PMRC IAB Meeting

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Turning Hardened Steel Using Rotary Tool

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Overview

1. Introduction
2. Self-propelled rotary tools (SPRT)
3. Surface integrity study
4. Temperature prediction model
5. Ongoing/Future work
6. Conclusions

Introduction

Introduction	SPRT	Surface integrity	Temperature model	Next studies	Conclusions
Situation	Challenges				

- Turning process being considered by industry to finish machine hardened steel parts
- Should be competent with well-established grinding process
- Challenges in hard turning process:
  - Surface integrity (white layer)
  - Economical tool life
- Studies on surface integrity and tool wear important to make hard turning viable

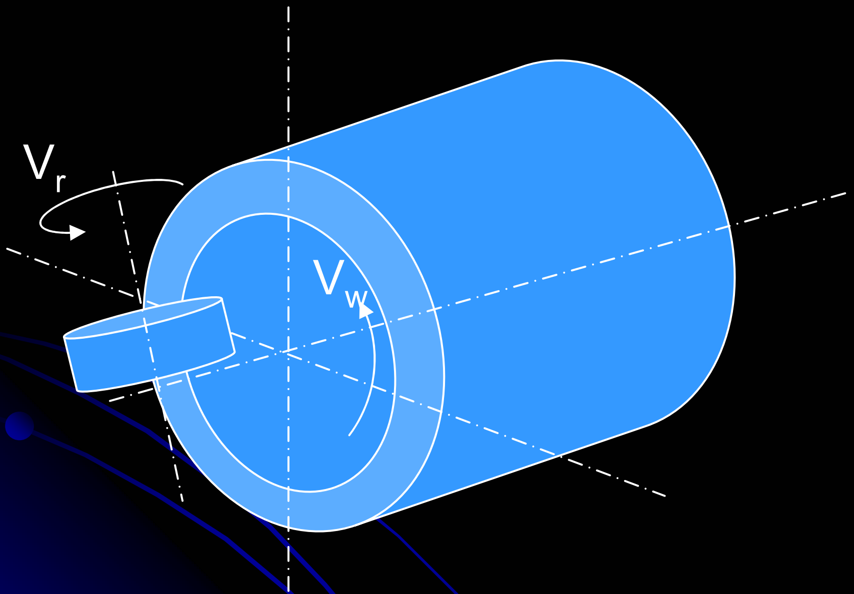
Hard Turning Challenges

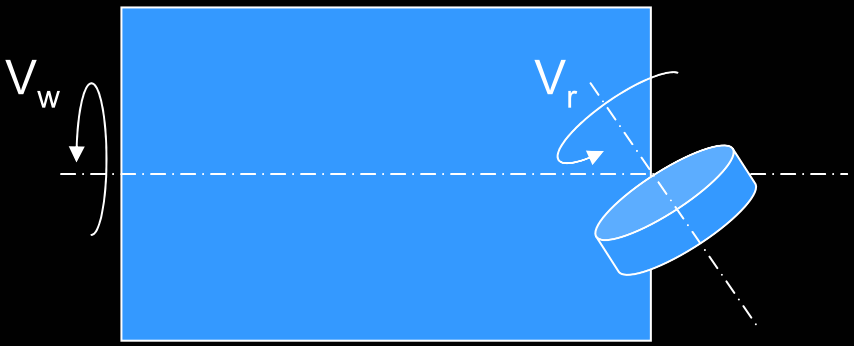
Introduction	SPRT	Surface integrity	Temperature model	Next studies	Conclusions
Situation	Challenges				

- White layer:
  - Featureless layer after etching
  - Different properties from bulk
  - Not desirable
  - Formed easily under aggressive conditions
  - Thermal phenomenon suspected
  - Need to reduce temperature
- Tool wear:
  - PCBN tool wear can be high
  - Need to improve tool life

Rotary Tools

Introduction	SPRT	Surface integrity	Temperature model	Next studies	Conclusions
Process	Features				



