HexBox Storage Container Project

DEFINE THE PROBLEM

DESIGN BRIEF

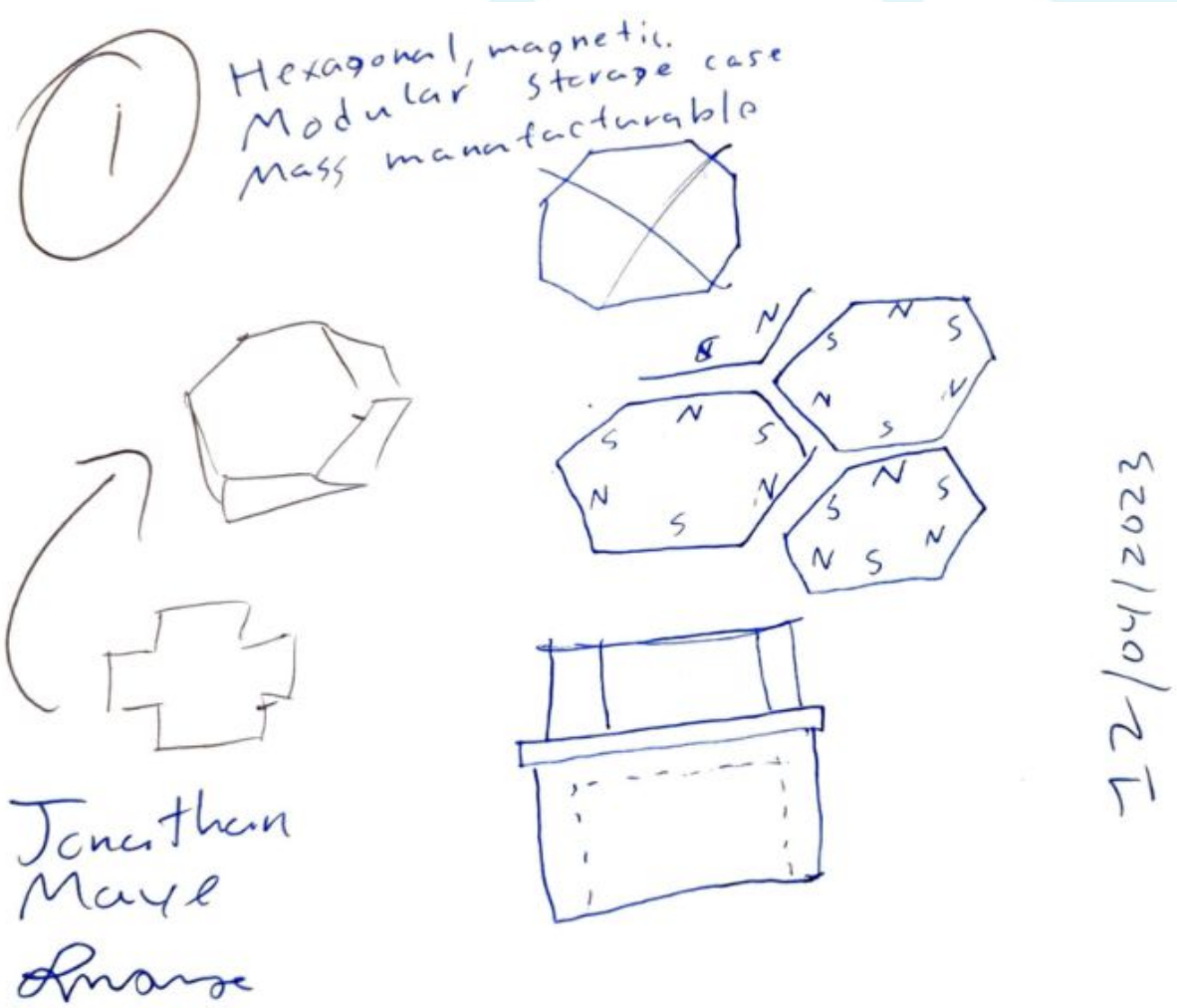
Client	Hopewell high school https://www.cmsk12.org/hopewellHS 980-343-5988 11530 Beatties Ford Road
Designer	TopTechnologies Jonathan Westly-Carlton Maye 704-960-3770
Problem Statement	Hopewell students and staff need a way to store small components, and tools, while also being able to uniquely organize these objects.
Design Statement	Engineers at TopTechnologies will design a mass-manufacturable storage container. We will manufacture this by using CNC, for its fast manufacturing speed and precision, compared to FDM or other manufacturing processes.
Criteria / Constraints	- Short manufacturing time. - Low cost ($5-10 per box) - Cover to hold objects inside. -Visually pleasing colors/design. -3”x3”x2” cut area
Deliverables	TopTechnologies will provide a working, and visually pleasing storage case, that helps students and staff better organize and protect their belongings.

