BME Design-Fall 2022 - TATUM RUBALD
Complete Notebook

PDF Version generated by

RACHEL KRUEGER

on

Dec 14, 2022 @09:46 AM CST

Table of Contents

Team contact Information

RACHEL KRUEGER - Oct 12, 2022, 10:18 AM CDT

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Project description

RACHEL KRUEGER - Oct 12, 2022, 10:20 AM CDT

Course Number: BME 400

Project Name: Guidewire Organizer for Endovascular Procedures

Short Name: EndoVasc

Project description/problem statement:

In many endovascular surgeries, surgeons must use multiple guidewires during a single procedure. Currently, most doctors store used guidewires under a wet towel for later use. These guidewires are hard to manage as they can get tangled and disorderly. This product aims to decrease the time it takes for surgeons to organize the wires and increase procedure efficiency and safety. Thus, the team will engineer a device to organize and store multiple guidewires and solve this issue. The device will consist of two parts: (1) a stand to store guidewire wheels and (2) three wheels in which the guidewires will be placed. The guidewire must stay organized and untangle when inserted and removed from the wheel. It must be easy to remove the wire from the wheel while stored on the stand or in the operating technician's hand. The wheels must also be easily placed and removed from the stand. The learning curve for the loading and unloading of the guidewire from the wheel should be small. The device will be able to be mass produced. The team will aim to manufacture the device in the most cost effective way possible.

About the client: Surgeon at UW health specializing in endovascular/vascular procedures.

09SEP22: Initial Client Meeting

TATUM RUBALD - Sep 19, 2022, 2:48 PM CDT

Title: Initial Client Meeting

Date: 09 SEP 22

Content by: Tatum Rubald

Present: Tatum Rubald, Addison Dupies, Dr. Y

Goals:

Discuss the current status of the project and the goals for this semester/year.

Content:

Questions:

- Your goal for us this semester, continuing into doing?
- Is finalizing the design okay? And move onto injection molding?
- Patent status? What is the company?
- Have you talked to more companies about mass producing?

Notes:

- The device is a commodity, not a device
    - Number of uses is higher than a device
- Competing device is just a bowl with hooks
- GOAL: Which diameter is optimal?
    - Number of holes at the bottom refs can change
    - Spool?
    - Tower?
    - How can we manufacture? Injection molding must be possible?
        - What material? cheap.
        - $2 per disk… or less
        - Manufacturer should be compliant with FDA
- Patent though Warf under review

1. Disk finalized first
    1. Diameter size
    2. Thickness
    3. Lip-overhang
2. Manufacturing plan
3. Stand
4. Cost

Conclusions/action items:

Create a timeline for project and update team on client meeting.

10/5 Faculty Member Injection Molding Meeting

RACHEL KRUEGER - Oct 05, 2022, 12:58 PM CDT

Title: Faculty Member Injection Molding Meeting

Date: 10/5/2022

Content by: Rachel Krueger

Present: Rachel, Victoria, Ben, Lily

Goals: Speak with a faculty member that is educated on injection molding to get feedback on our current design and ideas for iterations.

Content:

1. Met with Dr. Tom Turng
2. Current design should be okay to injection mold if we use collapsible mold tooling.
3. If not, may need to use snap feature or parting lines to mold into two pieces and then combine.
4. Current ProtoLabs quote is $8K for the tooling and $72 for 25 pieces.
5. Referenced us to Evco Plastics
    1. He does a lot of work out of Sun Prairie location
    2. He is taking his class on a fieldtrip soon and invited us with if we want to get more information
6. Could use a more flexible material that allows for the tooling to "wiggle" out
    1. Would allow us to mold in one part
7. If we need a stiff material, likely need to mold in multiple parts or collapsible tooling due to overhand (interferance)
8. Look into how a frisbee is injection molded - very similar design
    1. Could be useful to see the most efficient way to mold

Conclusions/action items:

Get a new quote at Evco to see options for lower cost molding. Experiment with different materials to see how flexible we can allow.

19OCT2022: Client Meeting Update

TATUM RUBALD - Oct 19, 2022, 11:45 AM CDT

Title: Client Meeting

Date: 19OCT2022

Content by: Tatum Rubald

Present: Tatum, Addie, Ben, Victoria

Goals:

Discuss testing times and the progress of the design.

Content:

- 10-11:30 case
- 11:30-Noon : come test
- Meet with his med student
    - will reach out to her
- Send Dr. Y prints
- Test will med students on Monday around 2

Conclusions/action items:

Email Dr. Y my phone number for his med student. Collect materials for the testing on Monday.

First Advisor Meeting 16SEP2022

LILY GALLAGHER - Sep 18, 2022, 10:28 AM CDT

Title: First Advisor Meeting

Date: 09/16/2022

Content by: Lily Gallagher

Present: The team

Goals: To meet our advisor and discuss semester expectations/goals

Content:

First Advisor Meeting

- Patent design
    - Where is our client looking to patent the design
    - Business plan
- Client meeting
    - Clear project goals/What will we be focusing on this semester
    - Injection molding?
- Design Structure
    - Restructuring the course deliverables to fit the clients goals
    - Paired up with business school
    - Business plan vs pds
- PDS
    - Update PDS by next week
- Weekly notebook updates
    - Present notebook additions in weekly meeting
    - ****MUST update weekly
    - Graded 1-5
    - Detailed notes
    - Conclusion/action items: specifically note whether or not the information is useful
- 16SEP2022 Mandatory Seminar
- Current meeting time @ 1:00 on fridays (looking for a different time)

Conclusions/action items:

Addie and Tatum are meeting with our client to discuss the current status of the project (patent plans, manufacturing plans, etc). The team is looking for an alternate meeting time.

Meeting - 9/29/22

VICTORIA HEILIGENTHAL - Sep 29, 2022, 12:25 PM CDT

Title: Advisor Meeting

Date: 9/29/22

Content by: Victoria

Present: All

Goals: To take notes from the advisor meeting

Content:

- Design matrix
  - Okay to just describe modifications of current design
  - Question: Will stand be prototyped this semester?
    - Focus on complete wheel before stand - stand shouldn't take long after wheel
    - Subset of team can work on stand to get prototype in place
    - Stand does not create cross contamination, design already allows for separation
- Manufacturing methods and design variations
  - Design variations for injection molding, variations are not currently injection moldable
    - Main focus is on manufacturing, designs have small changes so just depend on how will manufacture the wheel
  - Prof. Oswald with injection molding help - referred to grad students
    - Where could we look into locally for quotes
    - In contact with Protolabs and Dr. P got contacts
      - Need mold file - send design to contacts to see how to make mold based on design
  - Client budget
    - Done prototyping with variations, send file and he will pay for injection molding
    - 3D printing prototypes, final design will move into injection molding - client does not seem worried about budget
- Preliminary deliverables
  - Send advisor slides before presentation - no later than next Wednesday
    - Get feedback
  - Next Friday, Tong auditorium
  - Design matrix - mention not changing design so mention variations and manufacturing
- Mid-term deliverables
  - Each person during regular meeting time talk about individual contributions to project
  - Every 3 weeks -revisit notebook
  - After presentations
  - Check what times open Monday or Tuesday to do notebook check - send back to her
- Outreach activity
  - Madison non-profit - Maydum
    - Get girls and people of color into STEM, middle and high school students
    - Decide on activity
    - Tracy has Box folder of activities

Conclusions/action items: The team can continue moving forward with the project

10/24 Meeting (Notebook Check)

RACHEL KRUEGER - Oct 24, 2022, 9:33 AM CDT

Title: Advisor Meeting, Notebook Check

Date: 10/24

Content by: Rachel Krueger

Present: All group members

Goals: Share status update and outline notebooks.

Content:

-All team members shared notebooks and their individual contributions.

Conclusions/action items:

Continue updating notebooks and sharing updates with our advisor.

23SEP22: Project Timeline

TATUM RUBALD - Sep 23, 2022, 12:11 PM CDT

Title: Project Timeline

Date: 23SEP22

Content by: Tatum Rubald

Goals:

I will create an ongoing project timeline to help split up roles and ensure the team is on track.

Content:

See attached Google Drive file.

Conclusions/action items:

As team leader, I will continue to update as the semester progresses.

TATUM RUBALD - Sep 23, 2022, 12:15 PM CDT

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02OCT2022 Manufacturing Process Design Matrix

LILY GALLAGHER - Oct 12, 2022, 9:32 AM CDT

Title: Manufacturing Design Matrix

Date: 02OCT2022

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To compare 3 different manufacturing processes and decide which one is best for our project

Content:

Table 3. Manufacturing Process Design Matrix. Individual criteria were graded on a scale of 1(Low) - 5(High), these scores were then multiplied by the predetermined weight of the criteria to calculate the weighted score. The highest scores for criteria are highlighted in blue and total scores are out of 100.

Manufacturing Process		 **Injection Molding [6]**		 **3D Printing**		 **Thermoforming [6]**
Production Efficiency (25)	**5/5**	**25**	1/5	5	4/5	20
Ease of Manufacturing (20)	3/5	12	**5/5**	**20**	4/5	16
Cost Per Part (20)	**4/5**	**16**	2/5	8	3/5	12
Material Compatibility (15)	**5/5**	**15**	4/5	12	2/5	9
Lead time (10)	2/5	4	**5/5**	**10**	3/5	6
Accuracy (10)	**5/5**	**10**	2/5	4	2/5	4
Total	**82/ 100**	**82**	59/ 100	59	67/ 100	67

I. *Production Efficiency (25%):* Production efficiency is the time it takes to produce one part. This is weighted as the highest criteria in **Table 3** because the final market device will be mass produced as a single-use product to fulfill the demand of the increasing endovascular device market. It is estimated that 1,020,067 vascular procedures would be done in 2020 [13].

Injection molding scored the highest for production efficiency as it is the most common and time-efficient process used to mass produce parts [14]. Depending on the size of the desired product, the injection molding process can take two seconds to two minutes to produce a part [14]. Thermoforming involves loading a single material sheet into the machine and then heating it to glass transition temperature before each pull. This makes the process take a longer to complete than injection molding [15]. Additionally, due to the geometry of the wheel, the design would need to be cut horizontally, manufactured in two parts and then welded together. 3D printing was ranked ⅕, because the process is extremely inefficient for our design. In Spring 2022, it took three hours to 3D print the device in PVA. Additionally, the inner supports of the overhang had to be dissolved away which took an additional two days.

II. Ease of Manufacturing (20%): Ease of manufacturing denotes the amount of additional tooling prototyping and initial costs to begin production of the final market device.

3D printing scored the highest in ease of manufacturing because it does not require additional prototyping or tooling costs. Injection molding and thermoforming are both mold forming processes. There is additional tooling prototyping to create the mold before the device can be mass manufactured. The cost of tooling for injection molding is more expensive than thermoforming because it is made out of a higher grade metal.

III. Cost Per Part (20%): The cost of production of the final design should not exceed 2$.
Injection molding scored the highest because it has the lowest cost per part. As seen in **Appendix D**, the team received a quote from Protolabs where the cost of production for one part is $2.88. Thermoforming scored ⅗ because there is excess material from the sheet that is accounted for in the cost per part. 3D printing scored the lowest, in spring 2022, it costs 6$ to print the part.

IV. Material Compatibility (15%): Availability of materials compatible for production.
Injection molding is ranked the highest as it is compatible with a wide range of thermoplastic, thermosets, or elastomers [16]. Though 3D printing is also compatible with a wide range of materials, is ranked ⅘ due to cost of using these materials in 3D printing. Thermoforming is ranked the lowest as it has restrictions on the thickness and temperature characteristics for compatible materials.

V. Lead Time (10%): The estimated lead time from now to final market device production.
3D printing the final market design was ranked the highest because there would be no additional prototyping steps to make our design compatible for 3D printing. The lead time for prototyping the tooling for injection molding is 12-16 weeks, and for thermoforming it is 0-8 weeks [17].

VI. Accuracy (10%): The degree of precision, or tolerance of the manufacturing process achieves.
Injection molding scored the highest for accuracy as it is ideal for creating smaller, more intricate and complex parts; it can accommodate tolerances +/- .005 mm [18]. Thermoforming scored ⅖ as it bends a sheet of plastic around the mold, it works best with larger parts with more basic designs[19]. 3D also scored ⅖ because it is difficult to dissolve the supports entirely, creating greater tolerances between parts.

Conclusion:

Overall the team is moving forward with injection molding

Protolabs Design Review Meeting - 10/12/22

VICTORIA HEILIGENTHAL - Oct 12, 2022, 11:06 AM CDT

Title: Protolabs Design Review Meeting

Date: 10/12/22

Content by: Victoria

Present: Victoria, Ben, Rachel, Addie

Goals: To understand what modifications need to be made to the design in order for injection molding to be successful

Content:

- Redesign for undercut to form
    1. Separate component to add
    2. Undercut ridge is problem – split apart then add together
        - Glue, mechanical fit option
        - Team consideration: splitting in half then have snap fit component
        - Have to injection mold both
            - Resolve undercut
    3. More flexible material – could pull out of mold?
        - Silicon rubber, could be better fit
        - Have materials supplier contact – can get better idea of what material might be best
- Other issues
    1. Size of part
        - Silicon rubber would be better and remove issues
        - Filling would increase pressure with current design
            - Increasing thickness between faces to remove pressure all around part
    2. Draft and thickness
        - Add draft wherever possible to help eject and mill mold
            - 0.5 degree draft
            - Add draft and thickness to chimney regions
                1. Make bottom or top portion of chimney larger, than smaller vice versus
- Sharper areas will be milled sharp
- Cosmetics
    1. Can add texturing
- Have ejection parts into part if use plastic
    1. Ejector pins help push off the mold
    2. Could be around part
- Biggest pieces to consider
    1. Select material
    2. Adjust undercut
    3. LSR material could get away with undercut potentially
- Up to 200
    1. After that, $50 production fee
    2. Life span of limited mold (first 2000 shots)
        - If something happened, pay for warranty of new mold
    3. Unlimited – they pay for warranty of mold

- Can always upload design changes
- Sydney sending email to source about material to help choose

Conclusions/action items: The team needs to meet to discuss what was said during the meeting so we can make design changes for injection molding

16OCT222: Task Delegation Oct 16

TATUM RUBALD - Oct 16, 2022, 3:50 PM CDT

Title: Task Delegation

Date: Oct162022

Content by: Tatum Rubald

Goals: Delegate tasks to teammates to keep project moving.

Content:

Task Delegation Week of Oct. 16

Task	Description	Member
Print all 4 designs	Print designs at makerspace	
Organize testing with residents	Contact Dr. Y about when residents would be available to test design	Addie
Contact EVCO	Contact EVCO about injection molding options	Tatum
Model stand	Modelatible with VHold design	Ben
Measure guidewire forces	Use a force gauge (or MTS) to measure the radial force of the GW when wound into various diameters. Measure for both stiffnesses of guidewires	

Conclusions/action items:

I will contact the team and answer any questions.

3NOV22: Team Brainstorm

TATUM RUBALD - Nov 10, 2022, 10:21 AM CST

Title: Team Brain Storm

Date: 03NOV22

Content by: Tatum Rubald

Present: Full team

Goals: Each member will present prepared slides on design ideas and modification.

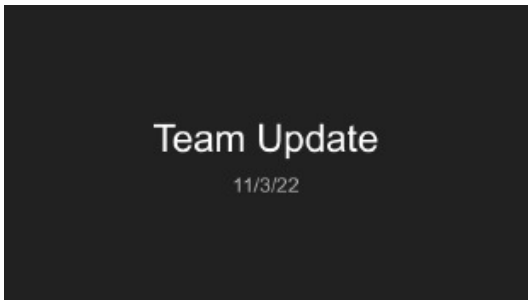
Content:

Attached slides.

