



**UNIVERSITY OF BANJALUKA**  
Faculty of Mechanical Engineering  
*Department of Production Engineering*



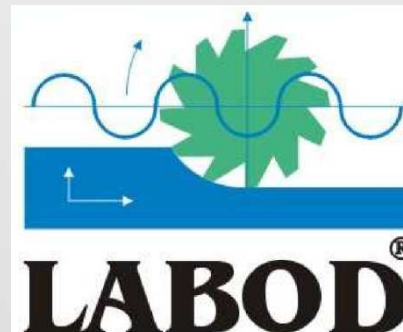
## The brief review

# Experimental results and future plans...

Assitant **Branislav Sredanović**, Univ. Dipl. Eng.



*Univerza v Ljubljani*  
*Fakulteta za strojništvo*





# CONTENT



1. My impressions about LABOD
2. What I learned during the visit
3. Eksperimental research and results
4. Future plans

**I will be short, really!**



# CONTENT



1. My impressions about LABOD
2. What I learned during the visit
3. Eksperimental research and results
4. Future plans



## MY IMPRESSIONS ABOUT LABOD



It is very dynamic  
environment.



LABOD has a good directions in  
the development and  
engineering.



## MY IMPRESSIONS ABOUT LABOD



In LABOD is doing good things.



All staff are ready to help and colaboration, and they are good persons and friends.



# CONTENT



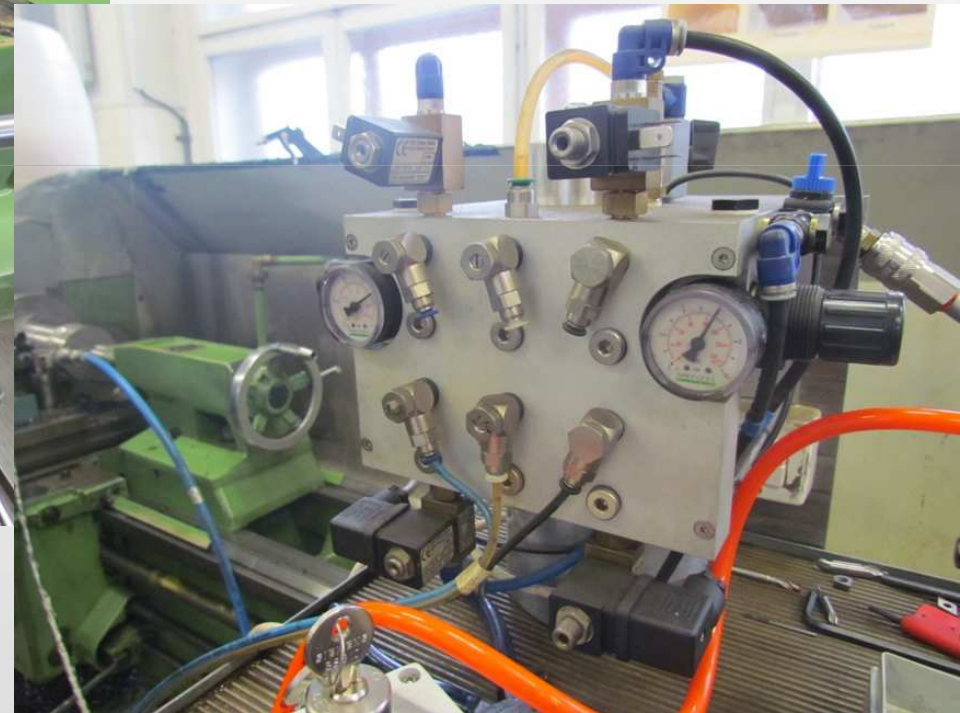
1. My impressions about LABOD
2. What I learned during the visit
3. Eksperimental research and results
4. Future plans



## WHAT I LEARNED DURING THE VISIT



I met up with current technologies of metal cutting.





# WHAT I LEARNED DURING THE VISIT



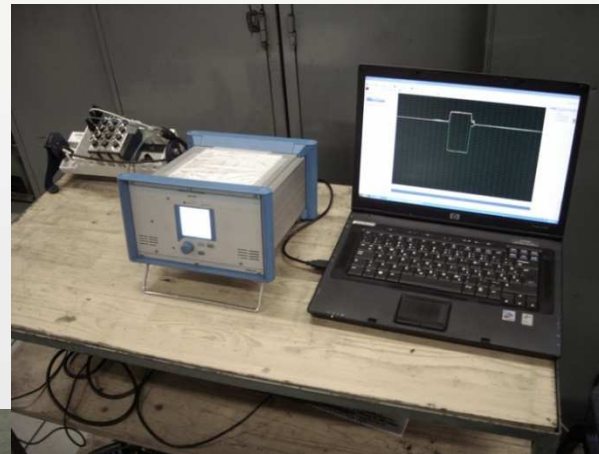
I met the laboratory equipment.



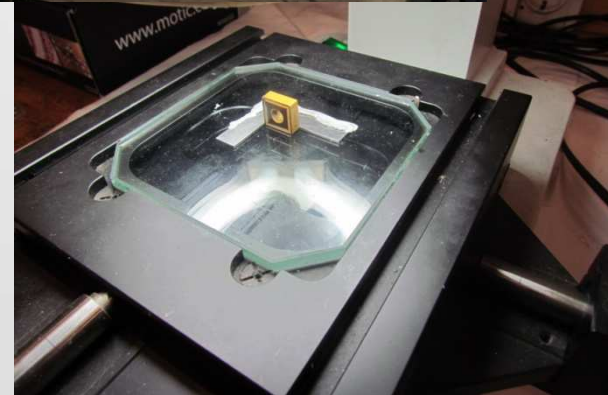
## WHAT I LEARNED DURING THE VISIT



I got the some praticle knowledge about process of experimental research in metal cutting...



I worked on tool microscope on first time.

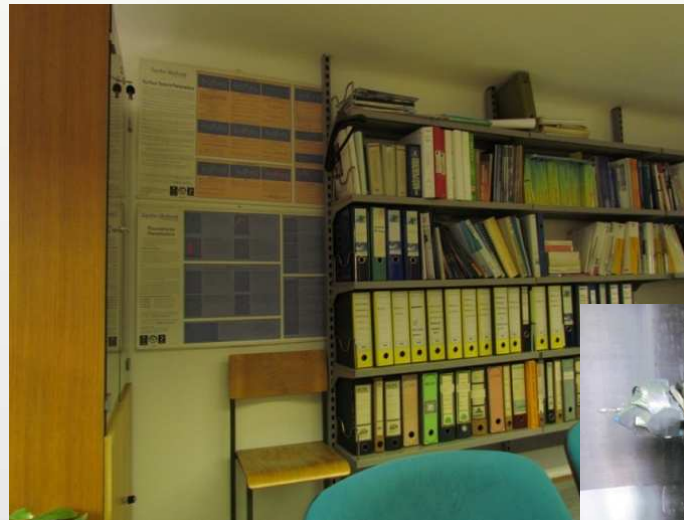




# WHAT I LEARNED DURING THE VISIT



I got some experience about development of good projects.



I got motivation for learning and future research!



Simply, I seen and learned many good things in LABOD.



# CONTENT



1. My impressions about LABOD
2. What I learned during the visit
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# EXPERIMENTAL RESEARCH AND RESULTS



Experimental setup in LABOD

Machine: **Universal lathe POTISJE**

Tool: **SNMG 120408 NMX (AC 3000)**

Material: **Ck45**

## Input parameters:

Type of process:

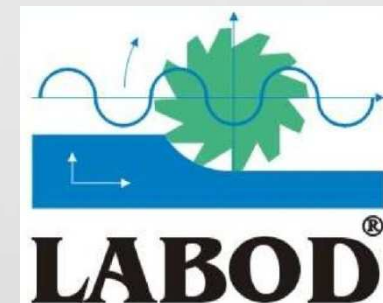
1) **Cutting with flood** 2) **MQL** 3) **High pressure assisted machining**

Technological parameters:

