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INCREASING THE LIFETIME OF HIGH-SPEED MODULAR MILLING CUTTERS WHEN MACHINING PARTS FROM HARD-TO-MACHINE ALLOYS BASED ON THE USE OF DEVELOPED MULTI-COMPONENT COMPOSITE COATINGS WITH A NANO-SIZED STRUCTURE

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Abstract: During cutting, tools experience significant mechanical and thermal loads, so special attention is paid to the correct selection of tool material, which plays a key role in ensuring performance characteristics such as wear resistance, productivity, and reliability. An analysis of the properties of the main tool materials reveals that currently no tool material offers the optimal combination of cutting properties. As hardness and wear resistance increase, strength typically decreases. Of all the available tool materials, hard alloys are the most widely used. They offer an optimal combination of hardness and wear resistance on one hand, and strength on the other, enabling high-performance machining.

Introduction

The wear pattern of carbide cutting tools depends on many factors, the main ones being: the type of processing; the physical and mechanical properties of the tool and workpiece materials; cutting parameters; the geometric parameters of the tool; the use of cutting fluids, and a number of other factors. This chapter presents an analysis of the problem of increasing the tool life of carbide cutting tools operating under interrupted cutting conditions, and in this case, during end milling of titanium alloy parts, and also presents common and widely used methods for improving the properties of the cutting tool. To solve the problem of increasing the tool life, it is necessary to study the wear mechanism of its cutting part. The distribution of wear of the cutting tool over its working surfaces depends significantly on the cutting conditions. In the contact zones of the cutting tool and the workpiece, tool wear occurs as a result of mechanical contact with the workpiece material, as well as due to thermal reactions occurring in the cutting zone.

[1] provides an explanation for the brittle fracture of carbide tools during interrupted machining. When the cutter tooth leaves contact with the workpiece, the chip adheres to the tool's contact surfaces, leading to chipping of the tool material during repeated cutting. Thus, after analyzing the primary research on the wear mechanism of carbide tools during interrupted milling, we can conclude that the reduction in tool life occurs primarily due to alternating thermal and mechanical loads on the cutting tool, leading to its wear and failure.

As noted above, carbide is currently the most widely used tool material. Due to the increasingly stringent demands placed on tool materials for strength and wear resistance, leading cutting tool manufacturers are devoting significant attention to the development of new grades of carbide.

Based on the literature review, we can identify key trends in improving cutting tool performance through improved tool materials. Alloy hardness increases by reducing carbide grain size, but at the same time, the alloy's resistance to abrasive wear decreases. Therefore, one approach to improving carbide tools is varying carbide grain size.

When cutting difficult-to -machine materials , high temperatures in the cutting zone weaken the cobalt bond, leading to failure of the cutting tool. The authors of [2,3,4] use a method of modifying the cobalt bond to improve the performance properties of carbide tools. For this purpose, an alloying component such as rhenium (Re) is introduced into the cobalt bond .

Methods of condensation of matter from the plasma phase in a vacuum with ion bombardment (the KIB method) have received wide application at present [5].

In the work [6, 7, 8-10], the results of durability tests of end mills (TT8K6, Z=4, d=12 mm) with the developed wear-resistant Ti-TiN -(TiAl)N coating were obtained when processing 40X (HB 200) steel under cutting conditions n=560 rpm, S=63 mm/min, b=3 mm, t=10 mm, the cutting properties of which significantly exceeded those of the control TT8K6 end mills and mills with standard single-layer TiN , (TiCr)N and (TiAl)N coatings .

Conclusions

1. This paper addresses the scientific and practical challenge of increasing the tool life of cutting tools used in end milling of VT-20 titanium alloy through the use of multicomponent composite nanostructured coatings. This coating structure effectively resists cyclic force and thermal loads typical of intermittent processes, particularly end milling.

2. Based on the multilayer architecture of the coating, which involves the presence of three functional layers, A rational composition of a multi-component multi-layer composite coating with a nanoscale structure (Zr-ZrN - (Cr 0.58 Zr 0.20 Al 0.22)N) **has been developed** , which allows increasing the durability of the cutting tool. The coating based on zirconium nitride Zr-ZrN - (C r ,Zr,Al)N demonstrated the best indicators for the period of tool durability of the cutting tool during end milling of titanium alloy VT-20;

3. To calculate the force parameters when using a cutting tool with a multicomponent composite nanostructured coating and without a coating for machining titanium alloy VT-20 in the milling operation using an end tool with indexable round inserts, empirical dependencies in the form of a multiplicative power function were developed. These dependencies were based on studies conducted to determine the instantaneous values of the force parameters acting on the cutting insert in its sharpened state. These empirical dependencies make it possible to predict the values of the force parameters arising during end milling of titanium alloy VT-20 depending on the selected cutting modes, as well as to calculate the values coefficient of friction and stress arising at the contact area in order to establish the actual influence of the selected cutting modes when using a cutting tool with the developed coatings.

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