THEORY OF MACHINING

HARD TURNING BY DIFFERENTLY SHAPED CUTTING TOOLS

Implementation of innovative learning methods and practical training to education in the field of production technologies and production management to increase the attractiveness of study and support the key competencies of the students (KEGA 026STU-4/2023)

Ing. Michaela Kritikos, PhD.

Hard Turning (Machining)

- Hard machining is the machining of parts with a hardness of above 45 HRC, although most frequently the process concerns hardness of 58 to 68 HRC.
- Hard turning is currently used as a substitute for grinding operation. Machining by cutting tool with defined geometry is one of the biggest advantages of this process. It can be performed by using two different cutting tool materials - CBN or mixed ceramic.

Hard Turning (Machining)

- Hardened steels are very often used for production of machine parts which are often loaded near their physical limits.
- The most important is the functional behaviour of these parts, which is influenced by the fine finishing process, representing the last step in manufacturing process and it could be grinding and turning as well.

CUTTING TOOL MATERIALS

- **Cubic Boron Nitride (CBN).** If the hardness ranges between 50-68 HRC and the depth of hardness is greater than the depth of material to be removed, then Cubic Boron Nitride is the best material. CBN will give good tool life and wear properties. Surface finishes of 0,25-0,4 micrometers can be achieved and maintained.
- **Ceramics.** Ceramics in hardened steel turning have applications and are very economically priced compared to other types of tool materials.
- **Natural and Synthetic Diamonds.** Natural diamond and synthetic diamond are the least preferred options for operations involving machining of hardened steel. They have high costs per edge, and poor reliability in terms of interrupted cuts and wear mode. Brazing cannot always be guaranteed and re-grinding is not always possible. Diamond also interacts chemically with steels and can cause failure.

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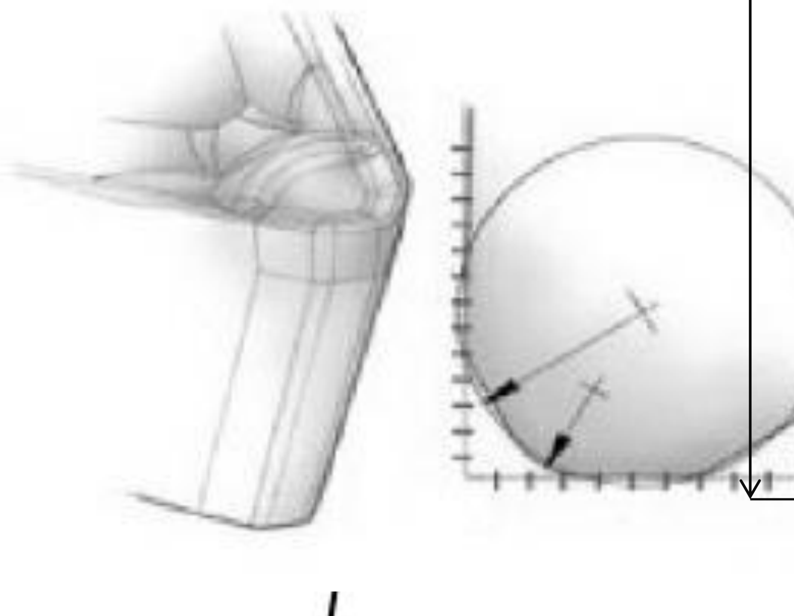
HARD TURNING (MACHINING)

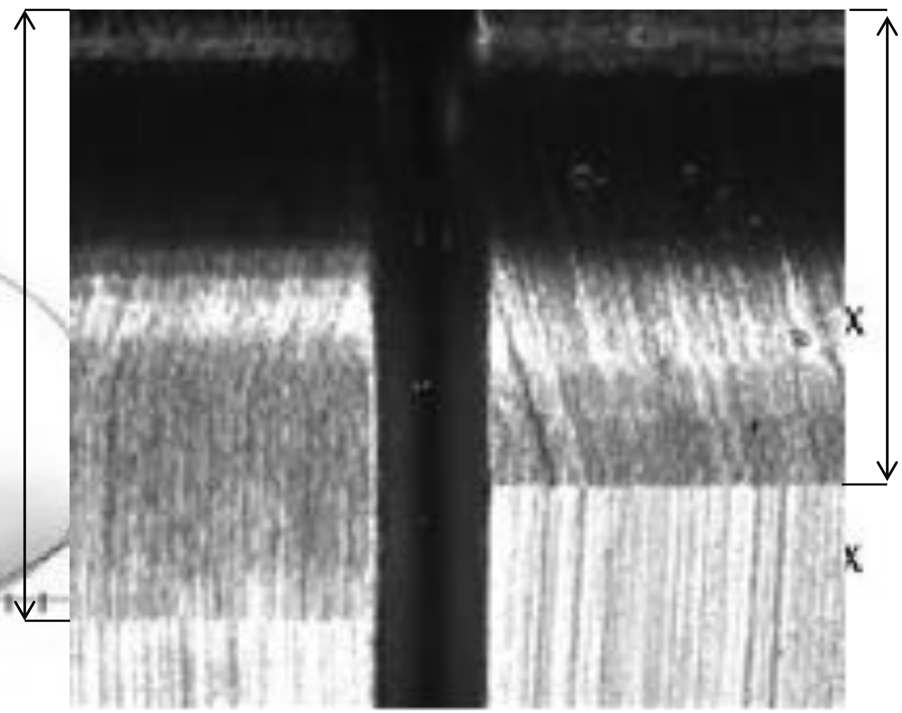
- There is a possibility to use different **cutting tool geometries** to perform hard turning.