1. Cutting depth  $a_p$  (mm)
2. Feed rate  $f$  (mm/rev)
3. Cutting speed  $v_c$  (m/min)

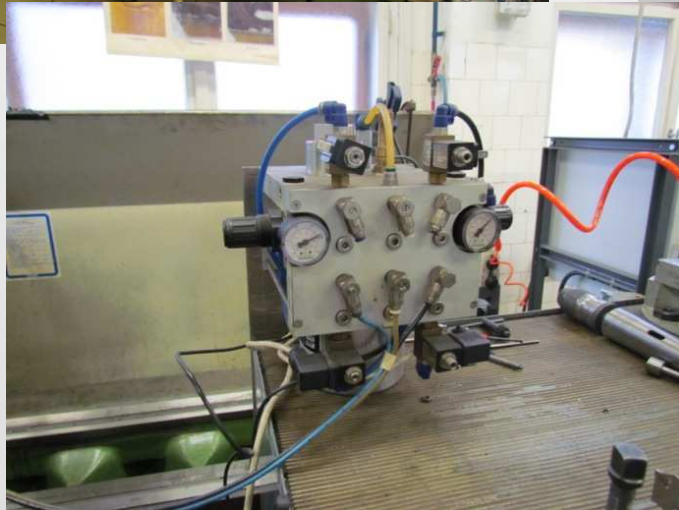
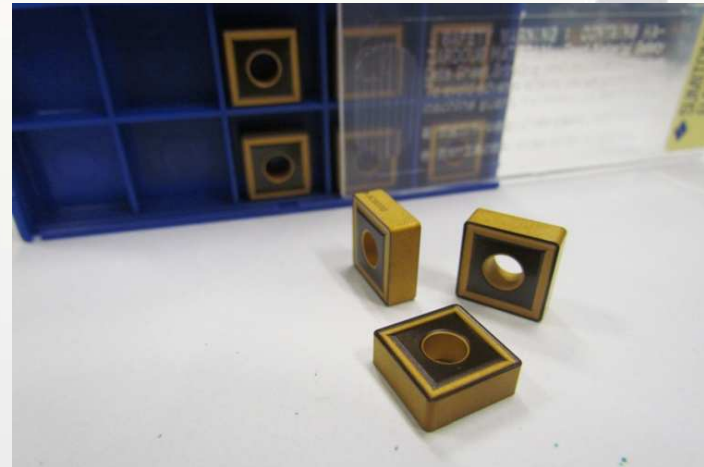
## Output parameters:

1. **Cutting forces,**
2. **Chip shape,**
3. **Surface roughness,**
4. **Tool wear**





# EXPERIMENTAL RESEARCH AND RESULTS





# EXPERIMENTAL RESEARCH AND RESULTS





# EXPERIMENTAL RESEARCH AND RESULTS



## Cutting forces - cutting with flood

Cutting with flood cooling										
f	vc	a = 2,5 mm			a = 2,0 mm			a = 1,5 mm		
		Fc	Ff	Fp	Fc	Ff	Fp	Fc	Ff	Fp
0.224	210 m/min	1237	586	411	1018	520	372	805	418	326
0.280		1419	607	451	1164	542	407	944	438	356
0.355		1834	716	559	1468	586	477	1165	481	418
0.400		2021	780	619	1609	615	518	1156	489	423
0.224	320 m/min	1211	570	409	989	448	341	798	393	314
0.280		1406	603	452	1137	478	379	<b>798</b>	<b>97</b>	<b>254</b>
0.355		1769	647	528	1451	528	452	1165	419	394
0.400		1976	696	580	1599	536	477	1265	443	430
0.224	390 m/min	1195	541	386	982	466	355	772	360	311
0.280		1381	572	431	1136	495	389	919	382	339
0.355		1748	641	527	1445	541	460	1149	427	402
0.400		1943	693	589	1598	556	493	1269	452	438



# EXPERIMENTAL RESEARCH AND RESULTS



## Cutting forces - MQL

Minimal quantity lubrication (MQL)										
f	vc	a = 2,5 mm			a = 2,0 mm			a = 1,5 mm		
		Fc	Ff	Fp	Fc	Ff	Fp	Fc	Ff	Fp
0.224	210 m/min	1203	551	400	995	477	358	825	417	339
0.280		1404	592	446	1156	511	398	939	442	362
0.355		1800	696	551	1469	568	475	1187	477	420
0.400		2011	758	611	1623	602	516	1281	499	455
0.224	320 m/min	1195	544	403	964	359	286	785	391	325
0.280		1388	582	453	1145	489	394	907	410	351
0.355		1755	657	543	1446	535	467	1136	445	412
0.400		1955	725	615	1603	579	517	1257	466	442
0.224	390 m/min	1205	576	441	972	427	342	735	318	283
0.280		1384	601	482	1130	460	382	849	343	316
0.355		1752	664	578	1422	500	451	1085	379	370
0.400		1938	715	654	1581	535	500	1191	389	403



# EXPERIMENTAL RESEARCH AND RESULTS



## Cutting forces - High pressure assisted machining

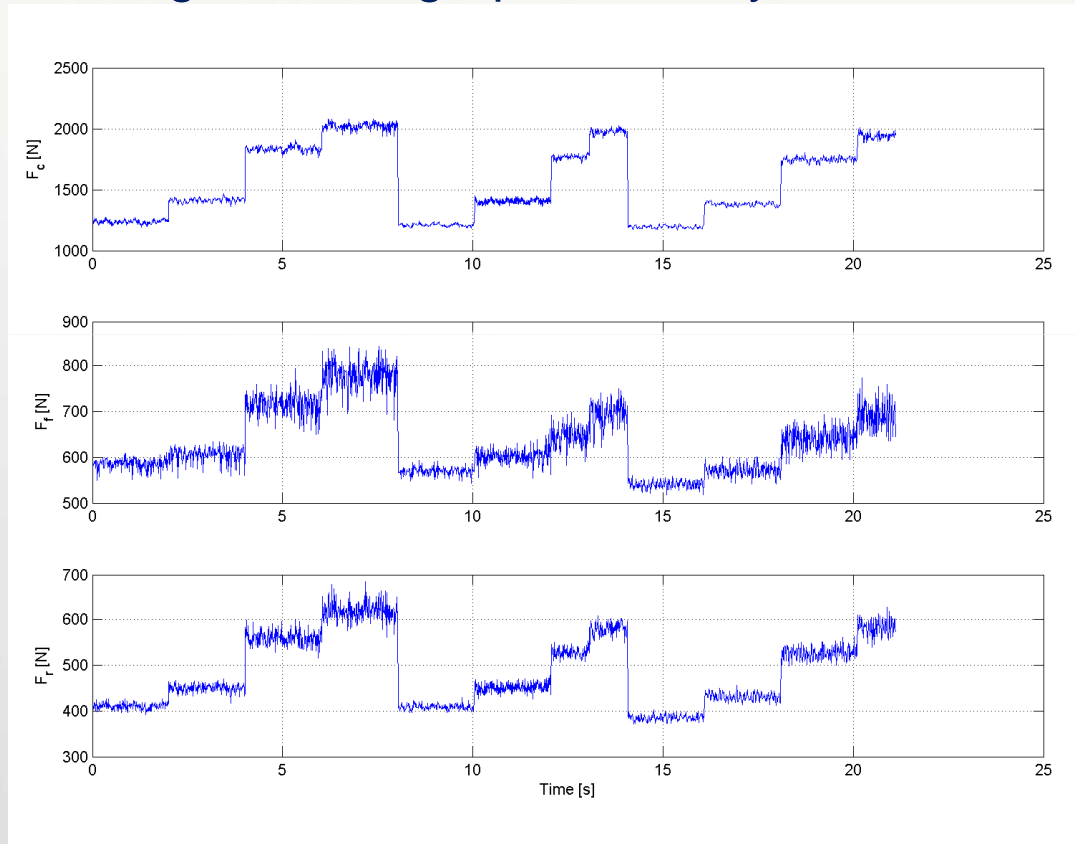
High pressure assisted machining (p = 500 bar)										
f	vc	a = 2,5 mm			a = 2,0 mm			a = 1,5 mm		
		Fc	Ff	Fp	Fc	Ff	Fp	Fc	Ff	Fp
0.224	210 m/min	1242	577	401	1015	455	346	774	371	311
0.280		1424	599	445	1168	483	388	898	386	337
0.355		1809	672	547	1471	541	464	1127	420	403
0.400		2015	732	606	1634	570	504	1248	450	441
0.224	320 m/min	1211	528	401	998	432	347	764	354	306
0.280		1394	569	450	1142	453	386	877	373	337
0.355		1770	641	542	1455	503	454	1108	397	395
0.400		1966	703	600	1569	523	497	1240	436	437
0.224	390 m/min	1191	536	409	974	422	348	757	344	302
0.280		1382	558	453	1135	449	386	865	358	334
0.355		1763	617	539	1431	499	459	1106	388	343
0.400		1985	698	610	1588	550	511	1224	422	428



# EXPERIMENTAL RESEARCH AND RESULTS



## Cutting forces – graphical analysis



An example of output from software for measuring signals:

