other characteristics along the length and width of the flat rolled product.

It should be noted that element segregation is a uncorrectable defect after casting. Therefore, only at the casting stage is it possible to eliminate or achieve an acceptable non-uniform distribution of elements in the cross section of the flat ingot. In general, the mechanisms of macrosegregation are well studied and described in review [4], however, despite this, macrosegregation in cast ingots still requires attention and experimental work. This is primarily due to the fact that there are general recommendations, without a reliable quantitative assessment of the distribution of alloying elements for various sections.

This paper describes the experience of producing flat ingots with a high magnesium content and is aimed at revealing the main technological factors affecting the distribution of magnesium over the ingot cross-section using the example of an AMg6 alloy type.

2. The Role of Casting Parameters and Melt Distribution in Ingot Casting

The work was carried out in the laboratory of computer modelling using the equipment of the pilot casting complex at the Krasnoyarsk aluminium Plant. At the first stage, calculations

(Figure 1a) were performed to assess the impact of technological parameters. The calculated data allowed one way or another to assess the effect of the casting speed, the distribution of the melt flow in the combo bag run on the profile of the flat ingot well, as well as to estimate the flow rate of aluminium melt at various points of the well profile.

The casting complex (Figure 1b) is used to perform physical modelling of the casting process, including validation of calculated data, which ensures the achievement of good results and ensures the production of high-quality ingots for customers. Casting was carried out on a model alloy which chemical composition is shown in Table 1. The casting speed was 40–60 mm/min, the melt modification was carried out with a consumption of a ligature rod of about 1 kg/t. The casting temperature was maintained in the range of 690–700 °C. The cross section of the ingot was 406 × 1300 mm and a combo bag size of 33 cm.

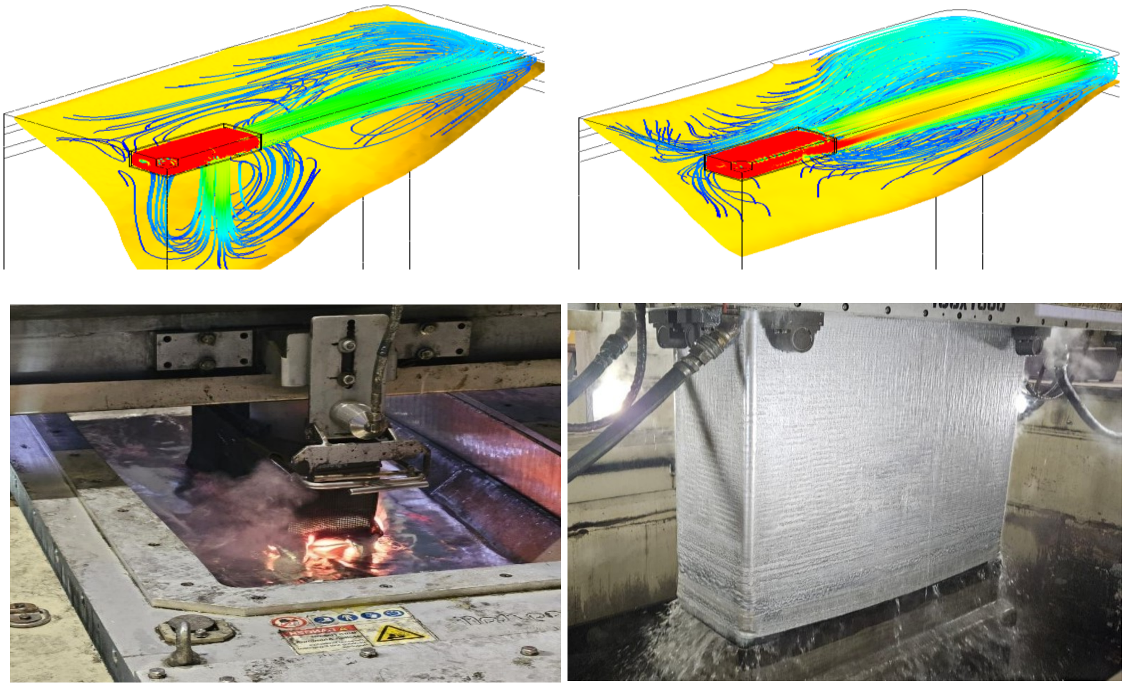

Figure 1. Top: Modelling the flow distribution during ingot crystallization, Bottom: Physical modelling during flat ingot casting.