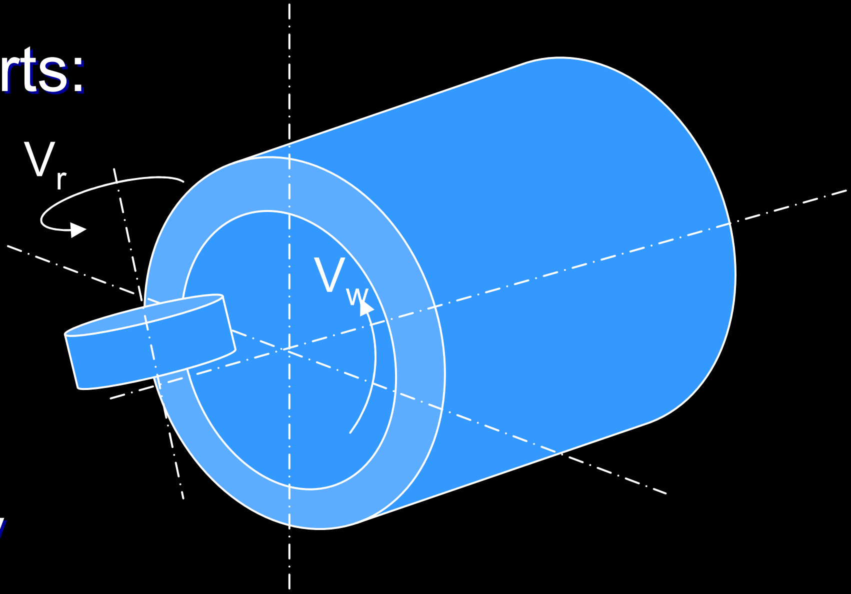


Self-propelled rotary tool process.

Features of Rotary Tool

Introduction	SPRT	Surface integrity	Temperature model	Next studies	Conclusions
Process	Features				

- With rotary tools, literature reports:
  - Lower cutting temperature
  - Lower forces
  - Lower tool wear
- Effect of this on hard turning?
  - Task 1: Surface integrity study
  - Task 2: Temperature and wear studies

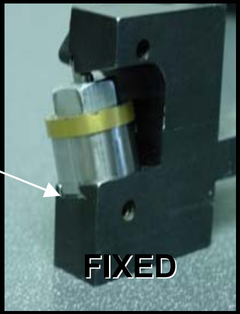


Task 1: Surface Integrity

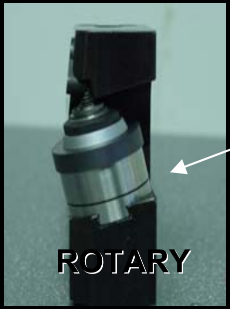
Introduction	SPRT	Surface integrity	Temperature model	Next studies	Conclusions
Situation	White layer	Conclusions			

- Perform experiments to compare surface integrity under fixed and rotary tool conditions

Fixed tool cartridge made similar to rotary unit



V = 60 m/min,
80 m/min,
100 m/min
f = 0.2 mm/rev
DOC 0.1mm



Rotary cartridge

- Workpiece: 52100 steel; ~58 HRc
- Tool: micrograin carbide with proprietary nano-coating (Rotary Technologies Inc.)
- Hardinge Precision Lathe T42SP
- Thermal analysis to confirm observed trends

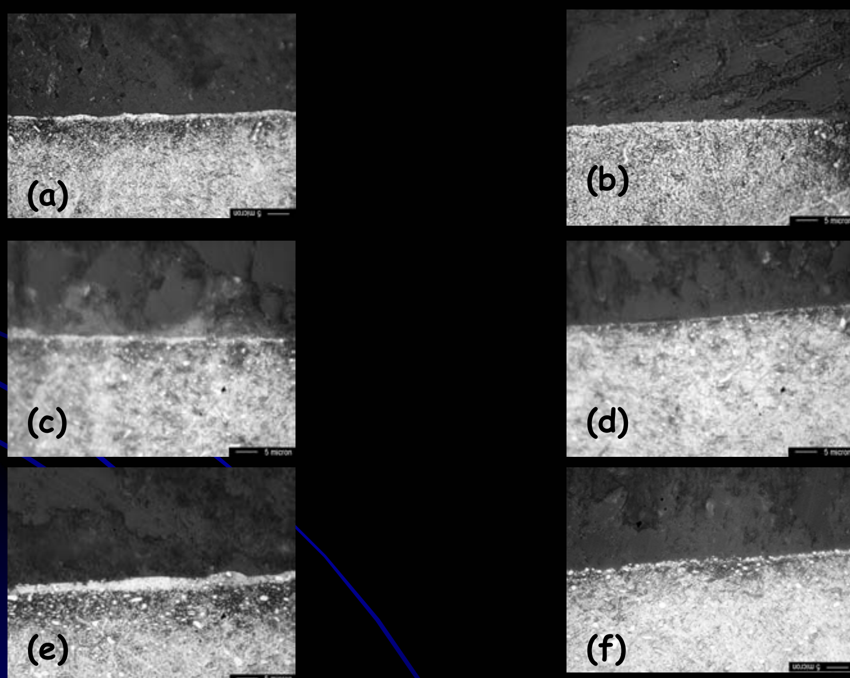
Task 1: Surface Integrity

Fixed Rotary

V60

V80

V100



- Well established theories in orthogonal, oblique and rotary tool cutting used
- Q: amount of heat transferred to workpiece
- R_1: heat partition coefficient

