Foam Capture

School of Engineering + Technology

Problem Statement

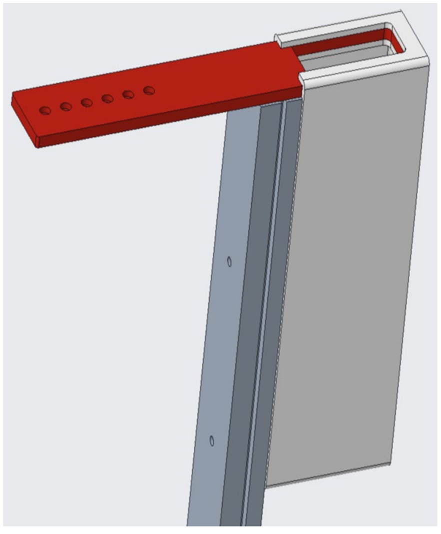
Foam infused doors are being produced within a heated press. When foam is injected into the doors, the foam expands and exits vent holes on the back (bottom) end of the doors. This escaped foam coats the sides of the heat press and hardens. Hardened foam on the sides of the heat press can damage future doors. To avoid damage to future doors, the workers must stop production and clean the heat press. Stopping production for cleaning results in a loss of an average $100,000 per year in labor alone.

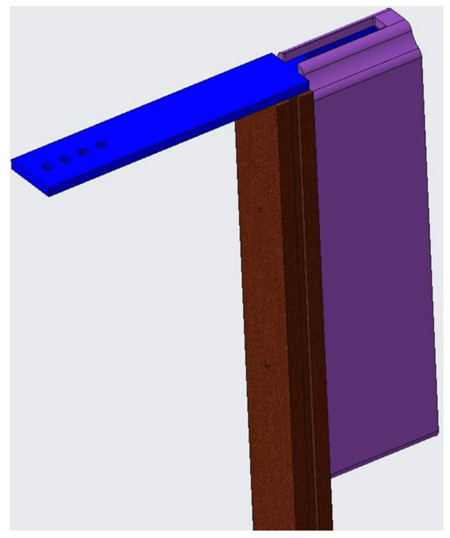
Requirements

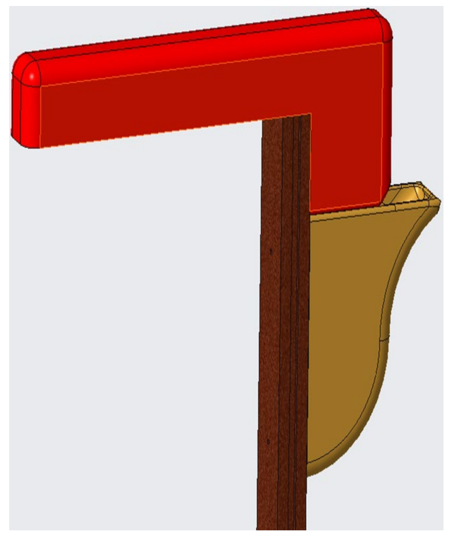
Req #	Requirement	Description	Verification	Requirement Type
1	No cycle time added	The problem solution should allow production time to decrease or stay the same.	Analysis	Performance
2	Safe for workers	The device should not endanger employees and must follow the company's safety protocols.	Demonstration	Performance
3	Causes no damage to doors	The device should not cause any structural or visible harm to the doors.	Inspection	Functional
4	Removable	The device can be removed from the process at any time.	Inspection	Interface

Concepts

- The team's initial concepts included
  - Capture tubes
  - Capture cups
  - Mesh guards
- The team decided to pursue the capture cup concept and design multiple iterations of a foam-capturing cup.
- Pictured below are three preliminary designs of the team's foam-capturing cup.

