

Improving the Efficiency of Milling with using Of the Milling Cutter with Cover (High Speed Milling (HSM))



Khamza Khamroev, Urinov Uygun, Lyudmila Dubrovets, Sukhrob Shadiev, Samandar Sayfulloev

Abstract: The method of high-speed milling has many advantages than conventional milling. Very often, high-speed milling is considered simply a way to increase productivity due to a higher cutting speed than commonly used. It is rarely emphasized that quality of the product can be improved by improving accuracy and improving the surface quality of the cutter.

Key words: cutting, high-speed cutting, high-speed machining, high-speed milling, tool wear.

I. INTRODUCTION

Some advantages of the high-speed milling method compared to conventional milling can be listed as follows: increased cutting speed, cutting feed and chip volume, improved surface quality, reduced cutting forces, which leads to increased accuracy due to the lower level of tool and machine loads, and heat from the cutting zone is transferred mainly to the chips, as a result of which the workpiece temperature remains relatively low, and the processing time and processing costs are reduced. Very

often, HSM is considered simply a way to increase productivity due to higher cutting speeds than commonly used. It is rarely emphasized that product quality can be improved by improving accuracy and improving surface quality. Cutting tools used in high-speed milling can be divided into solid and multi-layer (Figure 1). In the field of scientific experiment, the STANKIN laboratory included the manufacture of complex parts, such as dies. End mills are mainly used in this area. According to our experience, most standard shapes of cutting tool are worked in high speed machining. The wear of the tool material is considered the most important factor limiting the cutting speed. High-speed steels and coated high-speed steels were excluded from our research because of their low wear resistance. It is known that the service life of carbide tools with high cutting speeds is short. However, they can be used for processing soft materials. Cermet is offered for steel finishes. Superhard tool materials, such as CBN and PCD, naturally belong to the HSM tool group.

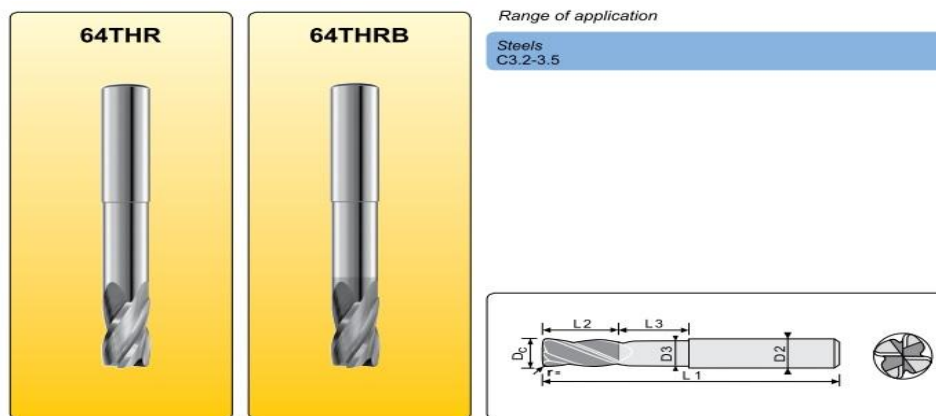


Fig. 1. Tools used in high-speed milling.

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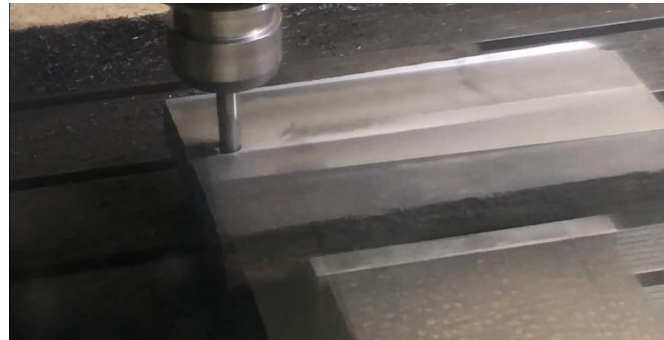
The upper figure shows an end mill with a diameter of 12 mm. Bottom figure: Cerin 12 mm end mill, with special geometry

Table 1 Constructive rice of various parameters of milling cutters.

