EAPSI 2015: Combination of Non-Axisymmetric Cutting and Polishing for Engine Components

By Max Stein

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Abstract

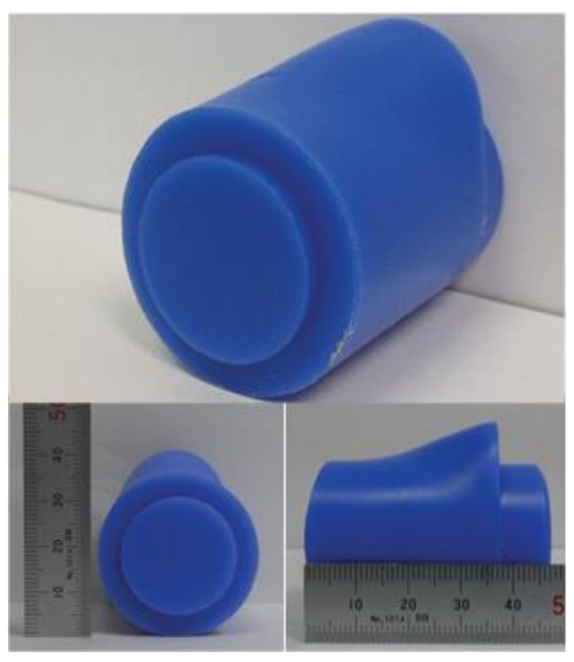
Non-axisymmetric components are prevalent in many engineering applications. Fabrication of these components requires multiple extremely precise computer numerically-controlled (CNC) cutting and grinding processes. Combining these processes into one machine would greatly reduce the cost of producing these parts both in terms of time and money, and decrease position errors caused by the un-chucking and re-chucking of the workpiece across multiple machines. Recently, Professor Yoshitaka Morimoto of the Kanazawa Institute of Technology in Japan has created a new machine capable of Non-Axisymmetric Curved Surface Turning (NACS-Turning). Using this new technology, this project focuses on the combination of NACS-Turning with the PI's work on Magnetic Abrasive Finishing (MAF) in a single setup to produce non-axisymmetric components for internal combustion engines. This will create a new machine capable of completely machining non-axisymmetric components from rough cutting to polishing with only a single chucking of the workpiece.

Research Objectives

- Integrate MAF into the existing NACS-Turning machine
- Determine necessary MAF parameters to finish D2 tool steel (SKD11)
- Characterize MAF material removal mechanism during finishing of components
- Determine feasibility of applying hybrid-tool MAF to magnetic, free-form components
- Publish results in reverent journals and present results at relevant conferences
- Utilize results in PI's masters thesis

