Effect of cutting fluids on the tool life in turning and milling of construction steel

Andrey Dugin[1], Lukas Volesky[2]
[1]Department of Machining and Assembly, Faculty of Mechanical Engineering, Technical University of Liberec.
[2]Centre for Nanomaterials, Advanced Technologies and Innovation, Technical University of Liberec
461 17, Studentská 1402/2, Liberec 1, Czech Republic.
E-mail: andrey.dugin@seznam.cz, lukas.volesky@tul.cz

Using cutting fluids often enables an increase of cutting tool life. A large amount of cutting fluids produced in the European Union exists on the market of Czech Republic. It is quite difficult for purchasers of cutting fluids to acquire reliable test data about the performance of the fluids in industrial conditions and choose the best cutting fluid, the use of which will guarantee the longest tool life. In this regard comparative tests of cutting fluids were conducted at the laboratory of the Department of Machining and Assembly of the Technical University of Liberec to determine the effect of cutting fluids from different producers (from England, Germany, Norway and Switzerland) on tool life in turning and milling.

Keywords: Machining, Cutting fluid, Wear

1 Introduction

One of the best ways to reduce tool costs during metal machining is the selection of cutting fluids [1-3]. The use of the best cutting fluid guarantees the maximum tool life. It was previously proved that cutting fluids are able to increase the tool life in many cases [3-7]. There are dozens of different cutting fluids of different producers on the market of Czech Republic, however not all customers are able to carry out a reliable and qualitative test to compare and choose the best cutting fluid from the whole range, ensuring the maximum tool life during machining.

The reliable and objective comparisons, the estimation of the effect of different cutting fluids on tool life for choosing the best cutting fluid is possible only in mass production. The same test conditions and the reliability of the obtained results are guaranteed in laboratory tests only [8, 9]. This study focuses on the determination of the effect of different cutting fluids on tool life in turning and milling under laboratory conditions in the laboratory of the Department of Machining and Assembly of the Technical University of Liberec.

2 Experimental procedures

In order to determine tool life when using different cutting fluids, the experiments were carried out by milling on the milling machine FNG 32 with manual control and by turning on the CNC lathe CHEVALIER FCL- 2140.

The tool used for turning was CTAPR 20x20 K16 KT 834 by the company Pramet Tools s. r. o. Turning of the structural steel 16MnCr5 (138 HB) was performed using cutting inserts TPUN 160304 of hard alloy S26 (P15 - P30) by the company Pramet Tools s. r. o. at a cutting speed of Vc= 85m/min, feed f = 0.1 mm/rev and depth of cut ap = 0.5 mm.

The cutter used for milling was a 63-diameter cutter by the company Narex s. r. o. Milling of the structural steel 16MnCr5 (138 HB) was performed with the cutting inserts SNUN 120412 of hard alloy S30 (P20 - P35) by the company Pramet Tools s. r. o., at a cutting speed of Vc = 85m/min, feed fz = 0.1 mm/tooth and depth of cut ap = 1 mm. The experiments were carried out with one insert fixed to the milling cutter.

Wear of the rear surface was measured in laboratory of the Department of the Preparation and Analysis of Nanostructures of Institute for Nanomaterials, Advanced Technologies and Innovation in Liberec. For the measurement of the wear on the rear surface of cutting tool in turning and milling, two types of microscopes was used: the light optical microscope Carl ZEISS Axio Imager M2 *(Fig. 1)* and the scanning electron microscope Zeiss Ultra Plus *(Fig. 2)* [10].

Each cutting edge was worn on the rear surface to 0.5 mm in turning *(Fig. 3, 5)*, and to 0.6 mm in milling *(Fig. 4, 6)*. To determine the average resistance value each experiment was repeated 5 times for turning *(Fig. 3, 5)* and milling [11, 12] *(Fig. 4, 6)*.

Each experiment was carried out under the same cutting parameters. The cutting fluid was only the one parameter, that was changed during the whole experiments.