D position teeth h10 mm	L ₂ , mm	L ₁ , mm	D ₂ , high different d6 mm	D ₃ , mm	L ₃ , mm	r, mm	γ	ω	Alloy grade surface alloy milling cutter	Type Increased Elevated Shank
12	22	105	12	11,8	22	1	-6°	30°	CK10-30-UF as gaps Ultrafine	DIN 6535 HA

The most interesting area of high-speed milling is the mechanical machining of cast iron, as they are the most

widely used materials for engineering purposes. High-speed milling can also be used when machining of hardened steels.


Fig.2.

The problem associated with high-speed milling of cast iron was the insufficient in wear resistance of tools, as well as the lack of knowledge about the cutting parameters of solid materials. The development of tool materials and geometry of tool made it possible to study high-speed milling of various steels, even high-alloy tool steels in a hardened state.

Four milling cutters of the same brand were used in the study: (Cerin 12 mm end mill)

- 1) mills No. 1 and No. 2 - without coatings;
- 2) mill No. 3 – coated with nACRo3®
- 3) mill No. 4 - coated with TiAlN.


Fig. 3. Microsections of samples with coatings: a) TiAlN, b) nACRo3®

The TiAlN multilayer coating is an alternating layer of the nitride phase, characterized by the content of Al and Ti, grown on an adhesive layer of TiN. Gradient layer TiAlN with a uniformly increasing concentration of aluminum nitride to the coating surface, and nACRo3® coating, which is a sequence of CrN, AlTiN layers and AlTiCrN / SiN nanocompositions are applied on the cutters Fig. 3.

II. PROPOSED METHODOLOGY

2. Proposed Methodology

Properties of coatings and main applications of coatings (Table 2,3.)

Table 2 Properties of used nitrides.

Nitride	Color	Nanohardness up to [GPa]	Thickness [μm]	Coefficient of friction (wear)	Max. Operating temperature [°C]
TiAlN	Violet Black	36	1-4	0,5	700
nACRo ³	Blue gray	40	1-7	0,45	1100

Table 3. The main areas of application of coatings.

Nitride	Cutting	Molding
TiAlN	Drilling, universal use, also for low power machines	-
nACRo ³	Rigid cutting with coolant of complex materials (heavy-duty alloys), micro-tools	welding, extrusion, injection molding

High quality of cutters provide consistent performance. Coating (TiAlN) makes possibility to maintain high productivity at high temperatures and to carry out

processing without coolant. Control of the parameters of the cutter after surface treatment was carried out with helping of optical measuring system



Fig. 4. Optical measuring system MicroCAD.

MicroCAD optical measuring system, provides 2D and 3D measurements on the surface of objects. The essence of the method is to measure the projection of a light strip using a micromirror projector. Light bands of various brightness levels are projected onto the surface of the measurement object at a certain angle of triangulation and their image is recorded. The height of the roughness of the measured object is calculated based on the data on the distortion of the position of the stripes. [14]

Key benefits of the MicroCAD optical measurement system include:

- 1) non-contact data recording;
 - 2) high speed;
- Measurement of rounding radii at two points

- 3) good resolution;
- 4) measurement accuracy;
- 5) simple operation.

Thanks to the use of a digital micromirror projector, the measuring system can be used to measure objects that previously could not be solved with optical measuring systems due to the insufficient depth of field of the lenses.

Using the integrated ODSCAD software, a three-dimensional and color-imitation model of the cutting edge is constructed, and the average, maximum and minimum values of the rounding radius are calculated in several hundred sections perpendicular to the cutting edge. [15]

