ABSTRACT

The doctoral dissertation entitled **"Formation of the structure of a gray cast iron matrix composite reinforced with SiC and Al_2O_3 particles as an advanced material for brake discs"** consists of three mutually complementary parts.

The literature review indicates that the dynamic development of the automotive industry, including brake systems, results from the necessity to adapt materials used in vehicle components that impact the environment to the applicable European Union directives. These needs arise both from economic considerations of manufacturers of components for electric and internal combustion vehicles, associated with production in heavy industry (steelworks, foundries), and from the necessity to implement new projects involving material and technological changes that support the competitiveness of customers (automotive corporations). Therefore, current research is primarily focused on optimizing production costs of automotive components intended for applications compliant with EU regulations, as well as on improving functional properties while reducing the proportion of defective products.

The second part comprises preliminary studies, which indicate that it is justified to seek new solutions consistent with foundry policies, aimed at improving the performance properties of brake discs and modifying technology without compromising the final product and with full customer acceptance as a necessary condition. The selected brake disc casting, representing the dominant product assortment of brake system castings at Brembo Poland, serves both as an example and as the subject of the research presented in the dissertation. Analysis of nucleation and solidification process parameters shows that it is possible to introduce ceramic particles such as SiC and Al_2O_3 into cast iron, where they act as active nucleation substrates. The formation of such a composite is intended to reinforce the structure of the brake disc casting, resulting in improved tribological performance.

The essential research, preceded by defined objectives and a thesis, concerns the development of manufacturing concept of cast iron matrix composite with a porous structure containing SiC and Al_2O_3 particles. Analysis of tribological studies indicates that such a composite exhibits significantly improved wear resistance. This also applies to the transition zone between the matrix and the reinforcing phase. Its characteristic feature is chemical reactivity influencing catalytic nucleation. Manganese sulfides (MnS) identified in the microstructural investigations may serve as substrates for heterogeneous graphite nucleation.

This enables the production of brake disc castings with improved metallurgical quality, determined by a uniform graphite morphology in critical regions that govern the approval of brake discs for service.

The doctoral dissertation also addresses the problem of developing a new method for graphite flake nucleation. The proposed solution involves modifying the activation energy of nucleation compounds through the introduction of a reactive ceramic phase and constitutes a modification of the well-known Riposan theory. This modification is based on the phenomenon of heterogeneous catalysis occurring at the interface between cast iron and ceramic phases containing SiC and Al_2O_3 particles. The dissertation concludes with a summary, conclusions, and technological recommendations regarding further directions for the development of cast iron matrix composite materials.