- Conventional geometry,
- Wiper geometry,
- Xcel geometry.

CUTTING TOOL GEOMETRY

- **Wiper geometry** differs from the conventional geometry in the shape of minor cutting edge.



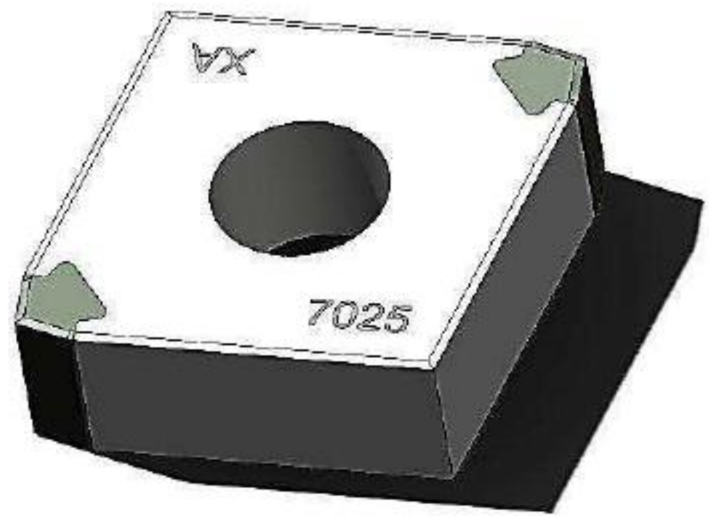


https://www.youtube.com/watch?v=qB6O4wfDDwQ&list=RDCMUCZ1sg-IuV-4msElOkNebqdg&start_radio=1&t=48

CUTTING TOOL GEOMETRY

- **Xcel geometry**

The difference of this geometry is in the shape of the cutting edge – there is no characteristic tip on this insert, which shape is copied into the workpiece surface. The cutting tool comes to the contact with the machined surface with skewed edge.



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SURFACE INTEGRITY

- It can be defined as a border between a machined workpiece and its environment.
- SI describes the state and attributes of a machined surface and its relationship to functional performance.
- SI concerns not only the topological (gemetric) aspects of surfaces but rather the whole assemblage of their physical, mechanical, metallurgical, chemical and biological properties and characteristics.

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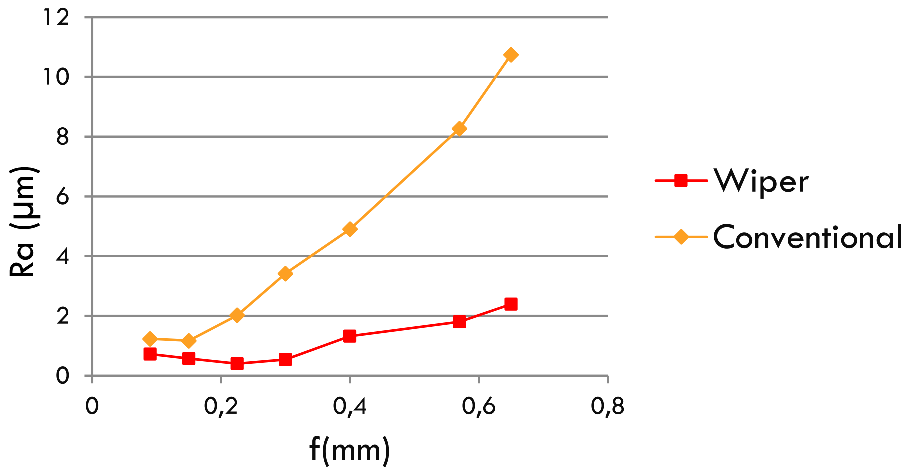
1. EXPERIMENT- CONDITIONS

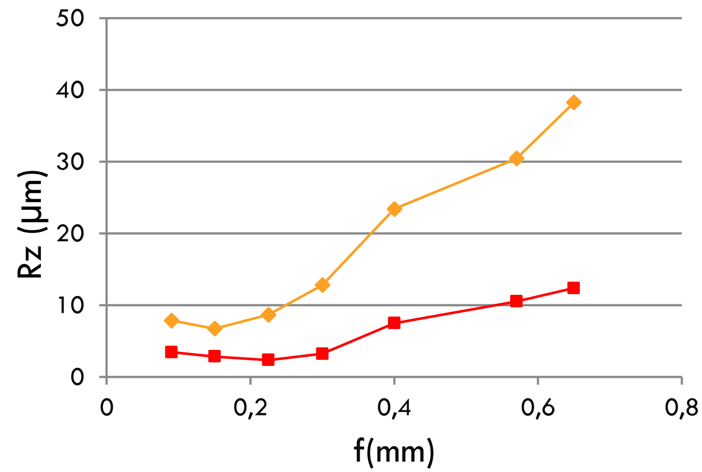
- Cutting tool geometry impact on the surface roughness parameters (Ra, Rz), surface topography and surface structure.

- *CONDITIONS:*
- conventional, Wiper geometry,
- CBN cutting tool inserts,
- workpiece material 100Cr6 (ISO 683-17, DIN 17230),
- hardened to 60±1 HRC.