	FIXED		ROTARY	
	R_1	Q (J)	R_1	Q (J)
V100	0.36	188.4	0.53	6.7
V 80	0.34	141.1	0.50	11.8
V60	0.31	131.9	0.46	18.5

Surface Integrity Summary

Introduction	SPRT	Surface integrity	Temperature model	Next studies	Conclusions
Situation	White layer	Conclusions			

- White layer less likely to form under rotary tool cutting
- Lower tool wear seen in rotary cutting
- Worn tools are known to produce white layer
- Analytical calculations show less heat is going into workpiece
- A combination of thermal and lower wear could be the cause of the thin/absent white layer

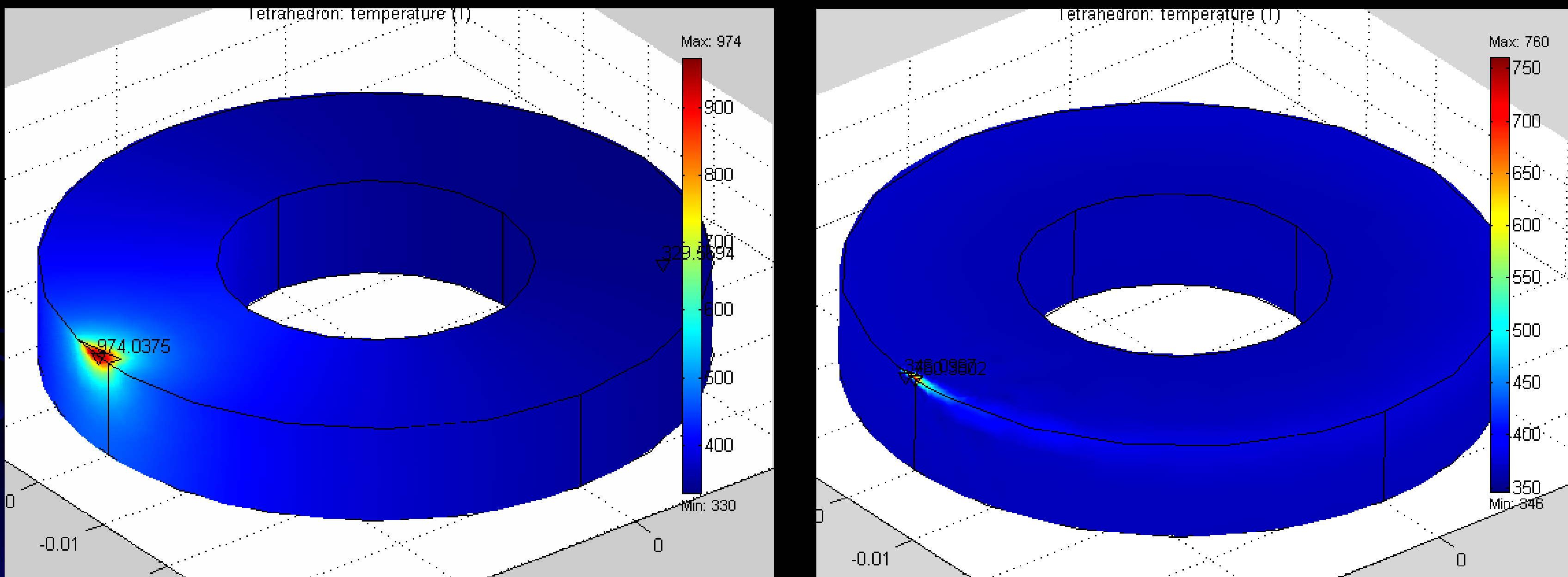
Task 2: Temperature Modeling

Introduction	SPRT	Surface integrity	Temperature model	Next studies	Conclusions
General	Results	Discussions			

