Structure and properties of injection moulding tool materials with nanocrystalline coatings

Klaudiusz Gołombek

Institute of Engineering Materials and Biomaterials, Silesian University of Technology,

Konarskiego Street 18a, 44-100 Gliwice, Poland

Corresponding e-mail address: klaudiusz.golombek@polsl.pl

Abstract

Goal: *The objective of the monograph is to elaborate the fabrication technology of ceramic-metal tool materials on the basis of cobalt or cobalt-nickel matrix and carbide phases with the application of polymer binder for the formation of injection powder, and to elaborate the modification technology of the surface layer of the fabricated tools, basing on the analysis of the structure and properties of the obtained coatings, using the method of cathodic arc evaporation with lateral rotating cathodes.*

Project/methodology/approach: *Within the scope of the completed works the following research studies have been done, at the first stage: the elaboration of the fabrication technology of ceramic-metal tool materials with the use of powder injection moulding (PIM), testing the rheological properties of polymer-powder slurry, depending on the kind and volumetric share of polymer binder, testing the impact of binder type, its temperature and degradation atmosphere on the structure and properties of injection moulding materials, testing the structure and properties of readymade ceramic-metal tool materials after sintering; at the second stage: using the cathodic arc evaporation method, nanocrystalline, nanocomposite, wear resistant nitride coatings were deposited on the basis of chromium, aluminium, titanium and silicon, analyses were carried out on the structure and properties of coatings deposited on ceramic-metal tool materials having the following required properties: high adhesion, microhardness, high resistance to abrasive, corrosive, diffusion wear in work conditions of high-efficiency tools applied in machining.*

Achievements: *The main accomplishment of the present work involves the elaboration of the fabrication technology of tool materials of desirable structure and usability properties, both in the core zone of the tool and in its surface layer, using a hybrid technology which combines the injection moulding method and powder consolidation with the technology of surface layer modification. The application of powder injection moulding with the use of polymer binders, being highly cost-effective and efficient, with relatively low fabrication costs, has yielded the acquisition of ceramic-metal tool materials of diversified composition of carbide phases and matrix material. On the fabricated ceramic-metal tool materials, nanocrystalline, nanocomposite wear resistant coatings of the type CrAlSiN and AlTiSiN were deposited. The coatings had a preset system of layers and appropriately shaped structure and properties*

in the surface zone as well as in the interface zones between particular layers of the coating, and also between the substrate and core-adjacent layer, whereby it was possible to furnish cutting tools with numerous desirable qualities, ensuring among others better operating durability.

Limitations of research/applications: *The monograph presents the results of research studies involving the selected ceramic-metal tool materials with the deposited nitride coatings on the basis of chromium, aluminium, titanium and silicon fabricated with the use of the cathodic arc evaporation method.*

Practical applications: *Designing and fabrication of tools having desirable properties of surface layer and core is feasible thanks to the application of the potential of hybrid technologies offered by modern powder injection moulding technologies and modified coating deposition technologies, which can considerably enhance their usability properties. The fabrication of tools with wear resistant coatings can considerably increase production efficiency by prolonging operation life of cutting tools with simultaneous reduction of energy consumption or material consumption connected with the reduction of production costs of engineering materials in effect of machining. The application of wear resistant coatings deposited on tool materials has a positive impact in terms of economic and ecological aspects of their operation, allowing among others to reduce costs effected by better efficiency of machining, acquisition of high-quality machined surfaces and also elimination of cutting-tool lubricants.*

Originality/value: *The Author's innovative achievement involves the elaboration of the fabrication technology of ceramic-metal tool materials on the basis of cobalt or cobalt-nickel matrix and carbide phases with the application of polymer binder for the formation of injection powder, and the elaboration of modification technology of the surface layer of the fabricated tools, basing on the analysis of the structure and properties of the obtained coatings, using the method of cathodic arc evaporation with lateral rotating cathodes. The Author's carried out research studies have demonstrated that a considerable rise of operating durability of a cutting tool is conditioned by synergic impact of alternating nanocrystalline, nanocomposite external layers of a coating, ensuring, among others, high hardness and resistance to abrasion as well as the resistance to the propagation of surface micro-cracks, preventing tool chipping, located on a gradient layer of changing concentration of aluminium and chromium or aluminium and titanium, compensating stresses between the layers in the adhesion zone and of core-adjacent layer, ensuring the reduction of stresses and hence very good adhesion of the coating to substrate in spite of relatively low hardness, with the substrate being fabricated from ceramic-metal tool materials, using the powder injection moulding method, ensuring a desirable, complex shape of the tool.*

Keywords: *Tool materials; Cemented carbides; Surface engineering; PVD; Nanocrystalline layers; Powder injection moulding; Sintering*

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