Conclusions/action items:

We will all complete our action items within one week.

LILY GALLAGHER - Dec 13, 2022, 4:56 PM CST



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Team_Update_Nov_3.pdf (696 kB)

11/4/22 Show and Tell

Ben Smith - Nov 04, 2022, 1:33 PM CDT

Title: Show and Tell

Date: 11/4/22

Content by: Ben

Present: Team

Goals: Get good feedback on our new designs

Content:

Feedback:

- Print in two parts to make injection molding easier
    - Multiple groups like the idea of having a top and a bottom half and having a way to just pop them together
    - Someone mentioned a lego like mechanism
- Consider an anchor mechanism to hold wire in place in actual wheel

Conclusions/action items:

RACHEL KRUEGER - Nov 07, 2022, 11:51 AM CST

Title: Show and Tell

Date: 11/7/2022

Content by: Rachel Krueger

Present: Team

Goals: Outline feedback from peers at show and tell.

Content:

1. Is there a two step plastic or material we can use?
    1. First step would allow the plastic to be injected into the mold and still be a flexible, soft plastic
    2. Second step would involve UV curing or acid bath that would harden the plastic to become a rigid structure
    3. This would allow the mold to pop off without breaking while still maintaining the integrity of the device
2. Pebax as a material - heat activated to become hard, flimsy and bendy before heat is applied
    1. same idea as two step plastic - easier to be injection molded
    2. is this material able to be molded?
3. Screw mechanism instead of snap fits
    1. since there is no torque applied, it may be easier to model threads instead of snap fits
    2. this way, the two parts can come together easier
    3. standards are readily available

Conclusions/action items: Consider feedback in next iteration of design.

Semester Expenses -12/8/22

VICTORIA HEILIGENTHAL - Dec 12, 2022, 10:41 AM CST

Title: Semester Expenses

Date: 12/8/22

Content by: Victoria

Present: N/A

Goals: To document the team's expenses during the semester

Content:

Item	Description	Manufacturer	Part Number	Date	QTY	Cost Each	Total	Link
All Prototype Wheels								
Wheel Iteration 1	Modification of current design	UW MakerSpace	N/A	10/19/22	1	$12.44	$12.44	UW-MakerSpace
Component 2								
Wheel Iteration 2	Modification of current design	UW MakerSpace	N/A	10/20/222	1	$8.14	$8.14	See above
Component 3								
Wheel Iteration 3	Modification of current design	UW MakerSpace	N/A	10/20/22	1	$11.76	$11.76	See above
Component 4								
Wheel Iteration 4	Modification of current design	UW MakerSpace	N/A	10/21/22	1	$11.46	$11.46	See above
Component 5								
Wheel Iteration 5	Modification of current design	UW MakerSpace	N/A	11/7/22	1	$5.82	$5.82	See above
Component 6								
Wheel Iteration 6	Modification of current design	UW MakerSpace	N/A	11/10/22	1	$5.65	$5.65	See above
Component 7								
Wheel Iteration 7	Modification of current design	UW MakerSpace	N/A	11/15/22	1	$5.61	$5.61	See above
Component 8								
Wheel Iteration 8	Modification of current design	UW MakerSpace	N/A	11/17/22	1	$7.12	$7.12	See above
Component 9								

Wheel Iteration 9	Modification of current design	UW MakerSpace	N/A	11/29/22	1	$5.20	$5.20	See above
TOTAL:	**$73.20**							

Table 1: Expenses Table

Conclusions/action items:

Semester Prototype Designs -12/13/22

VICTORIA HEILIGENTHAL - Dec 13, 2022, 10:19 AM CST

Title: Semester Prototype Designs

Date: 12/13/22

Content by: All

Present: N/A

Goals: To document the team's wheel prototype designs throughout the semester

Content:

The team's prototype designs can be found in Tatum, Addie, Ben and Lily's folder

Conclusions/action items:

Testing Protocol -12/8/22

VICTORIA HEILIGENTHAL - Dec 08, 2022, 8:48 PM CST

Title: Testing Protocol

Date: 12/8/22

Content by: Victoria

Present: N/A

Goals: To document the protocol the team followed during testing

Content:

Guidewire Holder Test Method

Loading

1. Start timer
2. Wind guidewire by hand
3. Pick up wheel from table
4. Use one hand to hold wheel, one to hold wire-loop
5. Slide wire-loop into wheel
6. When guidewire is fully secured within the wheel, place wheel in one hand
7. Stop timer

*If the guidewire is not able to load properly, record load time as MT (mistrial)

Grade the Load Trial (0-3)

0 - Unable to load guidewire
1 - The wire slid into the wheel, but there were some issues (i.e. the tip of the wire hangs out too far, had to manually maneuver the wire to fit into the wheel, e.g.)
2 - Wire slid into the wheel with ease, but the wheel itself made the sliding motion uncomfortable/less time efficient
3 - Wire slid into wheel without complications

Unloading

1. Start timer
2. Use one hand to hold wheel, and one hand to thread guidewire out of loop
3. When wire is fully out of wheel, stop timer

DO NOT STICK FINGERS THROUGH CENTER OF WHEEL TO AID IN REMOVAL. MUST REMOVE WIRE WITHOUT TOUCHING
*If the guidewire is not able to unload properly, record load time as MT (mistrial)

Grade the Unload (Thread trial) (0-3)

0 - Unable to unload the guidewire
1 - The guidewire was partially removed from the wheel before tangling and popping out

2 - The guidewire was removed from the wheel without tangling but partially falls out of wheel during unloading
3 - The guidewire was removed without complications

Unloading Pull

1. Use one hand to hold wheel, and one hand to remove guidewire out of loop
2. When wire is fully out of wheel rate the difficulty of removing the guidewire

Grade the Unload Trial (Pull Trial)(0-3)

0 - Unable to unload the guidewire
1 - The guidewire was removed from the wheel but significant effort was needed (2 hands, extra person utilized)
2 - The guidewire was removed from the wheel but was caught on middle chimney
3 - The guidewire was removed without complications

Record the following values for each trial:

- Member or Participant Number
- Design Used
- Guidewire Used
- Load time
- Unload time
- Grade

Conclusions/action items: This protocol ensures all testing is done the same across all test subjects

Testing Results and Analysis -12/8/22

VICTORIA HEILIGENTHAL - Dec 08, 2022, 8:49 PM CST

Title: Testing Results and Analysis

Date: 12/8/22

Content by: Victoria

Present: N/A

Goals: To document all team testing

Content:

All team testing results, and analyzation can be found under Victoria's Folder

Conclusions/action items: These results can be used to help finalize the wheel design

09/23/2022 BME 400 PDS

ADDISON DUPIES - Oct 10, 2022, 2:14 PM CDT

Title: BME 400 PDS

Date: 09/23/2022

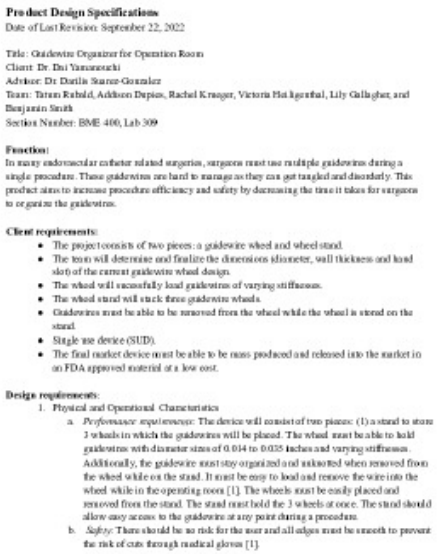
Content by: All

Present: All

Goals: Upload PDS

Content:

ADDISON DUPIES - Oct 10, 2022, 2:13 PM CDT



Product Design Specifications
Date of Last Revision: September 22, 2022

Title: Guidewire Organizer for Operation Room
Client: Dr. Dai Yamamouchi
Advisor: Dr. Dorilis Suarez-Gonzalez
Team: Tatum Rubold, Addison Dupies, Rachel Krueger, Victoria Hultgenthal, Lily Gallagher, and Benjamin Smith
Section Number: BME 400, Lab 309

Function:
In many endovascular catheter related surgeries, surgeons must use multiple guidewires during a single procedure. These guidewires are hard to manage as they can get tangled and disorderly. This product aims to increase procedure efficiency and safety by decreasing the time it takes for surgeons to organize the guidewires.

Client requirements:
- The project consists of two pieces: a guidewire wheel and wheel stand.
- The team will determine and finalize the dimensions (diameter, wall thickness and load slot) of the current guidewire wheel design.
- The wheel will successfully load guidewires of varying stiffnesses.
- The wheel stand will stack three guidewire wheels.
- Guidewires must be able to be removed from the wheel while the wheel is stored on the stand.
- Single use device (SUD).
- The final market device must be able to be mass produced and released into the market in an FDA approved material at a low cost.

Design requirements:
1. Physical and Operational Characteristics
   a. *Performance requirements:* The device will consist of two pieces: (1) a stand to store 3 wheels in which the guidewires will be placed. The wheel must be able to hold guidewires with diameter sizes of 0.014 to 0.035 inches and varying stiffnesses. Additionally, the guidewire must stay organized and unknotted when removed from the wheel while on the stand. It must be easy to load and remove the wire into the wheel while in the operating room [1]. The wheels must be easily placed and removed from the stand. The stand must hold the 3 wheels at once. The stand should allow easy access to the guidewire at any point during a procedure.
   b. *Safety:* There should be no risk for the user and all edges must be smooth to prevent the risk of cuts through medical gloves [1].

Download

PDS_BME_400.pdf (107 kB)

BME 400 Preliminary Report -12/8-22

VICTORIA HEILIGENTHAL - Dec 08, 2022, 8:54 PM CST

Title: BME 400 Preliminary Report

Date: 128/22

Content by: All

Present: All

Goals: Upload Preliminary Report

Content:

VICTORIA HEILIGENTHAL - Dec 08, 2022, 8:54 PM CST

Guidewire Organizer for Endovascular Procedures

BME 400
University of Wisconsin - Madison
Department of Biomedical Engineering
12 October 2022

Client: Dr. Dai Yamamoto, MD, PhD
University of Wisconsin School of Medicine and Public Health
Department of Surgery

Advisor: Dr. Durlin Suarez
University of Wisconsin - Madison
Department of Biomedical Engineering

Team Members:
Tatum Rahold (Team Leader)
Addison Dupies (Communicator)
Victoria Heiligenthal (BPAG)
Rachel Krueger (BWIG)
Lily Gallagher (Co-BSAC)
Benjamin Smith (Co-BSAC)

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BME400_Preliminary_Report.pdf (3.92 MB)

BME 400 Preliminary Presentation-12/8/22

VICTORIA HEILIGENTHAL - Dec 08, 2022, 8:55 PM CST

Title: BME 400 Preliminary Presentation

Date: 12/8/22

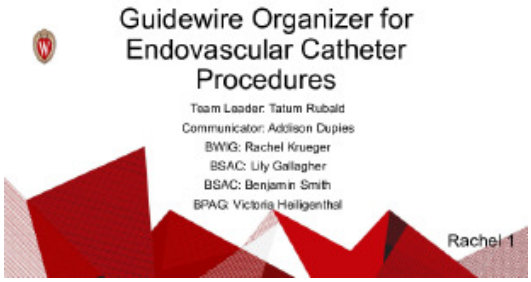
Content by: All

Present: All

Goals: Upload Preliminary Presentation

Content:

VICTORIA HEILIGENTHAL - Dec 08, 2022, 8:55 PM CST



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400_-_EndoVasc_Prelim_Presentation.pdf (1.27 MB)

BME 400 Final Presentation -12/12/22

VICTORIA HEILIGENTHAL - Dec 12, 2022, 10:42 AM CST

Title: BME 400 FInal Presentation

Date: 12/12/22

Content by: All

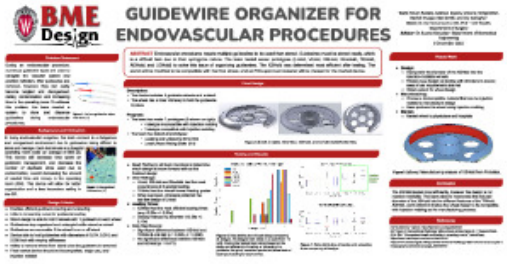
Present: All

Goals: Document the team's final presentation

Content:

Conclusions/action items:

VICTORIA HEILIGENTHAL - Dec 12, 2022, 10:43 AM CST



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BME 400 Final Report -12/13/22

VICTORIA HEILIGENTHAL - Dec 13, 2022, 10:15 AM CST

Title: BME 400 Final Report

Date: 12/12/22

Content by: All

Present: All

Goals: Document the team's final report

Content:

https://docs.google.com/document/d/1PUeg7vLcbNdxuvQhfhlc5TAy6NurbxARTVis3XWcknk/edit?usp=share_link

Conclusions/action items:

27SEP22: Injection Molding

TATUM RUBALD - Oct 07, 2022, 10:08 AM CDT

Title: Injection Molding

Date: 27Sep22

Content by: Tatum Rubald

Goals:

I will determine the requirements for a product to have the ability to be injection molded.

Content:

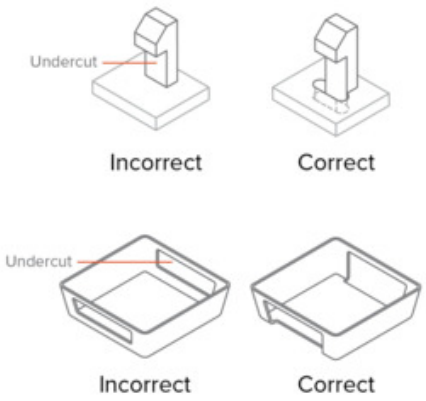
https://www.hubs.com/guides/injection-molding/

- Most defects in injection molding are related to the flow of material or non-uniform cooling rate
- warping: when certain sections cool faster than others, then the part can permanently bend due to internal stresses
    - parts with non-constant wall thickness are most prone to warping
- Sink marks: when interior solidifes before its surface
    - parts with thick walls or ribs are prone to sinking
- Drag marks: as the plastic shrinks, it applies pressure on the mold. During injection, the walls of the part will slide and scrape against the mold
- Undercuts: the simplest mold consists of 2 halves. Features with undercuts may not be manufacturable with a straight pill mold though
    - avoid undercuts using shutoffs: add cost and complexity
        - redesign can often eliminate undercuts
            - material is removed in the area under the undercut, eliminating the issue altogether
        - Move the parting line: suitable for many designs with undercuts on an external surface
        - stripping undercut (bump offs): can be used when the feature is flexible enough to deform over the mold during injection
            - flexible plastics such as PP, HDPE or Nylon (PA)

Conclusions/action items:

We will continue to look into injection molding, and find companies in the area that do it.

TATUM RUBALD - Sep 27, 2022, 11:15 AM CDT



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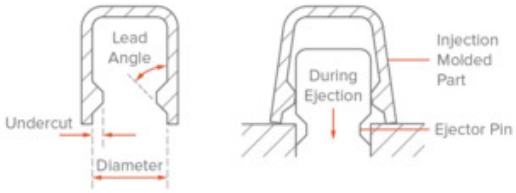
TATUM RUBALD - Sep 27, 2022, 11:15 AM CDT



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27SEP27: Snap Clips

TATUM RUBALD - Sep 27, 2022, 12:45 PM CDT

Title: Snap Clips

Date: 27SEP22

Content by: Tatum Rubald

Goals:

Research snap clips used I injection molding. We would use this method if we had to make it in two pieces.

