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INFLUENCE OF MONOLITHIC SHANK TYPE CUTTER CUTTING EDGE MODIFICATION BEFORE PVD COATING ON THEIR DURABILITY

VLIV ÚPRAVY BŘITU MONOLITNÍCH FRÉZ PŘED PVD POVLAKOVÁNÍM NA JEJICH TRVANLIVOST

Abstract

To increase the quality of machine tools they are often gained by coatings of hard materials. These layers are applied by PVD and CVD methods. Thanks to these coatings the tool life is increasing or the most applicable cutting speed. The quality of coating depends primarily on the quality of surface, deburring and edge sharpness. The paper deals with evaluation on the impact of adjustment of the cutting edge before tumbling deposition PVD coating on durability of front shank cutters. The article presents results of long-term tests on which basis were established optimal conditions and parameters of tumbling shank milling cutter before applying PVD coating.

Abstrakt

Pro zvýšení kvality obráběcích nástrojů jsou tyto často opatřovány povlaky tvrdých materiálů. Tyto vrstvy jsou nanášeny metodami PVD a CVD. Díky těmto povlakům se zvyšuje trvanlivost nástroje nebo maximálně použitelná řezná rychlost. Kvalita povlaku závisí především na kvalitě povrchu, ojehlení a ostrosti břitu.

Příspěvek se zabývá zhodnocením vlivu úpravy řezného břitu omíláním před depozicí PVD povlaku na trvanlivost čelní stopkové frézy. V článku jsou uvedeny výsledky dlouhodobých zkoušek, na jejichž základě byly stanoveny optimální podmínky a parametry omílání čelní stopkové frézy před nanesením PVD povlaku.

1 INTRODUCTION

The smoother is tool surface, the better is chip leave and the lower is heat tool. In this way are enabled higher cutting speeds and therefore can be achieved higher tool life. Smooth surface of the tool reduces a hazard associated with the workpiece material. Coatings generally deteriorate value of surface roughness. Also for this reason it is required a high smoothness of the instrument surface before coating [6].

Tools defined for deposition through a number of adjustments. By default is a chemical and ion-cleaning of the substrate, in order to achieve the highest purity, morphology and chemical composition of the substrate surface. In case of redeposition so called stripping [1] is fronted before these processes.

If we want to increase tool cutting power is is not enough just to use a layer and deposit it on the sharpened surface. Before those operations it is necessary to apply technological treatment of the edge. Cutting edge arise at the intersection of face and flank, has after sharpening some inequalities that cause increased stress on the cutting edge and lead to more rapid tool wear [2,3]. By using cutting edge rectification it is occurred elimination of inequalities, edges become smoother, it reduce its roughness and instead of an imaginary edge is created a small curvature of the cutting edge - figure 1. For these adjustments are mostly used methods such as sanding, brushing, lapping, tumbling and laser treatment.

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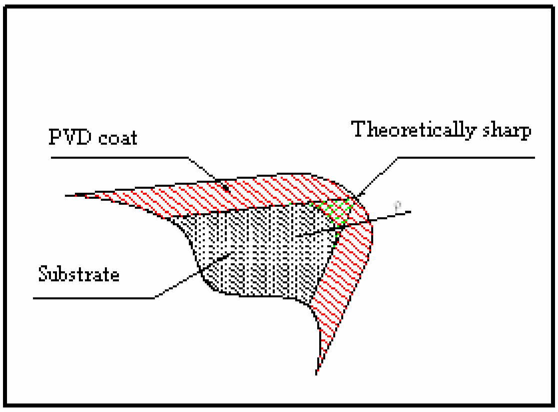

Fig. 1 Theoretical shape of the cutting edge before and after treatment

By careful microadjustment of cutting edge it is possible to achieve higher edge quality compared to the surface created by grinding [5]. We can imagine many factors under the term quality, especially geometric shape of the cutting edge, blade surface condition, front and back, structure of the tool material and physical-mechanical processes in the surface layers of the edge [4].

2 MECHANICAL ADJUSTMENT EDGE BEFORE COATING BY TUMBLING IN GRANULES

Tumbling in granules belongs to mechanical adjustments of instruments. Due to coating has this method an essential meaning for good adhesion of the substrate layers. After the fine grinding of tools from cemented carbide the edges are uneven and may cause a reduction of cutting power tools. During the following PVD coating application may occur further power reduce due to a flaking coating created by springing-off layers on the intermittent cutting edges created by this uniformity. This is prevented by the tumbling in machinery with appropriate elected and abrasive granulate. For axial tools is suitable a tumbling equipment with planetary motion. The final effect is reflected in a good layer adhesion of PVD, as well as in the final cutting power and tool service life [1].

