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Comparison of binderless carbide with conventional carbide as a cutting material for milling

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Abstract

In order to be able to use the resources more sustainably and at the same time reduce the costs of machining, it is important to identify new types of cutting materials. Up to now, tools made of carbide have often been used in machining. Carbide has a high hardness H and, compared to other tool materials, enables long tool life T. This has a positive effect on process reliability. Conventional carbide usually consists of tungsten carbide WC and cobalt Co. The tungsten carbide WC represents the hard material itself. The cobalt Co is a binder and ensures that the hard materials are kept together. This combination makes the carbide less hard than the pure hard materials. The reduction of the hardness H of the material also results in a reduction in the tool life T of the milling tool.

Various approaches are being pursued to increase the tool life T of the milling tool. One approach is the reduction of the binder in carbides. The reduction of the binder increases the hardness H of the material and thus the tool life T of the milling tool.

Conventional carbide has a cobalt content of 6% < Co < 10%. The new cutting material, the binderless carbide, on the other hand, has a cobalt content of 0.40 % < Co < 3 %. The complete elimination of a binder is not possible from a manufacturing point of view at this time.

To validate the milling tool made of binderless carbide, it is compared with milling tools made of conventional carbide. The two milling tools have identical geometries. This is to ensure that the influence of the cutting material on the machining result can be identified. For this reason, the identical experimental milling tests are carried out with the milling tool made of binderless carbide and the milling tool made of conventional carbide. The following parameters are recorded during the experimental tests:

- Mean roughness depth Rz depending on the cutting path lc
- Arithmetic average roughness Ra depending on the cutting path lc
- Cutting edge rounding rß depending on the cutting path lc

The experimental results show that the increased hardness H of the material has increased the tool life T of the milling tool. This makes it possible to use the available resources more sustainably and efficiently. In addition, the increase in tool life T results in an increase in the economic efficiency of milling.

Milling, Milling tools, Wear behaviour, Tungsten carbide, Cobalt

1. Introduction

In cutting technology, there are various approaches being pursued in order to meet the growing demands of the industry and to be able to use the resources employed more sustainably and cost-effectively. One approach is the use of new cutting materials. A currently very important group of cutting materials are those based on hard materials. According to BERGMANN AND LEYENS [1], "hard metals are currently probably the most important group of cutting materials". The reason for this is the high strength R of the cutting material with simultaneous high hardness H. Therefore, this cutting material is also a constant topic in research and continuous further development of the material is required. Carbide is partly made of hard materials, which are responsible for the hardness and wear resistance. Only by embedding these hard materials in a softer binding phase (binder) can the carbide used in the cutting technology. The binder gives the cutting material the necessary toughness properties, but at the same time lowers the hardness H and correspondingly the wear resistance. The material cobalt Co is usually used as a binder. In addition to technical limitations, the use of this material also raises political and ethical problems. These problems have caused the cost of cobalt Co to fluctuate greatly in recent years. [2, 3]

2. Binderless carbide

Binderless carbide represents a new type of cutting material. Binderless carbide has a cobalt content of 0.40 % < Co < 3 %. Conventional carbide, on the other hand, has a cobalt content of 6 % < Co < 10 %. The reduction of the cobalt Co content ensures that the hardness H and thus also the tool life T are increased. The complete elimination of a binder is not possible at the present time from the point of view of production technology.

3. Comparison

In order to be able to determine the influence of the new cutting material on the milling result, the milling tool made of binderless carbide is compared with a milling tool made of conventional carbide. It should be noted that both milling tools have the identical geometry and are operated with identical process parameters. The process parameters have already been identified through the Design of Experiments (DoE) and are shown in Table 1.

Table 1 Process parameters

Axial depth of cut a_p	9 [mm]
Radial depth of cut a_e	3 [mm]
Feed velocity v_f	6000 [mm/min]
Rotational speed n	17737 [1/min]

For the comparison, aluminium blocks (EN AW 7075 T651) are machined and the following key figures are recorded at regular intervals:

- Surface quality of the workpiece in depence of the cutting path lc
- Cutting edge rounding rß of the tool in depence of the cutting path lc
- Width of flank wear land VB

4. Results

After a cutting path lc = 200 m with each milling tool, the manufactured surface qualities could be examined. For this purpose, the averaged roughness depth Ra and the mean roughness value Rz are considered and are shown in Table 2. The metrological investigation was carried out on the measuring device of the type “Hommel-Etamic nanoscan 855” from Jenoptik AG, Jena. DIN EN ISO 4287 was referred for the measurements.