GENERATE CONCEPTS

BRAINSTORMING

Sketches of Early Designs

A container that can be made out of a 3”x3”x2” block of wood, and CNC milled to maximize product output.



Criteria and Constraints

Engineers at TopTechnologies will design a mass-manufacturable storage container with the following constraints.

- Short manufacturing time. Maximum of 10 minutes (including post-processing) for each part
- Low cost ($5-10 per box)
- Cover to hold objects inside.
- Visually pleasing colors/design. (chatoyant wood)
- 3”x3”x2” cut area for the entire product.

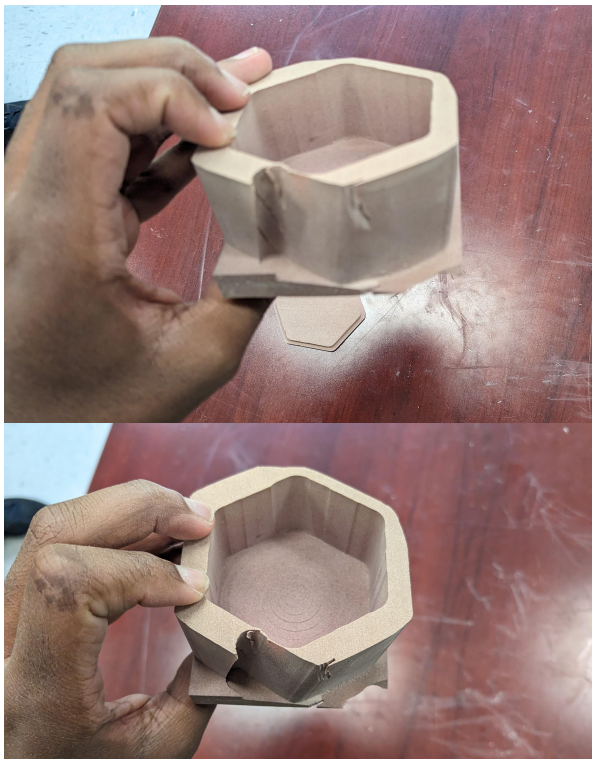
DEVELOP SOLUTION

SOLUTION DEVELOPMENT

Preparation and CNC Milling

```
%
; HexBox_Box
; T1 D=9.525 CR=0 - ZMIN=-33.1 - flat end mill
N0 G90
N1 G17
N2 G71
N3 G53 G0 Z0
; 2D Pocket2
N4 M6 T1
N5 S5000 M3
N6 G17 G90
N7 G54
N8 G0 X40.867 Y38.772
N9 Z15
N10 G0 Z5
N11 G1 Z2.5 F333.3
N12 Z-29.148
N13 X40.868 Y38.775 Z-29.231
N14 X40.873 Y38.785 Z-29.313
N15 X40.881 Y38.801 Z-29.394
N16 X40.892 Y38.824 Z-29.473
N17 X40.904 Y38.853 Z-29.55
N18 X40.918 Y38.889 Z-29.624
N19 X40.932 Y38.931 Z-29.694
N20 X40.945 Y38.98 Z-29.76
N21 X40.957 Y39.035 Z-29.821
N22 X40.966 Y39.095 Z-29.877
N23 X40.972 Y39.161 Z-29.928
N24 X40.973 Y39.231 Z-29.972
N25 X40.968 Y39.305 Z-30.011
```