Content:

- Snap clips eliminate screws in the assembly of the project

- snaps increase tooling cost

- cause product to have undercuts

- clips must endure a certain amount of deflection as they move in and out of position

- factors that affect stress on clip:

  - length of arm: longer = less stress

  - limit hook size

https://www.protolabs.com/resources/design-tips/design-more-effective-clips-on-plastic-injection-molded-parts/

Conclusions/action items:

We will determine if we need to use snap clips to help manufacture our design.

02NOV22: Examples of Injection Molded Devices

TATUM RUBALD - Nov 02, 2022, 5:07 PM CDT

Title: Examples of Injection Molded Devices

Date: 02NOV22

Content by: Tatum Rubald

Goals:

I want to research different products that are injection molded, and compare the design to our product to see if we can use their manufacturing methods.

Content

- Car dashboard
  - Techniques:
    - Gas-assisted injection molding
    - sequence valve injection
    - compositie injection
  - Application to our product:
    - intricate design has rims/edges like our wheel does
  - Ideas:
    - use an injection molding technique listed above for our device

- 
- Cell phone case
    - Materials:
        - ploycarbonate
        - polyurethane
        - polypropylene
    - Connection:
        - cell phone cases have a rim
    - Ideas:
        - can we make our device have a rim similar to a phone case? Do we need such a large overhang, or can the GW be held in with a simple edge

https://www.rapiddirect.com/blog/injection-molding-examples/

Conclusions/action items:

I am going to model a wheel that resembles a phone case.

17NOV22: Thermoforming

TATUM RUBALD - Nov 18, 2022, 3:00 PM CST

Title: Thermoforming

Date: 17NOV22

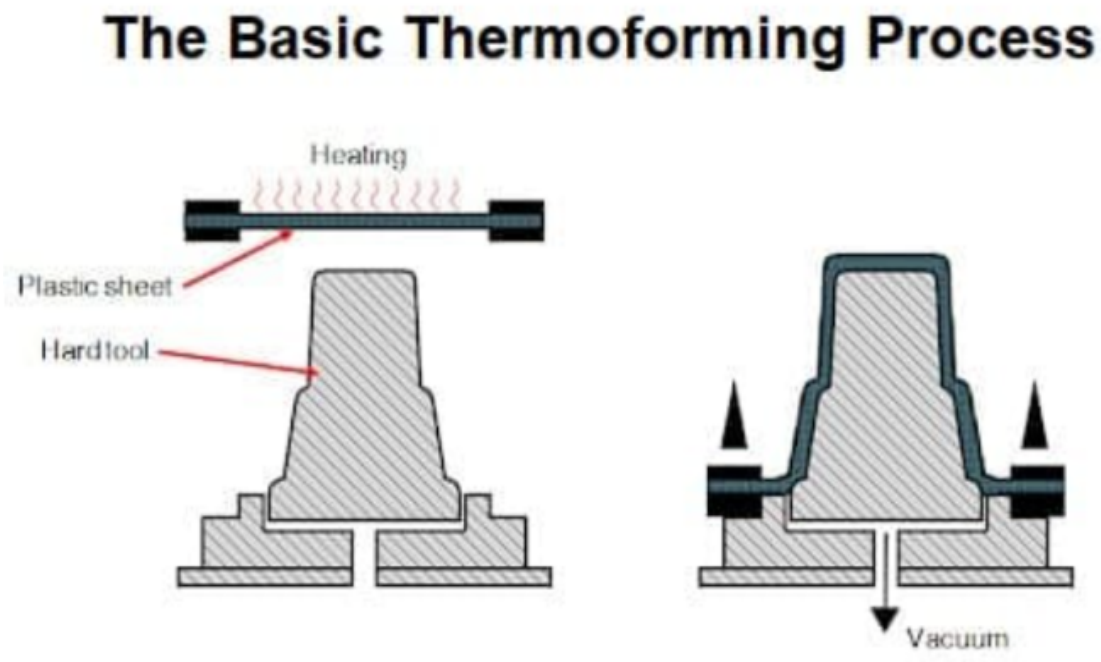
Content by: Tatum Rubald

Goals:

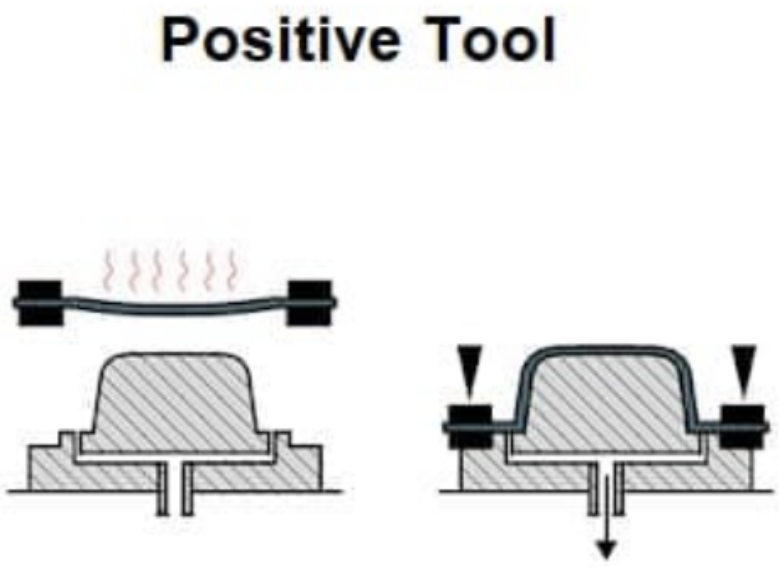
Look more into thermoforming after Victoria sent initial info about it.

Content:

- Thermoforming is a plastic manufacturing process that uses pressure or the force of a vacuum to stretch thermoplastic material over a mold to create a three-dimensional shape
    - thin sheets: cups, containers, lids, trays, and clamshells
    - thicker sheets of thermoplastic are used to produce car doors and dash panels, refrigerator liners, and plastic pallets
- two processes used for thermoforming:
    - vacuum forming
    - pressure forming
    - both used to stretch the heated thermoplastic over the surface of the mold



-
- The forming phase of thermoforming happens in a mold cavity
    - the plastic sheet is drawn by air or vacuum pressure
    - the mold cavity contains the shape of a single part
    - the mold tool ("tooling"), is a collection of mold cavities
- Suitable for high-volume manufacturing of molded products due to its fast turnaround times
- Thermoplastic sheets, are continuously fed into the heating chamber and formed into the desired shape
- Thin gauge thermoforming
    - produces products with thicknesses of less than 1.5 mm
    - FDA Thermoforming Grade is a thin polypropylene (PP)
- Mold cavities



Conclusions/action items:

I am unsure if thermoforming would be a plausible method for our current design. However, could we consider making a bowl shape for this project? This is a product currently produced by Medline, but could we make it better?

Using thermoforming to produce our design would require an entire redesign of our product (essentially changing it into something completely different). Thus, I think we continue to go down the path of injection molding so we can keep our clients design idea alive.

13DEC22: Additional Research on Endovascular Procedures

TATUM RUBALD - Dec 13, 2022, 2:39 PM CST

Title: Endovascular Procedures

Date: 13DEC22

Content by: Tatum Rubald

Goals:

Research additional information about endovascular procedures based on preliminary report feedback.

Content:

- Currently, most doctors store used guidewires under a wet towel.
    - these towels may shed fibers onto the wire
    - these fibers have the potential to be displaced into the body
    - Lint contamination can cause serious harm to the patient, and lint related complications include: thrombogenesis, infections, amplified inflammation, poor wound healing, granulomas, adhesions and capsule formation [1].
- The use of guidewires spans a variety of different surgical sectors including:
    - angioplasty, stenting, pacemaker insertion, electrophysiology studies, atherectomy, thrombolysis, and endourology and therapeutic endoscopy of the gastrointestinal system [2].
- Guidewires vary in diameter and stiffness because they have different purposes in the procedure
    - Dduring a coronary angioplasty, a flexible GW is used in very angled vessels where as a high support GW is used to provide more support in cases of tortuous anatomy and distal lesions [3].

Conclusions/action items:

[1] "Lint Fiber–Associated Medical Complications Following Invasive Procedures," *News*. https://array.aami.org/do/10.2345/article.073cc92d-0ff5-49c9-8d71-7462c5939054/ (accessed Dec. 08, 2022).

[2] H. Sharei, T. Alderliesten, J. J. van den Dobbelsteen, and J. Dankelman, "Navigation of guidewires and catheters in the body during intervention procedures: a review of computer-based models," *J Med Imaging (Bellingham)*, vol. 5, no. 1, p. 010902, Jan. 2018, doi: 10.1117/1.JMI.5.1.010902.

[3] "Coronary Angioplasty Guidewires: Differential Characteristics and Technology," *Coronary angioplasty guidewires (CAG)*, vol. Volume 8, no. Issue 2, Feb. 2017, doi: 10.15406/jccr.2017.08.00278.

09NOV22: EVCO Feedback

TATUM RUBALD - Nov 10, 2022, 10:31 AM CST

Title: EVCO Meeting

Date: 09NOV22

Content by: Tatum Rubald

Present: Tatum and Kate (EVCO rep)

Goals: Get feedback on design

Content:

Comments:

- The design overall looks decent. A more thorough review could be conducted if solid CAD was available.
- It's difficult to tell from the screen shots, but assuming the part is 3"-6" in diameter, the nominal wall thickness appears to be in-line for reasonable injection molding cycle times, cost, and reducing defects like sink. There don't appear to be any oddly thick areas that would stay molten and lead to visible depressions in functional part surfaces.
- Something to consider is allowable gate locations, or where one would allow the material to flow into the physical mold cavity. Depending on gate design, it may need to be clipped flush on an edge, so it's important to consider vestige allowances and potential impacts of having that remnant on the part given the part's end use. In general – one should gate thick to thin, in terms of nominal wall, however this isn't always possible.
- Radii look nice, plastics certainly do not like sharp corners. This can lead to heightened residual stress concentrations and failures in the field if the part is subjected to a load.
- When I look at this part, I am visualizing the 'A' side of the molding tool to be the top face, and the 'B' side being the bottom face. The cutouts in the part are certainly a good idea, and greatly reduce tool complexity, as they negate the need for a lifter. They are essentially ridding the design of an undercut. At location 1 I'm visualizing core (B side) steel coming up to form the tab feature. The steel will roughly look like the thin red lines illustrated below. From the view presented, the radius that is physically pointed out by location 1 would need to be removed. The cutout created should allow the steel to form the complete underside of the feature and the attached vertical wall all the way down to the cutout feature itself.
- This is more granular type feedback, but anytime mold steel meets for a vertical shutoff (location 1 B side steel contacting A side steel) the steels should be given 3-5 degrees draft. This allows better force distribution and lessens the odds for flash and mold damage. This 3-5 degrees should be a consideration in all cut out areas where steel from different halves are meeting.
- Area 2 looks somewhat thin, but it's hard to tell.
- Eventually you'll need to eject your part out of the mold. In most circumstances, ejector mechanisms are on the B side of the mold. Depending on the parts end use, there may be restrictions to where pins can be placed to push the part out of the mold. This is common for parts that have seal surfaces. In general it's possible to get theses features flush to 0.005" to the parts surface, but you will always see a witness line. This is because ejector pins have designed clearance, because they need to actuate each molding cycle to eject the part. The die line is the plastic physically flowing into this clearance. Just something to consider…
- The shark fin cutout North of location A appears to get pretty sharp. That means the physical steel required to form and shutoff against other steel would be thin and sharp. This could be a long term issue location, and could benefit from having the cutout modified to allow thicker steel.

Conclusions/action items:

EVCO will not manufacture our design, but we should take these notes into account.

TATUM RUBALD - Nov 10, 2022, 10:31 AM CST

Download

EVCOFeebackImage (268 kB)

23SEP22: Design Modification Brainstorm

TATUM RUBALD - Sep 23, 2022, 2:38 PM CDT

Title: Design Modification Brainstorm

Date: 23SEP22

Content by: Tatum Rubald

Goals:

Determine different ways to modify design.

Content:

- instead of 3/4 circle overhang, use an oval shape-- this could make the design injection moldable

- decrease chimney height and add chimney overhang-- this will make it easier for the user to slide their hand in without hitting the chimney

- decrease diameter of wheel

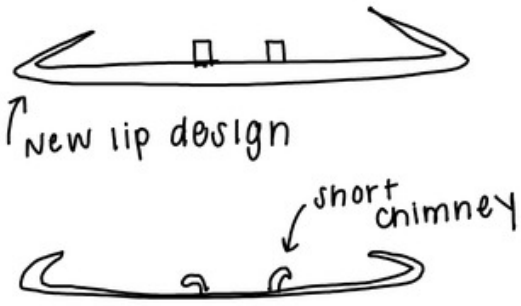
- increase hand opening

- decrease wheel height

Conclusions/action items:

I will design all of these on solid works within the next week.

TATUM RUBALD - Sep 23, 2022, 2:40 PM CDT



Download

sketch_1FE5DE55-B850-4181-8308-4D2069482DF9.png (129 kB)

27SEP22: Design Variations

TATUM RUBALD - Oct 07, 2022, 10:21 AM CDT

Title: Design Variations

Date: 27 Sep 2022

Content by: Tatum Rubald

Goals:

Model different design variations. I will make 4 different designs: VHold, XSHold, XtraHold, LHold

Content:

- see attached doc with design variations and the differences between them

- we need the chimney section to hold in the guidwirie as we unload it.

- how will this effect our desire to injection mold our product?

Conclusions/action items:

I will discuss these variations with the team.

TATUM RUBALD - Sep 27, 2022, 11:03 AM CDT

Embedded private docs from Google Drive cannot be displayed in PDF

7OCT22: VHold SW File

TATUM RUBALD - Oct 07, 2022, 10:28 AM CDT

Title: VHold SW File

Date: Oct 7

Content by: Tatum Rubald

Goals:

Download SW file so it can be accessed by the team.

Content:

See attached file.

Conclusions/action items:

We will print this design

TATUM RUBALD - Oct 07, 2022, 10:28 AM CDT

Download

VHold.SLDPRT (207 kB)

7OCT22: XSHold SW File

TATUM RUBALD - Oct 07, 2022, 10:29 AM CDT

Title: XSHold SW File

Date: Oct 7

Content by: Tatum Rubald

Goals:

Download SW file so it can be accessed by the team.

Content:

See attached file.

Conclusions/action items:

We will print/modify this design

TATUM RUBALD - Oct 07, 2022, 10:29 AM CDT

Download

XSHold.SLDPRT (200 kB)

7OCT22: XtraHold SW File

TATUM RUBALD - Oct 07, 2022, 10:30 AM CDT

Title: XtraHold SW File

Date: Oct 7

Content by: Tatum Rubald

Goals:

Download SW file so it can be accessed by the team.

Content:

See attached file.

Conclusions/action items:

We will print/modify this design

TATUM RUBALD - Oct 07, 2022, 10:30 AM CDT

Download

XtraHold.SLDPRT (237 kB)

7OCT22: LHold SW File

TATUM RUBALD - Oct 07, 2022, 10:31 AM CDT

Title: LHold SW File

Date: Oct 7

Content by: Tatum Rubald

Goals:

Download SW file so it can be accessed by the team.

Content:

See attached file.