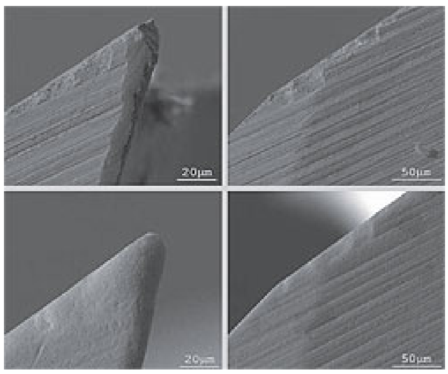

Fig. 2 Cutting edge of tool from cemented carbide without an adaptation and after a microadjustment by tumbling [7]

3 THE METODOLOGY OF USED EXPERIMENTS

The aim of used experiments was to compare the durability of cemented carbide coated milling cutters, which were adjusted before this coating buzzing with different exposure times of a tumbling media. The tested tools were two-edges milling cutters with shank diameter of 10 mm from the cemented carbide with a trade designation TSF 44 (ISO K10-K30) with a fine-grained structure of the following parameters: grain size 0,2-0,5 μm, 12% Co content, density 14.1 $g.cm^{-3}$, hardness of 1760 HV10.

Cutting tool geometry used in the test was: tool side rake γ_f = 4°48´, tool side clearance α_f = 8°12´ and helix angle ω_f = 30°. Mills were coating by MARWIN G layer produced by SHM, s.r.o., it is a nanobedding gradient TiAlN system which consists of a layer with a continuous stoichiometry change with following properties: microhardness 33 $GN.mm^{-2}$, thickness 2-3 μm, Ra 0,10-0,13 μm and thermal stability >900 °.

Fig. 3 Tasted tool

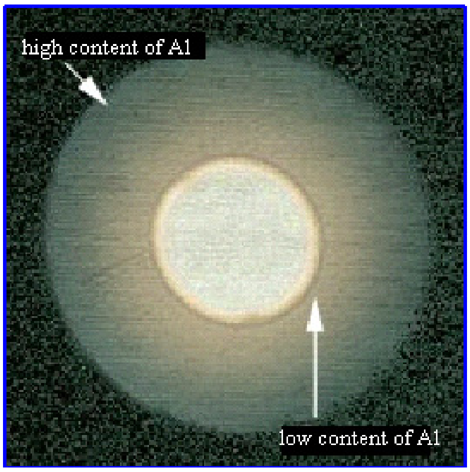

Fig. 4 The MARWIN G layer

The test milling cutters were before the deposition coating tumbled for 40, 80, respectively 120 seconds in an edging equipment OTEC DF 35. The speed tumbling on the perimeter tool was for all cutters 25 $m.min^{-1}$ and sense of rotation 90% of the time along the edges and 10% against the edges. Tumbling medium was grain SiC and opalescenced crushed walnut shells. For comparison were left some mills without tumbling.

Fig. 5 Tumbling Machine OTEC DF 35

For cutting tests was used a tool high chrome steel ČSN 19 436 (ISO C210Cr12) treated by hardening on 60±2 HRC. It is part of difficult-to-machine materials and due to shorter tool life makes the experiments less time-consuming.

Cutting conditions of the experiments were: cutting speed 124 m.min^{-1}, feed 0,08 mm, the depth of cut a_p 3 mm and a_e 0,5 mm. Milling was carried out by down-feed method and dry, the criteria for wear was VB 0,15 mm.

4 THE RESULTS OF TESTS CARRIED OUT

In order to determine the tool life was used a long term cutting power test. It was performed until reaching the wear criteria. The measurement results are averaged for every two cutters and two edges. In figure 6 the tools are identified as follows: No. 1 and 2 are mills without tumbling, no. 3 and 4 are mills tumbled for 40 seconds, no. 5 and 6 are mills tumbled for 80 seconds and no. 7 and 8 tumbled for 120 seconds.