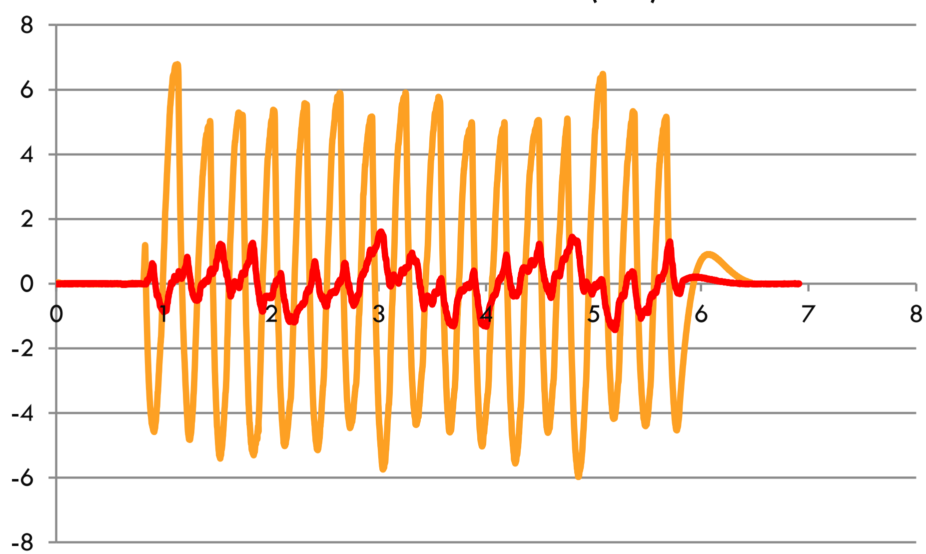
- Turning lathe: SUI 40,
- Roughness measurement: Hommel tester T 2000 (handy surf),
- Software : Surfer,
- *RTG* diffractometer *HZG4*.

1. EXPERIMENT - RESULTS

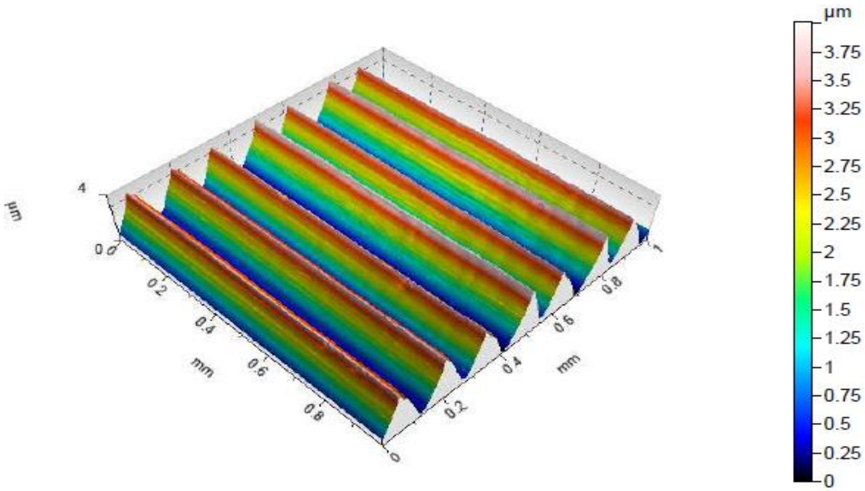




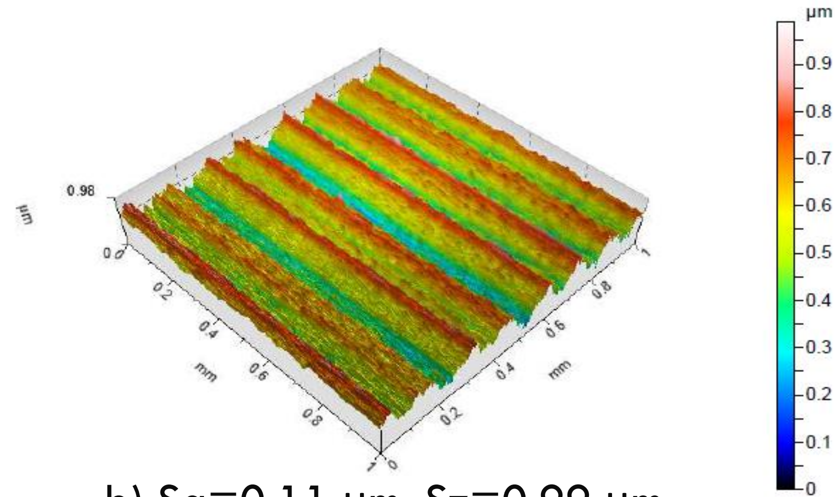
Surface roughness parameters Ra a Rz and achieved profile by differently shaped tools (conventional and Wiper geometry)