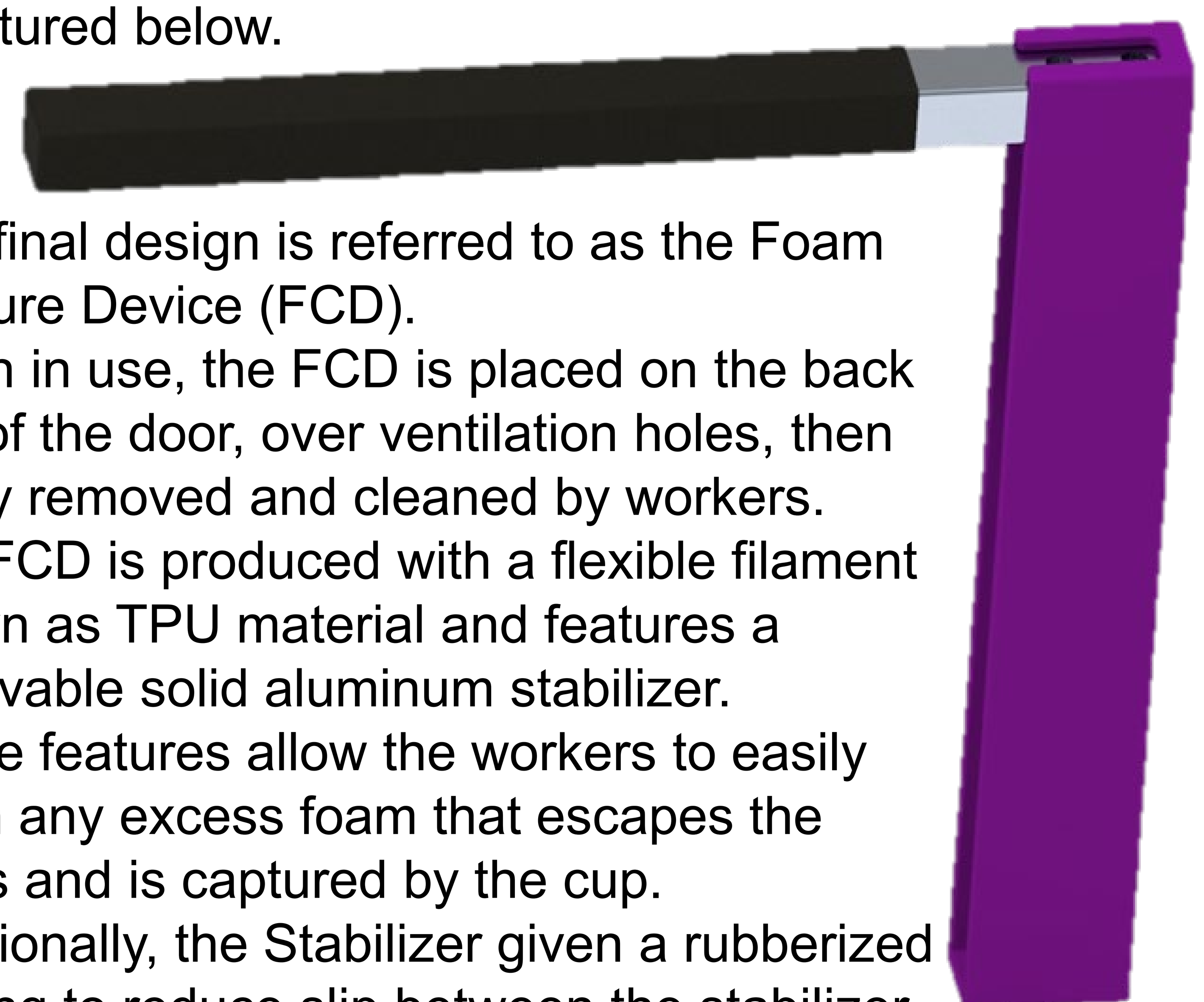




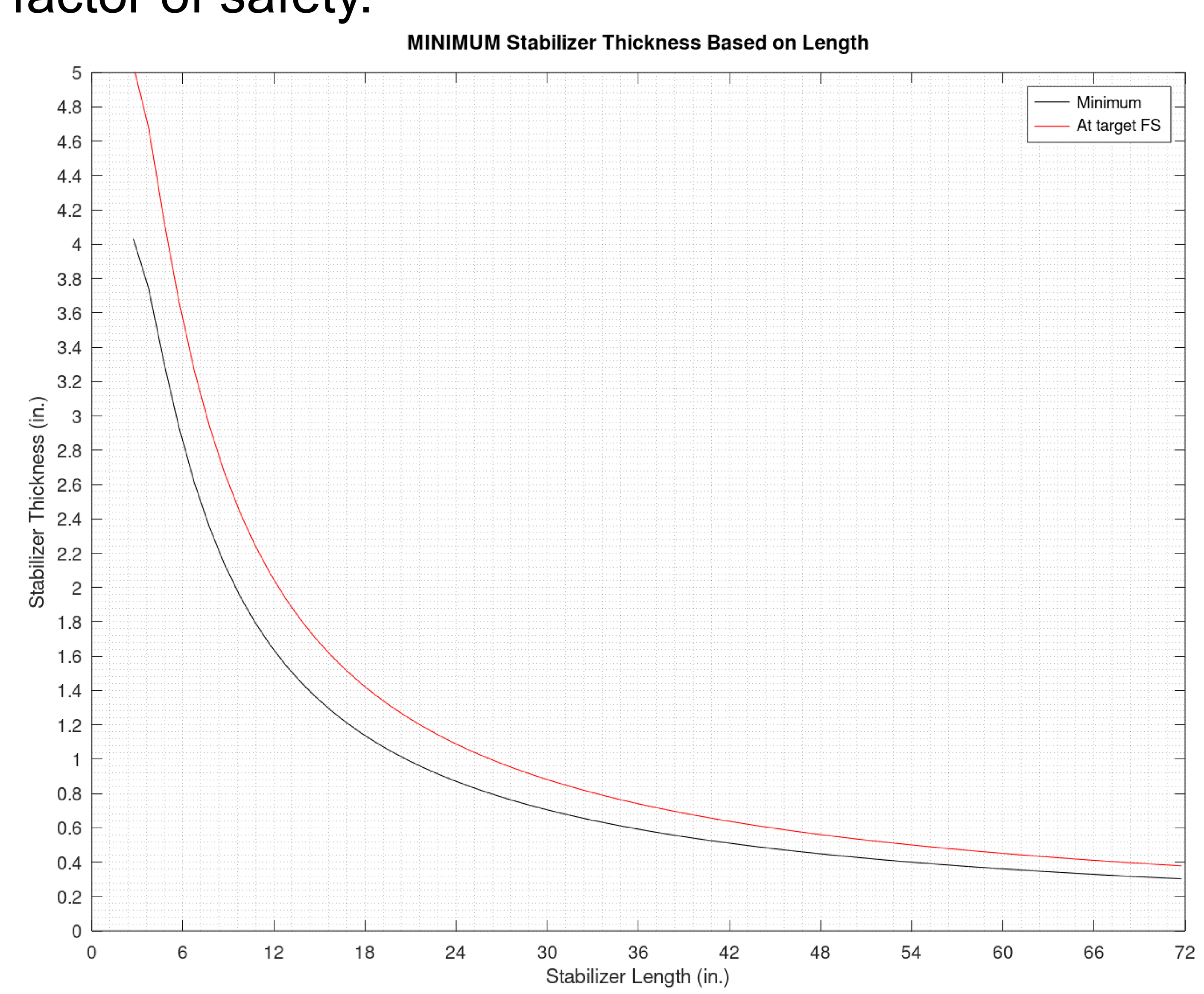


Final Design

- After weighing the benefits and drawbacks of each primary design the team landed on a final design, which is pictured below.