NACS-Turning

- Faster than traditional grinding processes
- Leaves a periodical cutting marks



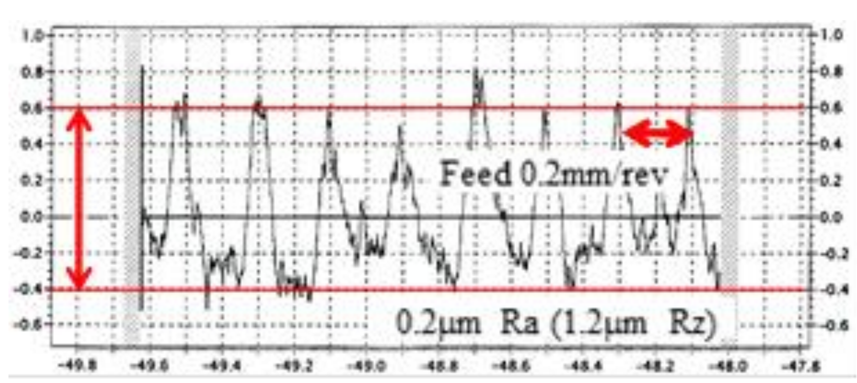


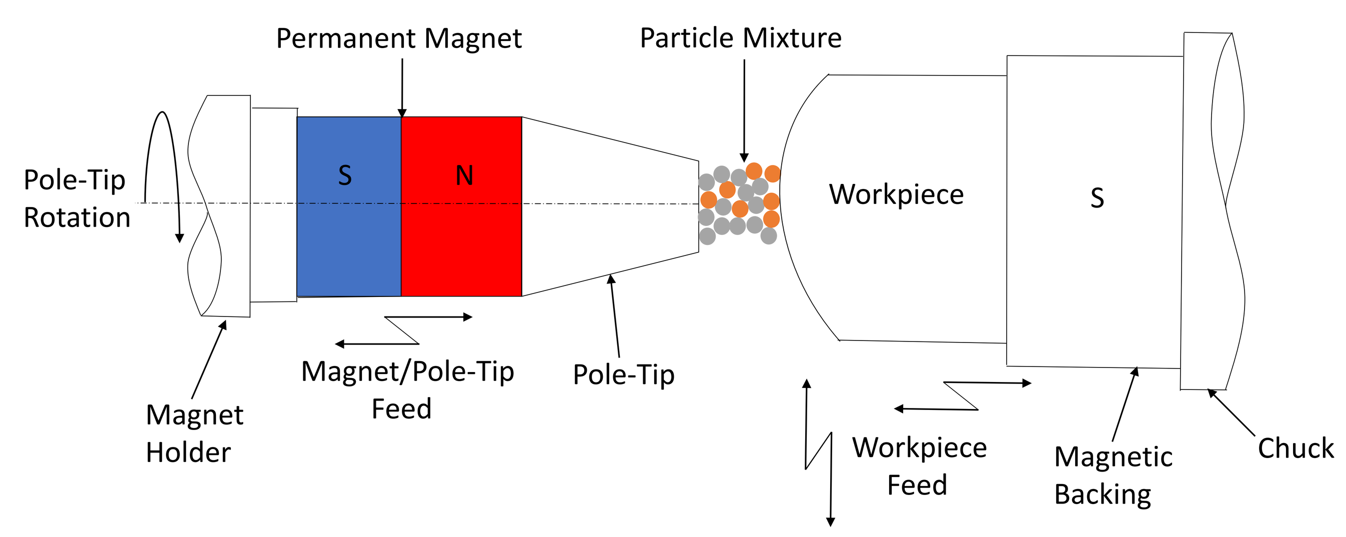
Figure 2: Typical surface profile created using NACS-Turning (courtesy of Prof. Morimoto)

Figure 1: Typical surface created using NASC-Turning [1]

Free-Form MAF

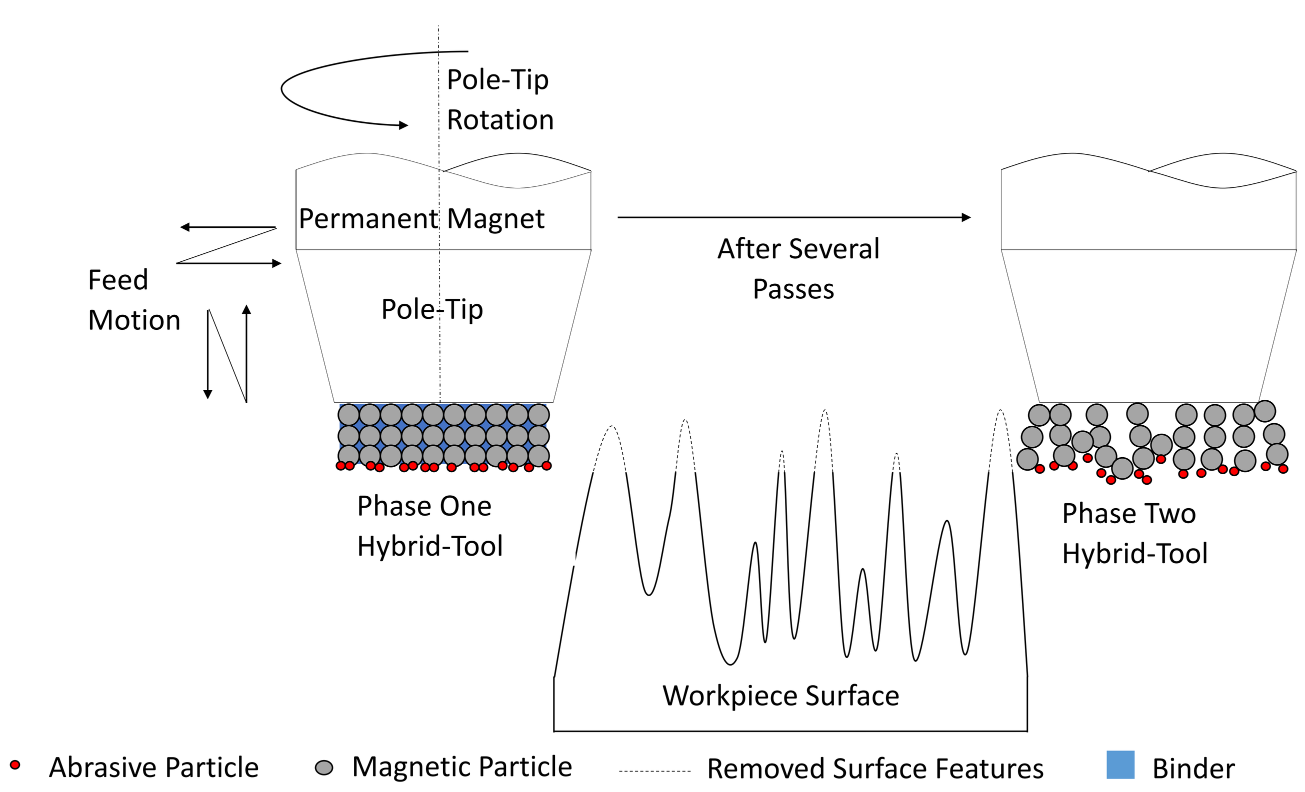
- Uses a magnetic field to manipulate magnetic and abrasive particles for material removal
- Equation for force [2]:

$$F = V\chi H \cdot \nabla H$$



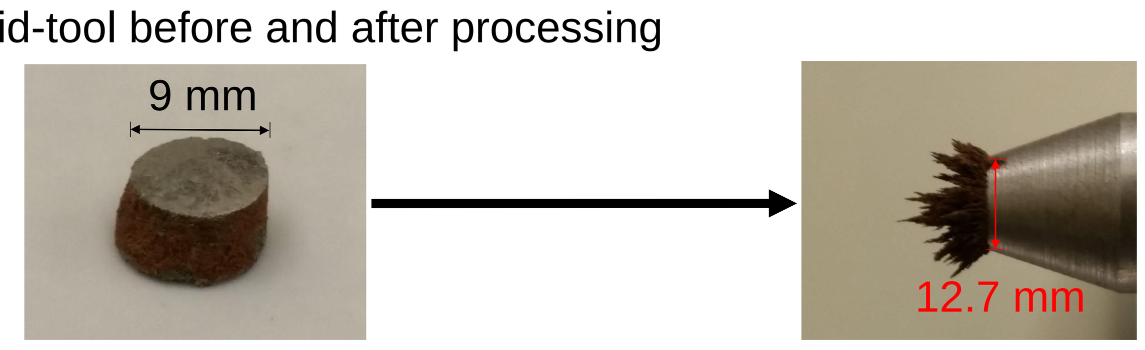
Hybrid-Tools

- Dual phase technology
  1. Grinding phase (fixed abrasive phase)
  2. Polishing phase (loose abrasive phase)

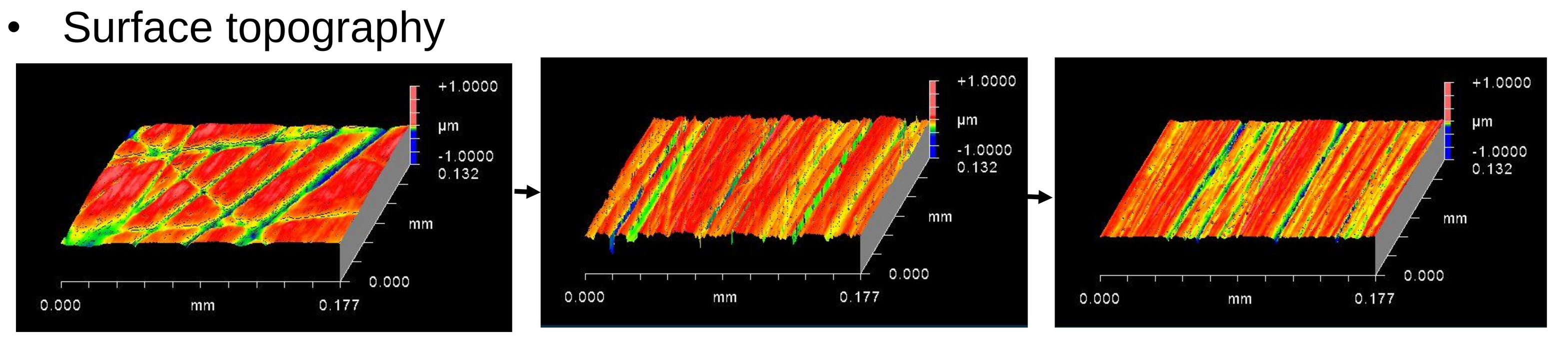


Preliminary Testing

- Hybrid-tool before and after processing



- Surface topography



Initial surface	4-8 μm abrasive	0-1 μm abrasive
Sa = 0.032 μm	*Sa* = 0.062 μm	*Sa* = 0.022 μm
Sz = 0.557μm	*Sz* = 1.165 μm	*Sz* = 0.617 μm

References

[1] Creation of Curved Surface by Lathe Turning – Development of CAM system using original tool layout. Morimoto. Y, et. al. 5th CIRP Conference on High Performance Cutting, 2012.

[2] Magnetic abrasive finishing of cutting tools for machining titanium alloys. Yamaguchi H., et. al. CIRP Annals – Manufacturing Technology 61, 311-314, 2012.

Acknowledgements

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