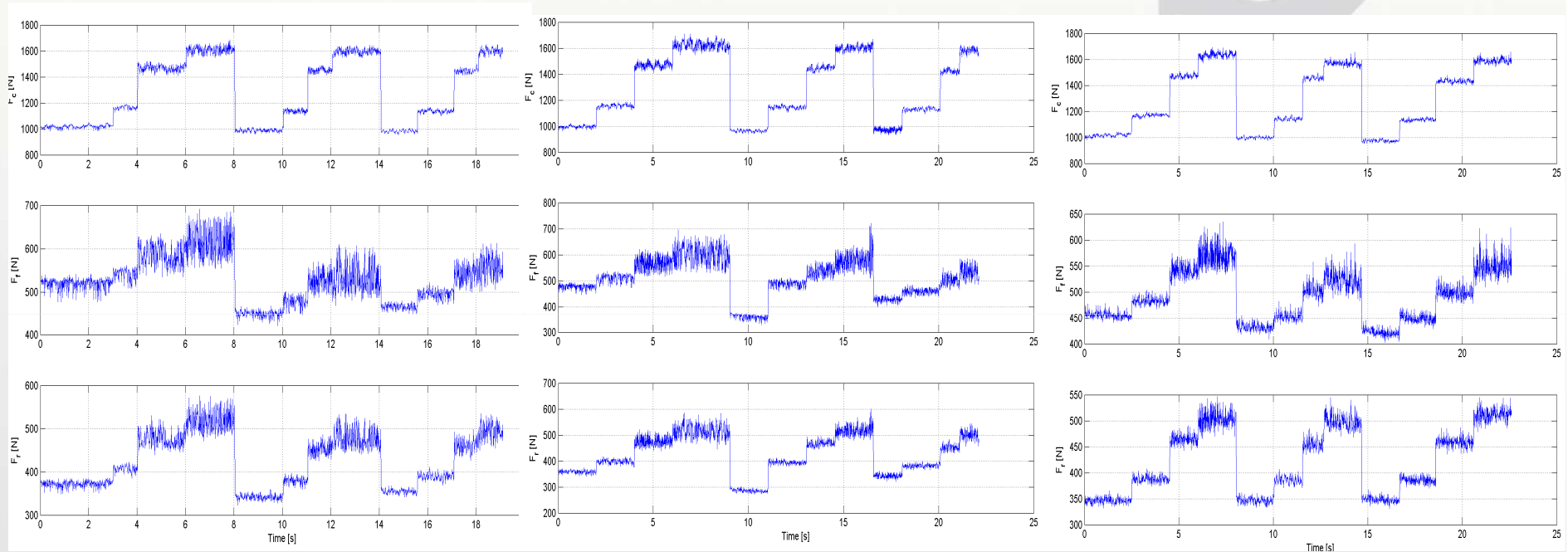
$a = 2,5$  mm

$v_c = 210$  m/min

$f$  - varied in four levels



# EXPERIMENTAL RESEARCH AND RESULTS



Flood

MQL

High pressure

Amplitudes of cutting forces are different for different processes.

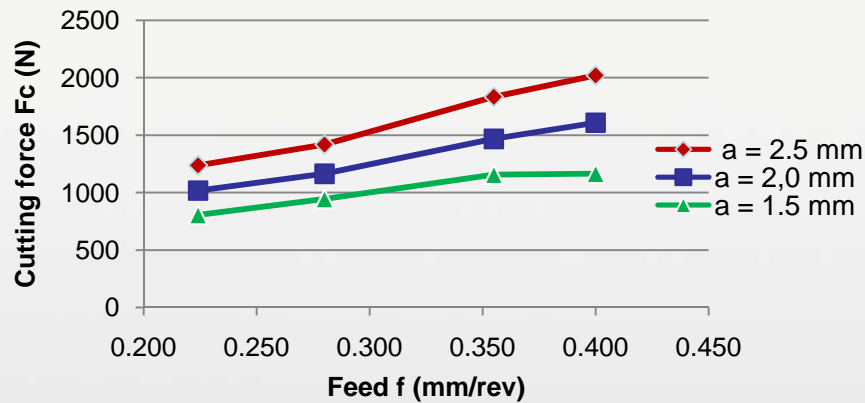


# EXPERIMENTAL RESEARCH AND RESULTS

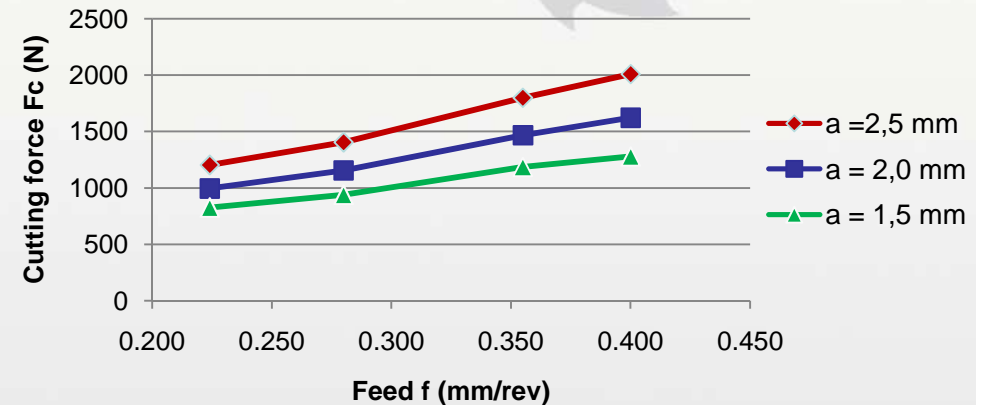


## Cutting forces – graphical analysis

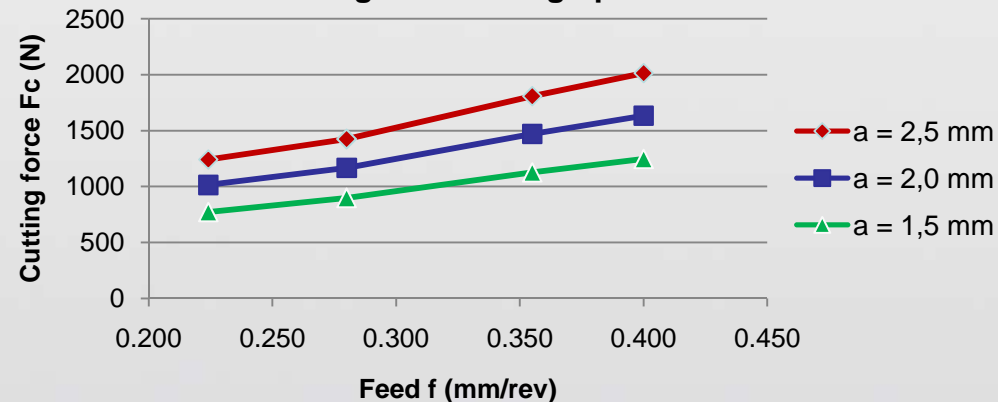
Cutting forces - cutting with flood cooling