- The analysis is based on data given by Shaw in a previous study when turning a steel tube with a *driven* orthogonal rotary tool
- The approach uses the finite element method (FEM). The required equation is derived from heat conduction theory
- The method involves modeling the rotating tool with a transport term added to the heat equation
- Numerical computation is performed with FEMLAB

Temperature Distribution

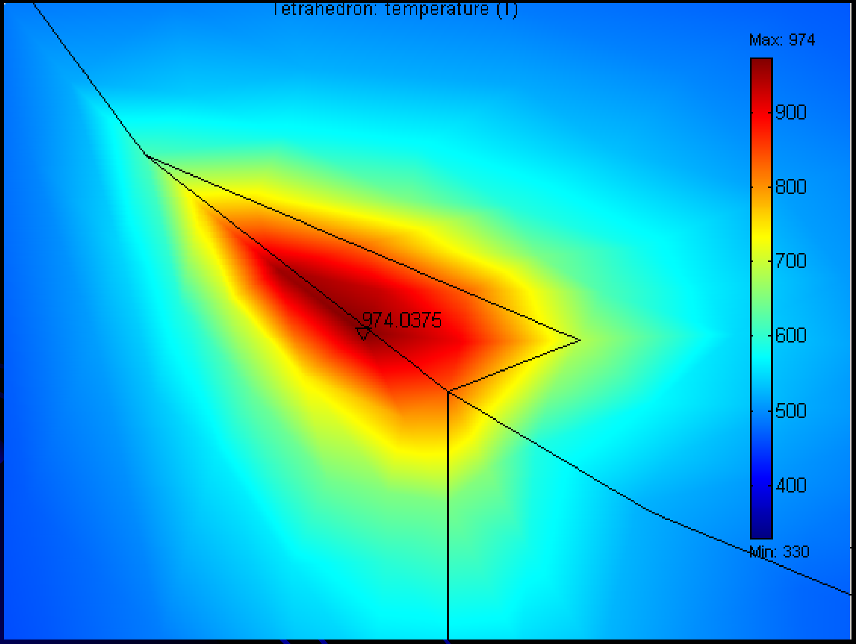
Introduction	SPRT	Surface integrity	Temperature model	Next studies	Conclusions
General	Results	Discussions			

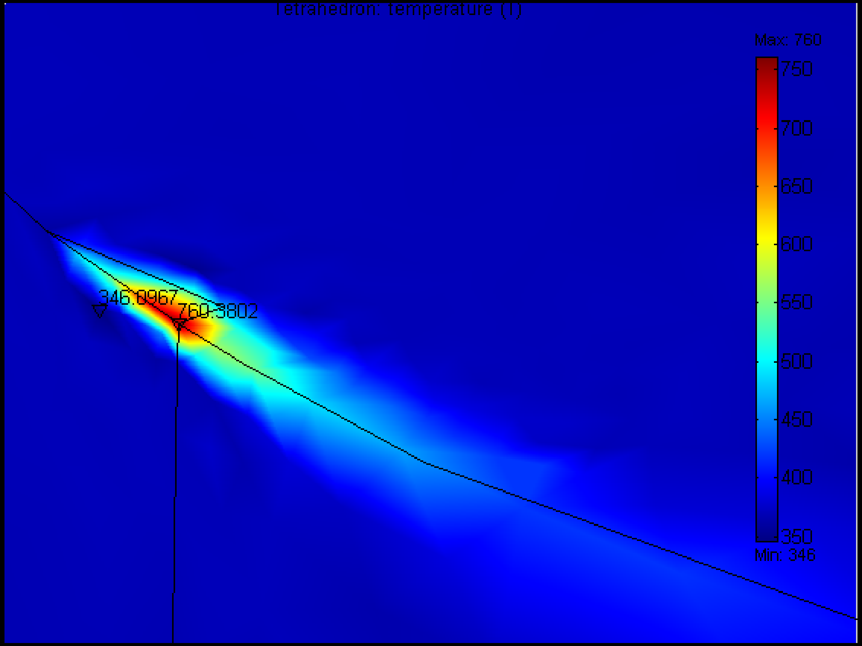


Temperature distributions in fixed and rotary tools

Temperature Distribution

Introduction	SPRT	Surface integrity	Temperature model	Next studies	Conclusions
General	Results	Discussions			