Conclusions/action items:

We will print this design

TATUM RUBALD - Oct 07, 2022, 10:31 AM CDT

Download

LHold.SLDPRT (222 kB)

8OCT22: VHold V2

TATUM RUBALD - Oct 07, 2022, 10:23 AM CDT

Title: VHold Version 2

Date: 7OCT22

Content by: Tatum Rubald

Goals:

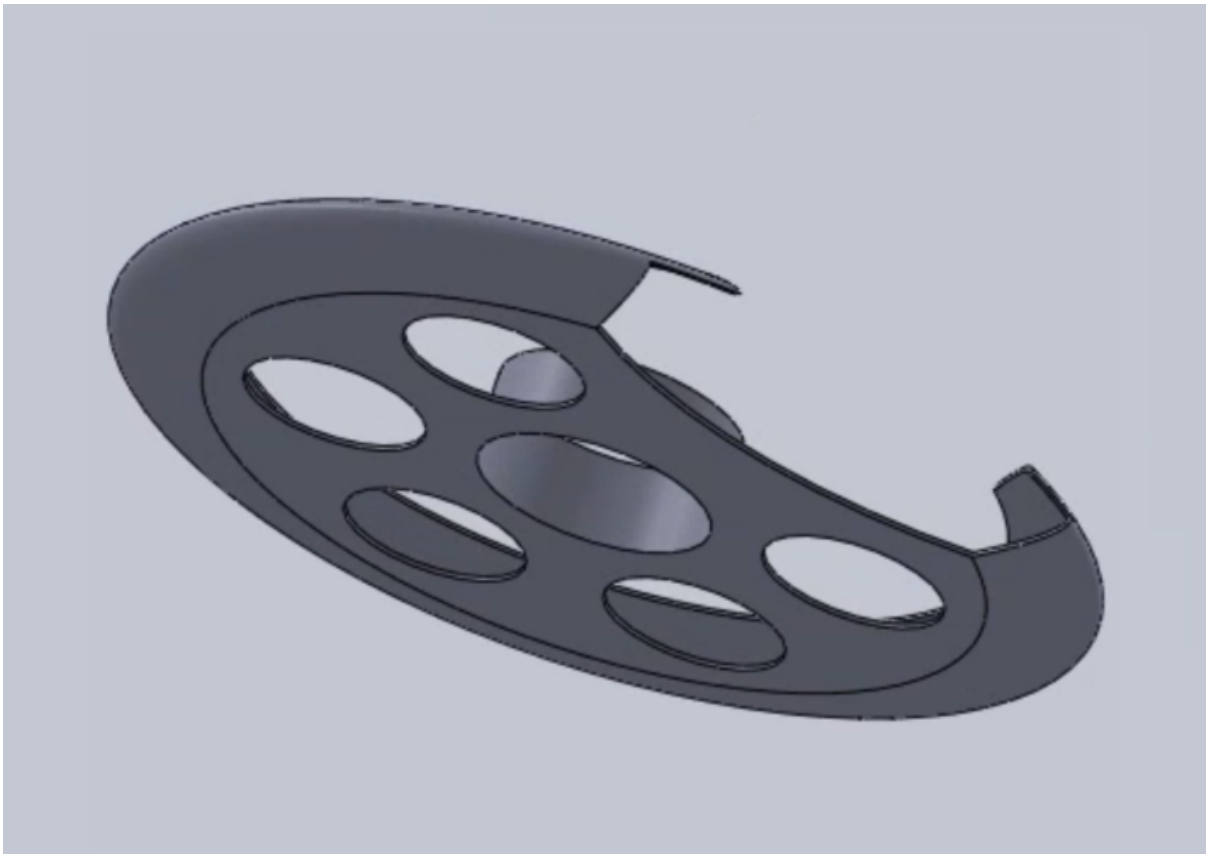
I will modify VHold to have a lip on the insertion point to help guide the guidewire into the wheel easier.

Content:

-attached SW file

-images

-this design modification should be applied to all designs



Conclusions/action items:

How will this affect its injection moldability?

TATUM RUBALD - Oct 07, 2022, 10:26 AM CDT

Download

VHoldV2.SLDPRT (216 kB)

02NOV22: Phone Case Design

TATUM RUBALD - Nov 02, 2022, 7:44 PM CDT

Title: Phone Case Design

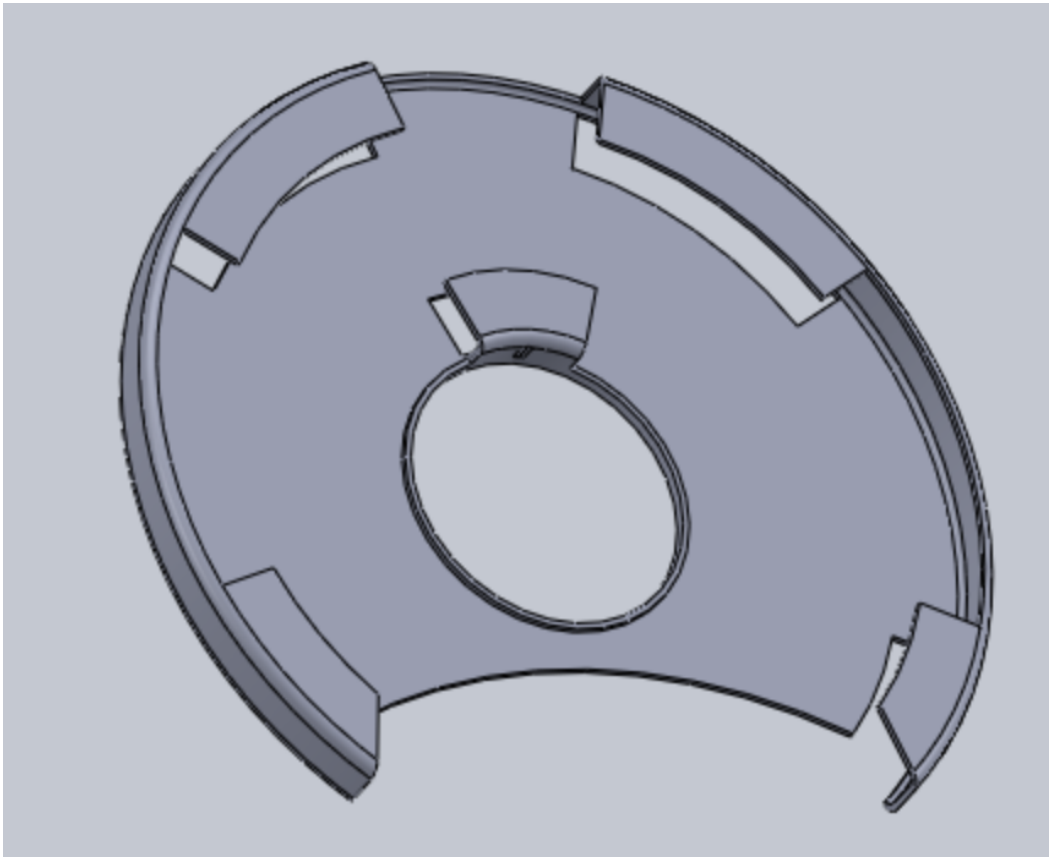
Date: Nov 2

Content by: Tatum Rubald

Goals:

Model a wheel that mimics a phone case (b/c phone cases are injection moldable)

Content:



- Rim mimics a phone case
- Undercuts for every overhang
- Should be injection moldable…
    - Will it still be functional?

Conclusions/action items:

We will discuss this design as a team tomorrow.

10NOV22: Modified CutOut

TATUM RUBALD - Nov 10, 2022, 10:17 AM CST

Title: Modified CutOut

Date: 10 NOV 22

Content by: Tatum Rubald

Goals:

Modify the phone case design to account for comments discussed during team meeting.

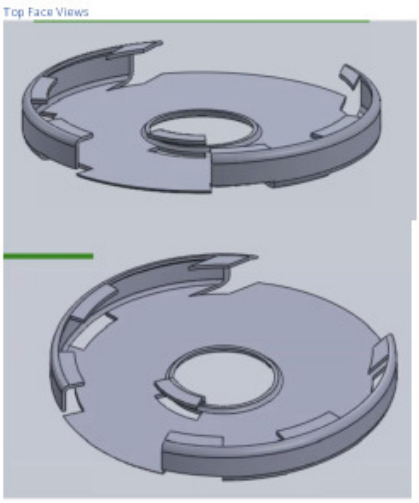
Content:

See attached PDF.

Conclusions/action items:

Print and test design.

TATUM RUBALD - Nov 10, 2022, 10:17 AM CST



Download

GWOrganizer_ScreenShots.pdf (158 kB)

25SEP22: Outreach Seminar

TATUM RUBALD - Sep 25, 2022, 1:56 PM CDT

Title: Outreach Seminar

Date: 25SEP22

Content by: Tatum Rubald

Goals:

I will go through the outreach seminar slides I had to miss due to COVID.

Content:

- Diversity is important to engineering so we can incorporate all perspectives into our designs
    - engineering challenges are complex
    - need different experiences and backgrounds to solve problems
    - cultural awareness is important
- Outreach is strongly encoraged
    - Presentation
    - Activity
        - 20-40 min fun and hands on
    - Report
    - Teacher/Leader evaluation

Conclusions/action items:

Where would the team be interested in completing our outreach assignment? Personally, I enjoy working with kids and middle schoolers. We could go to a school and teach the kids about what engineering is, and do a simple project to encourage engineering skills from a young age. If we wanted to do something medical related, our hands on activity could be as simple as creating a band-aid. We could start by brainstorming with the kids ways to make band-aids more inclusive. I believe it would also be important to set the kids up into groups because this is how many engineering projects are completed.

As a group of 5 females and 1 male, I think we could set a good example for girls in STEM. I know when I was in elementary school, a female doctor came in and taught us about in-vitro fertilization. I think it could be cool to each share a personal experience with the class about how we have done engineering in the "real-world".

2022/09/15 General Review

ADDISON DUPIES - Oct 10, 2022, 1:47 PM CDT

Date: 9/15/2022

Content by: Addie Dupies

Present: NONE

Goals: Review basics of endovascular procedures to address any misconceptions/unknowns

Content:

- Guidewires are used in many different endovascular procedures - up to 4 guidewires can be used in each procedure
- Each guidewire in a procedure can vary in diameter and stiffness because they each have different purposes in the procedure

How it works:

1. Guidewire is inserted into the patient and then directed into the area of interest
2. The catheter is fed along the guidewire to the correct area
3. Once the catheter is in the correct position, the guidewire is removed
4. Guidewire must be stored in case it is used again during the procedure

Risk of Endovascular Procedures:

- Endovascular procedures are minimally invasive - the guidewire and catheter are inserted through a small incision
    - This lowers the risk of large, invasive surgeries as the only foreign object be inserted into the body is the guidewire and the catheter
- Used to treat problems affecting the blood vessels - like in an aneurysm (fixes the swellings of the blood vessels)
- Reduced the need to have open surgeries (positive risk - benefit ratio for patients)

https://www.brighamandwomens.org/surgery/vascular-and-endovascular-surgery/procedures

https://www.ucsfhealth.org/treatments/endovascular-surgery

Conclusion/Action Items: Reviewed the basics and feel comfortable discussing these topics, especially with the new team members if they have any questions about basics of endovascular procedures.

2022/09/20 Medline Guidewire Bowl

ADDISON DUPIES - Sep 26, 2022, 5:40 PM CDT

Title: Medline Guidewire Bowl

Date: 09/20/2022

Content by: Addie Dupies

Present: None

Goals: Research competing design of Medline Guidewire Bowl

Content:

Description:

- Bowls provide a secure location for guide wires while preparing for a procedure
- Easily graspable while wearing surgical gloves
- Five tabs help ensure that the wires stay in place
- Diameters - 11" and 8.5"
- Volume: 5,000 mL and 2,500 mL
- Latex free
- Provide a secure location while preparing for a procedure
- Easy to grasp while wearing surgical gloves
- Have the volume measurements on the inside of the bowl
- Has a lid to keep out unwanted particles
- Comes in 28 and 10 count or individual
- Sells in a kitting component

Disclaimers:

- Pre-sterilized item

Conclusion/Action Items: Newer competing device. Similar to our device but a little different. Should look into patent infringement.

https://punchout.medline.com/media/catalog/Docs/MKT/LIT941_CAT_Namic_19W1581299.pdf

2022/09/20 Medline Dual Securement Guidewire Clip

ADDISON DUPIES - Sep 26, 2022, 5:45 PM CDT

Title: Medline Dual Securement Guidewire Clip

Date: 09/20/2022

Content by: Addie Dupies

Present: None

Goals: Research competing design of Medline Dual Securement Guidewire Clip

Content:

- Securely and gently holds any flexible elongated medical device, such as a guidewire, catheter, or balloon, in between uses during or after a procedure
- Adhesive backing allows for placement on a back table cover or drape
- 20 count
- The downside is that it only holds 2 guidewires - not useful for endovascular surgeries/cath lab
- Single-use/ Latex Free
- Bright color makes it easy to spot in any light
- Can be purchased in a single, sterile pack or added to a custom kit
- Developed in partnership with a physician the Dual Securement Guidewire Clip provides an added level of procedural efficiency
    - Just fix the clip to a patient drape or back table cover, secure the guidewire and continue with your procedure—no more dropped wires or wasted time and supplies

Conclusion/Action Items: Could be a competitor, however, it only hold two guidewires which doesn't provide a lot of usage.

https://punchout.medline.com/media/catalog/Docs/MKT/LITe20369_SSH_Namic_WirePro_19W10035.pdf

2022/09/16 Injection Molding (Manufacturing)

ADDISON DUPIES - Sep 26, 2022, 4:50 PM CDT

Title: Injection Molding (Manufacturing Guide)

Date: 09/16/2022

Content by: Addie

Present: None

Goals: Identify how injection molding works and if it is a process that would be feasible for our device

Content:

- Plastic is first melted and then injected into the cavity of a mold. When the material cools, it solidifies and takes the form of the mold. The part is then ejected and the process starts over.
- A fundamentally different way of manufacturing compared to 3D printing (considered additive) and CNC machining (considered subtractive)
- Flow and solidification of the material during injection have a significant impact on the key design restrictions for this technology
- Most things are injection molded because of the low cost and high volume production
    - Start-up costs for injection molding are relatively high because they are custom tooling
    - Mold costs can cost anywhere between $3,000 to $100,000
- The most common materials are Polypropylene (PP), ABS, Polyethylene (PE), and Polystyrene (PS)

Basics (how does this work): Three main parts: the injection unit, the mold, and the clamping/ejector unit

Injection Unit

- This melts the raw plastic and guides it into the mold
- It consists of the hopper, the barrel, and the reciprocating screw
- In the hopper, the plastic pellets are mixed with any color pigments or other additives that are needed for the material properties
- Then the material is sent through the barrel (this contains the screw)
- The screw carries the pellets to the mold and at the same time compresses them
    - The forces caused by the movement of the screw produced 60-90% of the heat needed to melt the plastic
- The ram will plunge forward when enough plastic is in front of the screw and the material goes into the empty cavity of the mold

Benefits of Injection Molding:

- High-volume manufacturing of plastics: most competitive technology for manufacturing high volumes of identical plastic parts - once the mold is created additional parts can be manufactured very fast and at a very low cost
    - Minimum production volume ~500 units (ROI when you reach this point)
- Wide range of materials (can mix plastic pellets)
- High productivity (15-60 seconds) depending on the size of the part and the complexity of the mold
    - A single mold can have multiple cavities further increasing productivity
- Great repeatability + tolerances: Has very small tolerances and can be compared to CNC machining and 3D printing however a single mold can be used up to 100,000+ cycles

Limitations of Injection Molding:

- High tooling cost: initial mold manufacture can cost between $3,000 to 100,000
- Design changes cost a lot

- Long lead times
- There are many products in healthcare that are injection molded -- should not be an issue with FDA approval

Conclusions/action items: There are many devices around the world that are injection molded. The ROI is good once 500+ cycles are produced of the product. The benefits seem to outweigh the limitations of the actual manufacturing process. Next, I will look into how our product must be designed in order for injection molding to be feasible.

