Zpět

Wear and Durability Milling Tools Depending on the CAM Strategies

Assoc. Prof. Peter Pokorný, PhD., Ing. Rudolf Zaujec
Materiálovotechnologická fakulta, UVTE Trnava Bottova 21, 917 74 Trnava
E-mail: peter_pokorny@stuba.sk, rudolf.zaujec@stuba.sk

In this paper is presented research on the influence of CAM strategies for wear and durability shank of cutting tools. We used two machining strategies in this process, when the effective radius change and does not change. Material of tool was hard alloy and high speed steel for machining steel STN 19 520. Shape of cutting tool was Ball Nose end mill. For milling, DMU 85 monoBLOCK 5-axis CNC milling machine was used. The cutting tool wear was measured on Zoller Genius 3, universal measuring machine. The results show different cutting tool wear depending on the milling strategy and material of tool.

Keywords: wear of tool, effective radius, CAM, strategy

1 Introduction

Nowadays, when is demand for high quality and economical advantageous components is already commonplace the companies try to find the maximum efficiency of the production process. One of the factors affecting the economic of production is the using of cutting tools. It is their choice and adjustment of cutting parameters can have positive as well as negative impact on the manufacturing cost and technological properties of components.

Tools wear is generally considered a negative factor that accompanies each of machining process. This affects the cutting forces, cutting temperature and surface quality. The complete elimination of wear is not real but in well-selected material of tool, coating and machining conditions we can minimize it. Taking into account these general conditions research will be focus on the impact of CAM strategies for wear and durability shank cutting tools.

Nowadays research of wear of shank cutting tools isn't focused in one field. In [1] is an influence of downward ramping and upward ramping on tool wear and Tian et al. [2] studied effect of cutting force to wear mechanisms for downward ramping and upward ramping. Research of cutting force on tool wear is too in [3]. Influence of inclination angles on wear of cutter after five-axis machining process [4]. Prediction of tool wear based on simulation [5], cutting force combinations of signal processing techniques such as DWT and TDA [6]. On-line tool wear measurement with CCD camera [7], online tool wear monitoring system that predicts the tool wear development by measuring the cutting force components in real time [8].

2 Experimental methods

Milling strategies we will explore for 5-axis machining and application of two different approaches:

- **R_{ef} does not change** in this case will be a constant point of contact with the tool and the machining area Fig. 1 a). The first finishing milling strategy for this case was chosen "projection point",
- **R_{ef} is change** this case provides the changing point of the cutting edge to machining area Fig. 1 b). As a second finishing milling strategy was chosen strategy "Constant Z".

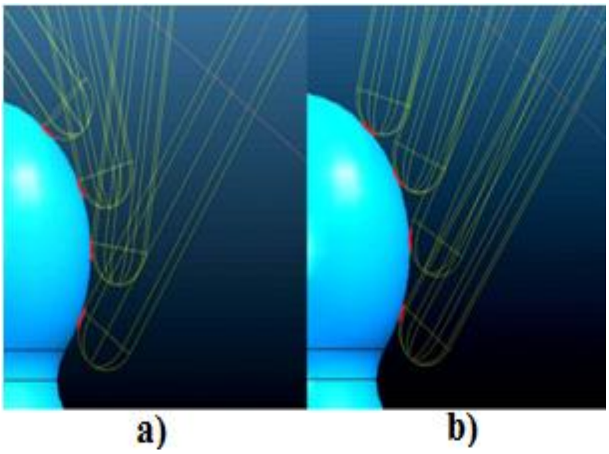


Fig. 1 Position of tool; a) R_{ef} does not change, b) R_{ef} is change

These principles will be applied from the theoretical assumption of a smaller tool wear when changing the effective radius. Reason of minor wear can be explained by the cutting process on the tool is distributed over the entire cutting edge. Fig. 2 show a theoretical model of the cutting edge calculated according to the formula.

