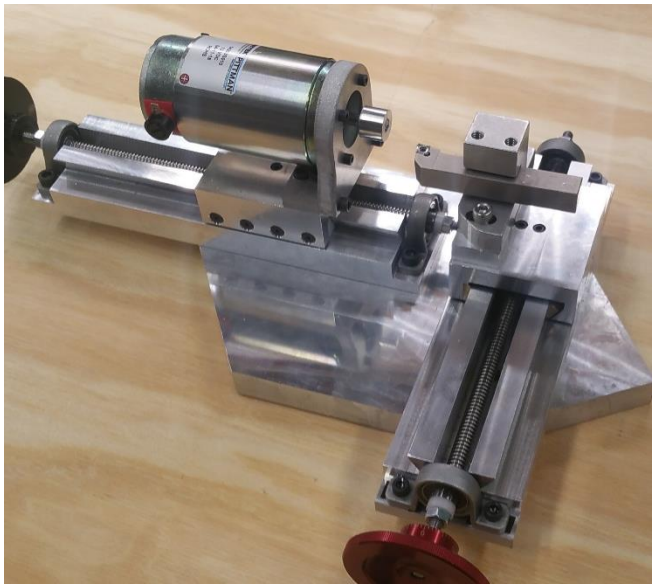
T-based Lathe – PROJECT SUMMARY

2.77 Precision Machine Design

VICTOR PROST – SPRING 2018

Project Goal

The goal of this work was to design a T-based lathe to face a 5/8" diameter aluminum part with a maximum flatness error of 20 micron with a depth of pass of 0.1 mm.



	TARGET	PREDICTED	MEASURED
Flatness Error (min-max) [um]	<20	5.7	3.4
Depth of pass [mm]	>0.1	-	0.1

Figure 1: T-based lathe assembly (left), faced test parts (right)

Design Strategy

From the design requirements for this project, I proceeded the following way:

- Constructed a list of **functional requirements** for the overall machine
- Estimated the **apportionment of the total error** for each axis and each source of error (Geometric and Load-induced)
- Divided the **machine in several modules**: Linear motion slides, Leadscrews, Spindle & Tool post
- From this basic layout of the overall machine, constructed an **error model using HTMs** to define the **stiffness and geometric error requirements** for each module,
- Similarly, for each module:
    - I constructed a list of functional requirements based on the above calculations
    - Generated a series of design concepts
    - Made an analytical model to size the different elements, predict and compare the different concepts' performance to the functional requirements
    - Built, tested the best concept and closed the loop on the model (measured VS predicted)
- Assembled, tested the entire machine and compare the results to the model.

