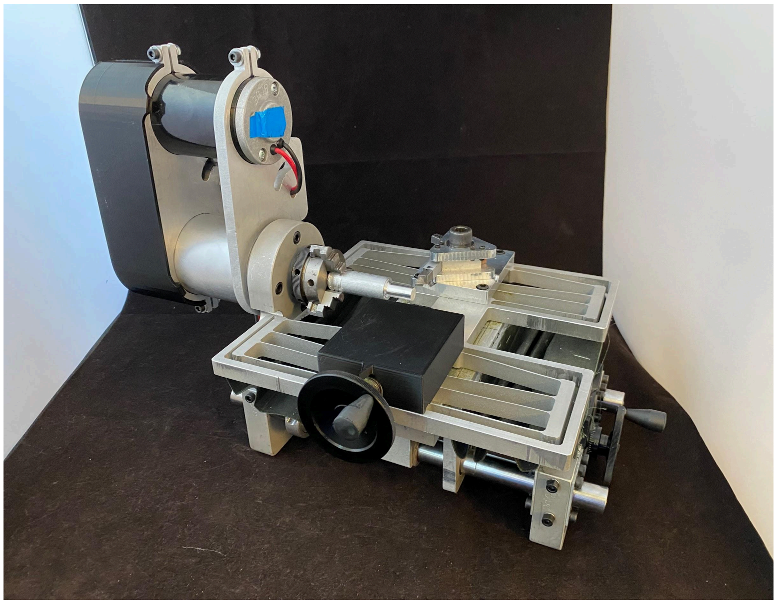
# 2.72 Final Report

Get Rotated



## I. Functional Requirements

The lathe was designed around maximizing our cutting force for steel while still being accurate enough for the lathe to be useful to the average home user. A competent user was assumed, able to set the hard stop when needed and take measurements between passes to ensure accuracy. The lathe hits all of the critical functional requirements and is able to cut both steel and aluminum. While it can hit our functional requirement of MRR for steel (0.3 $in^3$/min), the surface finish is not ideal. An image of this can be seen in the supporting data. The lathe is able to achieve a very nice surface finish for smaller passes on parts, and can achieve a repeatability of 0.0011” in x (radial direction of part) and 0.0004” in z (lengthwise direction of part). The lathe can handle a 3” long by 1” diameter stock if the jaws are flipped, but is limited in how close the carriage can reach the headstock. In an effort to maintain the schedule, we opted to include an adjustable hard stop on the lathe to prevent the user from crashing into the carriage. **The lathe also includes an indexable tool post, designed to allow the user to repeatedly change out tools with an accuracy of 0.0009”**. The lathe was optimized to decrease the friction in the spindle as well as to remove the taper it was cutting in the workpiece. An alignment tool was used to align the cross slide.

| Name | Priority | Value | Units | Results |
|---|---|---|---|---|
| Weight | Low | 90 | lbs | 24.5 lbs |
| Footprint (envelope) | Low | 2x1.5x1.5 | ft x ft x ft | 1.6 ft x 1.0 ft x 1.1 ft |
| Lifetime | Medium | 2000 | hr | 2000 hrs |
| Cost | High | $800 | Dollars | $780 |
| Survivability | High | 100 | Gs | Measured at contest |
| Ingress Protection (sealability) | Medium | IP41 | - | Pass, 0.7mm |
| Thermal Sensitivity | High | 0.0001 | in/ºF | 7 x $10^{-6}$ in/ºF |
| Continuous Use User Actuation Force | High | 5 | N | 3 +/- 1 N (X & Z) |
| Slip Stability | Medium | 50 | N | 70 N |
| Tip stability @ User Input | Medium | 50 | N | >100 N |
| Repeatability of cut | High | 0.002 | in | X: 0.0011” Z: 0.0004” |

| | | | | |
|---|---|---|---|---|
| Resolution in X | Medium | 0.0005 | in | 0.00029 in |
| Resolution in Z | Medium | 0.0005 | in | 0.00010 in |
| Accuracy in X | High | 0.01 | in | 0.00225 in |
| Accuracy in Z | High | 0.01 | in | 0.00669 in |
| Range of motion in X | Medium | 0.7 | in | 0.75” |
| Range of motion in Z | Low | 3.5 | in | 3.5” |
| Swing | Low | 1 | in | 1 in |
| Stock stick out to diameter ratio supported | Low | 3 | - | 4 |
| Length of stock | Low | 3 | in | 3 in |
| Minimum MRR | High | 0.3 | $in^3$/min | 0.3 $in^3$/min |
| Load capacity in Y | High | 290 | N | 575 N |
| Load capacity in Z | High | 104 | N | 575 N |
| Load capacity in X | High | 185 | N | 575 N |
| Cutting RPM | Medium | 500 - 1500 | RPM | 1300 RPM |
| Maximum power input | High | 1500 | W | 120 W Max |

## II. Measurement, Results, & Optimization

A. Measurement & Results

Specific measurement plans for high priority results are as follows:

