Streszczenie rozprawy doktorskiej w języku angielskim

Regardless of the direction in which vehicle propulsion systems develop, the future of wheel rims will involve reducing their weight while maintaining the required functional properties and pursuing greater aesthetic personalization. To meet these requirements, wheel manufacturers are introducing structural and material changes while maintaining the required quality and safety standards for road users. The most popular method of wheel production is casting under pressure, which ensures products of good quality, the required properties and appearance, at relatively low production costs. These requirements can be met by high-strength Al-Si-Mg-Mn alloys, which make it possible to satisfy aerodynamic requirements, reduce weight, and achieve the required degree of personalization and high strength.

Despite the fact that advanced technologies enable the production of wheel rims by flow forming, forging, or gravity casting, the most commonly used manufacturing method is low-pressure casting. This is mainly due to the high quality of the products, reflected in their efficiency, dimensional accuracy, and well-developed surface, as well as relatively low casting costs (approximately 3–4 times lower than those of forged wheel production).

In addition to a review of the literature, the dissertation consists of four parts. The first part presents the research concept. Since the research problem was reported by Superior Industries Production of Poland in Stalowa Wola, the main (scientific) and applied (industrial) objectives were defined. Two theses of the dissertation were formulated, and the novel aspects that have no basis in the literature were identified. The methodology, material, and research setup are described. The AlSi7Mg alloy, which is the main material used for wheel castings, was selected for the research.

The next chapter presents preliminary studies, in which the successive stages of the wheel production process at Superior Industries Production of Poland in Stalowa Wola were described. The analysis of the automotive wheel casting process focused on identifying those production areas that may be affected by an increase in the proportion of secondary aluminium (scrap). Particular attention was paid to the fact that an increase in the proportion of scrap (from 50 to 80%) is associated with an increase in gas impurities (e.g. hydrogen, water, fluxes) and metallic impurities. A literature review showed that one of the most harmful metallic contaminants is iron, which crystallizes in the form of morphologically unfavorable and dimensionally brittle β-Fe phases. Their sources in aluminium scrap include steel filters used as melt filters in ladles, steel foundry tools used for taking samples for chemical-composition control, and various steel sleeves used in older-type wheels.

The third chapter comprises the main research. It follows from these studies that, in order to change the unfavorable morphology of β-Al_5FeSi phases, various chemical modifiers were introduced, the most popular of which is manganese. Due to the similarity of its crystal lattice and lattice parameters to those of iron, manganese changes the morphology of β-Fe phases from a platelet-like form to the so-called “Chinese script” form (in gravity casting) or to a polyhedral shape (during pressure casting), increasing hydrogen removal and causing the particles to settle more rapidly. It was also found that nitrogen refining is ineffective when the proportion of scrap is increased. Therefore, a series of studies was conducted on modifying the refining process, resulting in the development of a new NH_2 mixture (90% N + 10% H_2), intended for refining aluminium alloys.

The final chapter contains an analysis of the results, followed by conclusions and technological recommendations. The results obtained from laboratory studies, simulations, and industrial tests were verified under production conditions on one of the pressure-casting machines. Implementation of the guidelines may contribute to changes in the technology of aluminium wheel production at Superior Industries Production and at other pressure foundries with a similar business profile.