Table 1. The actual chemical composition of the model alloy (wt.%).

Si	Fe	Cu	Mn	Mg	Zn	Ti	Al
0.06	0.19	< 0.001	0.65	6.5	< 0.001	0.04	Rest

It is known that macrosegregation is caused by mass transfer in the liquid phase. Moreover, the researchers [4] showed that the casting rate and melt distribution have a dominant effect on macrosegregation. Taking this into account, using calculated and experimental data, at the first stage, the influence of the casting speed in the range of 40–60 mm/min on the depth of the hole for an ingot with a cross section of 406 × 1300 mm was estimated. The calculation was carried out for two melt distribution options:

- Combined melt distribution (horizontal and vertical),
- Horizontal distribution of the melt.

The calculation results are shown in Figure 2, where the figures show the minimum values from the profile of the well, which is most strongly observed in the central part of the ingot.

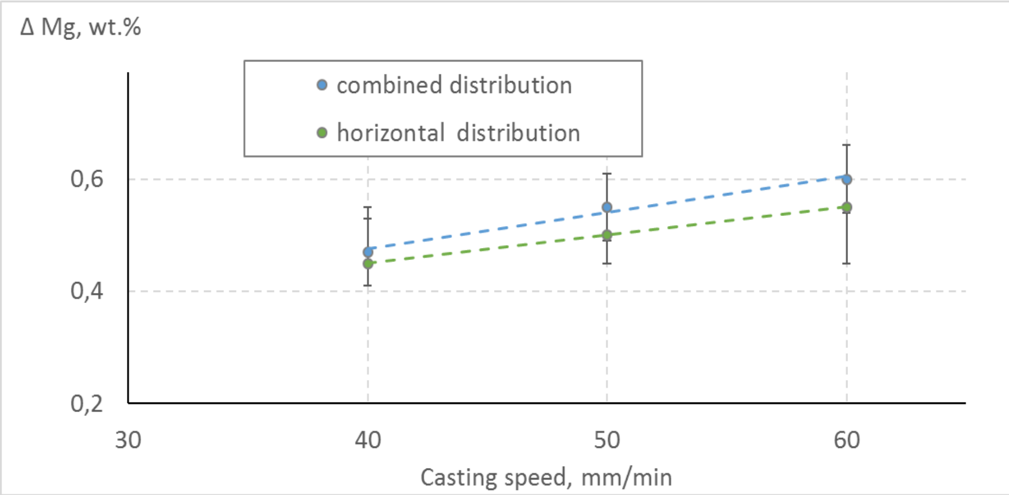

Figure 3. Characteristic changes in the hole profile depending on different types of combo bags.

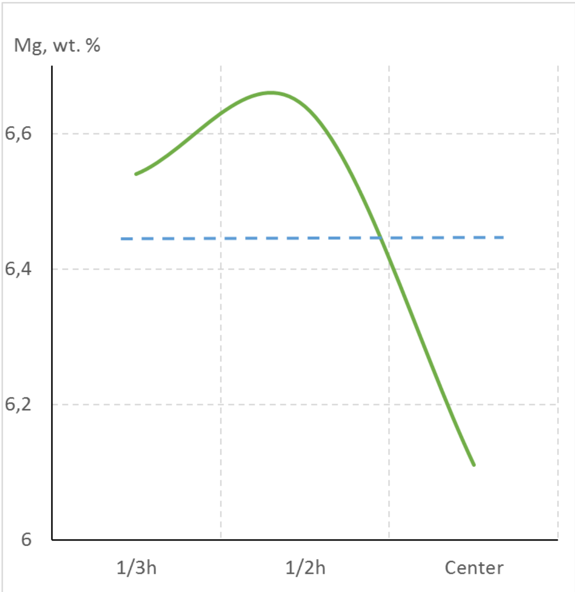

Figure 4. Actual values of magnesium distribution along a narrow face (horizontal distribution, casting speed 60 mm/min).

3. Conclusions

Based on the results obtained, practical recommendations were given for production of ingots, which made it possible to reduce the spread between the minimum and maximum values of the magnesium distribution. These recommendations were also valid for normalizing the distribution of other elements for 5xxx series alloys, among which manganese and chromium, as well as iron and silicon impurities, should be highlighted.

4. References

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