1. Survivability - drop test will be performed after the competition. Its results will not be included in this report
2. Thermal Sensitivity - FEA was performed to predict thermal expansion of components exposed to chips. After manufacturing as-built measurements were entered into the model to verify positive margin. (Fig. 2)
3. Continuous Actuation Force - a force gauge was attached to each end and the maximum force for actuation measured.
4. Repeatability of Cut - Subsequent cuts were performed to the same dial indicator depth in X and Z. Standard deviation of these results was recorded. (Fig. 3)
5. Accuracy in X and Z - Part was measured and a specified depth of cut performed. Part was again measured and the difference between actual and target reported as accuracy.
6. Load Capacity in X, Y, Z - Team member weight 575 N stood on the lathe carriage while handles were actuated. (Fig 4).
7. Maximum Power Input - While applying 12 V, a maximum 10 amps were measured while supplying power for cutting.

B. Optimization

After the Design Review 3 smoke test, the following items were targeted for optimization prior to competition:

1. Belt Run-In
   a. Belt was run in for 3 hours to reduce the running torque of the motor when cutting
2. Tool Post Height Adjustment
   a. Cutting tools were adjusted cut at the center of a part
3. Taper elimination
   a. Taper in part reduced from 0.04 deg to 0.01 deg through alignment

4. X-Drive Alignment
    a. X-Drive was rotated to ensure perpendicularity to the spindle axis.
5. Tool post repeatability
    a. Grease was applied to the surfaces between kinematic coupling and grooves.
    b. Balls were depressed into grooves 100 times to improve seating.

## III. Lessons Learned

- Stay ahead of schedule
    - Staying ahead of schedule makes the project much less stressful. It also allows for time to address any issues that may come up.
- Ask for help
    - Asking for help early on can save a lot of trouble later. Asking for guidance allowed our group to focus our energy on the most important parts of the lathe.
- Leave time for optimization
    - Optimization improved the performance of our lathe. Leaving time for optimization created a much less stressful end of semester.
- Yes, no, maybe decision making
    - After learning our lesson being behind schedule on the spindle due to over modeling, we made more of an effort to quickly make decisions and move forward. This allowed us to get back ahead of schedule.
- Check all parts provided
    - One of the parts that is limiting the performance of our lathe is the chuck as parts will slip out and can be difficult to get to sit concentrically. We decided to stick with the chuck due to time constraints, but should have looked more in depth at the chuck we were given.
- Distributed manufacturing
    - Planning ahead for manufacturing to schedule machine time ahead of other groups allowed our group to be ahead of schedule later in the semester. Our group spent the later half of some weeks fixing minor issues with our lathe while other groups were still fighting the waterjet.
- Always check bearing lifetime
    - Even on components that are not critical for safety, it is important to check the bearing lifetime of all bearings for performance of any machine.
- Apply lubrication for moving components
    - Lubrication helps decrease oxidation of parts as well as improves their lifetime. It is important to apply lubrication to any parts that move.