Cutting forces - MQL



Cutting forces – High pressure



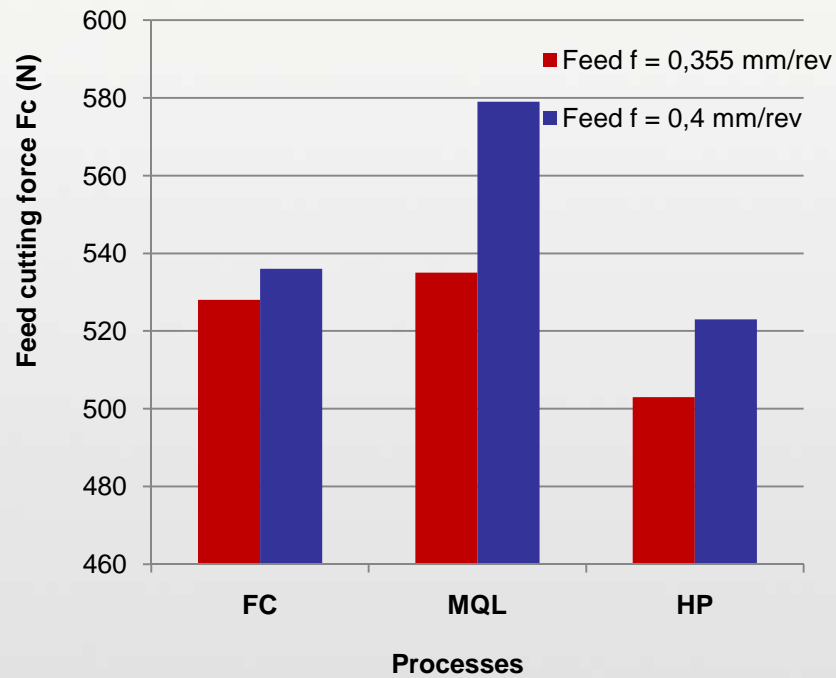


# EXPERIMENTAL RESEARCH AND RESULTS

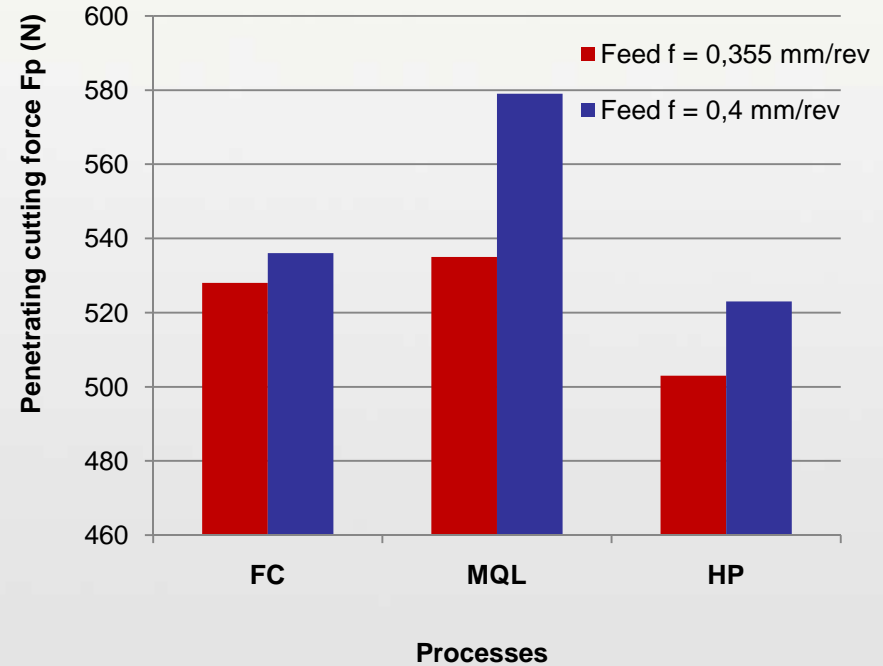


## Cutting forces – graphical analysis

Feed cutting forces for  $a = 2$  mm



Penetrating cutting forces for  $a = 2$  mm

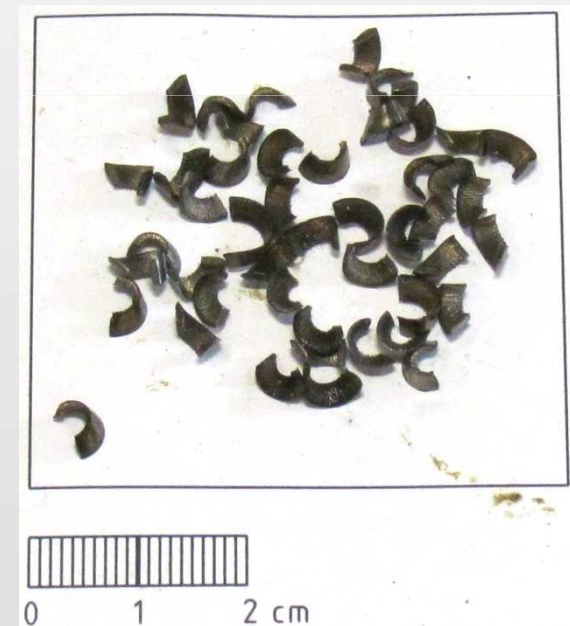




# EXPERIMENTAL RESEARCH AND RESULTS



Chip shape - cutting with flood cooling

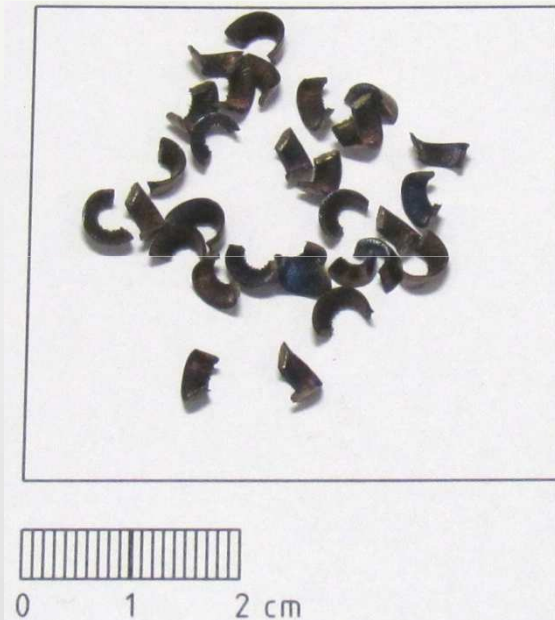




# EXPERIMENTAL RESEARCH AND RESULTS



## Chip shape - MQL

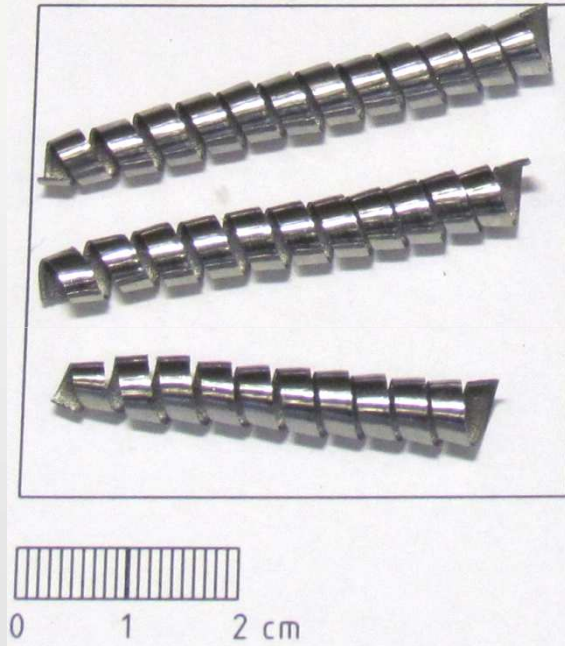




# EXPERIMENTAL RESEARCH AND RESULTS



## Chip shape - High pressure assisted machining

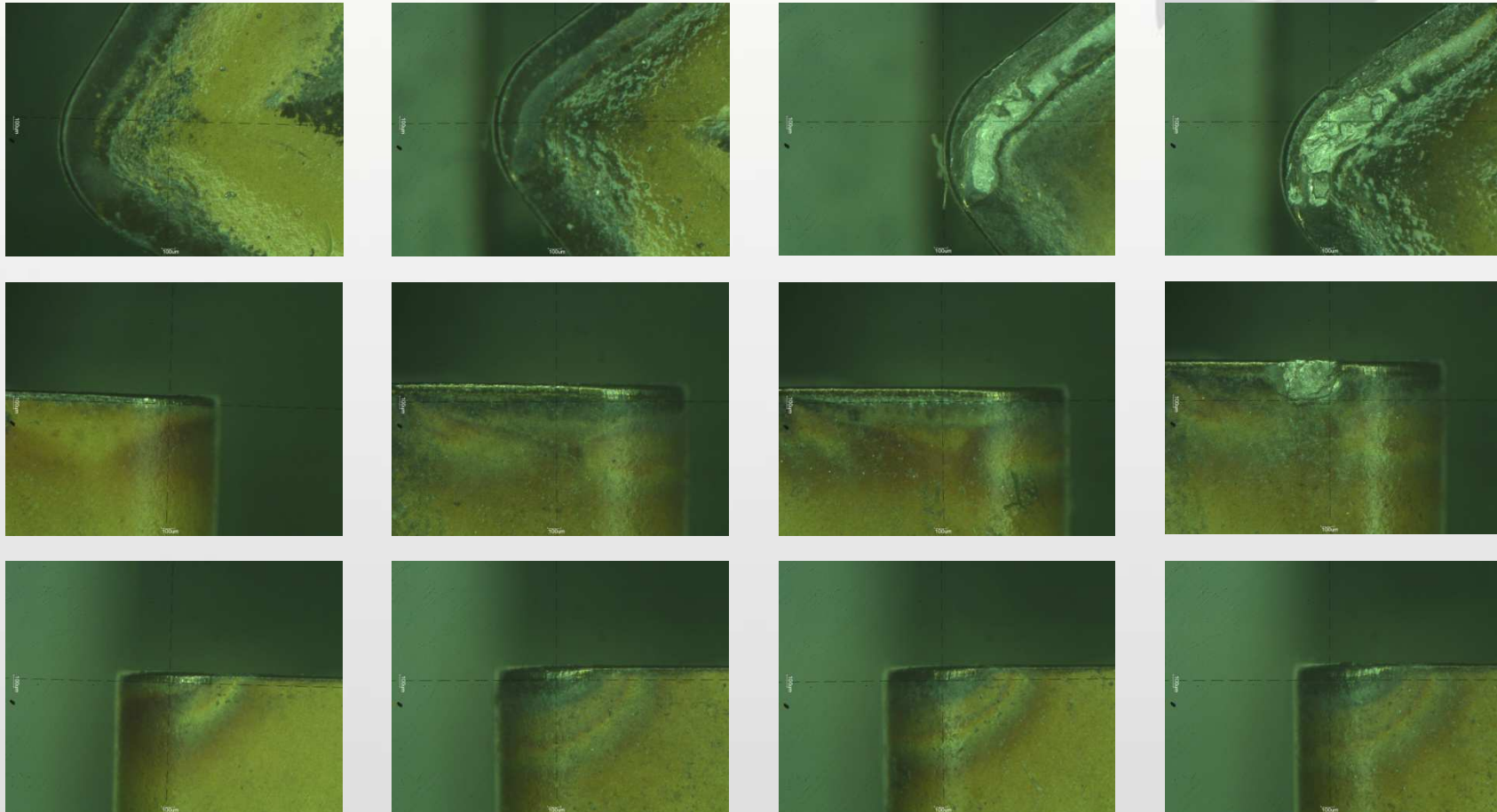




# EXPERIMENTAL RESEARCH AND RESULTS



## Tool wear – Cutting with flood cooling





# EXPERIMENTAL RESEARCH AND RESULTS



## Tool wear – Cutting with flood cooling

Dubina obrade **2**  
 Korak obrade **0.28**  
 Nazivna brzina **320** **FC**

Redni broj mjerenja	0	1	2	3	4	5	6	7
Broj ciklusa	0	2	2	3	4	4	5	5
Vrijeme obrade jednog ciklusa (sec)	0	28	21	21	16	11	16	17