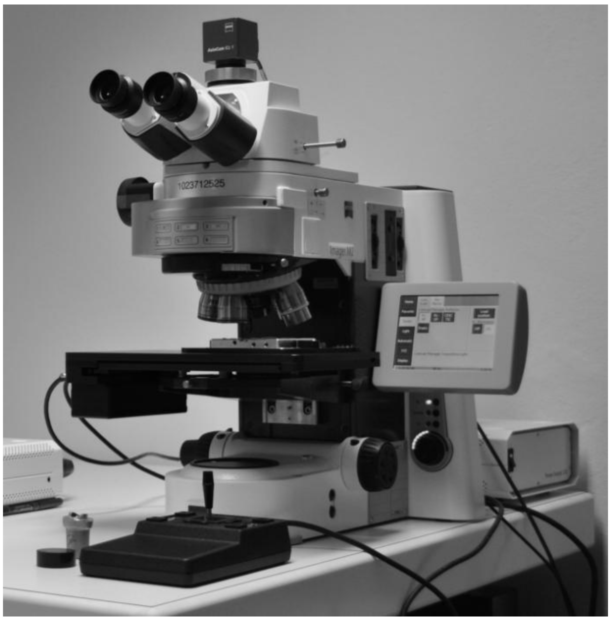
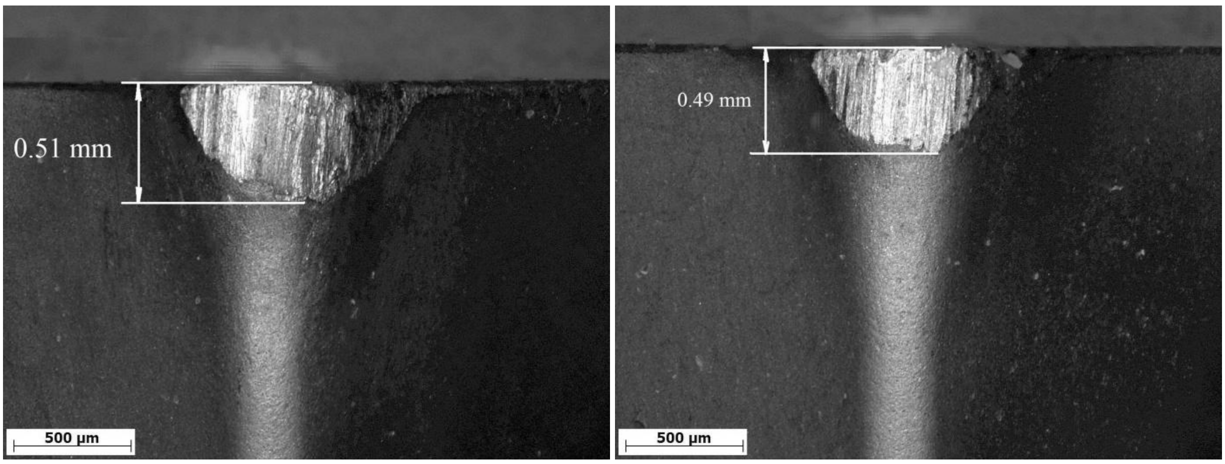


Fig. 1 *Light optical microscope Carl ZEISS Axio Imager M2*

Fig. 2 *Ultra-high-resolution field emission scanning electron microscope Zeiss Ultra Plus*