## IV. Supporting Data

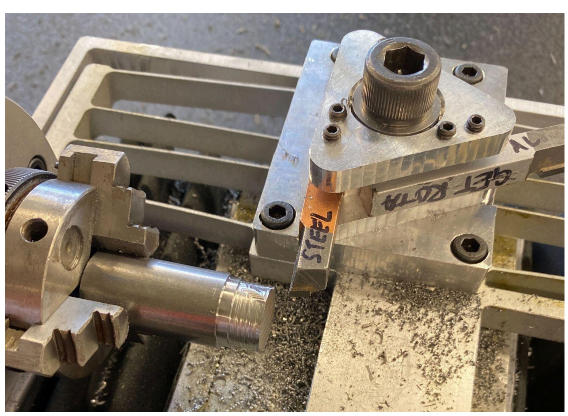



Fig. 1 Surface finish on steel for maximum MRR of 0.3in^3/min

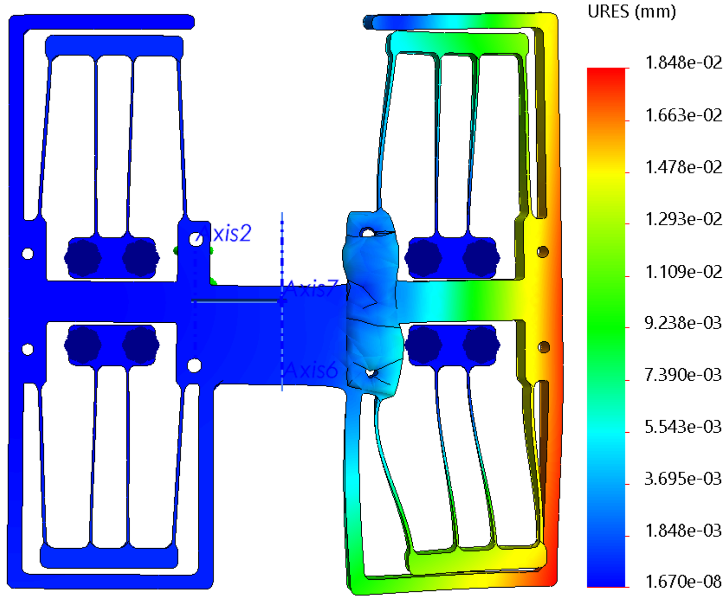



Fig. 2: Thermal FEA simulation

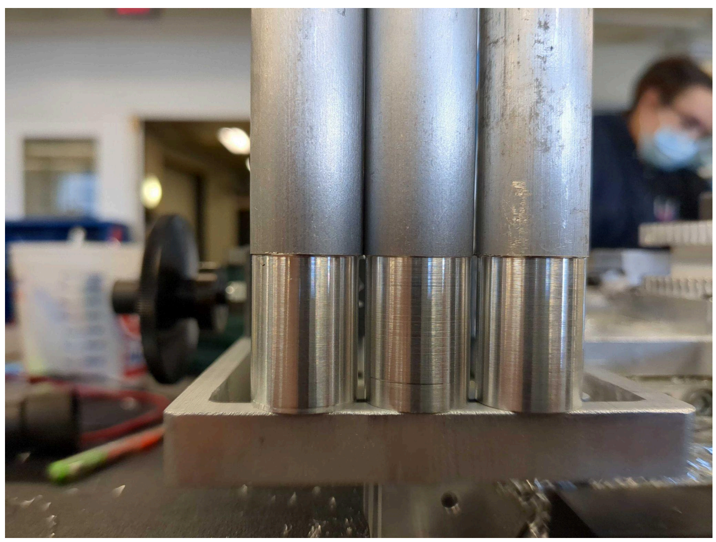


Fig. 3: Repeatability testing

Fig. 4: Load capacity testing

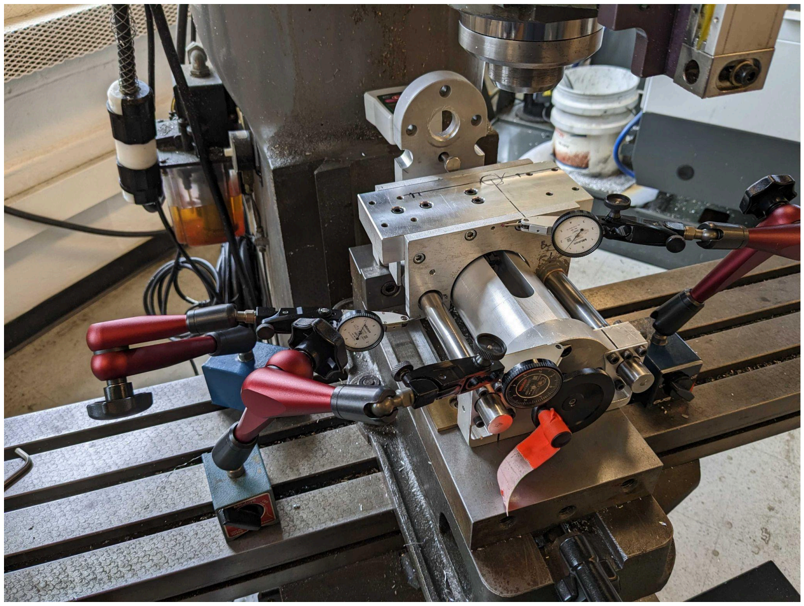


Fig. 5: Example of stiffness measurement

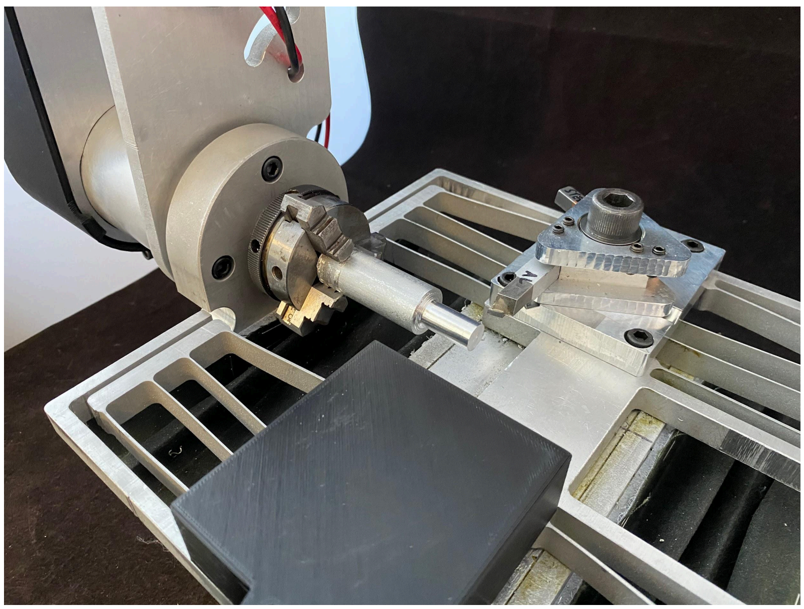


Fig. 6: Close up of tool post