2022/09/26 Injection Molding (Design Requirements)

ADDISON DUPIES - Sep 26, 2022, 5:21 PM CDT

Title: Injection Molding (Design Requirements)

Date: 09/26/2022

Content by: Addie Dupies

Present: None

Goals: Establish the Design Requirements of Injection Molding

Content:

Common Injection Molding Defects:

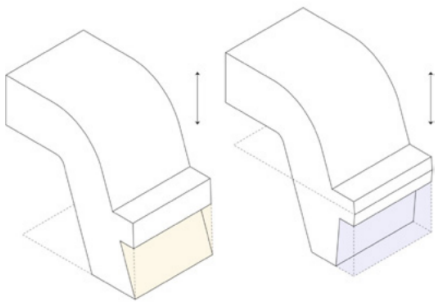
- Warping: a section cools and then shrinks faster than other - objects with non-constant wall thickness are prone to warping
- Sink marks: When interior of a part solidifies before its surface, a small recess in an otherwise flat surface may appear, called a sink mark. Parts with thick walls or poorly designed ribs are most prone to sinking.
- Drag Marks: As the plastic shrinks, it applies pressure on the mold. During ejection, the walls of the part will slide and scrape against the mold, which can result to drag marks. Parts with vertical walls (and no draft angle) are most prone to drag marks.
- Knit Lines: When two flows meet, small hair-like discolorations may develop. These knit lines affect the parts aesthetics, but also they generally decrease the strength of the part. Parts with abrupt geometry changes or holes are more prone to knit lines.
- Short Shots: Trapped air in the mold can inhibit the flow of the material during injection, resulting in an incomplete part. Good design can improve the flowability of the melted plastic. Parts with very thin walls or poorly designed ribs are more prone to short shots.

Design Rules:

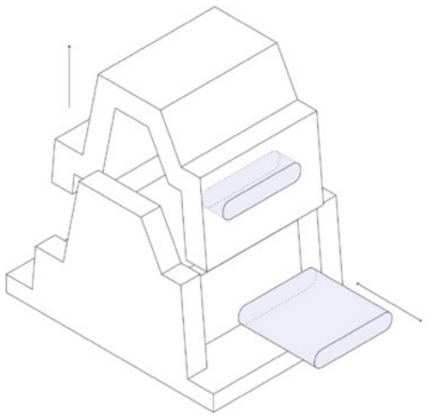
- Use a constant wall thickness (1 - 3 mm) this helps avoid warping and sinking
    - If thicker is needed - hollow them out and use ribs to add stiffness instead
- Add smooth transitions: use chamfer or fillet to make the transition from different wall thicknesses
- Add draft angles: add a draft to all vertical walls to avoid drag marks and make the ejection of the part easier

Dealing with undercuts:

- Undercuts in Injection molding are part features that cannot be manufactured with a simple two-part mold, because material is in the way while the mold opens or during ejection.
- Moving the parting line: move the parting line of the mold to intersect with it
- The solution is suitable for many designs with undercuts on an external surface



- Stripping Undercuts: If the part is flexible enough then deforming over the mold during ejection is an option. Stripping undercuts are used for internal features (threads of bottle caps)
    - Select a flexible material (PP, PE, Nylon)
    - The height of the undercut should be 5% the diameter of the hold
- Side Action Cores: When no other solutions are viable this can be done. This increases the cost of the mold by 15-30%



https://downloads.hubs.com/Injection_Molding_the_Definitive_Engineering_Guide.pdf?utm_campaign=Gated%20Content%20Downloads&utm_medium=email&_hsmi=80170925&_hsenc=p2ANqtz-91YdrtmE5Br6EgvSG9SrENxcc6Rxv8YJW2VkI8Lkq_CIM5YgAl6Bf3dYocvQMlhE02DH2yxqVXmTLyN7w3AauB-wtxaA&utm_content=80170925&utm_source=hs_automation

Conclusions/action items: Our design must be modified as there is an undercut and these aspect must be taken into account

2022/10/05 FDA Approved Class I Materials

ADDISON DUPIES - Oct 10, 2022, 2:09 PM CDT

Title: FDA Approved Class I Materials

Date: 10/05/2022

Content by: Addie Dupies

Present: None

Goals: Identify FDA Approved Plastics for Class I Devices

Content:

- Polyurethane - widely used with intravascular catheters
- Polypropylene - mainly used with surgical mesh
- PETG - common for medical device packaging

Why use polymers?

1. Versatile: Highly moldable into different shapes. Versatile use in medical technology. Due to their versatility, medical polymers are suitable for making many medical parts. Examples include bedpans, inhalation masks, IV tubes, and catheters.

2. Easy Sterilization: important in many medical component manufacturers consider during manufacturing. Depending on whether they are chemical or heat resistant, most medical grade plastics are sterilizable.

3. Infection Resistant
   Medical product manufacturers have also created plastic materials, such as microplastics, to reduce bacteria by 99%. This plastic surface has anti-microbial properties due to certain modifications so that it can repel or kill any bacteria on them.

4. Cost-Effective
   Using plastic in making medical parts is cost-effective. The material cost is low, and the manufacturing cost is economical due to large production.

5. Environment friendly
   Most medical thermoplastics are recyclable. For example, polypropylene melt under heat and is shapeable using any manufacturing process. During the manufacturing process, remnant and unused plastic polymers are reusable.

6.

Conclusion/Action Items: Use this research when meeting with protolabs to get their opinion.

https://www.fda.gov/medical-devices/science-and-research-medical-devices/medical-device-material-safety-summaries

https://www.rapiddirect.com/blog/medical-grade-plastics/

2022/11/03 Design Variation Slide for Team

ADDISON DUPIES - Nov 09, 2022, 11:07 AM CST

Title: Design Variation Slide for Team

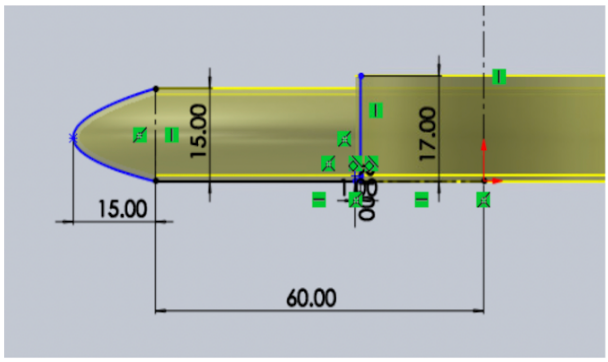
Date: 11/03/2022

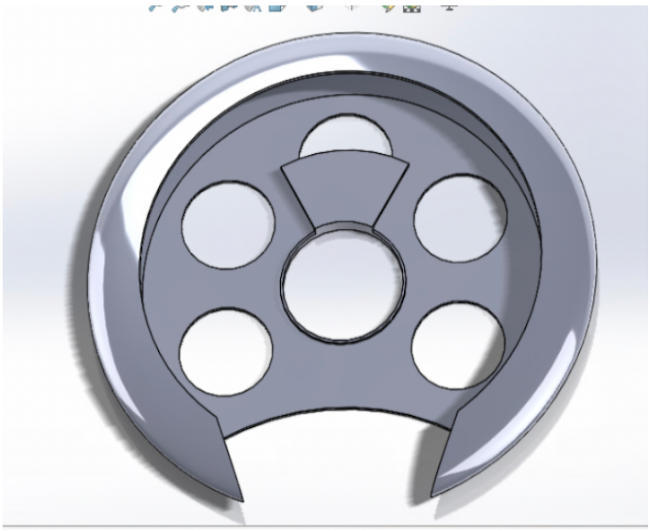
Content by: Addie Dupies

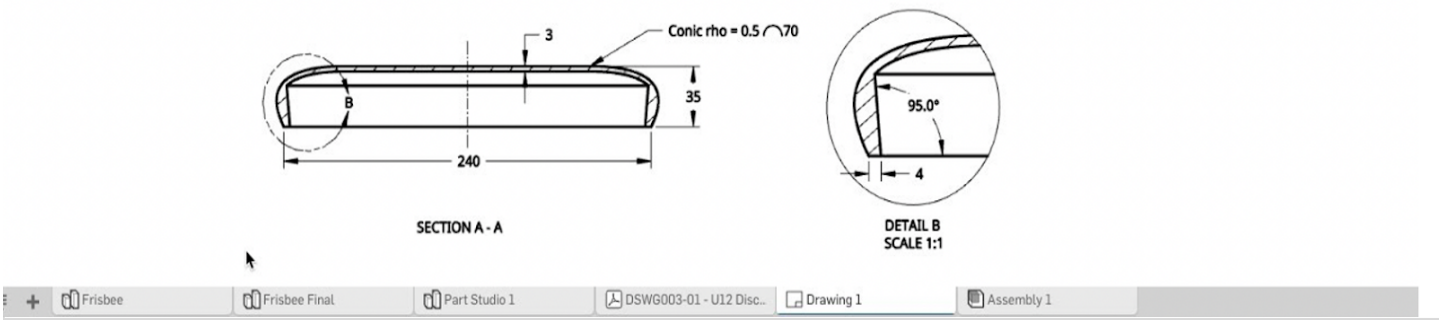
Present: None

Goals: Re-design the wheel to make injection moldable

Content:







Conclusion/Action Items: Design the wheel in Solidworks so that Rachel can print it

2022/11/08 Plastics in Single Use Medical Devices

ADDISON DUPIES - Nov 09, 2022, 2:06 PM CST

Title: Plastics in Single Use Medical Devices.

Date: 11/08/2022

Content by: Addie Dupies

Present: None

Goals: Establish plastics that can be used with this new re-design of the wheel from previous entry

Content:

- Polyethylene terephthalate glycol (PETG). PETG is a material that is safe to use in contact with food. It's a common plastic used in the food prep area of clinics and hospitals, but you'll also find PETG sterilization trays.
- Acrylonitrile butadiene styrene (ABS). ABS plastic sheets are durable and tough, providing a clean aesthetic appearance that is perfect for medical environments.
- Single-Use Items
    - Single-use items make up some of the most common uses of plastic in the medical field. A wide range of single-use items uses plastic because it's inexpensive and because throwing away these items is safer than sanitizing equipment.
      For instance, reusing a catheter isn't safe since E. coli bacteria can develop regardless of the sanitation method used. You can find plastic single-use tubes, syringes, catheters, lancets, bandages, gloves and more.
    - The research field also uses medical plastic for single-use items like vials and sample bags.

https://www.acplasticsinc.com/informationcenter/r/medical-uses-for-plastic-materials

- Polypropylene: Polypropylene can be configured to be a biocompatible thermoplastic with high chemical resistance that withstands stress, cracking, impact, and fatigue. Polypropylene is typically used to manufacture disposable syringes, connectors, and finger-joint prostheses with high melting-point properties.
- Polyamide: Also known as nylon, polyamide is a synthetic polymer used as a weaker metal alternative due to its strength, inflexible properties, high-temperature resilience, and chemical resistance. It's a good option for producing plastic components for medical devices using CNC machining, injection molding, or 3D printing. Polyamide can also be combined with other medical-grade materials to improve its strength.

https://bmpmedical.com/what-plastics-are-used-in-medical-devices/

Conclusion/Action Items: Find what plastics IV Tubing and bedpans are made of. Polypropylene is most likely the best option.

2022/11/09 Best Plastics for Medical Devices

ADDISON DUPIES - Nov 09, 2022, 2:38 PM CST

Title: Best Plastics Medical Devices.

Date: 11/09/2022

Content by: Addie Dupies

Present: None

Goals: Continue research on plastics for medical devices that are feasible for design

Content:

- Medical plastic products have become more advanced as the global market for high-quality medical devices continues to expand. Such devices have become a necessary and vital component in the modern healthcare system
    - Test equipment like vials and beakers to surgical instruments, catheters, and implants, plastics are used more and more for their high performance, lightweight, and lower costs.
- Just as important, medical-grade plastic materials must meet regulatory requirements
- Polypropylene is a cost-effective medical-grade plastic material and is used where steam-sterilized medical devices are necessary. In addition to resistance to steam sterilization, mechanical performance properties of polypropylene include durability for the number of cycles it can be reused. Its recyclability also makes it an attractive medical-grade plastic.
- Polyethylene is a versatile, durable thermoplastic with a wide range of applications. Its high impact resistance and resistance to chemicals, along with low moisture absorption make it a choice medical grade plastic. It doesn't fade nor retain dangerous bacteria and can withstand harsh cleaning agents. It is often one of the materials used in medical implants because it is a porous synthetic polymer that is biologically inert and does not degrade in the body.

https://bmpmedical.com/what-plastics-are-used-in-medical-devices/

IV TUBING:

- Polypropylene, nylon and dynaflex are some of the more common materials that intravenous tubing is made from. As plastics, these synthetic materials can be manufactured with particular qualities that make them ideal for this use. These materials used are flexible, strong, leak proof and do not react with the chemicals transported through them. Manufacturers of intravenous tubing can make tubes of various thicknesses and shapes according to the specifications given to them.

https://www.thehealthboard.com/what-is-intravenous-tubing.htm

Conclusion/Action Items: Polypropylene and polyethylene seem to be the most common for SUD in the medical field. We can use these if the design is injection moldable