1. EXPERIMENT - RESULTS

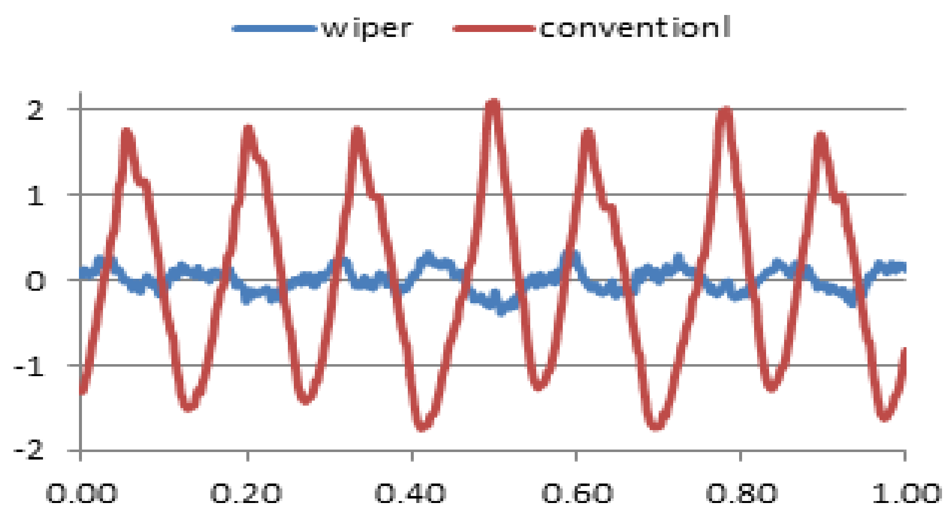


a) Sa=0.92 µm, Sz=4.01 µm



b) Sa=0.11 µm, Sz=0.99 µm

Surface topography
a) conventional (C), b) Wiper (W)



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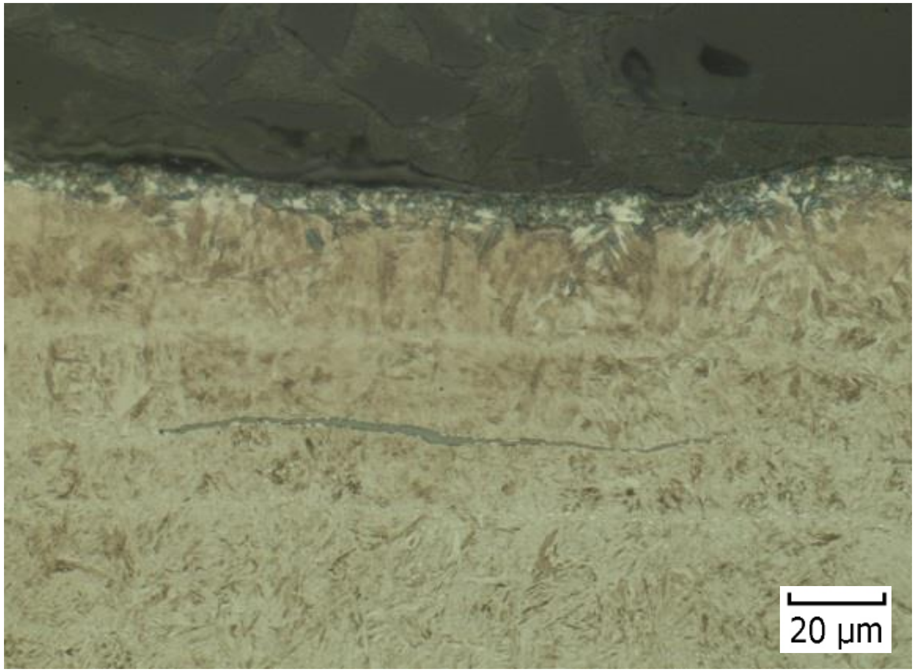
1. EXPERIMENT - RESULTS

Samples for metallography for „white layer“ evaluation

1. EXPERIMENT - RESULTS



Surface white layer structure (left – conventional, right– Wiper)

* WL is produced by exceeding the austenitization temperature and subsequent rapid cooling

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1. EXPERIMENT - CONCLUSION

- Surface roughness is influenced by cutting tool geometry – Wiper geometry allows to achieve better surface quality.
- 3D roughness parameters are also influenced by the cutting tool geometry – conventional geometry leads to more symetrical surface but 3D roughness parameters are 3 – 4 times higher than with Wiper geometry.
- Cutting tool geometry effects also the surface layer structure. Wiper geometry leads to higher martensite content and lower austenite content.

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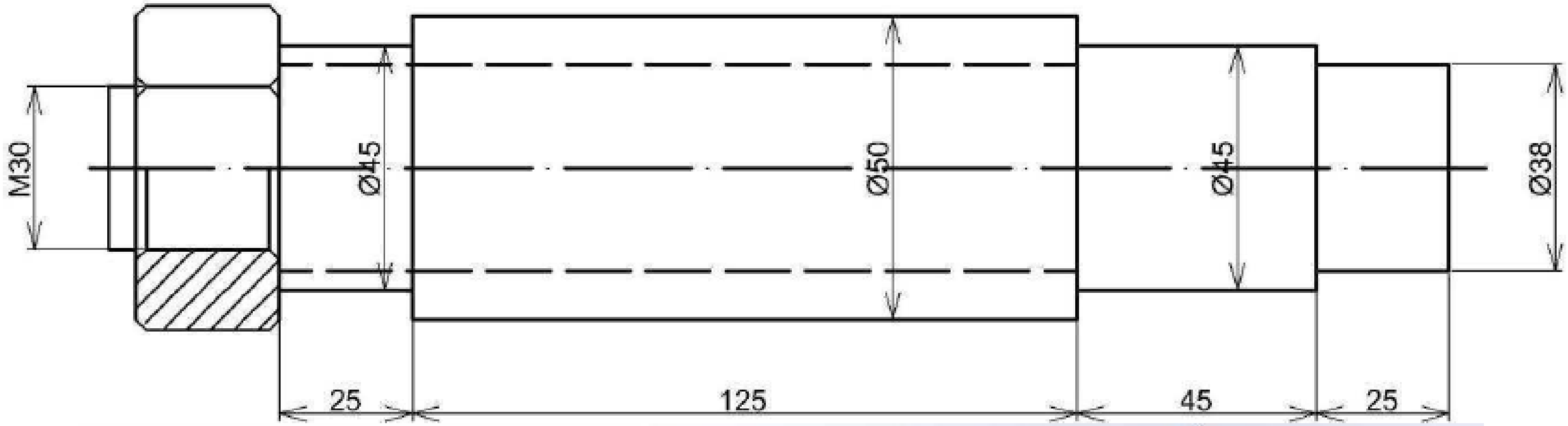
2. EXPERIMENT - CONDITIONS