- This final design is referred to as the Foam Capture Device (FCD).
- When in use, the FCD is placed on the back end of the door, over ventilation holes, then easily removed and cleaned by workers.
- The FCD is produced with a flexible filament known as TPU material and features a removable solid aluminum stabilizer.
- These features allow the workers to easily clean any excess foam that escapes the doors and is captured by the cup.
- Additionally, the Stabilizer given a rubberized coating to reduce slip between the stabilizer and the vertical stiles of the doors.
- A script was created to display an array of possible stabilizer thicknesses, at any given length, as well as the minimum allowable thickness.
  - Using this relationship, the red line represents a 1.25 factor of safety.



Results

- To ensure optimization, the team sent the sponsor seven variants of the FCD for testing; each with varying wall thickness and infill. In the table below, the results from testing are shown.
  - The goal was to optimize area of foam capture, FCD rigidity, and ease of cleaning.

Foam Capture Device Testing

FCD Letter	FCD Details	Number of Cycles Run	Quantity of Foam in FCD	Quantity of Foam Escaped	Stabilizer-FCD Connection Deformation	Ease of Cleaning	Cleaning Time	Operator Notes	Engineer Notes
A	1/8in Wall Thickness	17	Minimal	None, but FCD is too short for an updated venting design	Unchanged	A	Time Not Taken	• Plastic being flexible allowed for quick cleaning • After 10 cycles the FCD began to twist • More pronounced when in press	• Overall, design C performed the best and is the one that the Capstone Team should proceed with • Jeld-Wen has requested that the FCD-C design be modified to a length of 20 inches, to accommodate the entire width of the door. This is not possible to 3D print at WCU, but Jeld-Wen has the capabilities to do so. • The redesigned models, documentation, and respective purchasing locations of materials for the devices are to be gathered and delivered to Jeld-Wen to be produced and implemented on site.
B	3/16in Wall Thickness	17	Minimal	None, but FCD is too short for an updated venting design	Unchanged	C	Time Not Taken	• Sturdy but hardest to clean • May be due to inconsistencies with the WCU CET Makerspace	
C	1/4in Wall Thickness	17	Minimal	None, but FCD is too short for an updated venting design	Unchanged	A	Time Not Taken	• The rubber allowed less slipping on 4-Sided doors because their stiles (vertical part of door frame) is more slick, due to all sides being cut back to the frame • Best Overall	
D	1/4in Wall Thickness (10% infill)	17	Minimal	None, but FCD is too short for an updated venting design	Unchanged	B	Time Not Taken	• Not able to hold metal without constantly beeing freed • Did not sit straight until press was closed (possibly warped in shipping) • Easiest to clean because of %infill and surface ripples causes by printing at that infill	
X	1/16in Perimeter Increase	TOO WIDE	STUDENT NOTES: This is somewhat of a good thing, as it means that FCDs A-D are at their maximum allowable width. This is important because we do NOT want to reduce thickness at the risk of reducing the FCD life, due to physical and thermal fatigue.		N/A	N/A	N/A	N/A	
Y	2/16in Perimeter Increase	TOO WIDE			N/A	N/A	N/A	N/A	
Z	3/16in Perimeter Increase	TOO WIDE			N/A	N/A	N/A	N/A	

Note: All FCD's have an infill of 50% unless otherwise stated.

Summary

- In conclusion, the team and the sponsor decided to go with variant C.
- This version of the FCD has a 1/4-inch wall thickness with a 50% infill.
- It is 20 inches in length to ensure it covers all vents.
- The decided stabilizer length is 18 inches, with a thickness of 1.5 inches.
- The team has sent their sponsor a stl. file of this variant and the sponsor plans to produce all further FCD's in-house.

Team & Acknowledgements

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- Dylan Langham BSET
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- Christopher Hall BSE-ME
- Mentor: Dr. Wesley Stone
- Sponsor: Ryan Kalanish