Temperature distributions in fixed and rotary tools

Cutting Temperature

Introduction	SPRT	Surface integrity	Temperature model	Next studies	Conclusions
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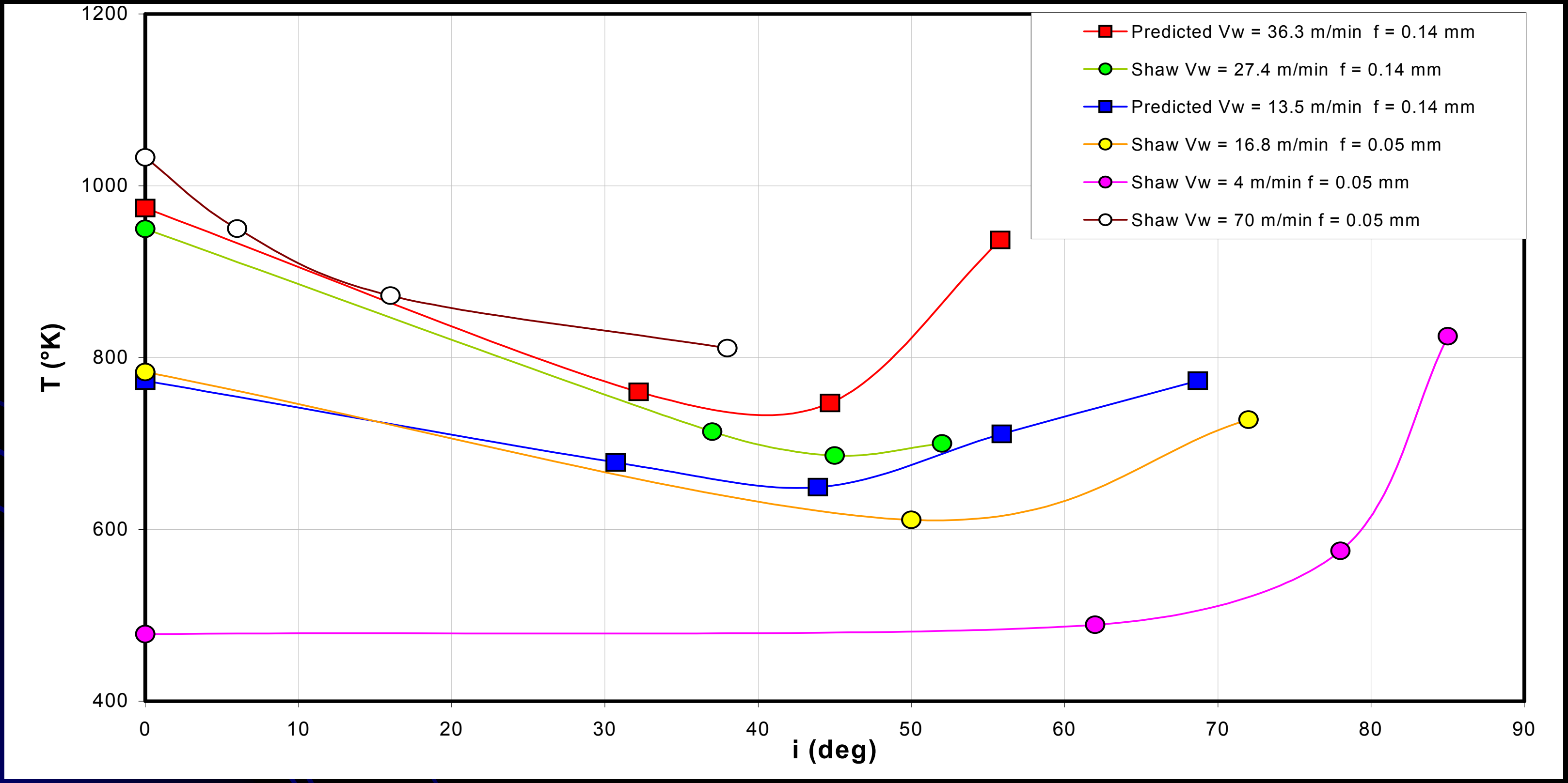

Discussion

Introduction	SPRT	Surface integrity	Temperature model	Next studies	Conclusions
General	Results	Discussions			

- Model needs tool-chip interface geometry parameters
- This model can also be used for a self-propelled rotary tool process
- Results given by the model show good agreement with measurements of Shaw
- Rotary tool temperatures are about 200°C lower than for an equivalent fixed tool
- Results thus far are promising for planned study of rotary tool wear

Ongoing/Future Work

- Further validate the temperature prediction model
- Compare the temperature distributions for both fixed and rotary tools
- Correlate temperature and wear of fixed and rotary tools
- Tool life