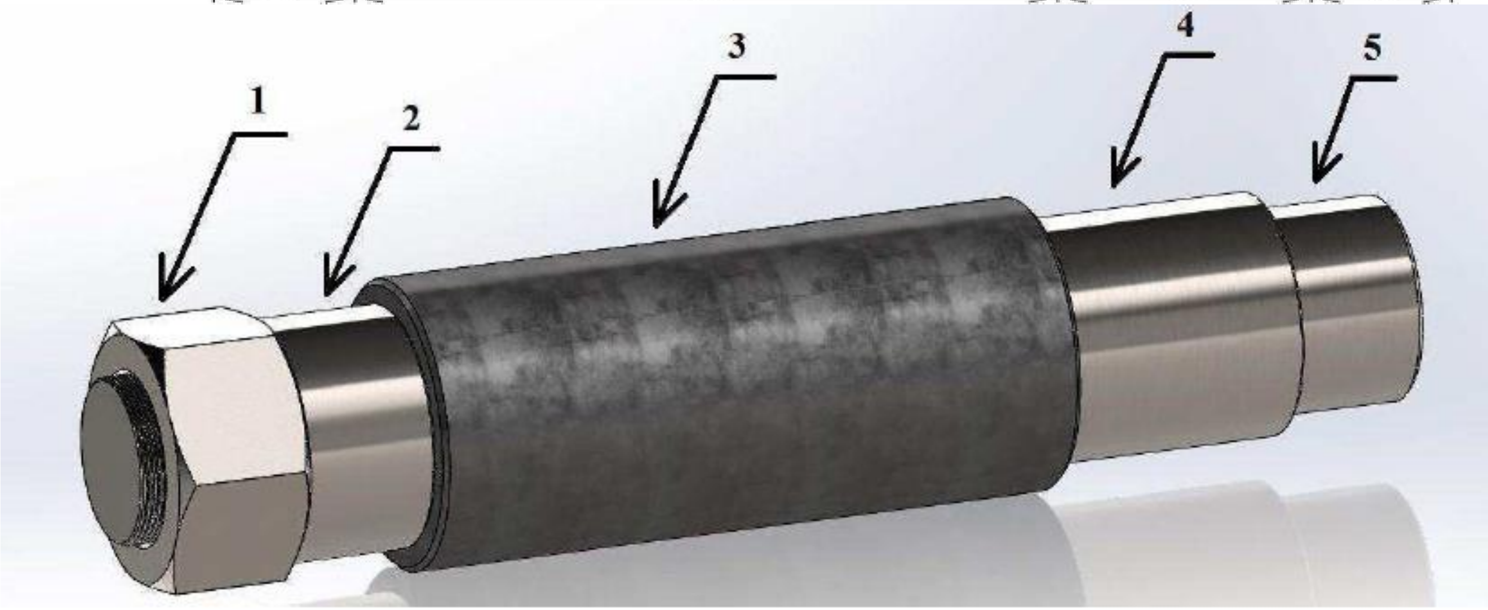
- Cutting tool geometry impact on the surface roughness parameters (Rp, Rv).

