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Influence of nanolayer thickness on the performance properties of multilayer composite nano-structured modified coatings based on nitrides of Ti, Zr, Al and Nb for carbide metal-cutting tools

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The paper considers multilayer composite nano-structured modified Ti-TiN-(Ti, Al)N, Zr-ZrN-(Zr,Al)N and ZrNb-(Zr,Nb)N-(Zr,Al,Nb)N coatings for metal-cutting tools. The coatings under the study have identical elemental composition and thickness (4 μm), but differ in the thicknesses of the nanolayers (20-100 nm). The mechanical characteristics of the coatings were studied, and the tool life tests were carried out for carbide tools with the above coatings for dry turning of steel at v_c = 300, 350, and 400 m/min. A tool with a coating characterized by a lower thickness of sub-nanolayers showed the longest tool life at all cutting speeds. Microstructural studies (using SEM) of the nature of wear and failure of metal-cutting tools with the coatings under the study were conducted. The microstructural studies have shown a marked difference in the mechanisms of wear and failure for the cutting tools with coatings under the study. For the cutting tool with coatings with a smaller thickness of nanolayers (20-50 nm), at lower cutting speeds, the balanced wear is typical with the formation of small longitudinal cracks and delaminations, while at high speeds (v_c = 400 m/min), the brittle fracture “as a whole” with the formation of a network of longitudinal and transverse cracks is typical. The cutting tool with coatings with a greater thickness of nanolayers (60-100 nm) at a speed of v_c = 300 m/min already shows active delamination between nanolayers with elements of brittle fracture. At a cutting speed of v_c = 400 m/min, it shows extensive delamination, both between sub-nanolayers and between intermediate and wear-resistant coating layers, with separation of large segments of coating. The mechanism of wear and failure of the cutting tool with coatings with a smaller thickness of nanolayers, especially at high cutting speeds, is more favorable in terms of the overall performance of coated tools.

Keywords
nanolayer thickness
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