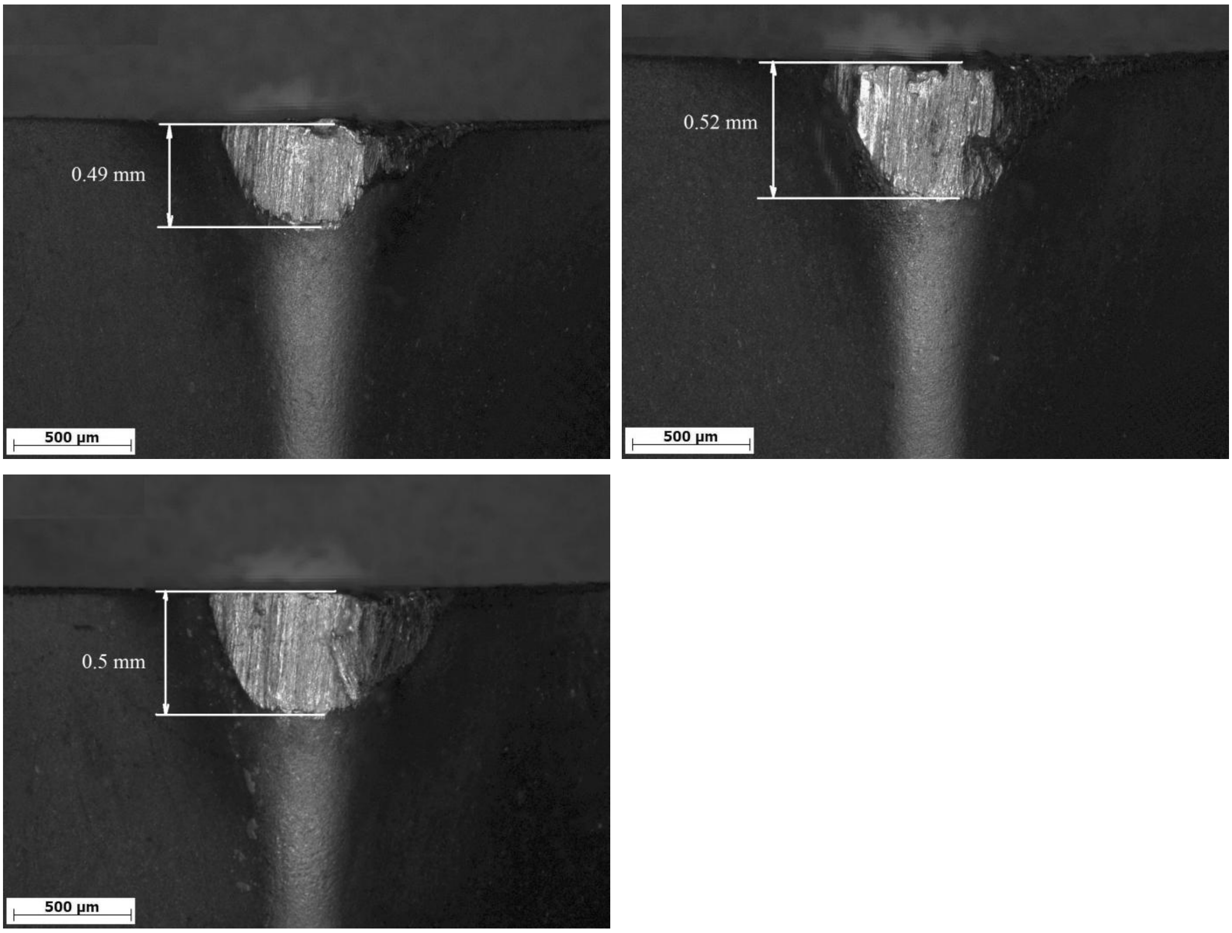
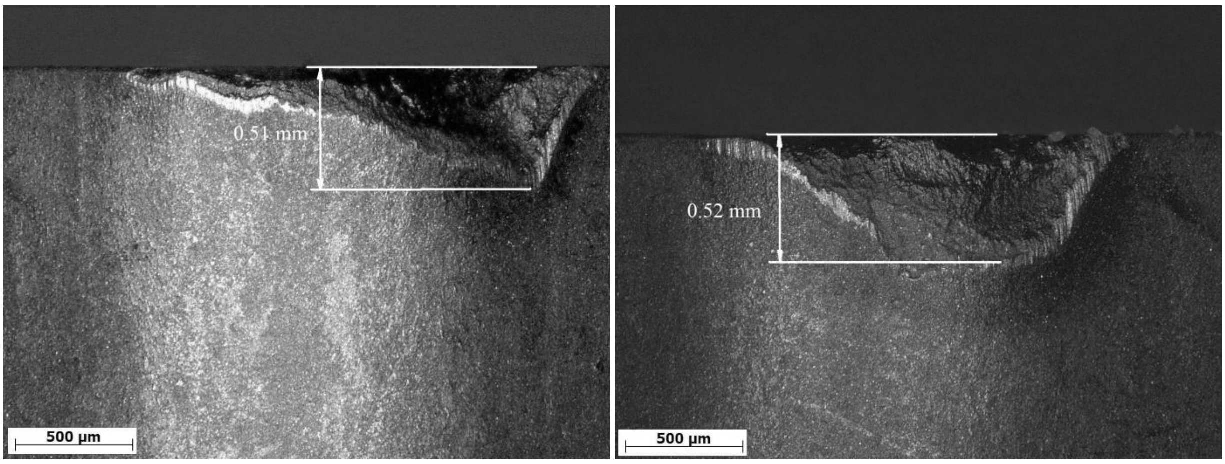


Fig. 3 *Flank wears measured by the light optical microscope after turning of structural steel with the cutting fluid Zubora Universal*