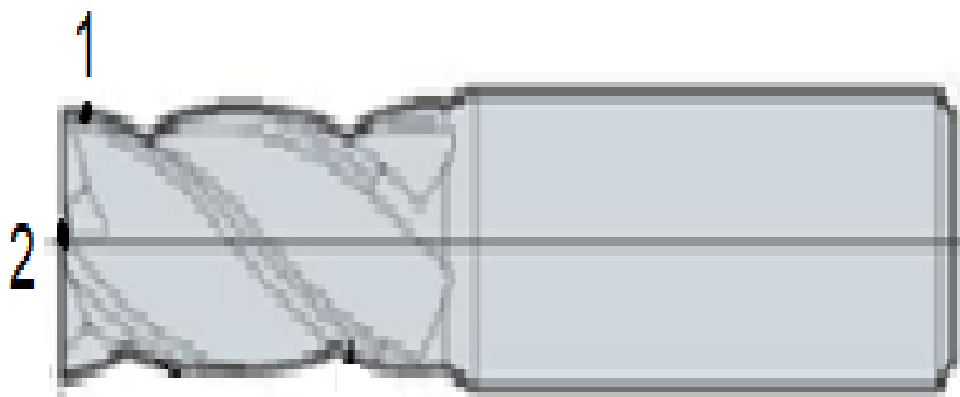


Fig. 5. Points by which the rounding radius was measured: 1-periphery, 2-end.

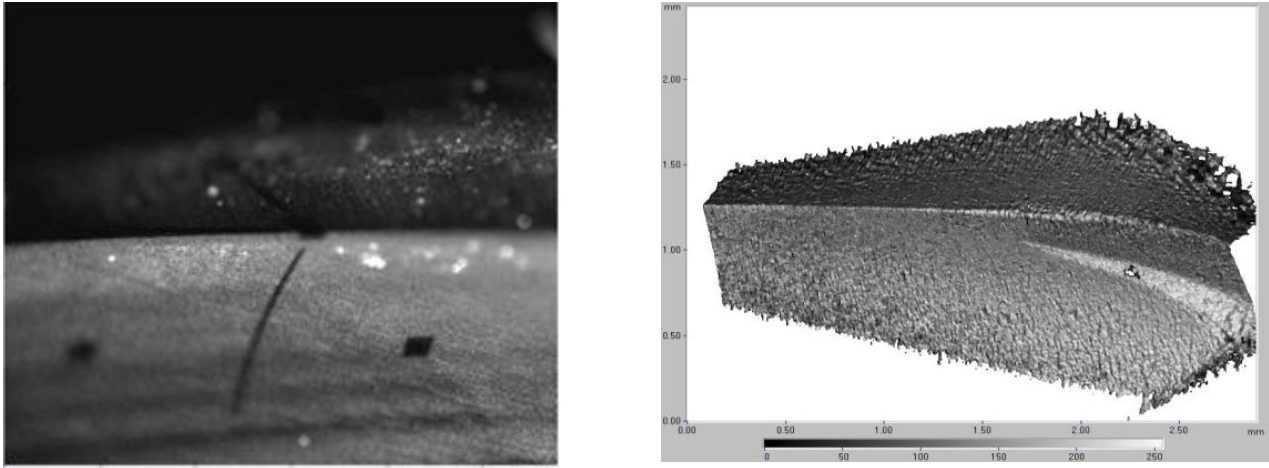


Fig. 6.a) Photo of the radius of rounding off of the periphery on a microscope. B) Three-dimensional model of the radius of rounding off of the periphery in the ODSCAD program.