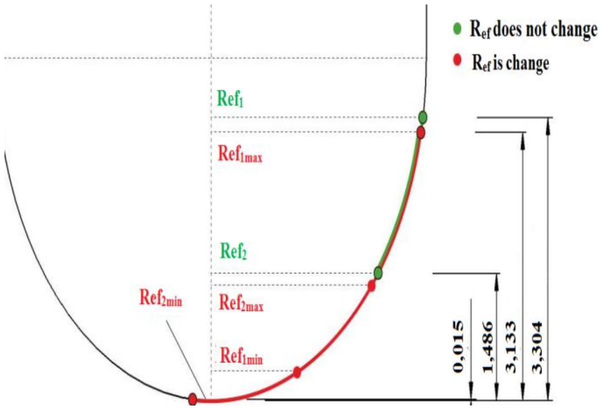


Fig. 2 Cutting edge in engagement - a theoretical calculation

On the contrary is a high probability that when machining with unchanging effective radius than can cause significant wear. These wear then has an impact on the final properties of components and tool life. If this hypothesis will confirmed, we will be able in the next phase of experiments find a suitable CAM machining strategy for the selected type area with the lowest possible tool wear. The program for CNC machine tool is generated in a CAM system [9]. We used software PowerMill see on Fig.3. Part model we created in CAD software PowerShape. Designing a part according to the application methods is important [10].

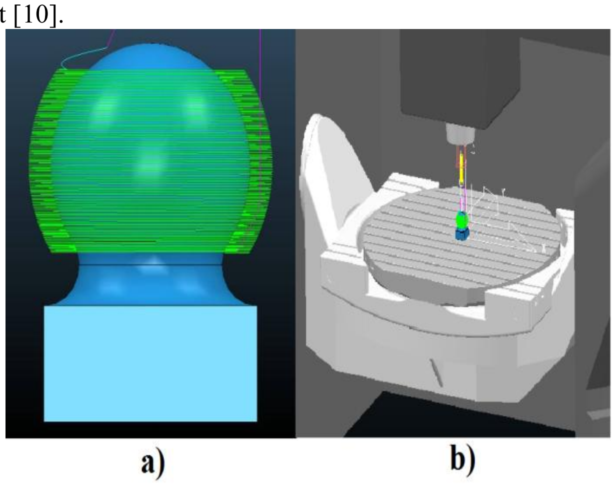


Fig. 3 PowerMill 2014; a) Modified tool paths; b) Simulation milling machine DMU 85

In the center of excellence FMST SUT [11] was made all kinds of experiments and measurements on particular devices:

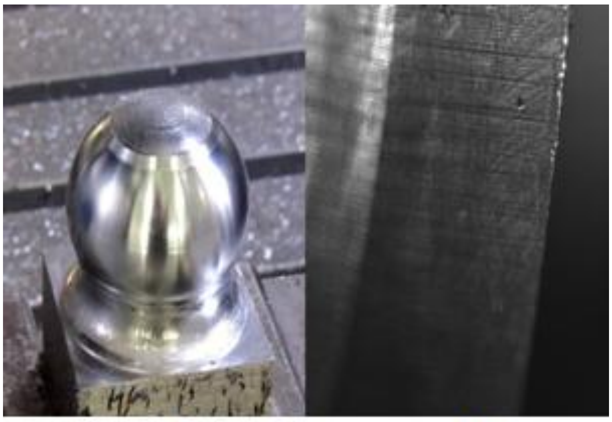
1 Milling machine was DMU 85 monoBLOK. Selected features:

- frequency of rotation of the spindle 18 000 min^{-1} (119 Nm),
- 32 kW spindle power,
- 5-axis simultaneous machining with direct drive in the headstock,
- Rocker NC-rotary table.

2 Zoller Genius 3 on this measuring device will run control tool wear and control the geometry of the cutting edge.

Workpiece material is steel STN 19 520 / EN 1.2311 and workpiece size: 45x45x100 mm. Cutting tool is SECO JabroTools JS532100D1B.0Z2-SIRA Ø10 mm. Finish milling parameters we have chosen:

- v_c = 400 m.min-1,
- f_z = 0,05 mm,
- n = 12,738 min^{-1}.



a) b)