Prečnik (mm)	0	103	98	90	78	62	149	129
Broj obrtaja (1/min)	0	900	1120	1120	1400	1800	710	710
Brzina obrade (m/min)	0	291	345	317	343	350	332	288
<b>Vrijeme obrade (min)</b>	0	0.9	1.6	2.7	3.8	4.5	5.8	7.2
<b>Dužina obrade (m)</b>	0	272	835	1684	2970	4541	6473	8553
Veličina sekundarnog habanja (mm)	0	0.050	0.050	0.050	0.900	0.920	0.101	0.105
Veličina primarnog habanja <b>VB (mm)</b>	<b>0</b>	<b>0.063</b>	<b>0.072</b>	<b>0.075</b>	<b>0.095</b>	<b>0.105</b>	<b>0.120</b>	<b>0.294</b>
Hrapavost površine <b>Ra (μm)</b>	<b>0.00</b>	<b>2.89</b>	<b>2.91</b>	<b>2.92</b>	<b>2.96</b>	<b>3.15</b>	<b>3.34</b>	<b>3.55</b>
Veličina neravnina <b>Ry (μm)</b>	0.00	14.80	14.08	14.69	14.89	15.20	17.61	17.23

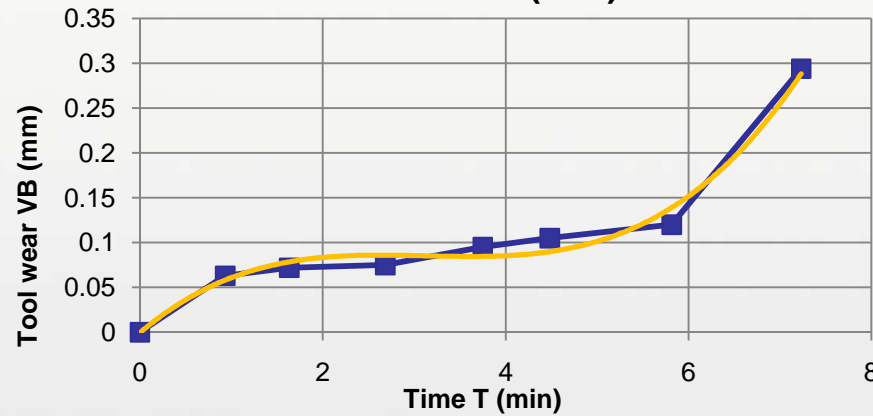


# EXPERIMENTAL RESEARCH AND RESULTS

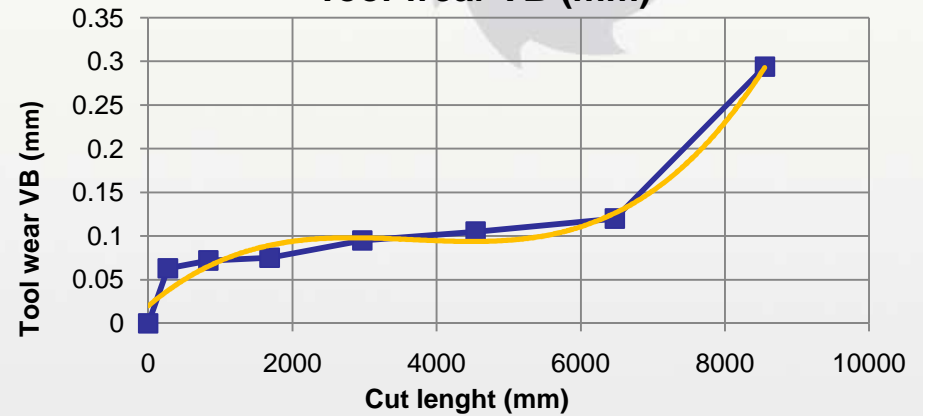


## Tool wear – Cutting with flood cooling

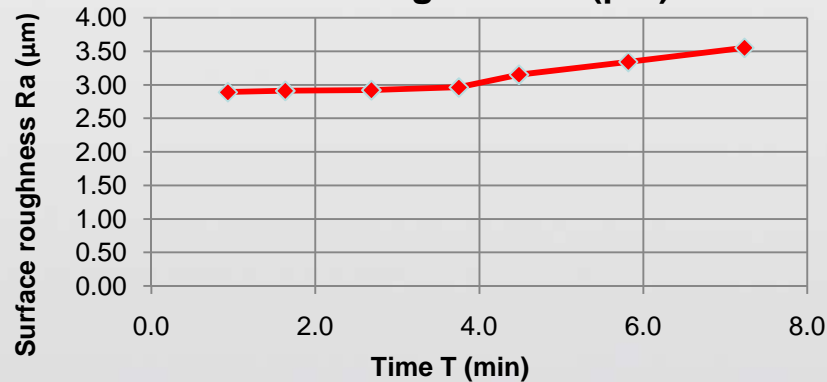
Tool wear VB (mm)



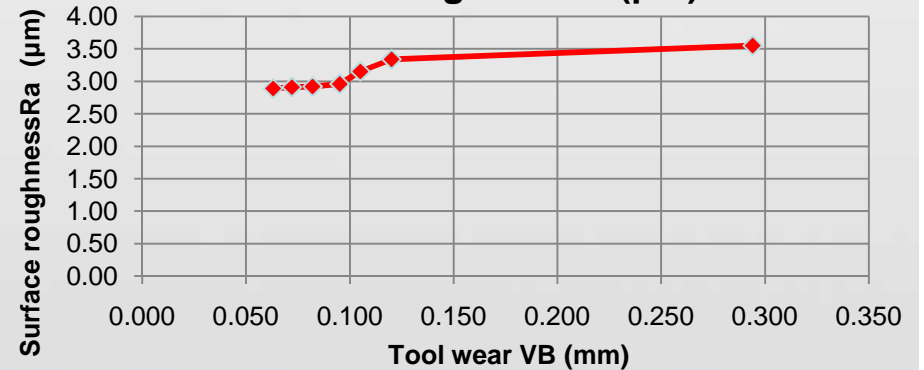
Tool wear VB (mm)



Surface roughness Ra ( $\mu\text{m}$ )



Surface roughness Ra ( $\mu\text{m}$ )