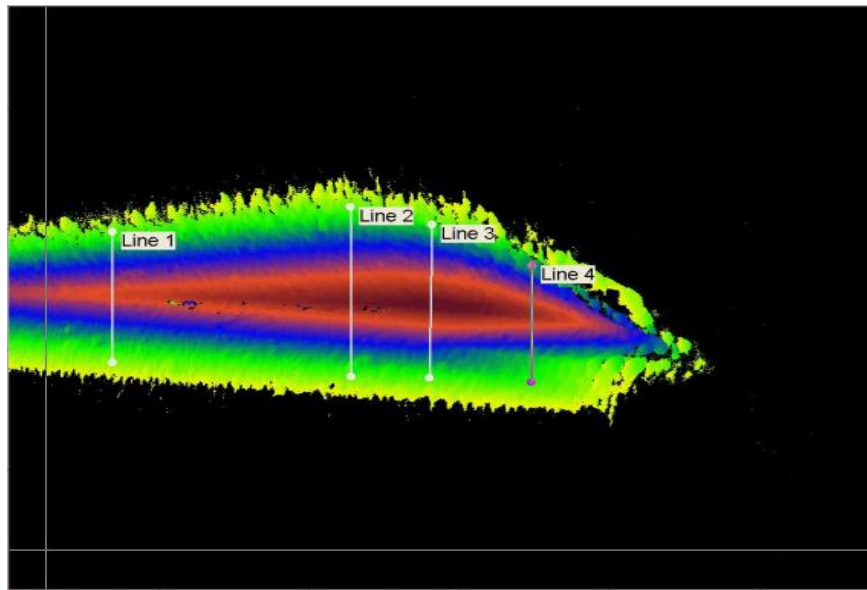


Fig. 7. Color-simulation model of peripheral rounding radius in ODSCAD

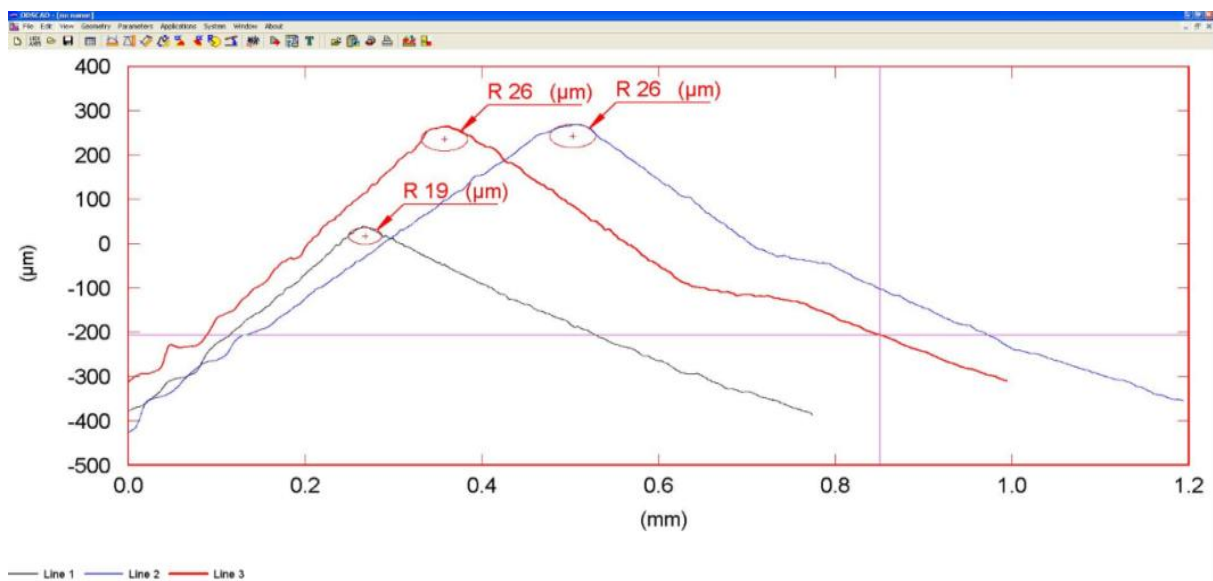


Fig. 8. Calculation of the average, maximum and minimum values of the rounding radius at the periphery in the ODSCAD program.

III. RESULT ANALYSIS

Table. 4. A summary table of the calculations of the average value of the rounding radius at points (1-periphery, 2-end) before and after processing

№ milling cutters	1 tooth		2 tooth		3 tooth		4 tooth	
	№ sector		№ sector		№ sector		№ sector	
	1 (μm)	2 (μm)	1 (μm)	2 (μm)	1 (μm)	2 (μm)	1 (μm)	2 (μm)
1 uncoated	22	21	16	23	11	7	18	15
2 uncoated	23	15	16	10	16	10	20	19
3 coated nACRo ³	17	17	20	14	19	20	17	18
4 coated TiAlN	15	17	18	14	18	13	14	12
after processing								
1 uncoated	24	11	15	10	22	11	16	12
2 uncoated	20	11	29	10	23	7	20	10
3 coated nACRo ³ nACRo ³	23	23	23	15	22	33	24	22
4 coated nACRo ³ TiAlN	27	24	24	15	28	25	20	22

Obtaining and processing profilogram of the surface of profile



Fig. 9. Obtaining profilogram of the surface of profile (Hommelwerke profiler-profilometr).