Fig. 4 After finish milling; a) workpiece, b) tool measuring in Zoller

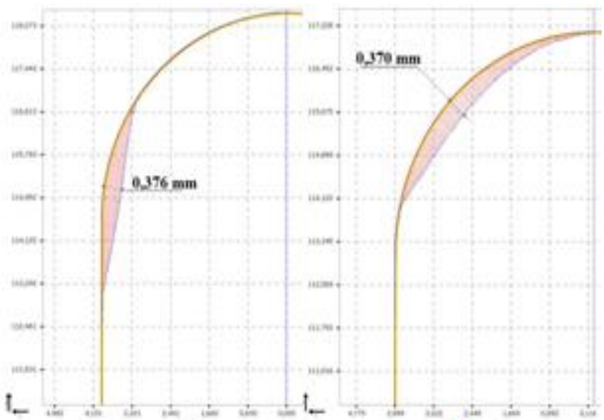
In Fig. 4 we can see the workpiece after finishing and tool wear measured by Zoller. Wear of the cutting edges of cuttters were small. In implementing the first strategy, we were unable to cutting edge tool worn out enough as to allow the interpretation of results. Wear value was around VB = 0.03 mm, despite a six time repetition of strategy. Whereas wear used ballnose cutter from hard alloy did not show expected values, we decided to use the cutter from high speed steel KESTAG D8 H12 HSS-1096 Co8. Cutting parameters were vc = 60 m.min-1, fz = 0,03 mm, n = 2387 min-1.

The milling process of first strategy (Ref does not change) we stopped at t = 50 min because we want to check wear of cutting tool. We have found that wear is extensive and therefore we have not continued in the milling. We started the same period of time of second milling strategy in order to keep the same conditions of experiment.

a) b)

Fig. 5 Surface after finishing; a) R_{ef} does not change, b) R_{ef} is change

Comparing the surface machined parts (Fig. 5) we can conclude that the tool wear at the first strategy Fig. 5 a) came quickly. Evidenced by the size of the machined surface followed by an area which has been rubbed tool, but stock removal material was minimal. Greater machined surface was created with second strategy because the deflection of tool was changing and cutting edge in engagement is constantly changing. This is creating precondition for reducing of tool wear.



a) b)

Fig. 6 Contour of the cutting edge; a) R_{ef} does not change, b) R_{ef} is change

By utilizing analysis software of the device Zoller we can after scanning a cutting edge compare the contour before and after machining with selected strategy Fig. 6. During machining with second strategy (Fig. 6 b) is a section of wear of the cutting edge significantly larger than the first strategy (Fig. 6 a), than we expected.

Theoretical (Fig. 2) and the actual section of the cutting edge are slightly different, which is caused a significant wear of the cutting tool when has ceased to have the capability to stock removal of workpiece and the shape of cutting tool started to copy the shape of the workpiece.

3 Future work

In the next part of the research we will focus on the testing defferent CAM strategies to machinning die for forge. For these different strategies we want measuring of tool wear with laser in the machining process. Correctly predict respectively prevent a significant tool wear is very marked aspect in terms of quality of machined surface and downtime in the process of machining. In many companies often CAD / CAM programmers elect cutting conditions to a lesser extent as possible. This is because of concerns about damage to the tool or workpiece. Additional device Laser Blum we will use for measuring of tool wear. We will be able to predict behavioral change tool during operation based on its output data. Such a device is placed directly in the CNC machine Fig. 7 a).

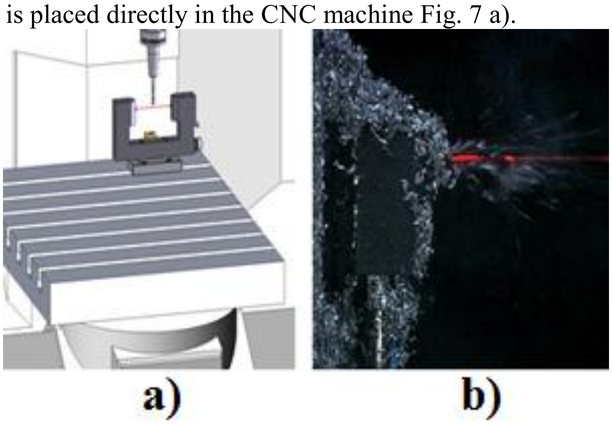


Fig. 7 Laser measuring component Blum [12]
a) Laser device, b) Protect technology

A sudden air blow cleans the device and ejects dirt and chips. During the short measuring sequence the shutter is open and an air purge protects the optics against contamination Fig. 7 b).

