Łukasz Szymański
Faculty of Foundry Engineering
AGH University of Science and Technology

ABSTRACT

Composite layers fabricated in situ in a casting based on Fe alloys

The subject of the present doctoral dissertation concerns the production of composite layers reinforced with titanium carbide, including the physicochemical phenomena which occur in reactive liquid-solid systems.

The whole work has been divided into four parts. The first part presents a brief description of issues related to metal matrix composites, surface engineering, as well as the phenomenon of wetting at high temperatures. The extensive analysis of the literature and statistical data indicates that the production of layered materials with increased mechanical and functional properties is an intensively developed topic of study as a result of the common problem that is material wear.

The experimental part began with conducting experiments the aim of which was to characterize phenomena occurring in the reactive titanium + graphite / gray cast iron system. For this purpose, high temperature wettability tests were carried out. The obtained results, together with the analysis carried out with the use of microscopic techniques, allowed to fully characterize the process of titanium carbide synthesis in terms of the phenomenon of reactive infiltration.

In the stage of the research that followed, the process of developing reactive foundry coatings for the production of composite layers of the TiC / iron alloy type was presented. For this purpose, suspensions were prepared on the basis of an aqueous solution with an addition of carboxymethylcellulose (CMC) as a binder and stabilizer. The selected cellulose ether was subjected to structural tests using spectroscopic and X-ray techniques. In turn, the aqueous CMC solutions prepared, as well as coatings with the addition of TiC reactants, were tested for viscosity and low-temperature wettability. Due to the use of organic coating ingredients, gas formation tests were carried out in order to select the chemical composition with the lowest gas emission level during thermal decomposition.

The final stage of the research included the in situ fabrication of composite layers reinforced with titanium carbide based on iron alloys. The local composite reinforcement has been characterized in terms of its structure, microstructure, mechanical and functional properties. The obtained results indicate the possibility of using reactive foundry coatings for the production of ceramic phases by reactive infiltration. An examination of the microstructure revealed the presence of a reinforcing phase in the form of titanium carbide and the presence of porosity which arises as a result of thermal decomposition of the binder and solvent, derived from reactive casting coatings. The phenomenon of fragmentation of composite layers was also identified, which manifests itself in the discontinuity of the structure due to the exothermic nature of the TiC reaction. The obtained results of mechanical properties demonstrated more than a twofold increase in hardness in the area of the composite layer as compared to the casting alloys used, which was reflected in the functional properties tests.

The presented method of producing layered castings seems to be attractive due to its single-stage nature, as well as the lack of a need to use specialized equipment. The technological process requires further research, especially in terms of the

modification of the chemical composition of reactive foundry coatings in order to eliminate structural defects that might arise.