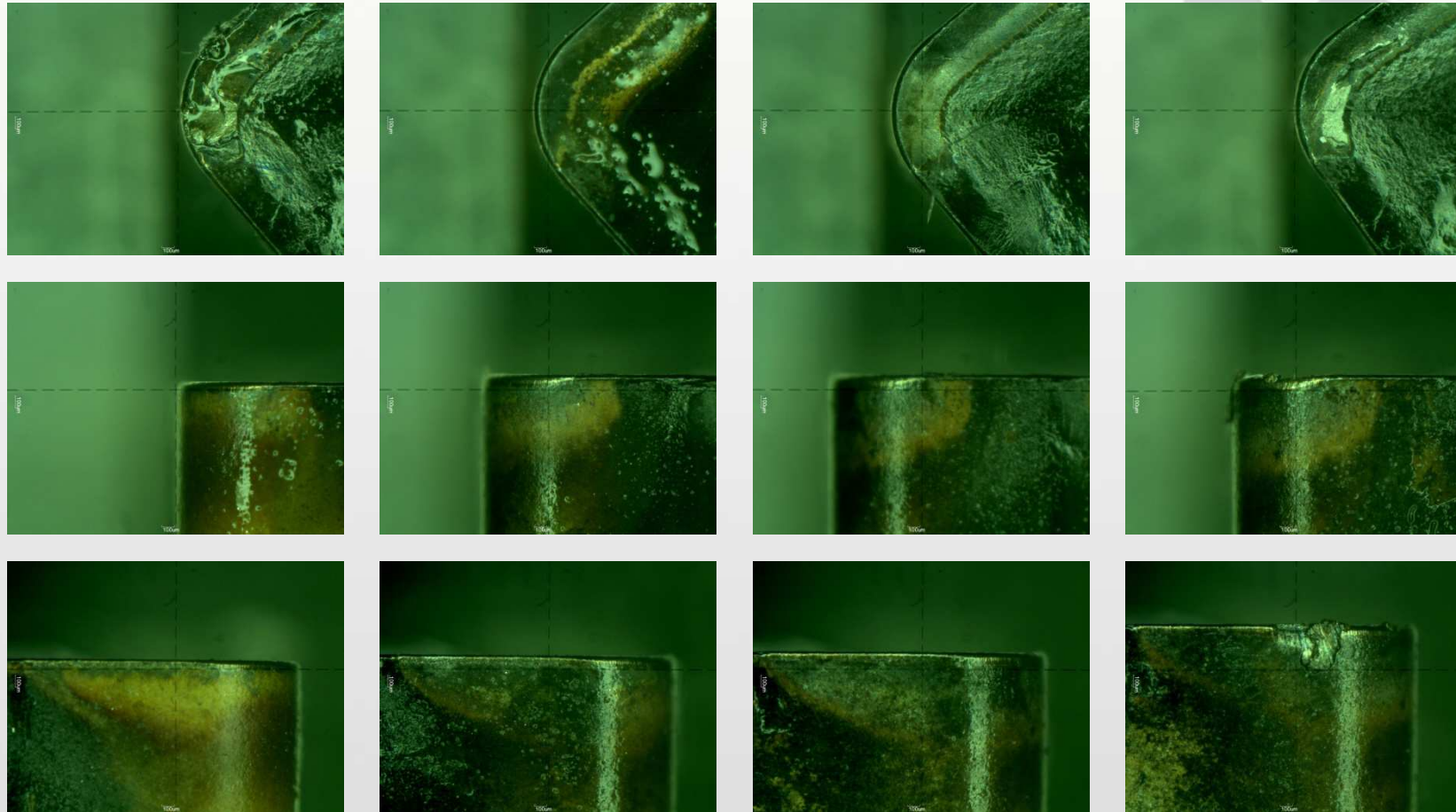




# EXPERIMENTAL RESEARCH AND RESULTS



## Tool wear – MQL





# EXPERIMENTAL RESEARCH AND RESULTS



## Tool wear – MQL

	2		MQL					
	0.355							
	320							
Redni broj mjerenja	0	1	2	3	4	5	6	7
Prečnik obrade(mm)	0	109	97	81	65	148	132	116
Broj obrtaja (1/min)	0	900	1120	1120	1400	710	710	900
Brzina obrade (m/min)	0	308	341	285	286	330	294	328
Broj ciklusa obrade	0	3	4	4	5	4	4	4
Vrijeme jednog ciklusa (sec)	0	22	18	18	17	15	16	22
<b>Vrijeme obrade (min)</b>	0.0	1.1	2.3	3.5	4.9	5.9	7.0	8.5
<b>Dužina obrade (m)</b>	0	339	1123	2120	3525	5478	7533	10303
Veličina sekundarnog habanja (mm)	0	0.032	0.063	0.064	0.068	0.091	0.101	0.105
Veličina primarnog habanja VB (mm)	0	0.058	0.086	0.094	0.100	0.117	0.119	0.301
Hrapavost površine Ra (µm)	0	3.34	3.37	3.27	3.34	3.26	3.30	3.04
Veličina neravnina Ry (µm)	0	15.59	16.43	16.08	15.69	15.11	22.09	12.92

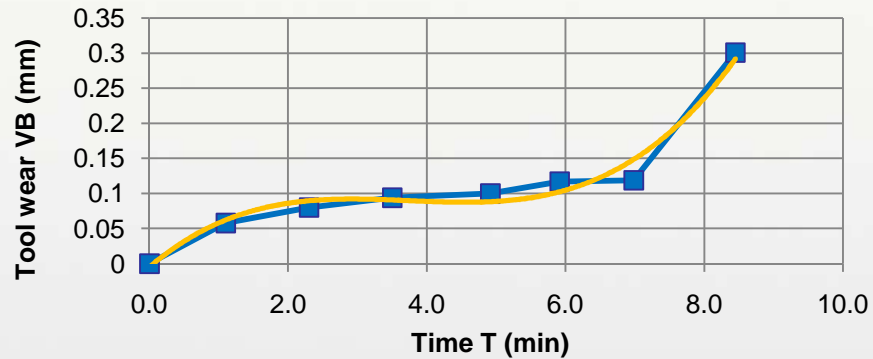


# EXPERIMENTAL RESEARCH AND RESULTS



## Tool wear – MQL

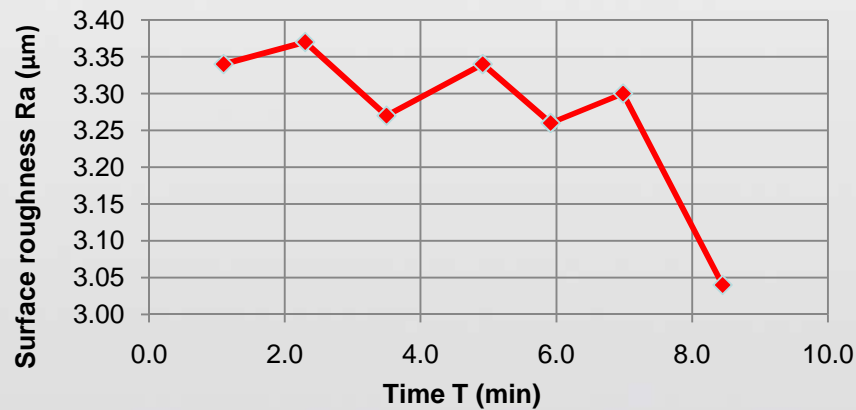
### Tool wear VB (mm)



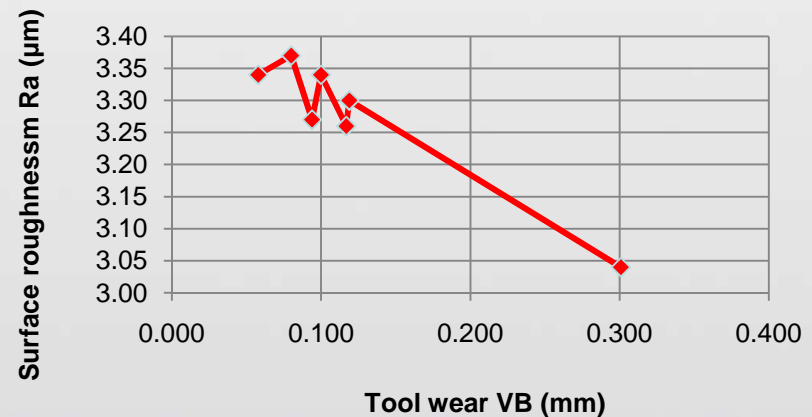
### Tool wear VB (mm)