2022/11/10 Design Solidworks

ADDISON DUPIES - Nov 10, 2022, 11:56 AM CST

Title: Design in Solidworks

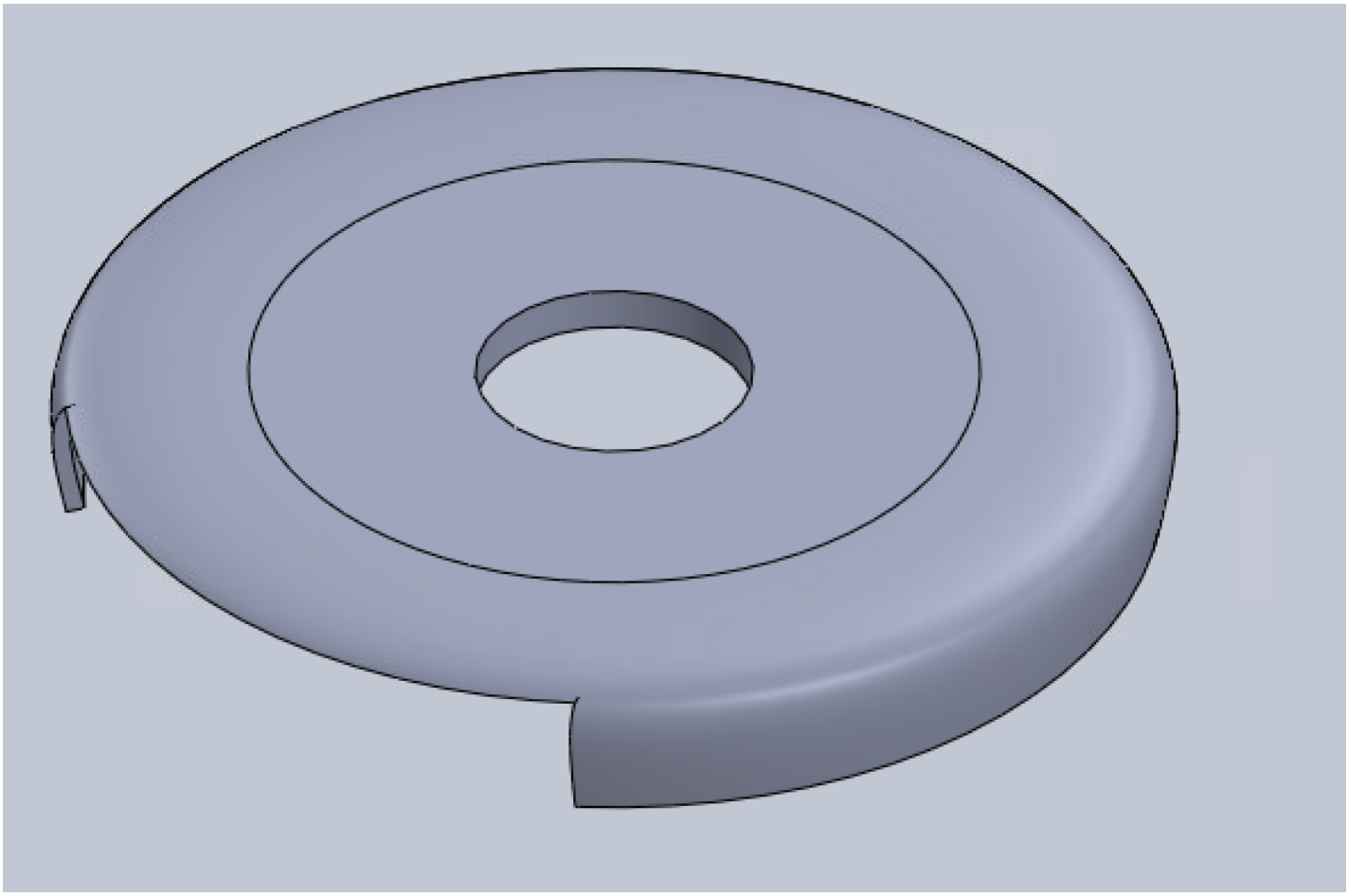
Date: 11/10/2022

Content by: Addie Dupies

Present: None

Goals: Display Solidworks

Content:



9/14 - Medical Grade Materials

RACHEL KRUEGER - Sep 14, 2022, 1:21 PM CDT

Title: Medical Grade Materials Research

Date: 9/14/2022

Content by: Rachel Krueger

Present: Rachel Krueger

Goals: Find materials that are able to be brought into the OR so that we could use this material instead of 3D printed PLA.

Content:

1. Based off of the "future work" section in the final deliverable, the team will move forward with either Nylon or Polyester
2. Nylon or polyester
    1. Materials already used in endovascular procedures
3. Nylon
    1. Polyamide that is formed from the condensation reaction of adipic acid (a dicarboxylic acid) and 1,6 – diaminohexane (a diamine).
    2. Used because it is light weight, high strength, durability, and resistance to damage
    3. Thermal processing of Nylon can cause many problems if one is exposed to the fumes or dust. Some of these problems include irritation of mucous membranes in the nose and throat, mechanical irritation of the eye and irritation of the skin.
    4. Although Nylon itself does not contain any compounds that are dangerous to the environment or one's health, manufacturing Nylon does. The process of manufacturing Nylon releases nitrous oxides and since factories have no use for the byproduct, it is released into the atmosphere as waste.
    5. **CITATION: W. Anderson, "Nylon: Background, dangers, disposal," *SchoolWorkHelper*, 2020. [Online]. Available: https://schoolworkhelper.net/nylon-background-dangers-disposal/. [Accessed: 14-Sep-2022].**
4. Polyester
    1. Durable, flexible, non-deformable, corrosion resistant, insulating, easy to clean and dry.
    2. Good chemical resistance, high strength and elastic recovery
    3. Poor resistance to melting
    4. **CITATION: S. Candice, "Advantages and disadvantages of polyester material," *Sungzu*, 03-Dec-2018. [Online]. Available: https://sungzu.com/advantages-disadvantages-polyester-material/. [Accessed: 14-Sep-2022].**

Conclusions/action items:

Narrow down which of the materials is the most cost effective, easily accessible, and best for injection molding/OR activities.

9/20 - Hands Research

RACHEL KRUEGER - Sep 20, 2022, 6:28 PM CDT

Title: Hands Research

Date: 9/20/2022

Content by: Rachel Krueger

Present: Rachel Krueger

Goals: Do basic research on hand sizes so we can identify the optimal size for the wheel.

Content:

1. There are three key measurements of adult hand size:
    - length: measured from the tip of the longest finger to the crease under the palm
    - breadth: measured across the widest area where the fingers join the palm
    - circumference: measured around the palm of your dominant hand, just below the knuckles, excluding the thumb
2. According to a comprehensive study of proportions of the human body by the National Aeronautics and Space Administration (NASA)
    1. Male: 7.6 inches (avg length), 3.5 inches (avg breadth), 8.6 inches (avg circumference)
    2. Female: 6.8 inches (avg length), 3.1 inches (avg breadth), 7.0 inches (avg breadth)
3. Determining your grip size can help you with proper tool selection. According to a 2005 studyTrusted Source, the optimal handle diameter is 19.7 percent of the user's hand length.
    1. For example, if your hand length is 7.6 inches, multiply that by 0.197 to get 1.49 inches. This means the optimum handle diameter for a tool such as a hammer would be about 1.5 inches.
4. **CITATION:** S. Frothingham, "Average hand size: For adults, children, athletes, and more," *Healthline*, 07-Aug-2019. [Online]. Available: https://www.healthline.com/health/average-hand-size#glove-sizing. [Accessed: 20-Sep-2022].

Conclusions/action items:

Use the information found here to decide on the optimal size for the surgeon gripping the device.

9/20 Law and Entrepreneurship Clinic

RACHEL KRUEGER - Sep 20, 2022, 6:37 PM CDT

Title: Law and Entrepreneurship Clinic

Date: 9/20/2022

Content by: Rachel Krueger

Present: Rachel Krueger

Goals: Understand the legal services available to us for patenting a product.

Content:

1. At a glance: ~300 clients per year, 9,905 billable hours in 2020-2021, 75% of past clients are still in business
2. The L&E Clinic provides free legal services to nascent entrepreneurs and early stage companies through the work of law students supervised by faculty and private sector attorneys.
3. They advise clients on the type of legal entity that best suits their goals by reviewing their funding strategies, ownership models, business plans and tax exposure.
    1. They then follow up to be sure the correct legal documents are properly filed.
4. The students and supervising attorneys routinely analyze the patentability of inventions, advise on trademark rights for brands and review content for copyright protection.
5. See informational videos for information on:
    1. Trademarks and copyright
    2. LLCs and corporations
    3. Choosing a lawyer for your small business
    4. Understanding worker classifications
6. **Website link:** Clinic Services | University of Wisconsin Law School

Conclusions/action items:

Refer to this entry for information on patenting and working with a legal team.

10/6 Evco Plastics

RACHEL KRUEGER - Oct 06, 2022, 1:02 PM CDT

Title: Evco Plastics

Date: 10/6

Content by: Rachel Krueger

Present: Rachel Krueger

Goals: Understand different methods we could use through Evco Plastics for manufacturing.

Content:

1. 50+ years injection molding experience
2. Focuses: fit, form, function
3. Two ISO class 8 clean rooms
4. Pieces are light, engineered for strength, use less material, and meet precise thickness specifications
5. Address: 121 Evco Circle, DeForest, WI 53532
6. Part of 5 keys to success: reduce cost, increase quality, and optimize performance
7. Core molding solutions:
    1. Stack molds: A series of interconnected, same-sized molds which are "stacked" next to each other. Without increasing the plastic injection molding machine platen size or tonnage, stack molds double the number of cavities producing parts (more for three-and four-level stack molds). Stack molds can also have different cavities in each mold parting surface to produce a family of parts per shot.
    2. Gas-assist molds: In gas assist plastic injection molding, the pressurized gas follows the path of least resistance and displaces the plastic material in the thicker areas of the part, leaving hollow sections for reduced material use and part weight. This technique reduces warpage, shrinking, surface blemishes, sink marks and internal stress.
    3. Unscrewing cores: Parts requiring threading can be put in an unscrewing mold, where the core rotates and applies the threading before the mold fully opens. The amount of threading on the part dictates how many rotations are necessary and the length of the core that is inserted into the mold.
    4. High cavitation molds: The part design, end use and production volume are a few of the variables taken into account to decide the right mold cavitation for the project. High cavitation molds reduce the price per part and generate more product per shot.
    5. Conformal cooling: Conformal cooling channels are incorporated into a mold and follow its shape, reaching hot spots and promoting temperature uniformity throughout the parts being manufactured. Incorporating this solution yields faster cooling and cycle times and improves part quality, CPK values and part sink.
8. Prototype options:
    1. Selective laser sintering (SLS): A rapid prototyping additive manufacturing process using a laser to sinter powder-based materials together, layer by layer, forming a durable solid prototype model ideal for functional parts in a variety of applications. SLS also enables production of injection molding prototypes with snap fits and living hinges.
    2. Stereolithography (SLA): A rapid prototyping additive manufacturing process employing a UV laser and vat of liquid UV-curable photopolymer resin to produce prototypes quickly, one layer at a time. SLA injection molding prototyping is ideal for checking part sizing, fit and function and for use as finished-part-looking marketing prototypes.

3. Fused deposition modeling (FDM): A solid-based rapid prototyping additive manufacturing process that extrudes material layer by layer to build the prototype. FDM is ideal for producing conceptual and engineering models and functional testing plastic injection molding prototypes.

9. Why use prototyping first before creating tooling?
    1. Quick lead time tooling/rapid prototypes
    2. One cavity pull up in a multi-cavity base
    3. Master Unit Die (MUD) inserts
    4. Single cavity to multi cavity
    5. Short run molds
    6. Simple or complex geometrics
    7. Aluminum or hard tool steel
10. Where we are right now: have gotten an 8K quote for tooling with 72 for 25 pieces
11. Website: Expert Contract Manufacturing & Custom Plastic Molding | EVCO Plastics

Conclusions/action items:

Continue prototyping before we decide if we will go with them - should have closest to final prototype as possible.

10/6 Protolabs

RACHEL KRUEGER - Oct 06, 2022, 1:13 PM CDT

Title: Protolabs

Date: 10/6/2022

Content by: Rachel Krueger

Present: Rachel Krueger

Goals: Understand the capabilities of protolabs to compare to evco plastics

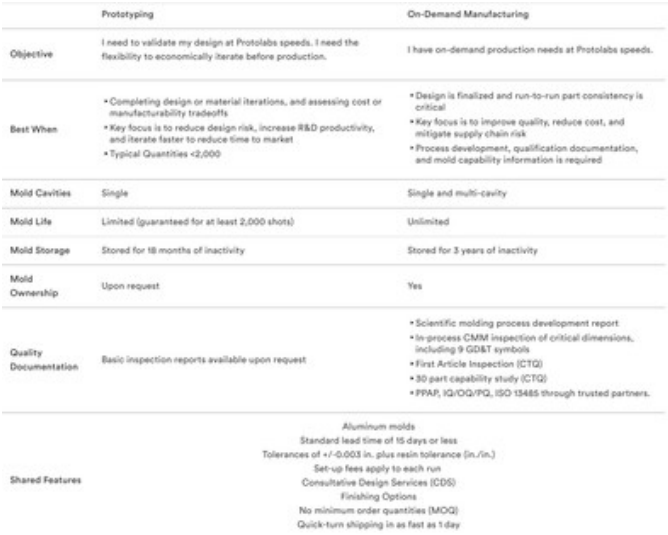
Content:

1. Certifications: ISO 9001:2015, ITAR registered
2. Statistics: 4.4 million parts molded each month, 50,000+ product developers served, 100+ plastic and elastomeric materials
3. Types of injection molding:
    1. Plastic injection molding: Plastic injection molding is a manufacturing process where resin in a barrel is heated to a molten state, then shot into a mold to form a final production-grade thermoplastic part.
    2. Liquid silicone rubber molding: Liquid silicone rubber molding is a thermoset process that mixes a two-component compound together, which is then heat cured in the mold with a platinum catalyst to produce a final part.
    3. Overmolding and insert molding: Overmolding and insert molding are two-part injection molding processes where one material is overlaid onto a second substrate part or metal insert to create a single component.
4. See figure 1 for injection molding tooling options.
5. See figure 2 for injection molding material options.
6. See figure 3 for plastic molding capabilities.
7. Website: Injection Molding Service | Get an Online Injection Molding Quote (protolabs.com)

Conclusions/action items:

Get quote from protolabs. Consider options/material choices to best suit the project.

RACHEL KRUEGER - Oct 06, 2022, 1:10 PM CDT



	Prototyping	On-Demand Manufacturing
Objective	I need to validate my design at Protolabs speeds. I need the flexibility to economically iterate before production.	I have on-demand production needs at Protolabs speeds.
Best When	• Completing design or material iterations, and assessing cost or manufacturability tradeoffs • Key focus is to reduce design risk, increase R&D productivity, and iterate faster to reduce time to market • Typical Quantities <2,000	• Design is finalized and run-to-run part consistency is critical • Key focus is to improve quality, reduce cost, and mitigate supply chain risk • Process development, qualification documentation, and mold capability information is required
Mold Cavities	Single	Single and multi-cavity
Mold Life	Limited (guaranteed for at least 2,000 shots)	Unlimited
Mold Storage	Stored for 18 months of inactivity	Stored for 3 years of inactivity
Mold Ownership	Upon request	Yes
Quality Documentation	Basic inspection reports available upon request	• Scientific molding process development report • In-process CMM inspection of critical dimensions, including 9 GD&T symbols • First Article Inspection (CTQ) • 30 part capability study (CTQ) • PPAP, IQ/OQ/PQ, ISO 13485 through trusted partners.
Shared Features	Aluminum molds Standard lead time of 15 days or less Tolerances of +/-0.003 in. plus resin tolerance (in./in.) Set-up fees apply to each run Consultative Design Services (CDS) Finishing Options No minimum order quantities (MOQ) Quick-turn shipping in as fast as 1 day	

Download

Protolabs.jpg (382 kB) Figure 1: Injection Molding Tooling Options

RACHEL KRUEGER - Oct 06, 2022, 1:10 PM CDT

Injection Molding Materials

We have wide selection of more than 100 thermoplastic and thermoset materials. And if you're looking for alternative material options, check out our guide to resin substitutes for ABS, PC, PP, and other commonly molded plastics.

Thermoplastics

- ABS
- ABS/PC
- Acetal
- Acetal Copolymer
- Acetal Homopolymer/Delrin
- ETPU
- HDPE
- LCP
- LDPE
- LLDPE
- Nylon
- PBT
- PC/PBT
- PEEK
- PEI
- PET
- PETG
- PMMA (Acrylic, Plexiglas)
- Polycarbonate
- Polypropylene
- PPA
- PPE/PS
- PS
- PSU
- TPU

Thermosets

- Standard silicone (30, 40, 50, 60, and 70 durometers)
- Medical-grade silicone
- Optical-grade silicone
- Fluorosilicone (fuel and oil resistant)

Download

Protolabs_materials.jpg (158 kB) Figure 2: Injection Molding Material Options

RACHEL KRUEGER - Oct 06, 2022, 1:12 PM CDT

Plastic Molding Capabilities

Our basic guidelines for plastic injection molding include important design considerations to help improve part moldability, enhance cosmetic appearance, and reduce overall production time. View our design guidelines page for more details.