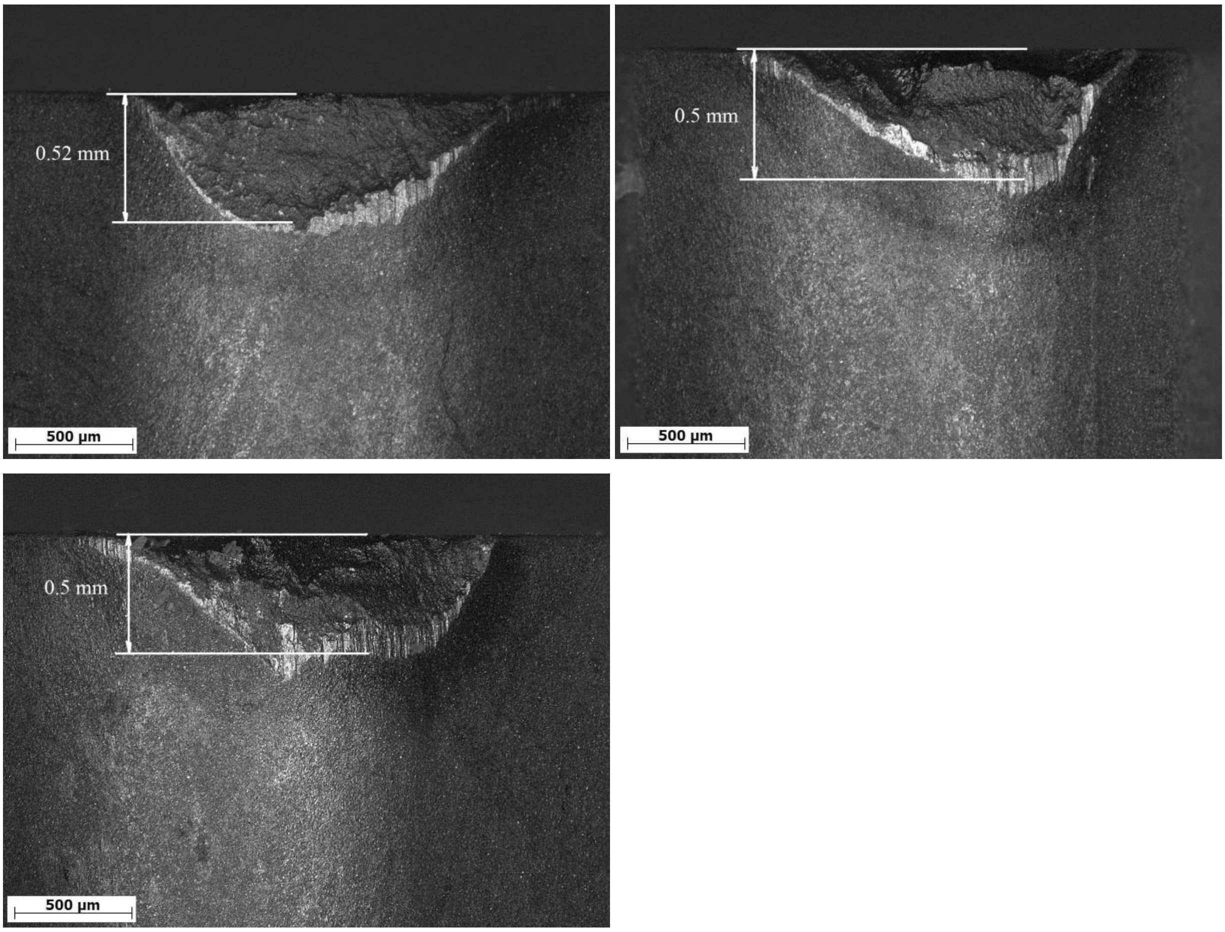
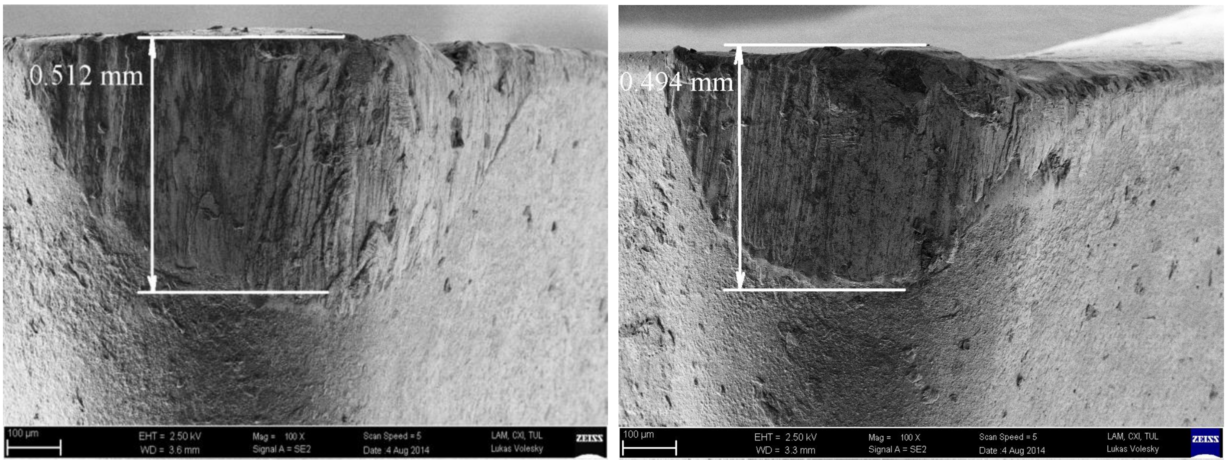


Fig. 4 *Flank wears measured by the light optical microscope after milling of structural steel with the cutting fluid Zubora Universal*



