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Shaping the structure and properties of the selected magnesium alloys in a semi-continuous casting process

Abstract

The subject of the doctoral dissertation is concerned with three main aspects, namely: the material, the way it is refined and the casting method. These three interconnected aspects presented a specific research challenge, demanding a special approach. Magnesium alloys in themselves constitute a difficult subject, due to the complicated nature of their melting and casting. This is caused by the fact that their temperature is higher than their point of ignition. Additionally, it should be noted that magnesium alloys are still not as popular as other non-ferrous alloys, including light alloys of aluminum and/or titanium, which results in the need for specialist tests and the necessity to conduct own experiments.

The situation is similar in the case of structure-improving treatments, which in magnesium alloys, due to the presence or absence of certain alloying components, must be considered separately. The technological process of semi-continuous casting is not

a simple technology. The course of the casting process depends on a number of factors, originating both in the thermal parameters within the crystallizer as well as in different ways solutions crystallize, their eutectics, etc. Undoubtedly, the factors that play the most important role in a semi-continuous casting process are the casting speed, solidification rate and intensity of cooling.

This work includes investigations of the selected magnesium alloys from the group containing aluminum and without its addition, cast into ingots in the vertical semi-continuous VDC system (Vertical Direct Casting). As part of the research work, tests were carried out to determine the possibilities of shaping the structure and properties of the alloys belonging to MgAl group, (AZ91), MgZn6 and MgZn6Zr (ZK60A) used for plastic working processes, by controlling casting and modification parameters in a semi-continuous casting process.

The specific objective of the doctoral dissertation was to determine the possibilities of shaping the structure and properties of magnesium alloys for plastic

working processes, by controlling the casting and modification parameters in a semi-continuous casting process.

A series of tests was carried out at a semi-continuous casting station, and the test material were ingots for plastic working, with the diameter of 102 mm, cast in a system with a crystallizer with a ceramic top, so-called hot-top.

Analyzing the results of the chemical composition test, no major differences were observed in longitudinal segregation for the AZ91 alloy. In the case of zone segregation, the phenomenon of enrichment of elements near the surface layer is visible, a clear case of reverse segregation. In the middle part, there is a phenomenon of reducing the content of the analyzed elements. From the point of view of the inhomogeneity of the chemical composition occurring along the diameter of the ingot, attempts should be made for the crystallization front to be as flat as possible.

There were attempts to modify the MgAl9Zn alloy (AZ91) and the MgZn6 alloy. The AZ91 alloy was modified by the addition of carbon nucleants. For the MgZn6 alloy, zirconium was used as the modifier.

For the AZ91 alloy after modification, the ingot casting process was conducted with constant casting parameters. For the MgZn6 alloys before and after the addition of zirconium, a series of tests with variable casting parameters was carried out. The modification treatment resulted in the reduction of the grain size. The effect of the casting parameters before and after the addition of zirconium is visible, where smaller grain sizes were obtained for lower casting parameters.

In the process of plastic processing of ingots, the extrusion force increases for materials with a finer structure (AZ91 after modification and ZK60A). In the case of AZ91 extruded rods, none of the modifiers caused an increase in the strength values, and a definite increase in the UTS, YS and HB values followed the addition of zirconium to the MgZn6 alloy.

The objectives of the work were accomplished by analyzing the possibilities of shaping the structure and properties of magnesium alloys by defining casting parameters, such as casting speed and the amount of cooling water, as well as the introduction of modifiers in the semi-continuous casting process.