Modules [Linear Motion Slides/Leadscrews/Spindle] and Assembly

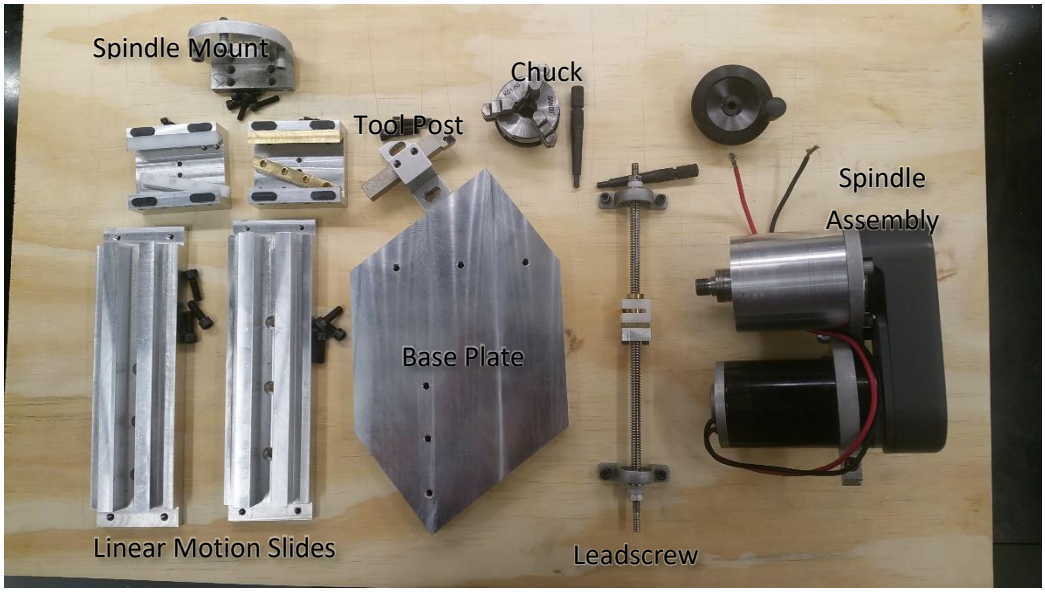


Figure 2: T-based Lathe Modules & Elements

Test and results

The flatness of the 0.1mm test cuts were then measured on a ZYGO white light interferometer, exhibiting a maximum height difference on the face of 3.4 ± 0.2 microns, and a misalignment between the two linear motion axes of 0.89 ± 0.05 mrad matching our design requirements and our predictions of 5.7 microns load induced errors.

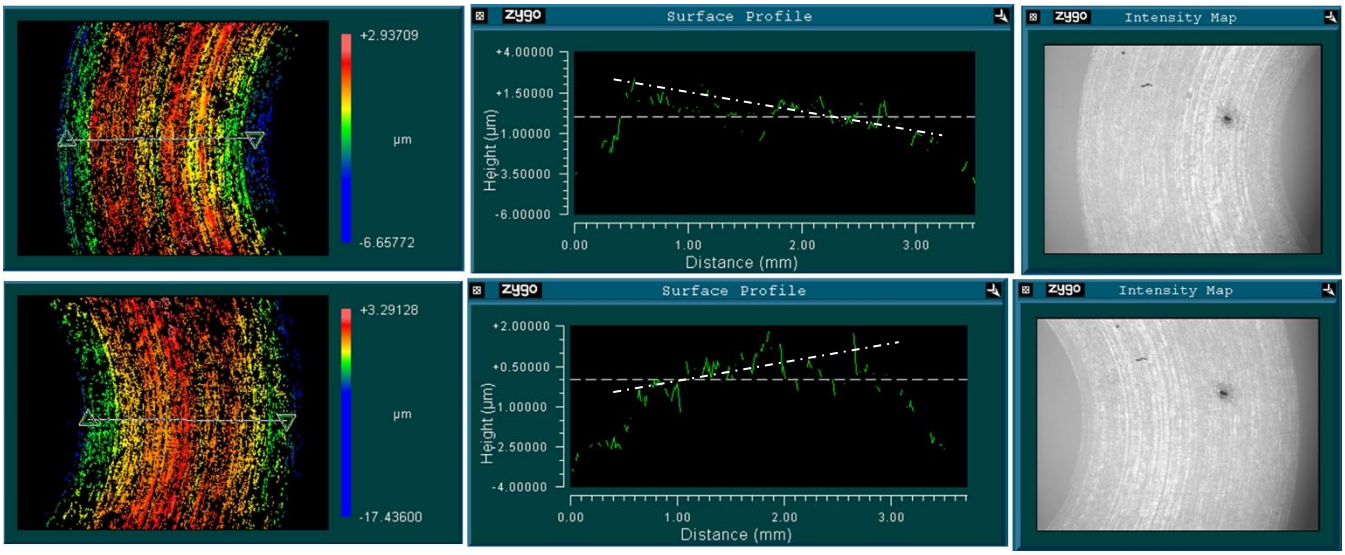


Figure 3: ZYGO White Light Interferometry of test part

Discussion

The T-based lathe performed as expected and this project was valuable in teaching me a deterministic and rigorous design process that includes: defining the functional requirements, concept generation, thorough analysis with a clear statement of the assumptions, testing and reflecting on the model.