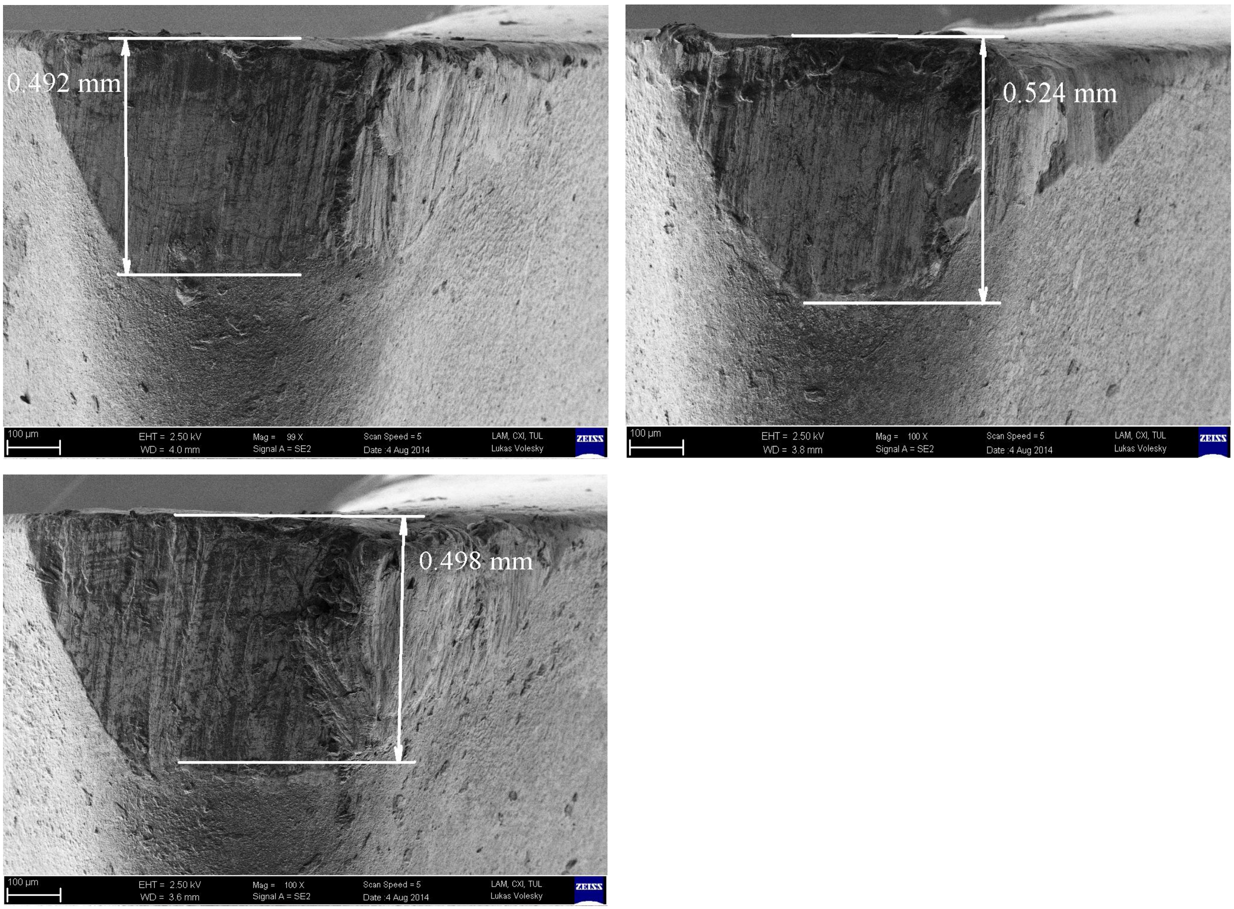
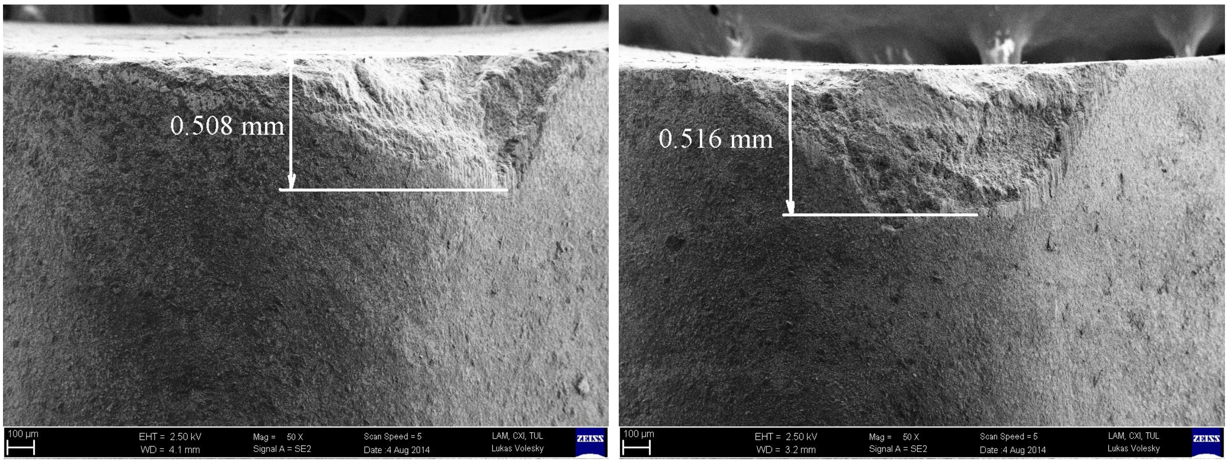