- *CONDITIONS:*

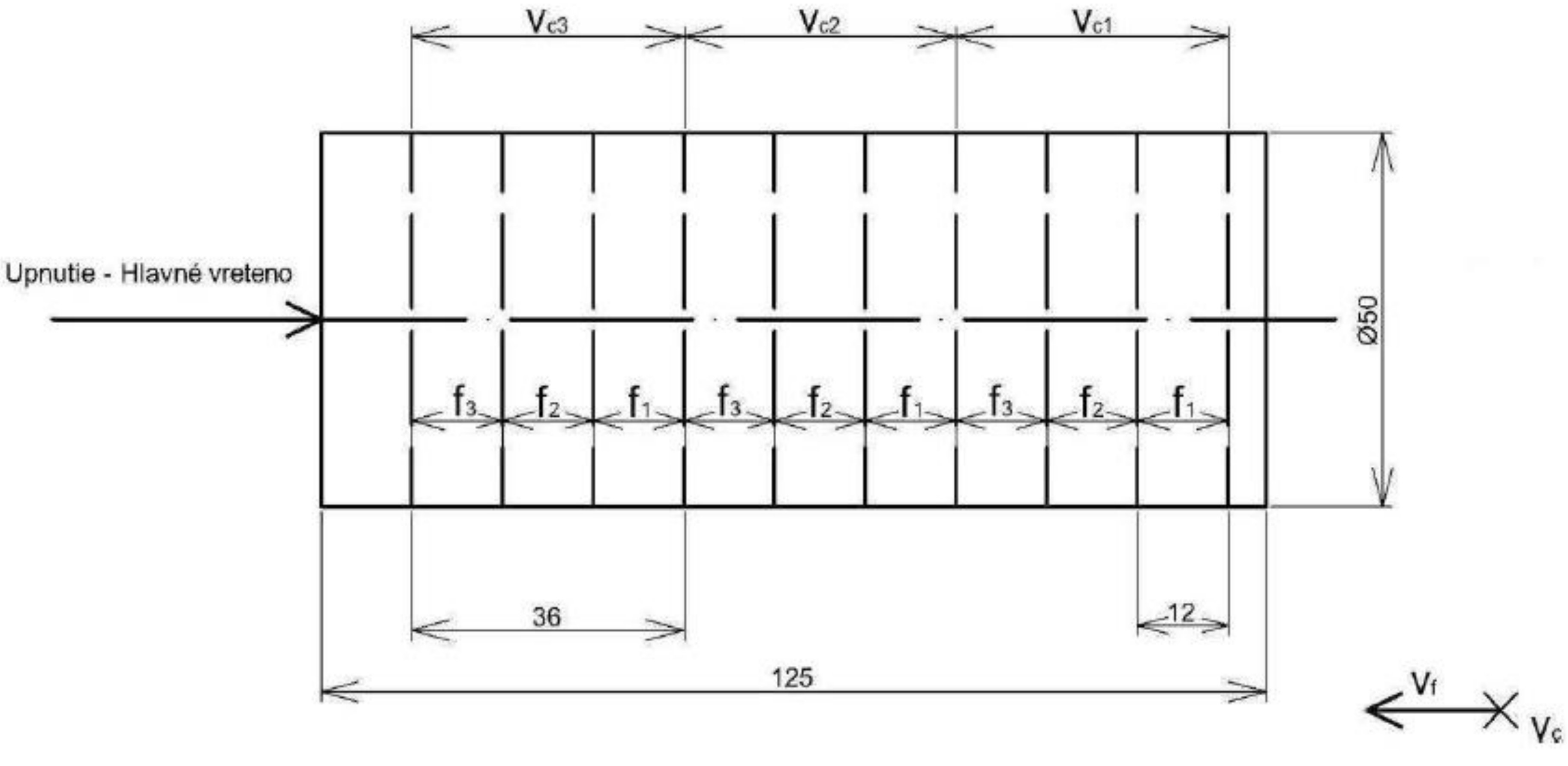
- conventional, Wiper, Xcel geometry
- CBN cutting tool inserts,
- a_p = 0,25 mm = constant,
- v_c =125 $m.min^{-1}$ (1) 145 $m.min^{-1}$ (2) 165 $m.min^{-1}$ (3),
- f = 0,15 mm (1) 0,3 mm (2) 0,45 mm (3).