Table 2 Determined surface quality with the milling tools

	Ra	Rz
Binderless carbide	0,263 ± 0,037 µm	1,330 ± 0,088 µm
Conventional carbide	0,840 ± 0,042 µm	3,593 ± 0,265 µm

The two surface quality parameters show lower values for the machining result with the milling tool made of binderless carbide and thus a higher surface quality.

The next parameter for assessing the milling results is the cutting edge rounding $r_ß$. The cutting edge rounding $r_ß$ can be used to assess the wear behaviour of the milling tools. Using the optical 3D measuring system "InfinityFocus" from Alicona Imaging GmbH, Graz- Austria, the cutting edges of the milling tools are recorded three-dimensionally and then evaluated.

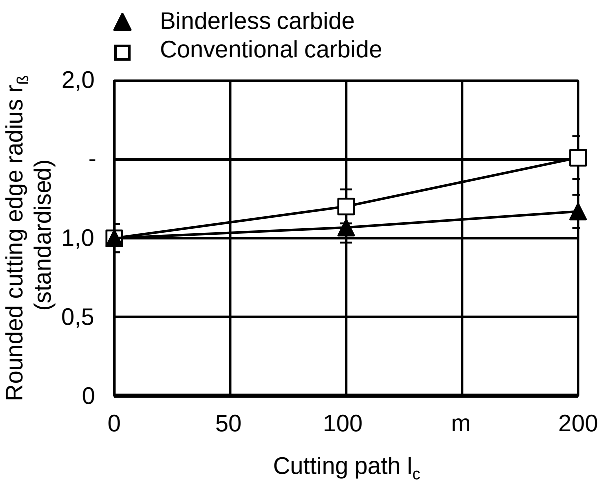

Figure 1. Standised cutting edge rounding $r_ß$ of the milling tools in depence of the cutting path l_c

The diagram shows that both milling tools have the identical cutting edge rounding $r_ß$ at first. As the cutting path l_c increases, the cutting edge rounding $r_ß$ increases less for milling tools made of binderless carbide than for milling tools made of conventional carbide.

Furthermore, the width of the flank wear surface VB can also be used to assess the wear behaviour of milling tools. The width of the flank wear surface VB is a measure of the wear of the flanks. With increasing wear of the milling cutter, the width of the flank wear surface VB also increases. This parameter was recorded with the SEM of the type JCM-5000 SEM BENCHTOP, of the company Joel Neoscope, Akishima- Tokyo with a magnification V = 50. The Table 3 shows the values determined for the width of flank wear land VB for both milling tools.

Table 3 Width of flank wear land VB of the milling tools after l_c = 200 m

	Width of flank wear land VB
Binderless carbide	0,057 ± 0,005 µm
Conventional carbide	0,091 ± 0,004 µm

The width of flank wear land VB for the milling tool made of binderless carbide is significantly smaller than for the milling tool made of conventional carbide. The wear on the milling tools can also be visualised with SEM images. The Figure 2 shows the cutting edges before machining and after a cutting path l_c = 200 m.

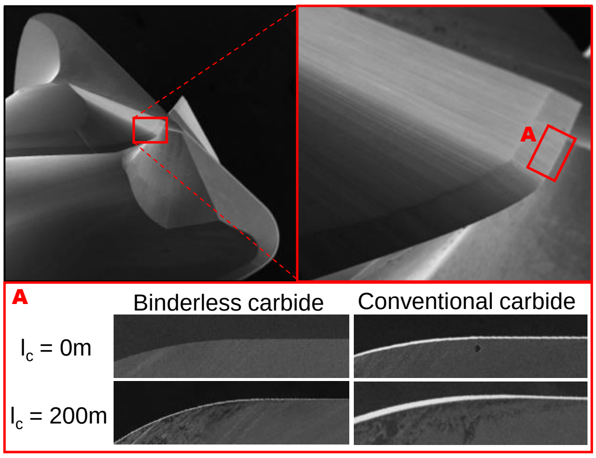

Figure 2. The cutting edges of the milling tools

5. Resume

The results show that higher surface qualities can be achieved with the milling tool made of binderless carbide. In addition, the milling tools made of binderless carbide show less signs of wear compared to milling tools made of conventional carbide. This reduced wear ensures that the tool life T of the milling tool is increased. This increases process reliability and the necessary resources are used more sustainably.

In summary, it can be said that the initial results indicate a high potential for milling tools made of binderless carbide. Nevertheless, further tests will be carried out to determine the total tool life T of the milling tools.

References

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