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Effect of Bond Type and Process Parameters on Grinding Force Components in Grinding of Cemented Carbide

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Abstract

This paper presents selected results of research in the field of grinding cemented carbide with the use of diamond grinding wheels. In the fundamental experiments two different types of diamond grinding wheels were used. The diamond grinding wheels were varied by bonding material. In the investigation, response surface method was used to predict grinding force components during grinding of the ductile cemented carbide CTS20D workpiece material. The grinding speed, depth of cut and feed rate were considered as input process parameters. Furthermore, the ANOVA (analysis of variance) was employed for checking the developed model results. The results revealed that grinding with the use of resin bond grinding wheel provides significantly lower grinding force components during the process. Moreover, the significance of models terms was determined. It was shown that for the adapted range of process parameters, grinding speed has significant effects only on tangential force for resign bond diamond grinding wheel.

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Keywords: grinding, cemented carbide, grinding force, ANOVA,

1. Introduction

Cemented carbides are commonly used in cutting tool industry due to their excellent mechanical properties at high temperature, such as high stability, corrosion resistance, high strength and hardness. They are distinguished by various material properties like high toughness, bending strength and Young's modulus because of their numerous possible variants. Cutting and grinding of cemented carbide is very problematic due to the high level of hardening carbide components within [1]. The growing demands in the field of precision tools have led to the develop of good quality grade line with adapted binder compositions, which convincingly demonstrate good toughness and heat resistance.

Nomenclature

F_t	tangential grinding force (N)
F_n	normal grinding force (N)
v_s	grinding speed (m/s)
a_e	depth of cut (mm)
f	feed rate (mm/min)
RSM	response surface method

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The machining of difficult-to-cut materials such as titanium based alloys with use of geometrically defined edges remains a constant challenge in terms of achievable material removal rates or tool life. Cemented carbides with submicron grade are extensively used for the universal machining of alloyed and non-alloyed steels, titanium alloys and nickel-based alloys and they offer high toughness and ensures a reduced risk of ruptures on the cutting edges.

Cutting tools are typically created using grinding. Grinding of cemented carbides with the use of diamond grinding wheels is well established as a primary process used to achieve a particular tool geometry with close tolerances prescribed by its design [2]. The quality of a cutting edge is primarily dependent on the process of the flute grinding operation but a subsequent flank face grinding with fine grained grinding wheels prevents excessive edge deterioration. The tool grinding process has a significant impact on the tool performance which is why a balance between the tool grinding productivity and the aimed tool life needs to be established [3]

The choice of grinding parameters depends on the type of grinding wheel, the properties of cemented carbide and adopted kinematics of the process. Cooling is also important in the grinding process. Here it should be noted that the cutting speed determines the rotational motion and therefore influences the ejection of cutting fluid from the grinding wheel [4]. Grinding of submicron-grade WC-Co with good lubrication exhibits peculiar 'size effect' behavior more similar to brittle materials. Higher wheel speeds can be detrimental if the coolant velocity is also not increased. Grinding WC-Co at low aggressiveness values leads to temperature-induced resin deterioration [5]

Studies in the field of grinding of cemented carbide have been focused on the modeling of the grinding process [6], [7] and surface integrity [2], [8] which is particularly connected with surface and subsurface damages. These damage forms are all closely related to the material removal mechanism [9].

A detailed knowledge in the field of grinding parameters, the grinding wheel topography [10] and bond material [11] would enable improved control of the grinding process. It is particularly important for ensuring efficient production of cutting tools by grinding using diamond grinding wheels.

The aim of the study was to determine the influence of the bond material and the process parameters on tangential and normal grinding force during the grinding of submicron-grade cemented carbide.

2. Experiment details

2.1. Test stand

Experimental tests to investigate the grinding force components are carried out on G+H FS 640 Z plane grinder (Fig. 1). This machine allows a maximum grinding speed 40 m/s and maximum power 7 kW.

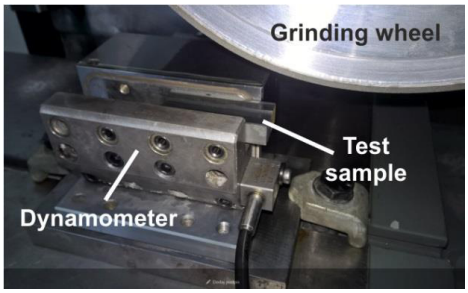

Fig. 1. View of test stand.

For the measurement of the normal and tangential grinding forces Kistler dynamometer type 9121 were mounted on the grinder table. Samples were clamp in the dynamometer.

2.2. Design of experiment

Obtaining the appropriate functional dependencies between the effects of the grinding process (including surface roughness, grinding force components) and adjustable parameters (grinding speed, feed rate, depth of cut) usually requires a large number of tests for different configuration of grinding tool-workpiece. A large number of experimental studies significantly increases the cost and scope of the experiment which is of particular importance in relation to difficult to cut materials. The solution in this field may be mathematical and statistical tools for the design of the experiment [12]

Among conventional techniques that allow modeling and optimization of machining and grinding processes, the response surface method (RSM) takes priority. There is a lot of research in the field of machining and grinding in which the researchers use the RSM method. In the design of experiment the RSM method was used – rotatable central composite design (CCD). The analysis of the results was performed using the Design-Expert 8.0.7 software.