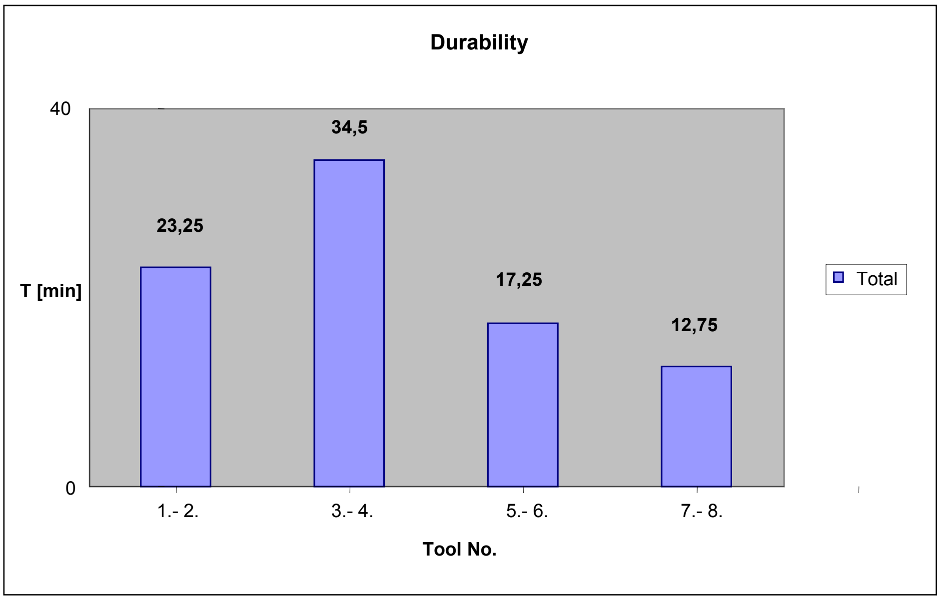

Fig. 6 Comparison of durability of the instruments studied [8]

The summary shows that the highest tool life at a specified criteria of wearing VB = 0,15 mm had tools tumbled by OTEC technology in 40 seconds. Based on gained results was created a line graph and after connection of the points by third degree polynomial function, was created a function whose derivative was found a theoretical optimum for tumbling time. This represents 28 seconds for a specific experiment situation.

5 CONCLUSION

The main aim of the experiments was to determine the most convenient times of tool contact with edging abrasive before coating deposition. Continuous tool measurements wearing were carried out on the tool flank and evaluated durability of tools on a base of achieving the limit values of wear VB = 0,15 mm.

The above results show that modification of the edge before applying the coating has a clear impact on the durability of the instrument. With limited power tests was confirmed that the adjustment of the edge with OTEC technology can affect the size of individual components of machining forces.

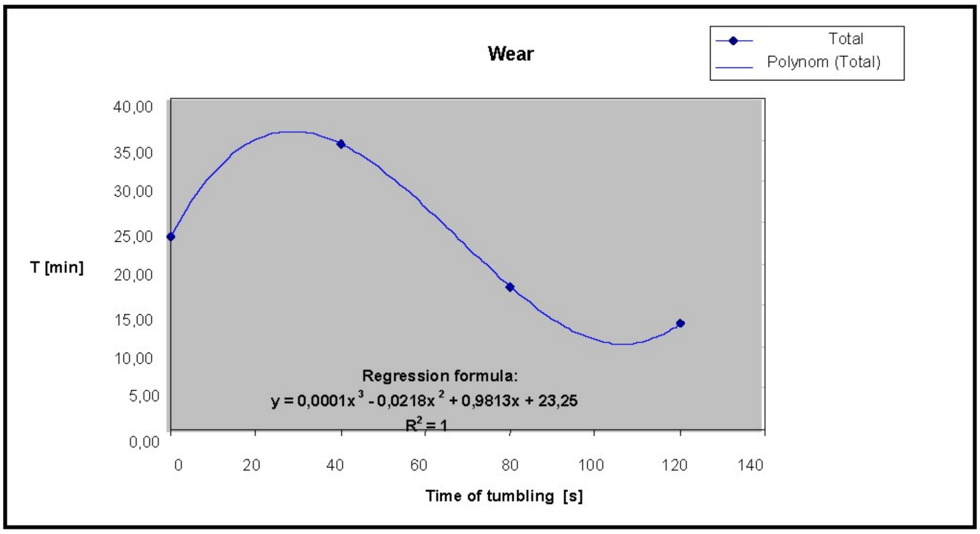

Fig. 7 Third degree polynomical function [8]

Rectification of tools edge can therefore increase its cutting power when inappropriately chosen parameters may cause significant reduction cutting power of tool, even compared with the tool without tumbling - see figure 6. Here you can see that the best cutting power showed tools no. 3 and 4, which means tools tumbled for 40 s. Similarly, we can also express about the instruments no. 10 and 11, which were rehashed to a calculated "optimal rehashed time" of 28 seconds - see figure 8.