Code scrubbing and Iterations



SOLUTION PUNCH LIST

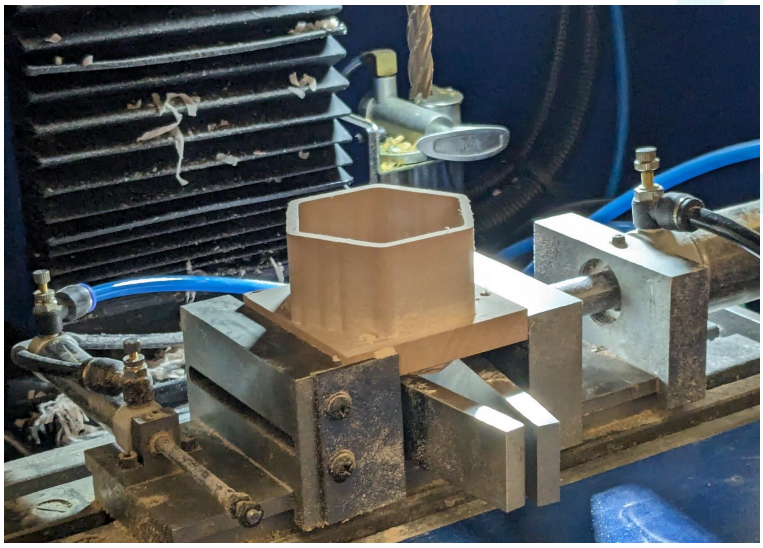
- **11/30 & 12/1**
  - Absent (excused, allergy) but researching at home
- **12/4:**
  - Finished Brainstorm and Design brief (with documentation). Started prototype 3D model
- **12/5:**
  - Plan to: Finish the first iteration of the 3D model, begin programming for CNC
- **12/6**
  - Modify the 3D model, tun g-code for CNC
- **12/7**
  - Complete manufacturing code in Fusion 360 - move code to CNC simulator
- **12/8**
  - Troubleshoot fusion code, and simulate CNC motion.
- **12/11**
  - Get a working prototype.
  - Got a semi-working box. Design changes required
- **12/12**
  - Edit g code for speed, and accuracy. Get a working model.
- **12/13**
  - Edit tolerances for the lid of the HexBox, continue to iterate with the CNC machine (currently on version 3 of the Hexbox)
- **12/14**
  - Complete iteration V4 and use the bandsaw to trim edges. The blade cut too much material off requiring more design changes to the model.
- **12/15**
  - Finished a working model, successfully cut the box with the CNC machine, trimmed off the edges, and sanded for a smooth finish.
- **12/18 - 12/19**
  - Absent (Working on portfolio)

CONSTRUCT AND TEST

FINAL IMAGES

Photos of the Final Prototype

After scrubbing code in Fusion 360, and simulation the cutting process. I prepare the 3”x3”x2” wooden block on a set of parallels to be cut. The parallels prevent the drill bit from cutting into the vice clamp, while also allowing me to cut both the container and the lid from one block by simply turning the block upside down.