### Surface roughness Ra ( $\mu\text{m}$ )



### Surface roughness Ra ( $\mu\text{m}$ )

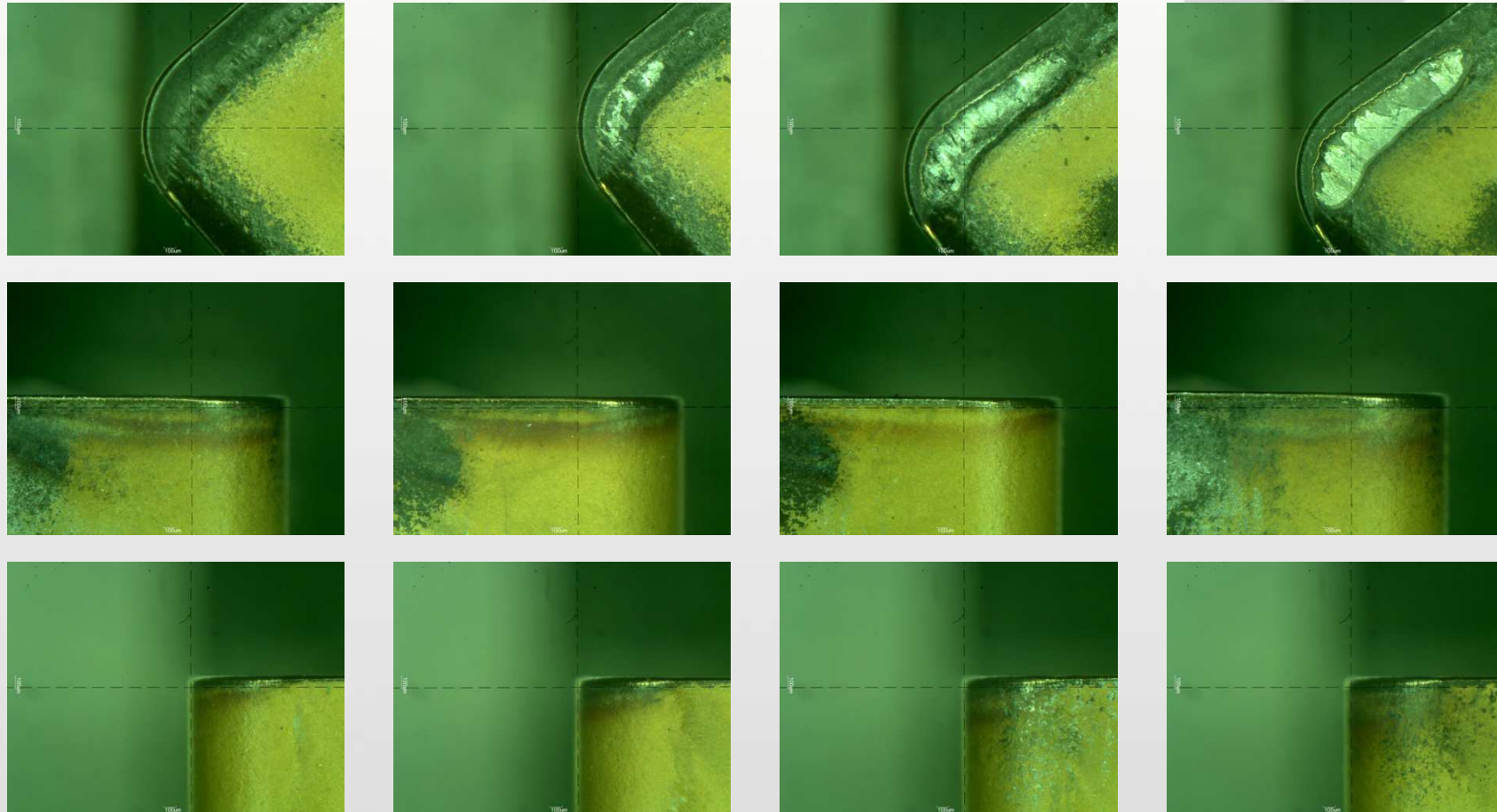




# EXPERIMENTAL RESEARCH AND RESULTS



## Tool wear – High pressure assisted machining





# EXPERIMENTAL RESEARCH AND RESULTS



## Tool wear – High pressure assisted machining

	2		HP					
Dubina obrade	0.355							
Korak obrade	320		Prosječna brzina					
Nazivna brzina			319					
Redni broj mjerenja	0	1	2	3	4	5	6	7
Prečnik obrade(mm)	0	100	92	80	64	98	82	66
Broj obrtaja (1/min)	0	1120	1120	1400	1400	1120	1120	1400
Brzina obrade (m/min)	0	352	324	352	281	345	288	290
Broj ciklusa obrade	0	2	3	3	4	4	4	4
Vrijeme jednog ciklusa (sec)	0	22.5	23	19	18	23	24	20
<b>Vrijeme obrade (min)</b>	0	0.8	1.9	2.9	4.1	5.6	7.2	8.5
<b>Dužina obrade (m)</b>	0	264	878	1881	3020	4945	7016	9487
Veličina sekundarnog habanja (mm)	0	0.061	0.062	0.068	0.071	0.073	0.074	0.075
Veličina primarnog habanja VB (mm)	0	0.061	0.068	0.071	0.079	0.081	0.087	0.097
Hrapavost površine Ra (μm)	0	3.24	3.34	3.36	3.22	3.32	3.36	3.38
Veličina neravnina Ry (μm)	0	14.37	15.04	22.60	14.18	14.49	15.96	15.28

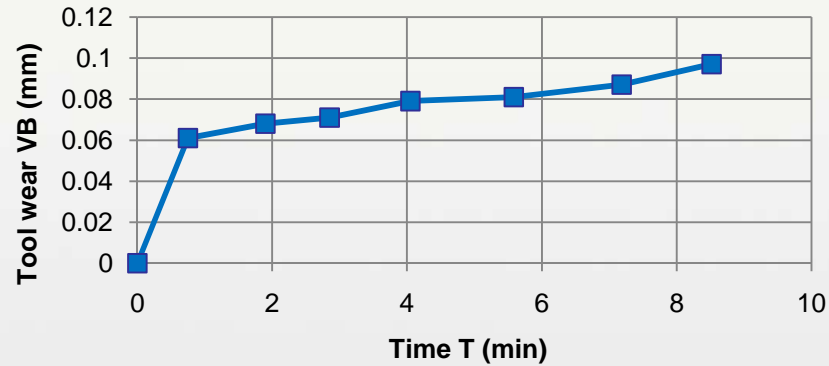


# EXPERIMENTAL RESEARCH AND RESULTS

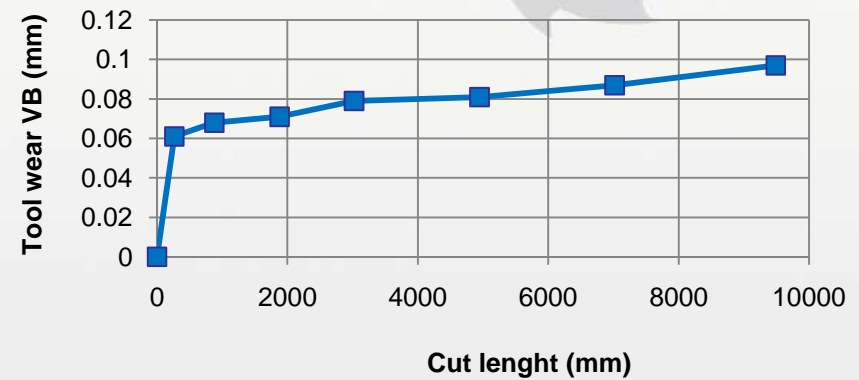


## Tool wear – High pressure assisted machining

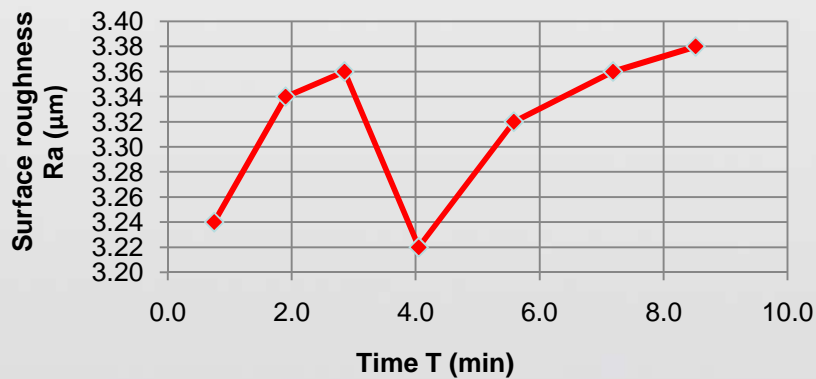
### Tool wear VB (mm)