2. EXPERIMENT - SAMPLE





2. EXPERIMENT - SAMPLE



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2. EXPERIMENT - MACHINES

- CTX Alpha 500 – turning centre with counter spindle (DMG MORI),

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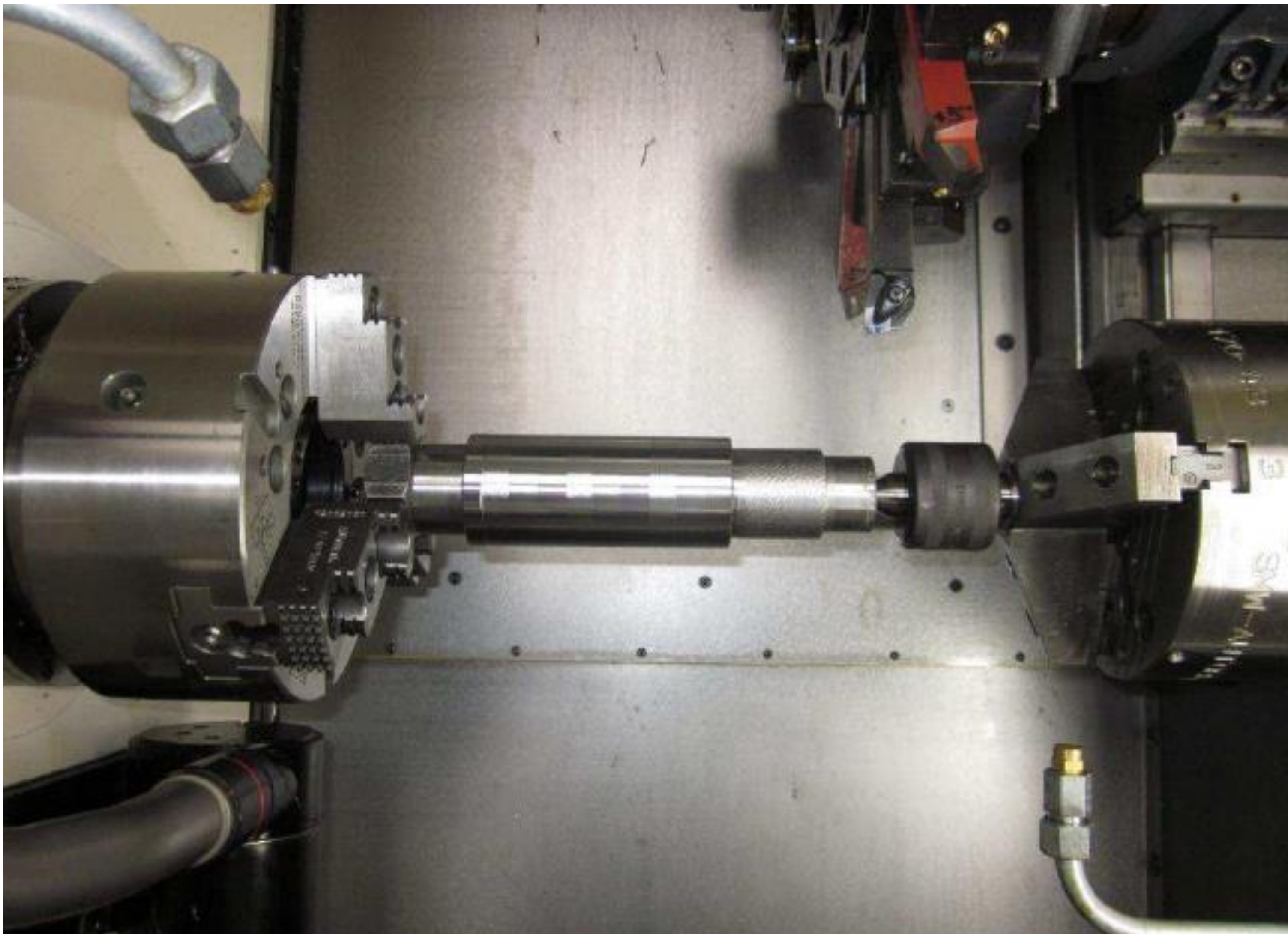
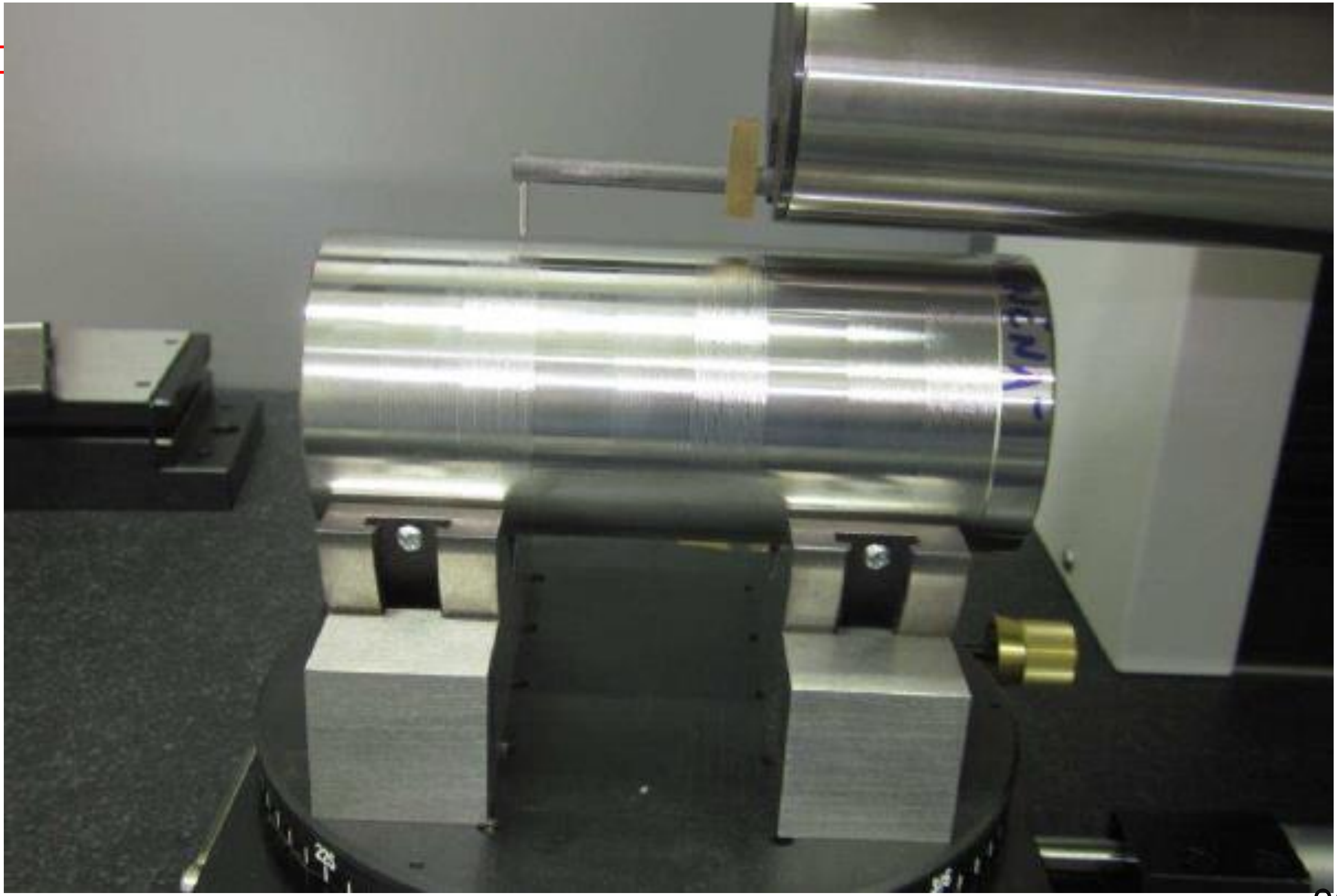
2. EXPERIMENT - MACHINES

- ndle



2. EXPERIMENT - MEASUREMENT



2. EXPERIMENT - MEASUREMENT

- **Maximum Profile Peak Height, Rp,** the distance between the highest point of the profile and the mean line within the evaluation length.

