Development and Experimental Testing of CBN Inserts

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Abstract

Geometries of pCBN inserts are well suitable for hard cutting processes because of their economically benefits. Since, there are a lot of possible development areas to achieve better properties in tool life, surface integrity, accuracy etc. In order to achieve higher accuracy, better process dynamics, lower forces, cutting geometries were developed based on varying cutting edge. Parameters of these geometries were chosen by experimental observations, finite element modelling and numerical optimizing algorithms. Micro Electrical Discharge Milling (μEDM) process was developed to machine pCBN materials. Geometries were realised on a μEDM machine using a CAM software to generate special tool path for the geometry. Prepared inserts were tested on a high precision CNC lathe while turning different hardened steels. Cutting forces were measured by a 3D dynamometer. The results showed that the cutting forces were lower than in the case of a commercial insert, tool life can be extended, and surface roughness can be better using these optimized inserts.

1 Introduction

In high precision hard turning the micro geometry of cutting tool has the most important role. The geometry such as tool nose radius, flank and rake angles, tool nose radii influences the cutting force, chip formation, cutting temperature and the surface integrity on the workpiece. Earlier researches [1-3] showed that the cutting force system may be influenced by varying the rake angle.

In most cutting inserts negative rake angle and honed edge are used to achieve high tool life, but these cause high radial forces.

Wiper-edge inserts are geometries for high feed turning, where the wiper-edge means a straight edge segment parallel to the feed direction. With these inserts, better surface quality can be achieved at high feed rates, but a very stiff machining system should be applied.

In most insert geometries, constant rake angles are applied along the cutting edge, but the load of the tool is not uniform because of the non-uniform chip thickness.

The radial force can change the theoretical depth of cut beceause of the machining stiffness. Higher radial force can decrease the depth of cut by diffracting the workpiece and increases the risk of vibration.

On the other hand, the tool life and edge stability are decrasing by using sharper edges. Usually honed edge is applied to increase the stability and decrease the brittleness of the edge.

Considering the hipothesises above it can be realised that the radial force can be decreased by increasing the rake angle at the cutting edge regions, where there is smaller load.

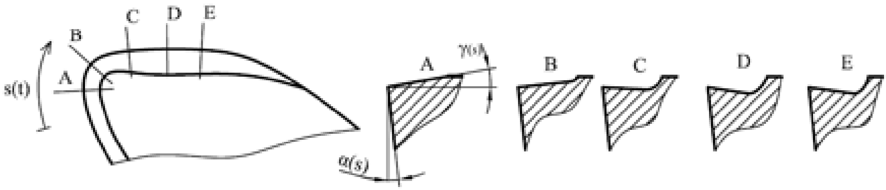

Figure 1: Theory of varying rake angle geometry

Optimal rake angle variation can be described by several algorithms such as analytical method using plasticity laws or numerical methods like finite element analysis.

2.1 Definition of parameters

Commercial wiper-geometry insert was selected for the modification and testing. Sumitomo CCMW09T304W CBN insert with grade BNX20 were used. This material has an electrical conductive binder phase which makes electrical discharge machining possible on the material.

Initially, this insert had a -20°rake angle. First, the geometry was modelled in a 3D CAD system. After modelling, sections were described in which the orthogonal sections of the tool were defined. A lofted cutting surface was created by using these sections.

2.2 Manufacturing of modified geometry

µEDM milling process was chosen for the machining of the CBN material. By using µEDM, concave surfaces can be created on the CBN edge.

2.3 Cutting experiments

Cutting experiments were carried out on a very stiff high precision Hembrug Slantbed 50 CNC lathe. Different workpiece materials were selected. A Kistler 9257 dynamometer was used for the measurement of cutting force. Data acquisition was taken by a National Instruments 6024E I/O-card and a LabView software.

Cutting parameters are given in Table 1 and Table 2. Cutting velocity was 200 m/min.

Depth of cut, [mm]	0.01	0.02	0.025

Table 1.

Feed, [mm]	0.08	0.1	0.12	0.15	0.2

Table 2.

As a workpiece material hardened Uddeholm Rigor steel was used. The hardness of the material was 62HRC.

3 Results

The force diagrams clearly show that, the passive force decreased. In Fig. 2 the radial force using modified edge has lower values at the lower feed rates. The trend of the diagram of cutting force is different. In this case the diagram tends to higher cutting forces using modified edge at higher feed rates.

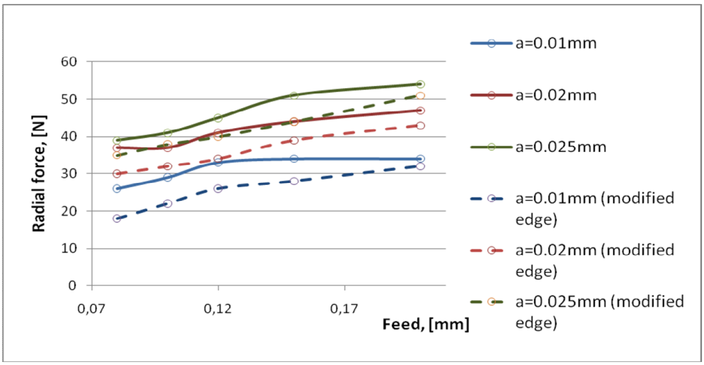

Figure 2: Radial force in the function of feed rate

Surface roughness is very sensitive on the setting of the wiper edge, but the test shows that the achieved surface roughness has a very little deviation comparing to the modified and non-modified cutting edge.

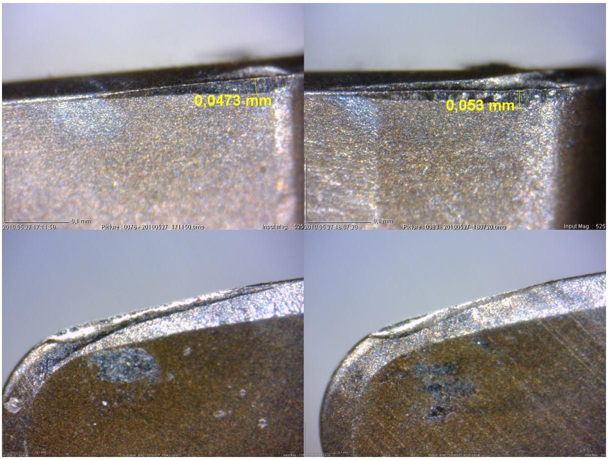

Figure 3: Tool wear on non-modified (left) and modified (right) cutting edge

Appearance of tool wear can be seen on Figure 3. The tool wear for the two types of geometry is similar. A higher flank wear was measured at the modified edge, but the difference between the values is in the tolerance of the measuring accuracy.

4 Conclusions

Varying geometry can decrease the radial force in high precision hard turning using higher rake angles at the less loaded regions of the cutting edge. The modification has very low influence on the tool wear. Stability of the machining increased, chipping of the cutting edge cannot be observed. Higher feeds can be allowed in turning of narrow parts to achieve the accuracy.

References:

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