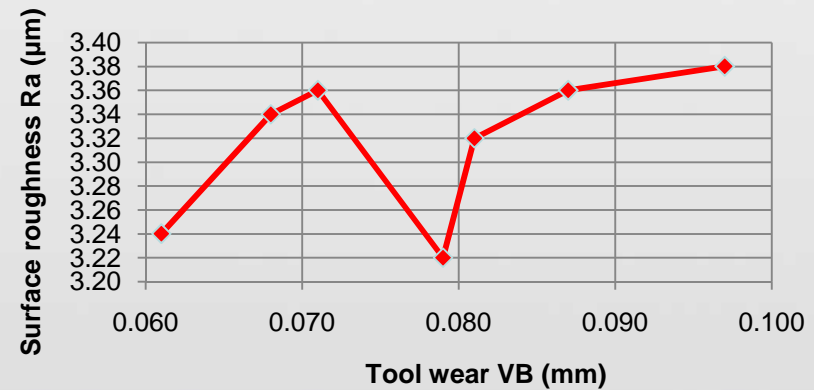
### Tool wear VB (mm)



### Surface roughness Ra ( $\mu\text{m}$ )



### Surface roughness Ra ( $\mu\text{m}$ )



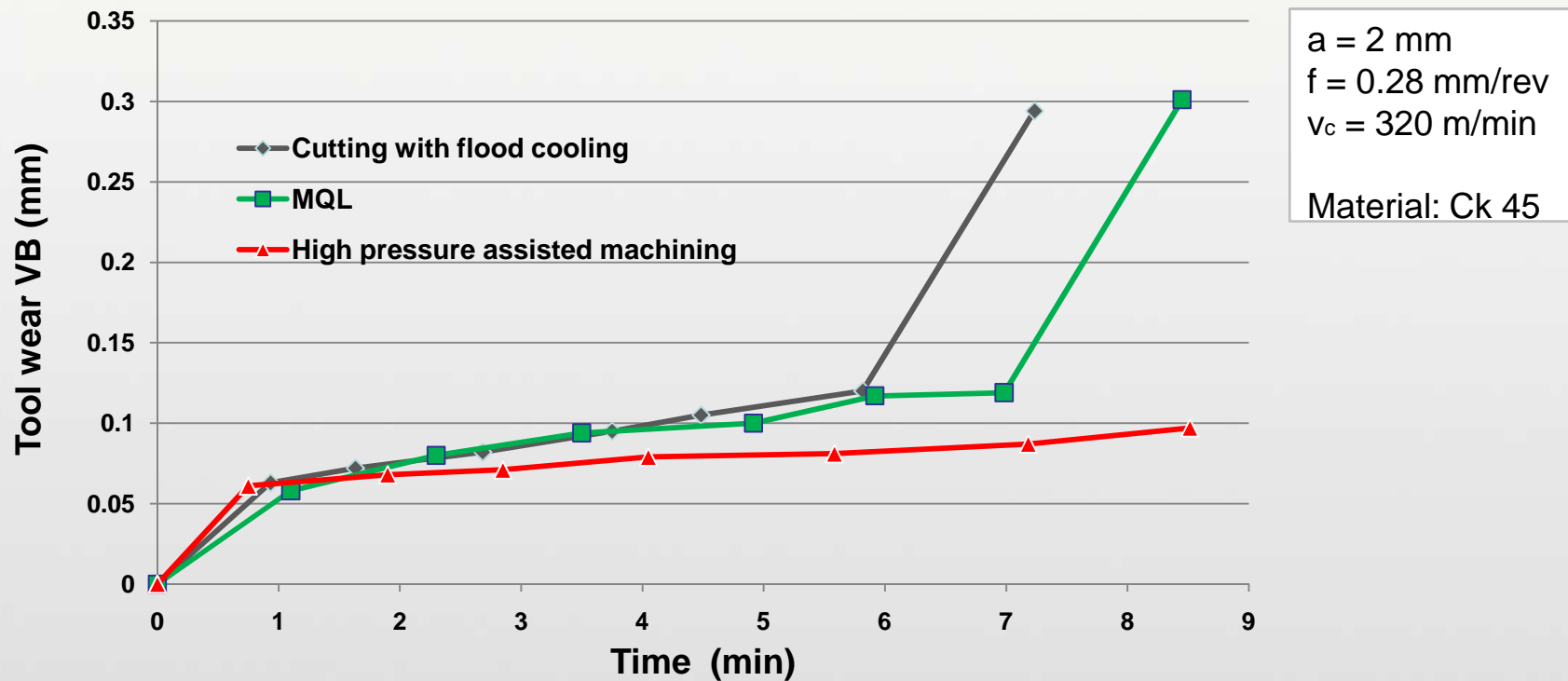


# EXPERIMENTAL RESEARCH AND RESULTS



## Tool wear – summary review

### Tool wear



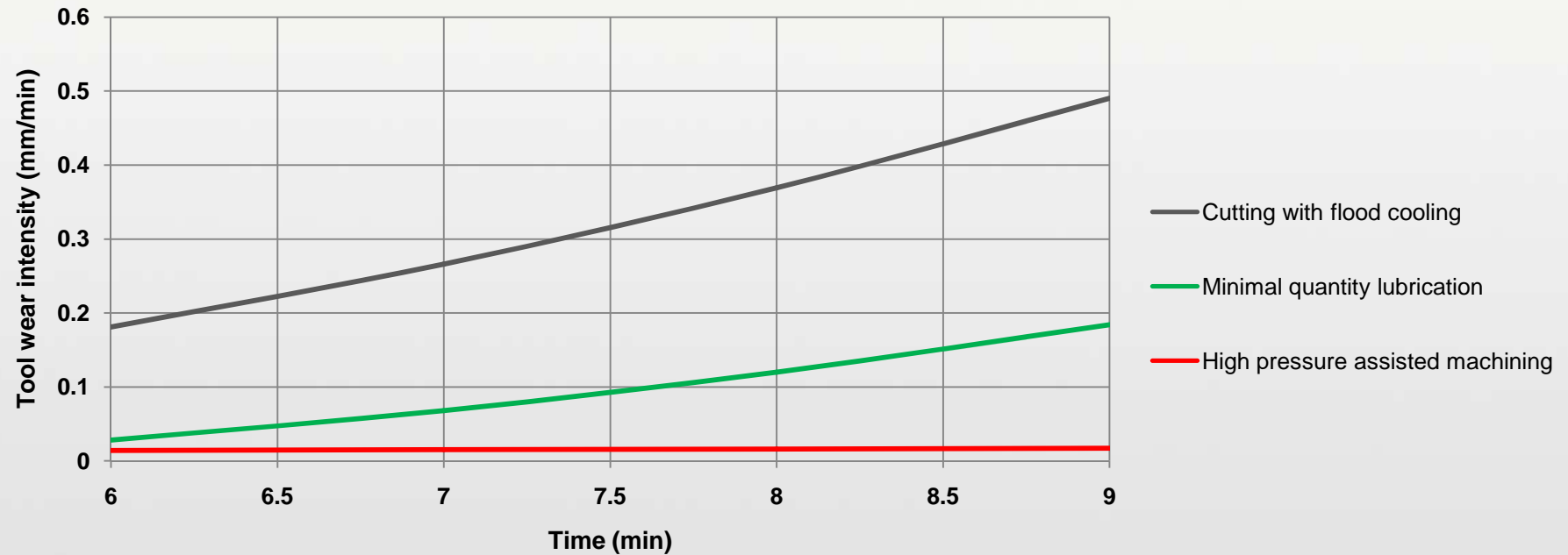


# EXPERIMENTAL RESEARCH AND RESULTS



## Intensity of tool wear – summary review

Intensity of tool wear





# CONTENT



1. My impressions about LABOD
2. What I learned during the visit
3. Eksperimental research and results
4. Future plans



## FUTURE PLANS



### Following can be done:

- Modeling and analysis of results with different approaches,
- Technological windows,
- Empirical equations of cutting forces,
- Analysis of chip type for different processes and parameters,
- Analysis of tool wear for different processes and parameters,
- Analysis of surface roughness,
- Analysis of individual machinability,
- Analysis of **universal machinability**,
- Analysis of material removal rate and economic analysis,
- Some type of optimization,
- **Software** for machinability analysis and monitoring.



**THANKS FOR YOUR ATTENTION!**





*VESEL BOŽIČ I SREČNO NOVO LETO!*

**Thanks You very much for all!**

**See you!**