Fig. 5 *Flank wears measured by the light optical microscope after turning of structural steel with the cutting fluid Zubora Universal*



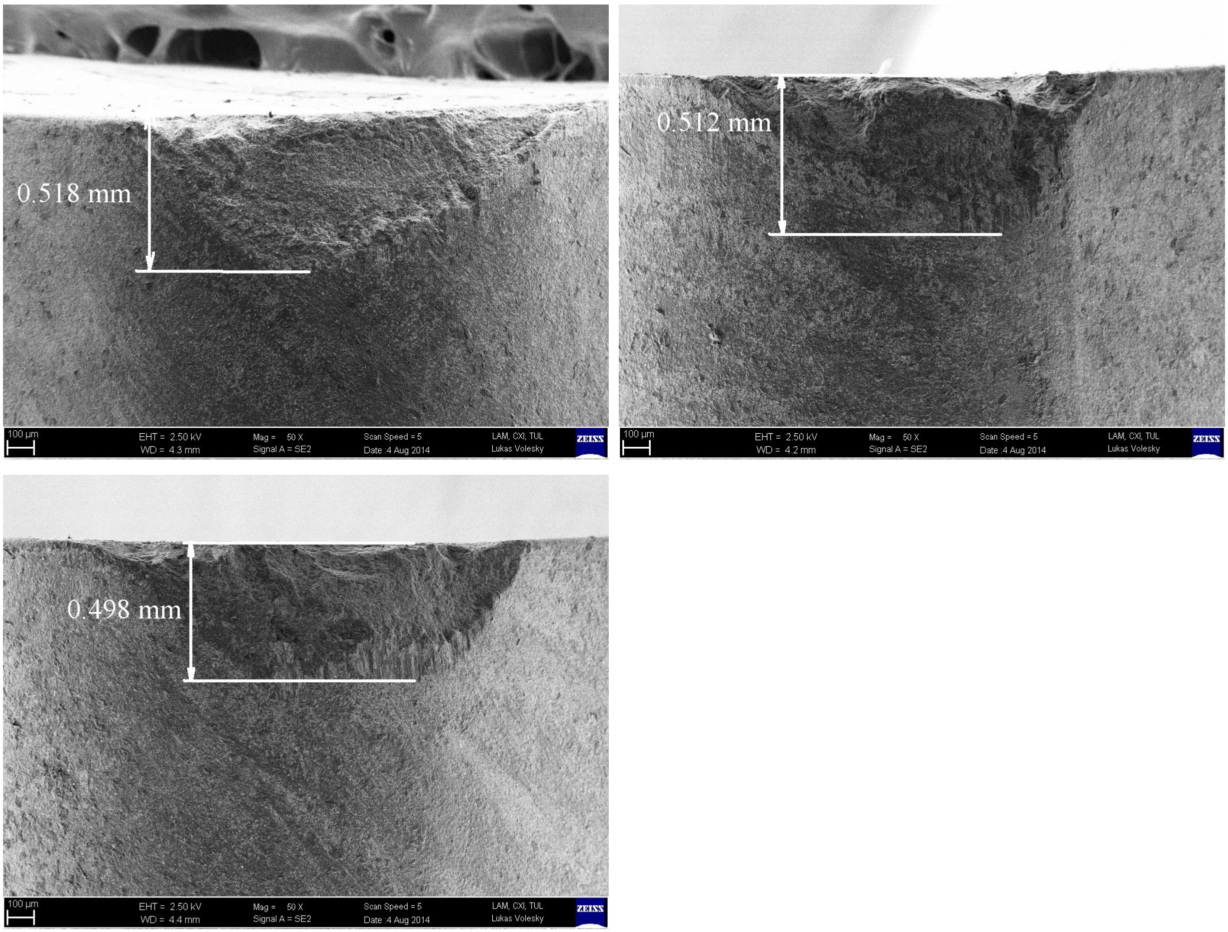


Fig. 6 *Flank wears measured by the scanning electron microscope after milling of structural steel with the cutting fluid Zubora Universal*