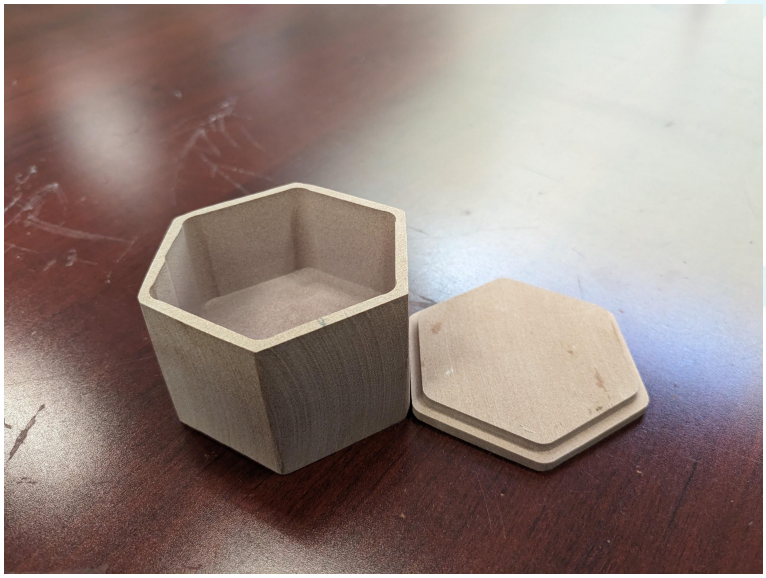


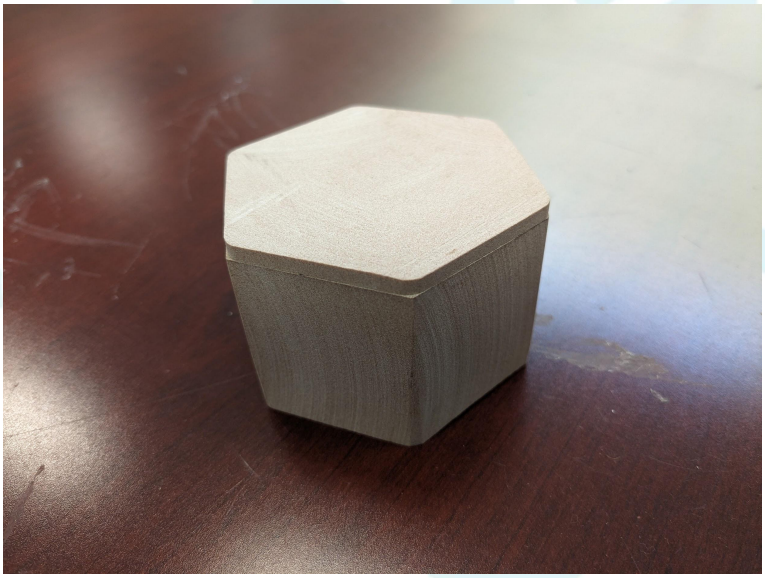
This also allowed me to test tolerances between a previous revision of the container, and an adjusted lid.

FINAL IMAGES

Photos of the Final Prototype

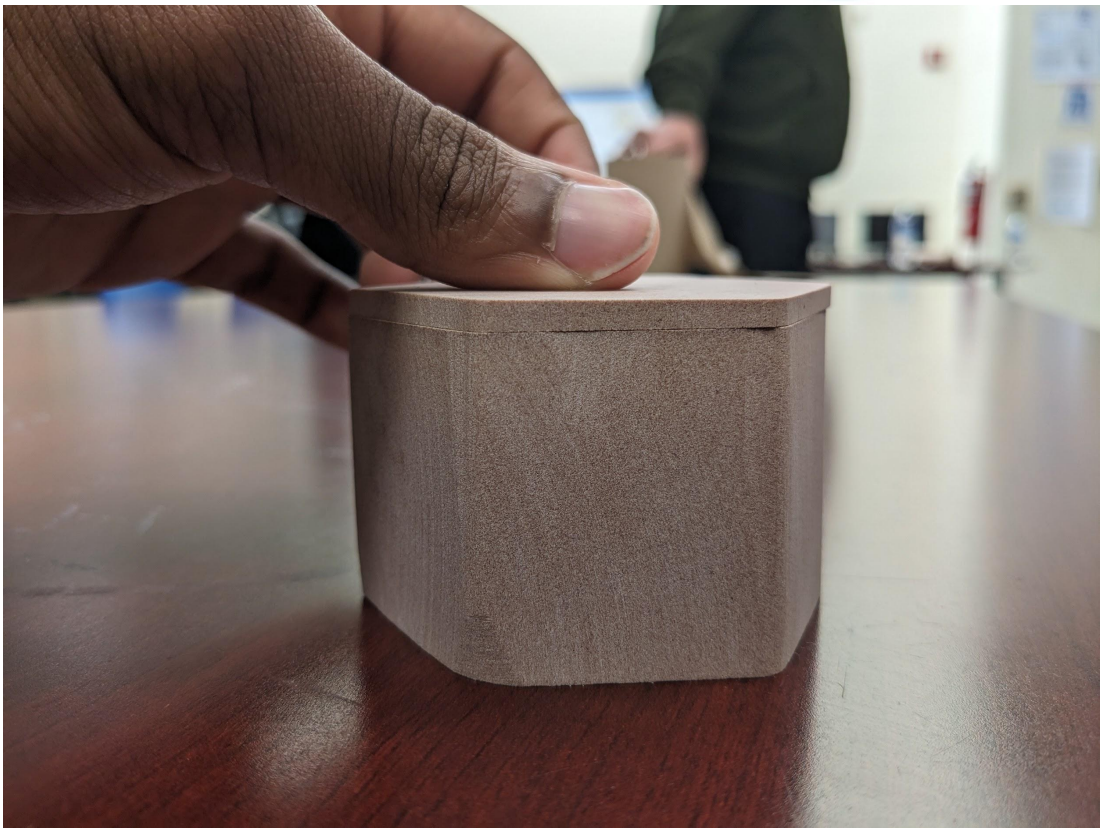
After using a bandsaw to separate the parts from the clamping boss, the parts were sanded down to remove overhangs and wood chips. On V5 the container and lid fit as intended with each other as a friction fit part.