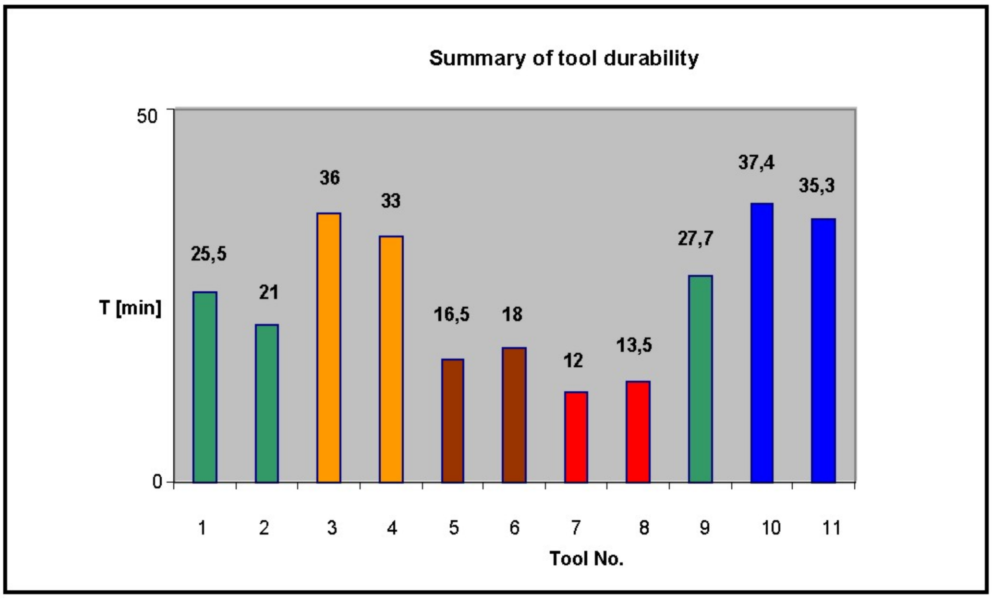

Fig. 8 Summary of life for all tested instruments [8]

Conversely tools that exceeded tumbling of 40 seconds, showed worse cutting power than tools without rectification, and this was deteriorated with the length of tumbling. Rectification edge, however, has a positive effect on the deposition of PVD coating on the blade. This eliminates the phenomenon of coating flaking mills by an angle of cutter, which is seen in mills with untreated surface.

From tests and following force verification came out an optimal tumbling duration of 28 seconds. This value should be taken as indicative and applicable to this particular type of cutters and cutting conditions. While tumbling edge of a cutter for this period (cutters no. 10 and 11) at the beginning grows up a bit the machining result force compared with untreated cutter (cutter no. 9). It depends mainly on the size of contact area between the tool and workpiece, especially on an artificially created radius while tumbling. However with continuous cutting each components of force grow only slightly, while the unadjusted cutter elements are growing rapidly and substantially shorten the tool life. Increase of durability can appropriately rectify up to 30% at the surfaces of tools.

From above-mentioned flows that till now were not used all possibilities of increasing tool cutting power. The most optimal time of tumbling may differ for different types of cutters and cutting conditions. However the above results show that tumbling is the way to increase the cutting power.

REFERENCES

[1] HOLUBÁŘ, P., ŠÍMA, M. a ZINDULKA, O. Technologie úprav nástrojů před a po povlakování. *MM Průmyslové spektrum*, 9/2005, pp. 70-72. ISSN 1212-2572.

[2] JURKO, J. and PANDA, A. Study of Cutting Zone Maschinability During the Drilling of Stainless Steel Cr20Ni12Ti. In *International Scientific Konference „Material Science and Manufacturing Technology MITECH 2009“.* Prague: Czech University of Life Science Prague, 2009, pp. 326-329. ISBN978-80-213-1931-8.

[3] JURKO, J., GAJDOŠ, M. and PANDA, A. Influence of Design Cutting Tool on the Produktivity in Drilling. In *International Scientific Konference „Material Science and Manufacturing Technology MITECH 2009“.* Prague: Czech University of Life Science Prague, 2009, pp. 330-336. ISBN978-80-213-1931-8.

[4] MRKVICA, I. a MORAVEC, V. Úprava břitů a povrchů řezných nástrojů. *MM Průmyslové spektrum*, 6/2007, pp. 58-59. ISSN 1212-2572.

[5] NESLUŠAN, M. Mechanická a tepelná expozícia reznej hrany při tvrdom sústružení. In *Sborník IX. Medzinárodnej vedeckej konferencie Nové smery vo výrobných technologiích 2008.* TU Košice: FVT so sídlom v Prešove, 2008, pp. 82-85. ISBN 978-80-553-0044-3.

[6] PÍŠKA, M. and POLZER, A. New Hard Nano-Crystalline Coating for Cutting Tools and Their Testing. *Manufacturing Engineering, Výrobné inženierstvo.* TU Košice – Fakulta výrobných technológií so sídlom v Prešove, 2008, vol. VII, No. 2, pp. 11-13. ISSN 1335-7972.

[7] *SHM Svět tvrdých a supertvrdých materiálů*. [online], poslední revize 10.12.2008, [cit. 2008-12-16[. Dostupné z URL: <http://www.shm-cz.cz/cs/sluzby/upravy-nastroju-pred-povlakovanim>.

[8] VIKTORIN, J. *Vliv úpravy břitu monolitních fréz s PVD povlakem na jejich řezivost.* Diplomová práce. Ostrava: VŠB-TU Ostrava, Fakulta strojní, 2008, 66 p.