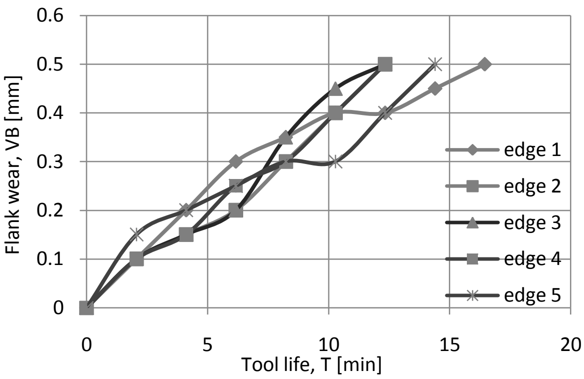


Fig. 7 *The dependencies of flank wear VB in turning of structural steel with the cutting fluid Zubora Universal*

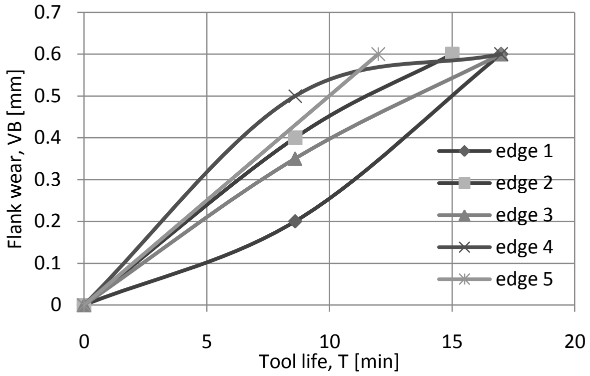


Fig. 8 *The dependencies of flank wear VB in milling of structural steel 16MnCr5 with the cutting fluid Zubora Universal*

In all experiments, 10 cutting fluids were used which had the same concentration of 5% [13-15]. These cutting fluids were made by the following manufacturers: BlaserSwisslube AG, Houghton plc, Zeller+Gmelin GmbH & Co., Statoil Lubricants. The cutting fluid concentration was controlled by the refractometer Optech Brix RLC / ATC, characterized by concentration measurement at a range of 0-18% and accuracy of 0.1%. The desired value for each fluid was calculated by the refractometer K using the following formula: K = 5/In, with 5 being the required concentration of 5%, and In being the refraction index whose value was provided by the cutting fluid manufacturer.