	US	Metric
SIZE	18.9 in. x 29.6 in. x 8 in.	480mm x 751mm x 203mm
VOLUME	59 cu. in.	966,837 cu. mm
DEPTH	4 in. from parting line	101mm from parting line
	Up to 8 in. if parting line can pass through the middle of the part	Up to 203.2mm if the parting line can pass through the middle of the part
PROJECTED MOLD AREA	175 sq. in.	112,903 sq. mm

Tolerances: Typically, Protolabs can maintain a machining tolerance of +/- 0.003 in. (0.08mm) with an included resin tolerance that can be greater than but no less than +/- 0.002 in./in. (0.002mm/mm).

Download

Capabilities.jpg (212 kB) Figure 3: Plastic Molding Capabilities

From 9/20/2022 Medline Guidewire Bowl

RACHEL KRUEGER - Oct 10, 2022, 2:55 PM CDT

Title: Medline Guidewire Bowl

Date: From 9/20/2022

Content by: Rachel Krueger

Present: Rachel Krueger

Goals: Identify the new competing design found and any pros/cons associated.

Content:

1. Bowls provide a secure location for guide wires while preparing for a procedure
2. Easily graspable while wearing surgical gloves
3. Five tabs help ensure that the wires stay in place
4. Different sizes available:
    1. Guidewire Bowl with 5 Tabs, 11" dia., 5,000 mL Capacity
    2. Guidewire Bowl with 5 Tabs and Lid, 8.5" dia., 2,500 mL Capacity
    3. Guidewire Bowl with 5 Tabs and Lid, 8.5" dia., 2,500 mL Capacity (different color)
5. Latex free, sterile
6. Pros: stores multiple wires, can fill with saline, single use
7. Cons: wires can get tangled, cross contamination
8. Website: Guidewire Bowls | Medline Industries, Inc.

Conclusions/action items:

Identify if there are any aspects of this device we like that we can incorporate - possibly the tab mechanism.

10/11 WARF

RACHEL KRUEGER - Oct 11, 2022, 11:49 AM CDT

Title: WARF Research

Date: 10/11/2022

Content by: Rachel Krueger

Present: Rachel Krueger

Goals: Understand WARF processes and how we can utilize them to further our patent hopes.

Content:

1. Wisconsin Alumni Research Foundation
2. Disclose vs license
    1. Disclose an invention: before going public, can fill out a technology disclosure form to protect work
    2. License an invention: bring early stage technology to market by licensing an invention
3. Statistics
    1. 645 active commercial licenses
    2. 2,000 active issued US patents
    3. $3.4 billion of cumulative grants to UW Madison since inception
4. 20% of the royalty income before expenses goes to the inventor group
5. WARF is a separate, independent 501(c)3 foundation which serves as the dedicated patenting and licensing organization for UW-Madison
6. Patenting process
    1. Submit innovation disclosure
    2. Set up disclosure meeting
    3. Decision committee makes a determination
    4. Equity review
    5. Apply for patent
7. Website: WARF - Wisconsin Alumni Research Foundation

Conclusions/action items:

Once final device is set in stone, contact WARF to start patent process.

11/1 Changes Needed for Injection Molding

RACHEL KRUEGER - Nov 15, 2022, 11:53 AM CST

Title: Changes Needed for Injection Molding

Date: 11/1/2022

Content by: Rachel Krueger

Present: Rachel Krueger

Goals: Outline modifications to the design in order for it to be injection moldable

Content:

1. Add 0.5 degree draft to all straight edges to allow the mold to pop out
2. Chimney needs draft and added thickness – top thicker and bottom thinner or vice versa, don't make smaller than already is
3. Can split the bottom plate off to mold into two parts – would take away undercut issue
4. Glue, snap fit, mechanical fit
5. Increase thickness of part to allow the material to fill entire mold – too much pressure right now
6. Upload design changes to protolab to see the if there are flaws – adjust as needed

Conclusions/action items: Make changes to design to reflect these modifications.

10/6 Frisbee Injection Molding Method

RACHEL KRUEGE

Title: Frisbee Injection Molding Method

Date: 10/6

Content by: Rachel Krueger

Present: Rachel Krueger

Goals: Understand how a frisbee is injection molded. Our design is similar to a frisbee, so we may be able to use the same method.

Content:

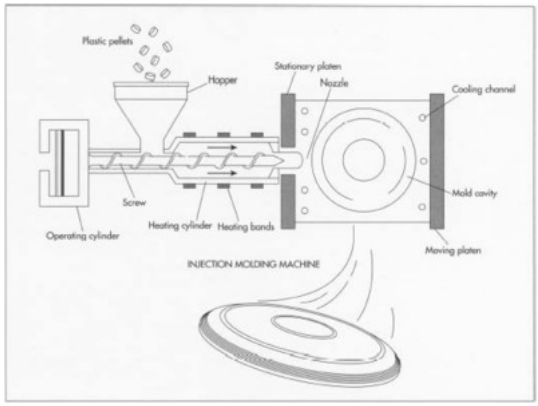
1. Material Preparation:
    1. Polyethylene plastic pellets
    2. Pigment of colors
    3. Oil to stick to color on pellets
2. Place into drum
    1. Shake drum to fuse materials together
    2. Weight enhancing additive is added
    3. Pellets are dried in a hopper
3. Melt Material
    1. Gradually melted in barrel
    2. Plastic is pushed to front of barrel and compressed with joint screw
4. Injection and cooling
    1. Injected by high pressure into frisbee shaped mold
    2. Flushed with a cooling fluid
    3. Frisbee is removed
5. **Citation: [1]** D. Gabrić “Frisbees 101: How are frisbees made?,” *branded.disruptsports.com*, 26-Aug-2020. [Online]. Available: https://branded.disruptsports.com/blogs/blog/how-are-frisbees-made#:~:text=The%20process%20of%20creating%20a%20frisbee%20is%20called,barrel%2C%20joint%20screw%2C%20nozzle%2C%20and%20a [Accessed: 06-Oct-2022].

1. Multi cavity method is typical
2. Minor trimming is required after
3. Usually more than one gate is used to deliver the material to the mold
4. Must be properly ventilated
5. See image attached for method.
6. **Citation: [2]** “Frisbee,” *How Products Are Made*. [Online]. Available: http://www.madehow.com/Volume-5/Frisbee.html#:~:text=Frisbees%20are%20produced%20in%20a%20high-speed%20process%20called,cooled%20to%20a%20shape%20reflecting%20the%20cavity.%20cavity. [Accessed: 06-Oct-2022].

Conclusions/action items:

Possibly use a multi cavity method - we will be able to slightly trim afterward and work around the interferences.

RACHEL KRUEGER - Oct 06, 2022, 12:49 PM CDT



Download

Frisbee.jpg (38.8 kB) Figure 1: Injection molding procedure for a frisbee.

10/10 Optimize Tolerances - Injection Molding

RACHEL KRUEGER - Oct 10, 2022, 2:40 PM CDT

Title: Optimize Tolerances - Injection Molding

Date: 10/10/2022

Content by: Rachel Krueger

Present: Rachel Krueger

Goals: Understand the best way to optimize the design prior to tooling to minimize error, reworking, and wasted money.

Content:

1. Stick to DfM for injection molding (design for manufacturing)
    1. limits occurrence of issues
2. Larger part = higher importance of tolerance
3. Uniform wall thickness
    1. will allow for even shrinkage upon cooling
        1. reduces - warping, sinking, cracking, and twisting
    2. avoid sharp internal corners, long unsupported spans, and poorly designed bosses
4. Draft angles
    1. allow for easy removal of part from tooling
    2. reduces damage of friction, minimizes wear and tear, and ensures smooth finish
    3. rules of thumb:
        - A draft angle of 1^0 to 2^0 is suitable for most parts.
        - Add 1^0 for 1-inch depth.
        - Use 3^0 for light texture and $>5^0$ for heavy texture
        - Use 0.5^0 on all vertical surfaces.
5. Incorporate bosses for unsupported walls
    1. reduces voids and sink marks
6. Material considerations:
    - **Plastic Composition:** Amorphous plastics, e.g., ABS, have lower shrinkage than semi-crystalline plastic e.g., polyethylene, due to their less-compact structure.
    - **Molecular Weight:** High molecular weight resins will have high viscosity and a high-pressure drop which increases the shrink rate.
    - **Additives:** The addition of fillers with low thermal expansion will reduce the shrink rate.

    Different resins have different shrinkage rates. Therefore, you must factor this into material selection and injection mold design to reduce cosmetic defects such as warping, sinking, cracking, and twisting, which affects the tolerance of injection molded parts

7. **Citation: [1]** “Injection molding tolerances: Four ways to optimize them,” *rapiddirect*, 20-Sep-2022. [Online]. Available: https://www.rapiddirect.com/blog/injection-molding-tolerances/. [Accessed: 10-Oct-2022].

Conclusions/action items:

Use rules of thumb and tolerance rules to optimize the design before creating the mold.

RACHEL KRUEGER - Oct 10, 2022, 2:36 PM CDT

· Concentricity/Ovality Tolerances +/- mm

	Commercial Tolerance	Precision Higher Cost
Dimension	up to 100 (+/-mm)	up to 100 (+/-mm)
ABS	0.230	0.130
ABS/PC Blend	0.230	0.130
GPS	0.250	0.150
HDPE	0.250	0.150
LDPE	0.250	0.150
PA	0.250	0.150
PA, 30% GF	0.150	0.100
PBT, 30% GF	0.150	0.100
PC	0.130	0.080
PC, 20% GF	0.130	0.080
PMMA	0.250	0.150
POM	0.250	0.150
PP	0.250	0.150
PP, 20% Talc	0.250	0.150
PPO/PPE	0.230	0.130
PPS, 30% GF	0.130	0.080
SAN	0.230	0.130

This involves determining the wall thickness (the difference between the outside diameter and inside diameter). The chart above shows the different tolerance and change in cost as regards achieving this tolerance.

Download

concentricity.jpg (203 kB) Figure 1-4: Tolerance levels.

RACHEL KRUEGER - Oct 10, 2022, 2:36 PM CDT

· Dimensional Tolerances +/- mm

	Commercial Tolerance				Precision Higher Cost		
Dimension	1 to 20 (+/-mm)	21 to 100 (+/-mm)	101 to 100 (+/-mm)	for each 20mm over 100 add	1 to 20 (+/-mm)	21 to 100 (+/-mm)	over 100
ABS	0.100	0.150	0.325	0.080	0.050	0.100	
ABS/PC Blend	0.100	0.150	0.325	0.080	0.050	0.100	
GPS	0.075	0.150	0.305	0.100	0.050	0.080	
HDPE	0.125	0.170	0.375	0.100	0.075	0.110	
LDPE	0.125	0.170	0.375	0.100	0.075	0.110	
Mod PPO/PPE	0.100	0.150	0.325	0.080	0.050	0.100	
PA	0.075	0.160	0.310	0.080	0.030	0.130	
PA 30% GF	0.060	0.120	0.240	0.080	0.030	0.100	
PBT 30% GF	0.060	0.120	0.240	0.080	0.030	0.100	project review
PC	0.060	0.120	0.240	0.080	0.030	0.100	required for all
PC 20% Glass	0.050	0.100	0.200	0.080	0.030	0.080	materials
PMMA	0.075	0.120	0.250	0.080	0.050	0.070	
POM	0.075	0.160	0.310	0.080	0.030	0.130	
PP	0.125	0.170	0.375	0.100	0.075	0.110	
PP 20% Talc	0.125	0.170	0.375	0.100	0.075	0.110	
PPS 30%GF	0.060	0.120	0.240	0.080	0.030	0.100	
SAN	0.100	0.150	0.325	0.080	0.050	0.100	

Maintaining the degree of accuracy can be very challenging. Therefore, designers make use of the (+/-) sign to show a range in measurement. Each material has a different tolerance range as the dimensions increase. The table above shows the dimensional tolerance of major plastic used in injection molding.

Download

dimensional.jpg (290 kB) Figure 1-4: Tolerance levels.

RACHEL KRUEGER - Oct 10, 2022, 2:36 PM CDT

· Hole Diameter Tolerances +/- mm

	Commercial Tolerance				Precision Higher Cost			
Dimension	0.3 (+/-mm)	3.1.6 (+/-mm)	6.1.14 (+/-mm)	14.40 (+/-mm)	0.3 (+/-mm)	3.1.6 (+/-mm)	6.1.14 (+/-mm)	14.40 (+/-mm)
ABS	0.050	0.050	0.080	0.100	0.030	0.030	0.050	0.050
ABS/PC	0.050	0.050	0.080	0.100	0.030	0.030	0.050	0.050
GPS	0.050	0.050	0.050	0.090	0.030	0.030	0.040	0.050
HDPE	0.050	0.080	0.100	0.150	0.030	0.050	0.050	0.080
LDPE	0.050	0.080	0.100	0.150	0.030	0.050	0.050	0.080
PA	0.050	0.080	0.080	0.130	0.030	0.040	0.050	0.080
PA30% GF	0.050	0.050	0.080	0.080	0.030	0.040	0.050	0.050
PBT30% GF	0.050	0.050	0.080	0.080	0.030	0.040	0.050	0.050
PC	0.050	0.050	0.080	0.080	0.030	0.040	0.050	0.050
PC 20% GF	0.050	0.050	0.080	0.080	0.030	0.040	0.050	0.050
PMMA	0.080	0.080	0.100	0.130	0.030	0.050	0.050	0.080
POM	0.050	0.080	0.080	0.130	0.030	0.040	0.050	0.080
PP	0.050	0.080	0.100	0.150	0.030	0.050	0.050	0.080
PP, 20% Talc	0.050	0.080	0.100	0.150	0.030	0.050	0.050	0.080
PPS 30%Glass	0.050	0.050	0.080	0.080	0.030	0.040	0.050	0.050
SAN	0.050	0.050	0.080	0.100	0.030	0.030	0.050	0.050

The larger the hole size, the more the need to consider tolerance. The chart above explicitly shows the tolerance for different sizes of hole diameter.

Download

holes.jpg (240 kB) Figure 1-4: Tolerance levels.

RACHEL KRUEGER - Oct 10, 2022, 2:36 PM CDT

· Straightness / Flatness Tolerances

	Commercial Tolerance		Precision Higher Cost	
Dimensions	0-100 (+/-mm)	101-300 (+/-mm)	0-100 (+/-mm)	101-300 (+/-mm)
ABS	0.380	0.800	0.250	0.500
ABS/PC Blend	0.380	0.800	0.250	0.500
Acetal	0.300	0.500	0.150	0.250
Acrylic	0.180	0.330	0.100	0.100
GPS	0.250	0.380	0.180	0.250
Mod PPO/PPE	0.380	0.800	0.250	0.250
PA	0.300	0.500	0.150	0.250
PA 30% GF	0.150	0.200	0.080	0.100
PBT 30% GF	0.150	0.200	0.080	0.100
PC	0.150	0.200	0.080	0.100
Polycarbonate, 20% Glass	0.130	0.180	0.080	0.100
Polyethylene	0.850	1.500	0.500	0.850
Polypropylene	0.850	1.500	0.500	0.850
Polypropylene, 20% Talc	0.850	1.500	0.500	0.850
PPS 30%GF	0.150	0.200	0.080	0.100
SAN	0.380	0.800	0.250	0.500

Warping occurs due to different mold shrinkage rates in the direction of mold flow and across the flow. It can occur due to different wall thickness, which has different shrink rates. Tweaking the mold design, better gate position, and process control can minimize warping. However, you might need to have a practical tolerance in terms of plastics as warping is hard to reach 100%.