Conclusions

Introduction	SPRT	Surface integrity	Temperature model	Next studies	Conclusions

- Improved surface integrity with rotary tool
- The lower temperature prediction is promising in terms of rotary tool wear
- These two aspects should make rotary tool hard turning viable

Acknowledgement

- Caterpillar Inc.
- Rotary Technologies Inc.
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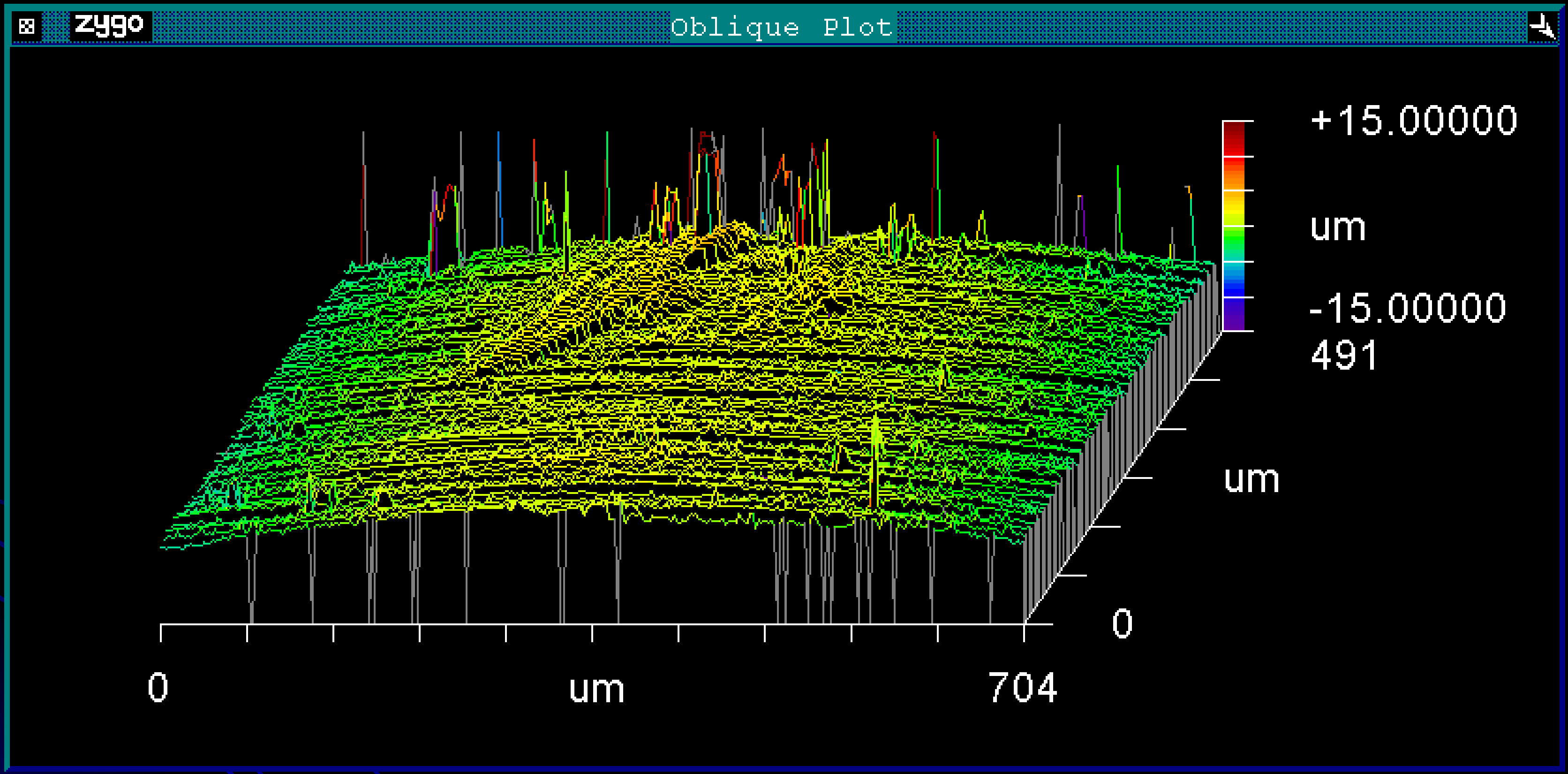
Thank you for your attention.

Any questions or comments?

Flank wear



Flank wear