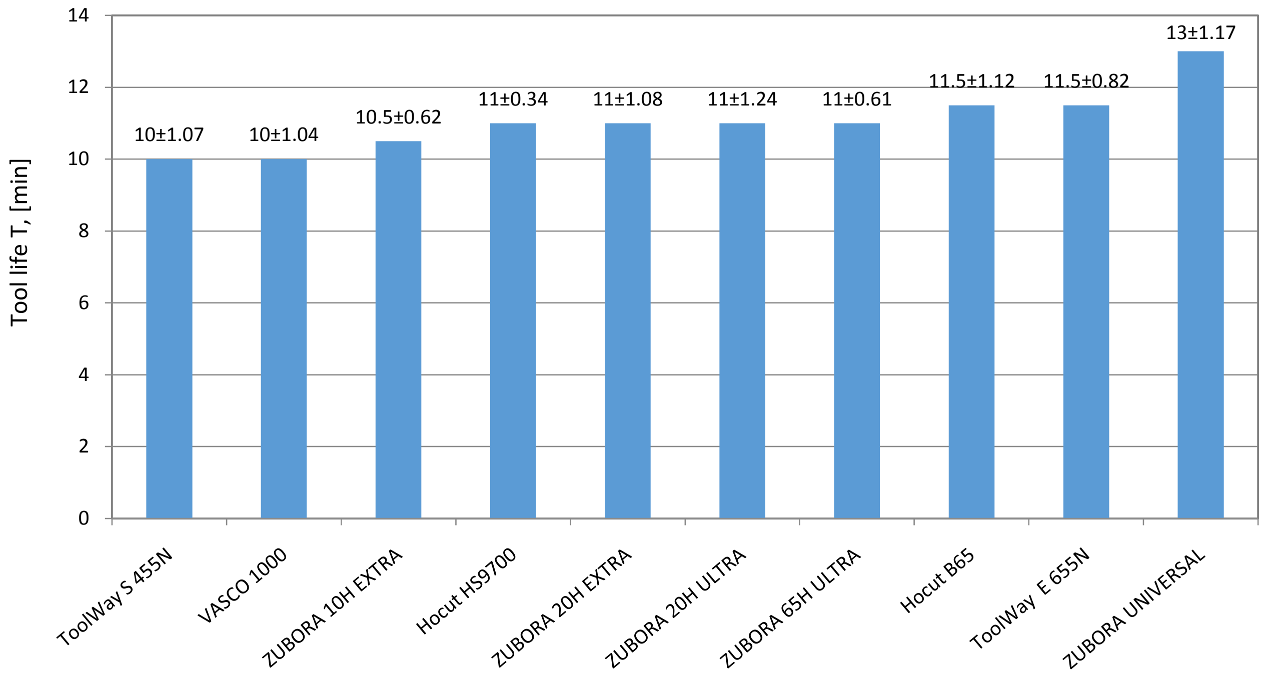


Fig. 9 *Effect of cutting fluid on tool life in turning structural steel*

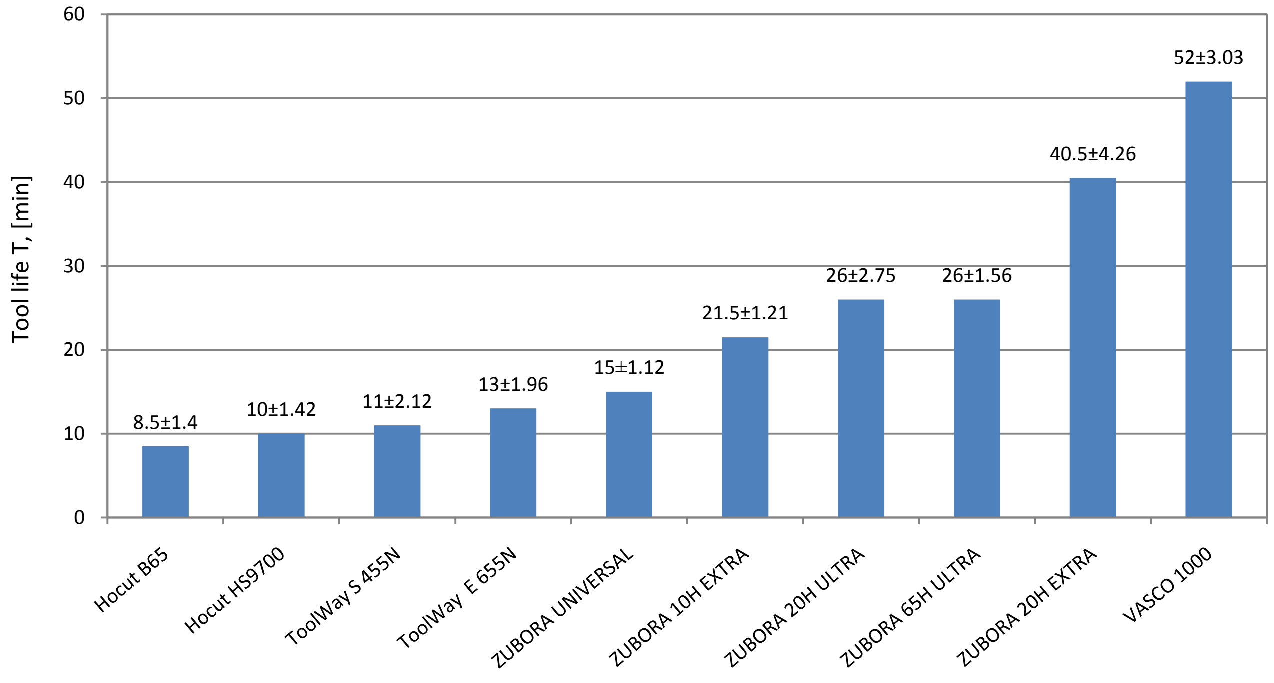


Fig. 10 *Effect of cutting fluid on tool life in milling structural steel*

3 Experimental results and analysis

Experiments carried out in turning presented that in turning a cutting fluid has insignificant effect on tool life of instrument ***(Fig. 9)***. The best cutting fluid Zubora Universal ***(Fig. 9)*** is able to increase tool life in turning by 15 – 30%. The difference of tool life in turning with different cutting fluids varies between 5 – 10%; that is not, technically, a large difference ***(Fig. 10)***.

Using cutting fluids in milling causes a significant effect on tool life. Using the best cutting fluid enables an increase of tool life by 6 times, compared with the worst cutting fluid. It was proved that using Hocut HS9700 in milling increases tool life by 18%, using ToolWay S455N increases by 29%, using ToolWay E655N - by 53%, Vasco 1000 by 6 times. The cutting fluids using could significantly reduce the cost of the cutting tool duting the turning and milling of construction steel 16MnCr5.

During the comparative tests of the effect of cutting fluids on the tool life in turning and milling of construction steel, two types of microscopes was used. Using the light optical microscope is more appropriate for these tests in aspects of required accuracy, operation time and material costs, compared with the scanning electron microscope.

4 Conclusion

This study determined that using the best cutting fluid in turning of construction steel 16MnCr5, enables an increase of the tool life by 30%, and using the best cutting fluid in milling causes an increase in tool life by 6 times at the cutting conditions, presented in this paper.

According to obtained data of study for turning and milling operations of construction steel 16MnCr5, the cutting fluids Vasco 1000 and Zubora 20X extra are recommended.

Using the light optical microscope is more appropriate in comparative tests for the estimation of the effect of different cutting fluids on tool life, compared with the scanning electron microscope.

5 Acknowledgments and References

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