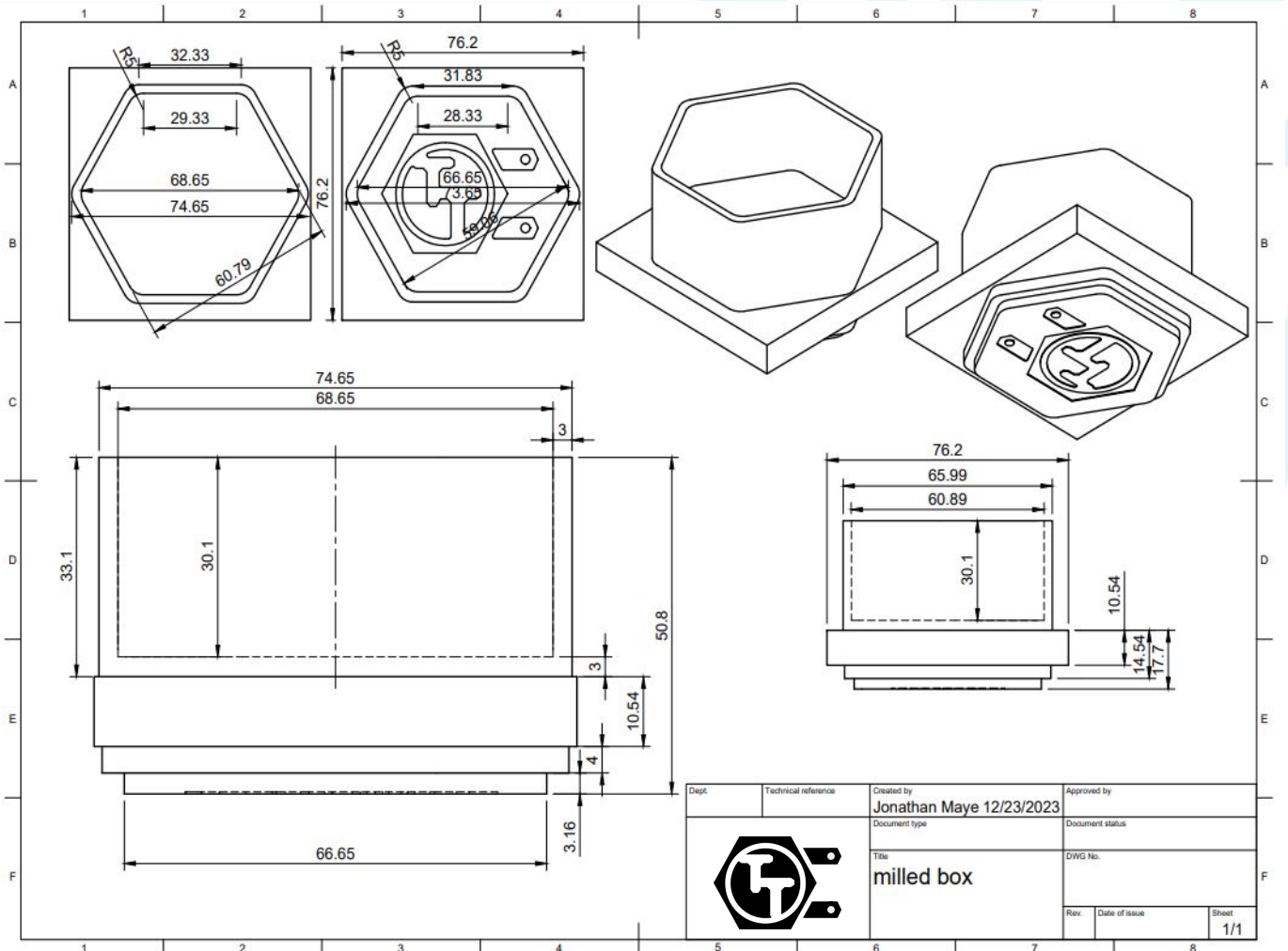


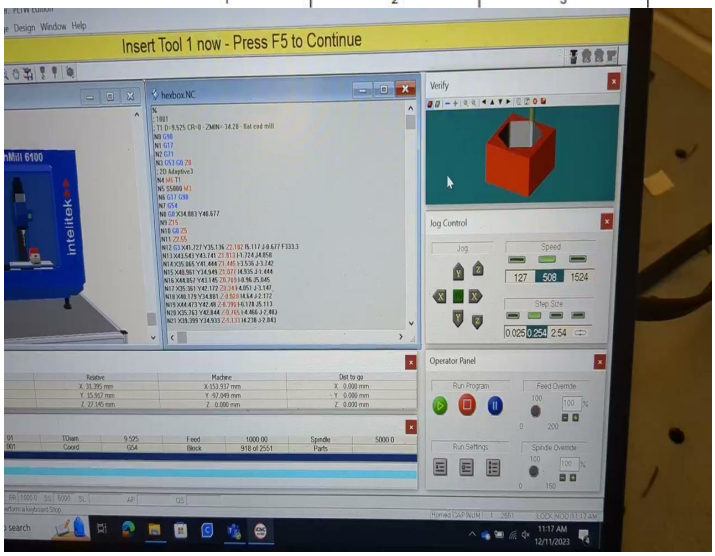
Time of manufacturing breakdown

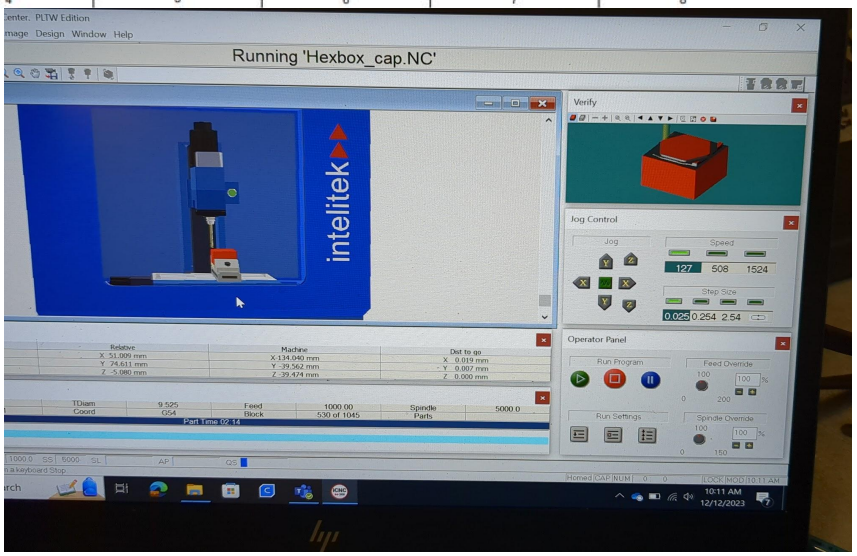
- **Container:** 00:03:21
- **Lid/Cap:** 00:01:29
- **Post processing:**
  - **Cutting:** 00:02:40
  - **Sanding:** 00:02:00
- **Total:** 00:09:30



TESTING, MATHEMATICAL MODELS AND/OR DATA







^This is a video^

EVALUATE SOLUTION

EVIDENCE THAT PROJECT CRITERIA WERE MET

After thorough design and iterative parametric modeling of the Hexbox, lead engineer Jonathan Maye has concluded that the completed part has met all design criteria and constraints. The Hexbox fulfills its purpose as being an easy-to-use storage container, with a working snap-fit cover to securely keep objects inside.

From start to finish, it takes approximately 9 in a half minutes to complete fabrication, including post-processing (cutting & sanding). In addition, the part is CNC cut with the Intelitek Benchmill 6100 to decrease manufacturing time as well. Furthermore, each block is approximately $1.50 with an added utility cost of $1.35 per hour of machine use. This sets each Hexbox at an approximate price of $1.71, which achieves our goal of a maximum of $5 per part.

Lastly, the product is fabricated from a single 3”x3”x2” block of wood that is inverted to cut both the container and lid from the same block of wood. This not only saves money on material but also decreases post-processing time, by only requiring an employee to trim the edges off of one block of wood, rather than repeat the process for two separate blocks.

REFLECTION AND RECOMMENDATIONS

Overall the project was a success, as all criteria and constraints defined at the beginning of this project were met. However, although this project was successful, if I were to start over, I would do several things differently.

The main issue that I had during this project was errors with tolerances. The Intelitek Benchmill 6100 CNC machine should have a tolerance of 0.038mm. However I soon found out that either the documentation I received was incorrect, or our specific machine was broken because the dimension that I had to use to get the intended snap-fit tolerance between the lid and container was 0.833mm; which is abnormal for such precise machines. One thing that this project has done is greatly expand my knowledge of parametric modeling and Fusion 360 manufacturing. If I had the opportunity to redo this project again in Fusion 360, I would definitely simplify the 3D model greatly, while also setting more user-defined variables to simplify the iterative process.

In the end, this project was an amazing learning experience, that taught me a lot about mass manufacturing, CNC machining, g-code scrubbing, and parametric modeling. This experience has helped me to better understand what it means to be an engineer, expanded my knowledge and skill set, separating me from my peers, and moving me a step further in my goal of pursuing a fruitful career.