Measuring cycle in Heidenhain allow the use of compensation tables. We can measure of wear and change of the cuting process with using a modified CAM strategy.

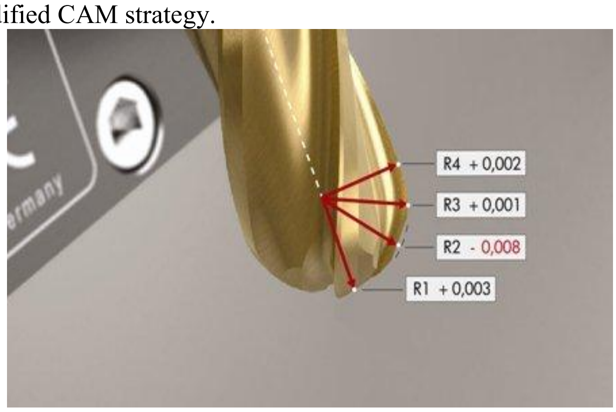


Fig. 8 Measuring of radius of the cutting edge with Blum [13]

This option would be particularly suitable for machining with unchanging R_{ef} where there is wear in one section. In this case, for example we change inclination of cutting tool, where we would obtain a different part of the tool in the cut. Another option is an automatic tool change after measure with Laser Blum. This case would be suitable to use the changing effective radius because is the assumption of wear on significant section of the cutting edge and change or inclination, deflection would be useless. By applying these steps we expect an increase of tool life.

4 Conclusion

The aim of this experiment was to determine whether and how much the proposed machining strategy will affect on wear of cutting tool. For movement of the tool over the workpiece were created two strategies. The first strategy has been set up to the point of contact of the cutting tool and the workpiece does not change and therefore was constant. This is creating a precondition for large but only a local wear of the cutting edge of the tool. In the second strategy is deviation of cutter to the workpiece surface is constantly changing and so the contact point of cutter and workpiece are constantly changing. Conclusions that we have managed to find out when machining with the tool of high speed steel are:

- The first is a comparison of the workpiece surface. Workpiece after the first strategy had little machined surface with a sudden transition to areas where the tool is only rubbed. Vice versa the second strategy had machined surface of workpiece bigger with more continuous transition to partial machined surface. It was caused by the fact that the second strategy cutting tool continuously varied of deviation. This can be considered an advantage of this strategy.
- The second important factor is the heat affected area of the cutting tool. Whereas the tool of the first machining strategy there was no naked eye visible heat affected area so the second strategy cutting tool had. It was caused due to large cutting forces during milling because the tool at some point in of process machining in the middle of axis cutting tool (zero cutting speed). This can be considered an advantage of first strategy.

The question arises active control of first strategy used with a constant effective radius so that the system after a certain period of time changed the the current tool position to another predefined, thereby created a new unchanging point of contact with the cutting tool and the workpiece. This multiple change point of contact could positively influence the cutting process because the system will be automatically changing the position of the tool when reaching a certain criterion of tool wear. We should avoid milling with center of tool and also the local intense wear of the cutting edge of the tool.

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Abstrakt

Článok: **Vplyv CAM stratégií obrábania na opotrebenie frézovacích nástrojov**

Autori: Assoc. Prof. Peter Pokorný, PhD.,
Ing. Rudolf Zaujec

Pracovisko: Materiálovotechnologická fakulta so sídlom v Trnave

Kľúčové slová: Opotrebenie nástroja, efektívny polomer, CAM, stratégia

V článku je prezentovaný výskum vplyvu CAM stratégií na opotrebenie a trvanlivosť stopkových rezných nástrojov. Boli použité dve stratégie obrábania, keď sa efektívny rádius počas obrábania menil a nemenil. Materiál polguľovej frézy bol spekaný karbid a rýchlorezná oceľ pri obrábaní materiálu STN 19 520. Proces obrábania prebiehal na 5 osovej frézovačke DMU 85 monoBLOCK. Kontrola nástroja sa realizovala na zariadení Zoller Genius 3. Výsledky poukazujú na rozdielne opotrebenie nástrojov v závislosti od CAM stratégie a materiálu nástroja.

Zpět