Abstract

This doctoral thesis entitled " Structure and properties of newly developed composite materials for injection molds manufactured using additive technology" presents the manufacturing technology and test results of steel-copper composites that can be used for injection mold components such as die inserts, which will increase the cooling rate of injection-molded plastics. The production of modern injection molds containing integrated cooling systems, thermocouple holes, and molding cavities using traditional subtractive machining technology is time-consuming and costly, which is why additive technologies are becoming increasingly important. They enable the creation of conformal cooling channels in molds, which is important in the plastic injection molding process, especially during product cooling. This paper proposes a different solution consisting in the possibility of increasing cooling efficiency by using composite steel-copper mold inserts with high thermal conductivity. To this end, the following thesis was adopted: *The use of 3D printing for the production of lithoporous fittings made of X40CrMoV5-1 tool steel and their copper infiltration will allow the production of composites with a precisely designed structure and properties predestined for use in injection mold inserts*. To achieve the objective of the work, the MFDM method was chosen, which is less popular but more accessible and cheaper than SLM technology, and which also allows for the printing of lithoporous steel elements, which were then infiltrated with liquid copper. It has been shown that the properties of sintered materials produced using the MFDM method are strongly influenced by the binder used, in particular the residual carbon that remains after its degradation. Compared to commercial binders, the proprietary binder used requires less energy for degradation but leaves more residual carbon, which lowers the sintering temperature and increases the hardness and brittleness of the sintered products. The sintering atmosphere is undoubtedly important for achieving high density and low porosity, which further affect mechanical properties and thermal conductivity. Research results indicate that the most favorable atmosphere is N_2-10%H_2. The use of a nitrogen-containing atmosphere causes the release of vanadium nitrides, which strengthen the matrix and improve abrasion resistance and microhardness. In addition, hydrogen as the second component of the atmosphere reduces oxides on the surface of the powder particles, increasing the density and reducing the porosity of the sintered products, which improves their thermal diffusivity and tensile strength. The method of liquid copper infiltration also affects the filling of channels and open pores in the resulting lithoporous sintered products. It has been established that infiltration should take place in a high vacuum, which ensures high efficiency of filling lithoporous steel sintered products

with liquid copper at relatively low cost. Final heat treatment increases the hardness and abrasion resistance of the steel matrix.