- **Maximum Profile Valley Depth, Rv,** is the distance between the deepest valley of the profile and the mean line within the evaluation length

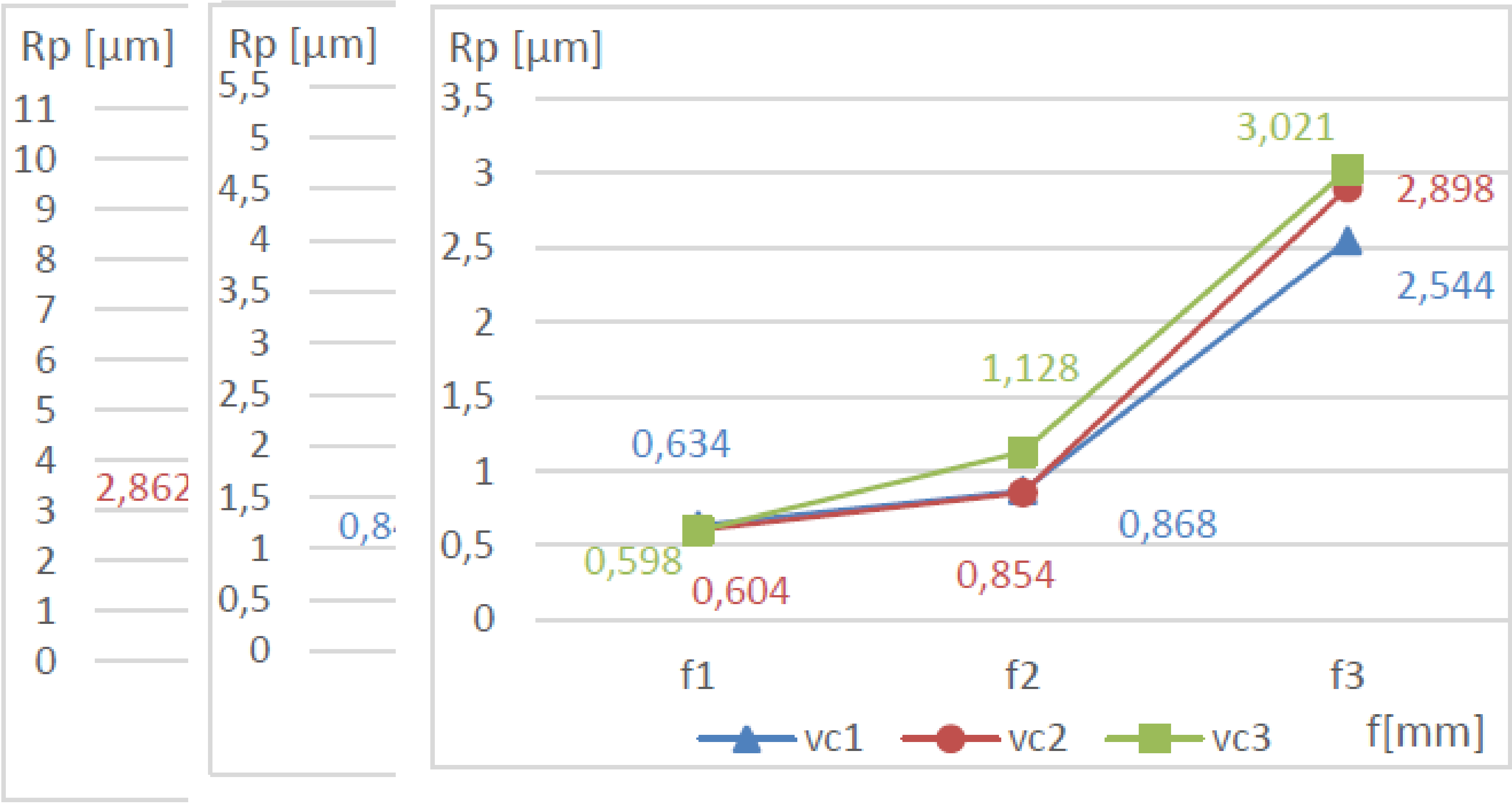
2. EXPERIMENT - MEASUREMENT

		Roughness parameter Rp (μm)		
		Conventional geometry	Wiper geometry	Xcel geometry
f1	vc1	3,267	0,849	0,634
	vc2	2,862	0,865	0,604
	vc3	2,786	0,759	0,598
f2	vc1	6,296	2,592	0,868
	vc2	6,376	2,685	0,854
	vc3	7,064	2,619	1,128
f3	vc1	9,725	4,980	2,544
	vc2	10,472	5,044	2,898
	vc3	10,243	4,896	3,021

2. EXPERIMENT - MEASUREMENT

		Roughness parameter Rv (μm)		
		Conventional geometry	Wiper geometry	Xcel geometry
f1	vc1	2,171	0,700	0,578
	vc2	2,218	0,728	0,687
	vc3	2,317	0,857	0,682
f2	vc1	5,380	1,743	0,812
	vc2	5,080	1,994	0,769
	vc3	4,996	1,841	0,978
f3	vc1	7,737	3,635	1,283
	vc2	8,428	3,200	1,988
	vc3	8,005	3,025	1,693

2. EXPERIMENT - ROUGHNESS



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2. Experiment - Conclusion

- Rp values are increasing with increasing of feed with every used geometry.
- Values achieved by Xcel geometry are 3 – 5 times lower than values achieved by conventional geometry and also lower than with Wiper geometry (but it is not so big difference).
- Parameter Rv has very similar growth but values achieved by all the geometries are lower.

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