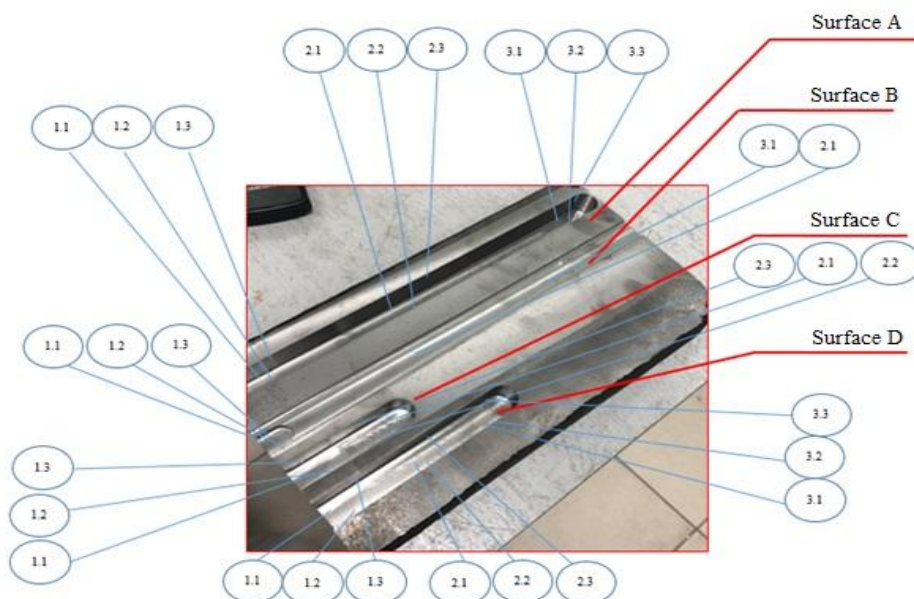


Fig. 10. Roughness of surface

Table. 5 Value of roughness of

№ surface		R _a (μm)	R _z (μm)	R _{max} (μm)
A (coated TiAlN)	1.1	0,438	4,953	8,422
	1.2	1,117	7,581	9,002
	1.3	0,294	2,395	2,536
	2.1	0,430	4,468	6,369
	2.2	0,735	5,038	5,940
	2.3	0,315	3,601	4,683
	3.1	0,471	5,380	9,743
	3.2	0,762	5,285	7,654
	3.3	0,394	3,241	3,727
B (uncoated)	1.1	0,693	4,293	4,639
	1.2	1,294	7,608	10,023
	1.3	1,840	9,902	10,724
	2.1	0,381	3,094	3,413
	3.1	0,448	3,216	3,749
C (uncoated)	1.1	0,671	7,094	9,998
	1.2	1,834	12,231	14,792
	1.3	0,228	3,175	6,499
	2.1	0,654	6,313	8,049
	2.2	1,850	12,064	14,599
	2.3	0,252	2,585	5,415
D (coated nACRO ³)	1.1	0,708	6,327	8,242
	1.2	1,774	11,964	14,811
	1.3	0,360	3,498	4,543
	2.1	0,901	7,933	16,784
	2.2	2,064	12,262	14,297
	2.3	0,415	3,071	3,488
	3.1	0,829	6,245	10,274
	3.2	1,784	11,399	12,923
	3.3	0,548	4,623	5,118

IV. CONCLUSION

High quality of cutter provides consistent performance. Coating (TiAlN) makes possibility to maintain high performance at high temperatures and conduct processing without coolant. TiAlN coating, which helps to reduce friction in the cutting zone, prevents build-up on the cutting edge, provides maximum tool life for high-performance

Machining of difficult materials such as cast iron and heat-resistant alloys. The exclusive coating TiAlN provides excellent wear resistance and increases tool life.

The conclusion is that with high-speed milling, the tool life with a targeted milling tool — the material being processed — a combination of cutting parameters is acceptable, and the processing result is satisfactory.

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