Download

straightness.jpg (269 kB) Figure 1-4: Tolerance levels.

10/10 Testing

RACHEL KRUEGER - Oct 10, 2022, 2:47 PM CDT

Title: Testing

Date: 10/10/2022

Content by: Rachel Krueger

Present: Rachel Krueger

Goals: Outline our testing protocol and any changes that we may need to make from last semester

Content:

1. Completed by surgeons and medical residents
    1. last year we only did other students/faculty
    2. using professionals in the field will give a better understanding of the effectiveness of the device as well as changes we may need to make based on industry preference
2. Timed tests
    1. efficiency of the device comes from time taken to load and unload the wire
    2. scaled from 0-3 based on ease and success of loading or unloading (0 is worst, 3 is best)

Loading

1. Start timer
2. Wind guidewire by hand
3. Pick up wheel from table
4. Use one hand to hold wheel, one to hold wire-loop
5. Slide wire-loop into wheel
6. When guidewire is fully secured within the wheel, place wheel in one hand
7. Stop timer

*If the guidewire is not able to load properly, record load time as MT (mistrial)

Grade the Load Trial (0-3)

0 - Unable to load guidewire
1 - The wire slid into the wheel, but there were some issues (i.e. the tip of the wire hangs out too far, had to manually maneuver the wire to fit into the wheel, e.g.)
2 - Wire slid into the wheel with ease, but the wheel itself made the sliding motion uncomfortable/less time efficient
3 - Wire slid into wheel without complications

Unloading

1. Start timer
2. Use one hand to hold wheel, and one hand to thread guidewire out of loop
3. When wire is fully out of wheel, stop timer

DO NOT STICK FINGERS THROUGH CENTER OF UWHEEL TO AID IN REMOVAL. MUST REMOVE WIRE WITHOUT TOUCHING
*If the guidewire is not able to unload properly, record load time as MT (mistrial)

Grade the Unload (Thread trial) (0-3)

0 - Unable to unload the guidewire
1 - The guidewire was partially removed from the wheel before tangling and popping out
2 - The guidewire was removed from the wheel without tangling but partially falls out of wheel during unloading
3 - The guidewire was removed without complications

Unloading Pull

1. Use one hand to hold wheel, and one hand to remove guidewire out of loop
2. When wire is fully out of wheel rate the difficulty of removing the guidewire

Grade the Unload Trial (Pull Trial)(0-3)
0 - Unable to unload the guidewire
1 - The guidewire was removed from the wheel but significant effort was needed (2 hands, extra person utilized)
2 - The guidewire was removed from the wheel but was caught on middle chimney
3 - The guidewire was removed without complications

Please note: This loading and unloading testing protocol was created last semester - this is a documentation of explanations, changes, and the protocol. (not created for this entry)

Conclusions/action items:

Use this testing protocol to evaluate the device.

9/14 - Injection Molding

RACHEL KRUEGER - Sep 14, 2022, 1:35 PM CDT

Title: Injection Molding Research

Date: 9/14/2022

Content by: Rachel Krueger

Present: Rachel Krueger

Goals: Understand the pros and cons of injection molding.

Content:

1. Pros:
    1. Keeps tolerances tight - uses a metal mold that's specifically designed and mold is completely filled before cooling to leave little room for error
    2. Works with multiple colors and materials - has to be able to melt, flow, and solidify when cooled
    3. Highly repeatable and reliable - one molder can make repeated identical units
    4. Very fast production times - the specific mold may take some time, but once the mold is completed parts can be produced very quickly
    5. Low costs over time - molder does not need hands on human interaction, can run around the clock, quicker to inject than to 3D print
2. Cons:
    1. Initial costs are high - high cost for tooling and calibration
    2. Long turnaround time at beginning - molds take some time to make
    3. Pricey and difficult to change unit design - can't change the mold easily after created (don't use for prototyping)

CITATION: “The 8 pros and cons of injection molding,” *Rapid Axis*, 18-May-2022. [Online]. Available: https://rapidaxis.com/guides/8-pros-and-cons-of-injection-molding/. [Accessed: 14-Sep-2022].

Conclusions/action items:

Look into possible companies nearby that can perform injection molding for us.

10/10 Thermoforming

RACHEL KRUEGER - Oct 10, 2022, 7:15 PM CDT

Title: Thermoforming

Date: 10/10/2022

Content by: Rachel Krueger

Present: Rachel Krueger

Goals: Understand thermoforming to explore possible alternatives in case injection molding isn't feasible.

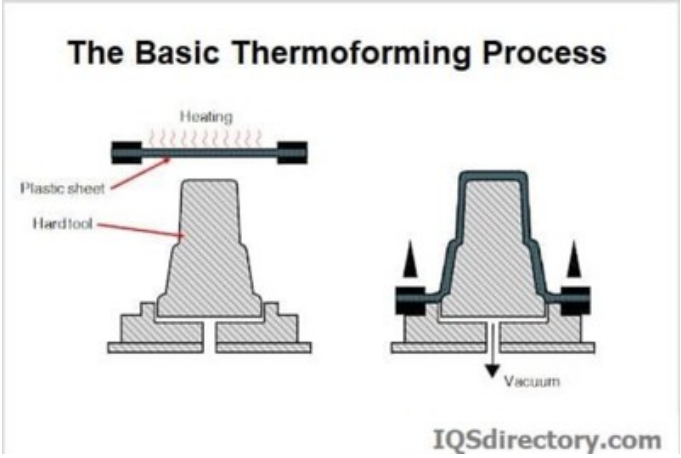
Content:

1. Uses pressure or force of a vacuum to stretch thermoplastic material over a mold to create a 3D part
2. Two processes: vacuum forming, pressure forming
    1. thermoforming happens in a mold cavity when the plastic sheet is drawn by air or vacuum pressure. The mold cavity contains the shape of a single part
    2. The steps of thermoforming are simple and straightforward, which makes it suitable for high-volume manufacturing of molded products due to its fast turnaround times.
    3. Thermoplastic sheets are continuously fed into the heating chamber and formed into the desired shape.
    4. For the thermoforming of larger parts, the thicker thermoplastic sheets are fed individually.
    5. In some operations, an extrusion machine is placed upstream of the thermoforming machine. Certain set-ups are designed to produce multiple parts with each stroke of the press using molds with several cavities.
3. The thermoforming process takes a sheet of thermoplastic, carefully heats it until it is sufficiently pliable, places it over a forming mold that forms it into a three-dimensional shape, and completes the process by trimming and finishing it into the desired shape of the product.
    1. It is a simple process that is quick, efficient, time-saving, and highly productive.
4. Heated plastic sheets are removed from the heating equipment and transported to a temperature-controlled and pre-heated mold tool.
    1. At this stage, the plastic sheet takes the shape of the mold cavity, which contains the desired form of the finished product
5. Positive Tool, or "male mold" is convex-shaped - the heated plastic sheet is positioned above the convex tool. The "humped surface", or the convex surface, will now give the plastic sheet its final shape. The exterior surface of a positive mold tool will give the shape of the inner surface of the part.
6. Negative Tool, or "female mold", on the other hand, is concave-shaped - the interior surface contour of a negative mold tool will give the shape of the outer surface of the part.

Conclusions/action items:

Explore thermoforming as an alternative to injection molding.

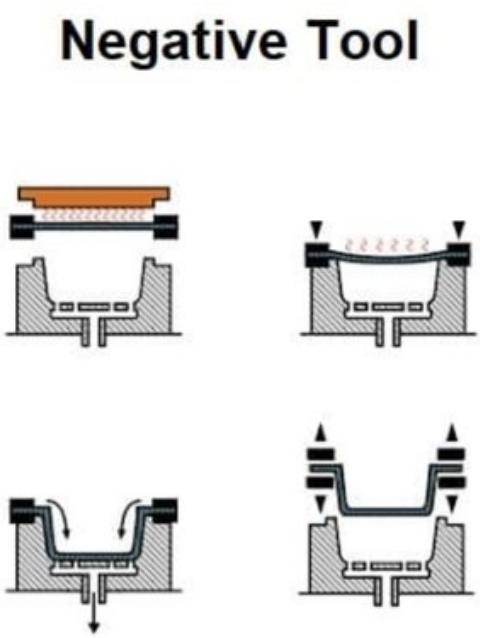
RACHEL KRUEGER - Oct 10, 2022, 7:16 PM CDT



Download

thermoforming.jpg (67.8 kB) Figure 1: Thermoforming diagram.

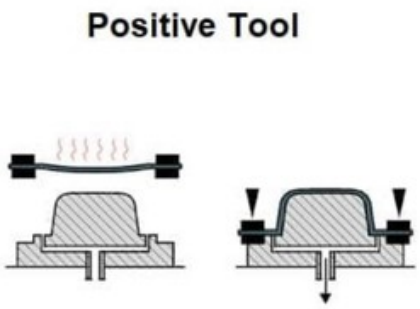
RACHEL KRUEGER - Oct 10, 2022, 7:16 PM CDT



Download

negative.jpg (48.3 kB) Figure 2, 3: Negative vs positive molds.

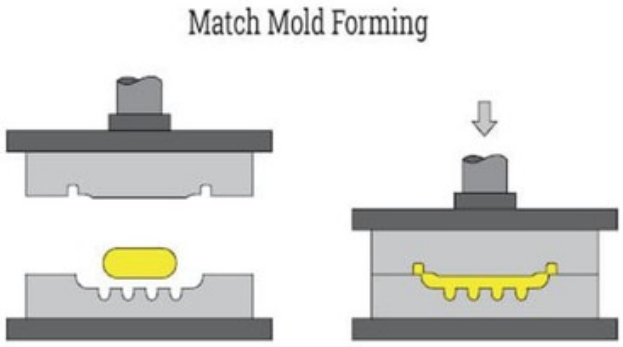
RACHEL KRUEGER - Oct 10, 2022, 7:16 PM CDT



Download

positive.jpg (32.5 kB) Figure 2, 3: Negative vs positive molds.

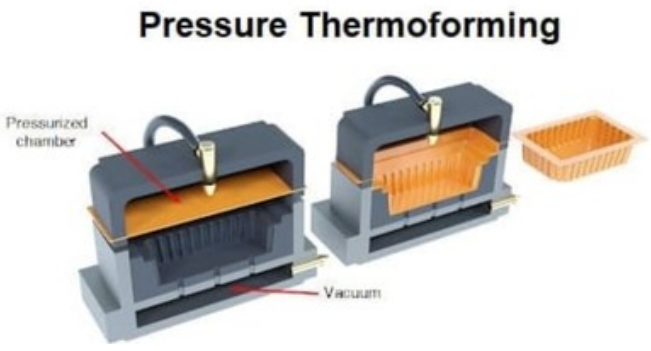
RACHEL KRUEGER - Oct 10, 2022, 7:17 PM CDT



Download

match_mold.jpg (32.3 kB) Figure 4, 5, 6, 7: Match mold, pressure, twin, vacuum.

RACHEL KRUEGER - Oct 10, 2022, 7:17 PM CDT



Download

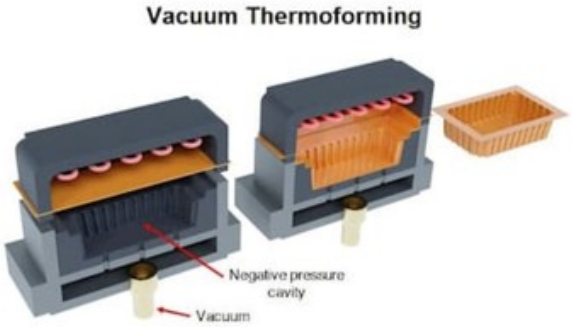
pressure.jpg (47.6 kB) Figure 4, 5, 6, 7: Match mold, pressure, twin, vacuum.

RACHEL KRUEGER - Oct 10, 2022, 7:17 PM CDT

Download

twin_sheet.jpg (48.1 kB) Figure 4, 5, 6, 7: Match mold, pressure, twin, vacuum.

RACHEL KRUEGER - Oct 10, 2022, 7:17 PM CDT



Download

vacuum.jpg (44.5 kB) Figure 4, 5, 6, 7: Match mold, pressure, twin, vacuum.

11/15 Snap Fit Parts

RACHEL KRUEGER - Nov 15, 2022, 12:02 PM CST

Title: Snap Fit Parts

Date: 11/15/2022

Content by: Rachel Krueger

Present: Rachel Krueger

Goals: Discuss the snap fit sample parts I printed from Ben's design.

Content:

1. Smallest sample - snap fit 1
    1. Female and male parts of the pieces fit together
    2. Device snapped shut but I was able to pull apart with low force
    3. Male parts were hard to print - easy to get messed up since they are so small
    4. Modifications:
        1. Make male part thicker and longer
        2. Make female part wider and longer into the part
        3. Create a ridge that allows the part to be pushed in but not pulled back out (see image example)
2. Medium sample - snap fit 2
    1. Non-functional because the two parts don't fit together
    2. Holes closed when 3-D printing so male part doesn't snap in place
    3. Modifications:
        1. Create a ridge that allows the part to be pushed in but not pulled back out (see image example)
3. Cantilever sample
    1. Concept is there, non-functional though because the ridge is too large to fit into the hole
    2. Seems as though this would be the best option because it doesn't seem as though it could be pulled apart
    3. Need to test on a smaller sample to see how thinner pieces hold together
    4. Modifications:
        1. Make ridge/male part smaller so it fits into the hole on opposite piece
        2. Make the whole sample smaller to see how changing the thickness/dimensions affect the integrity of the device
4. See images below for examples

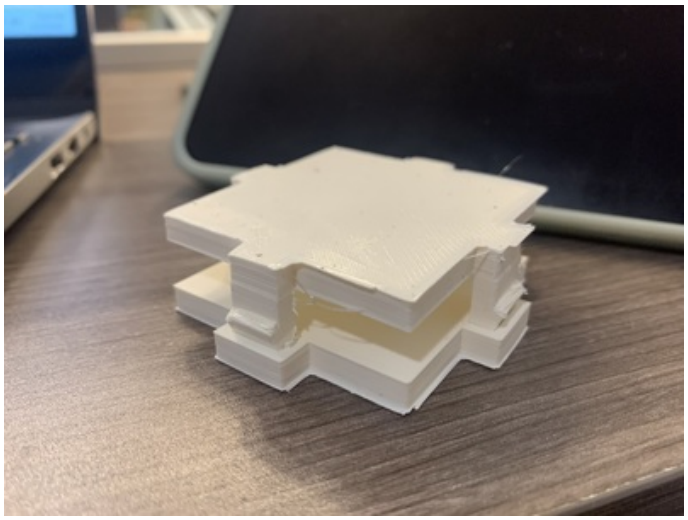
Conclusions/action items: Make modifications and reprint.

RACHEL KRUEGER - Nov 15, 2022, 12:03 PM CST

Download

Fastener_Idea.jpg (162 kB) Image 1: Fastener concept Idea for snap fit 1 and 2

RACHEL KRUEGER - Nov 15, 2022, 12:06 PM CST



Download

cantilever.jpg (2.13 MB) Figure 2-4: Snap fit samples

RACHEL KRUEGER - Nov 15, 2022, 12:06 PM CST

Download

snapfit_1.jpg (1.43 MB) Figure 2-4: Snap fit samples

RACHEL KRUEGER - Nov 15, 2022, 12:06 PM CST

Download

snapfit2.jpg (1.75 MB) Figure 2-4: Snap fit samples

11/15 CutOut Wheel

RACHEL KRUEGER - Nov 15, 2022, 12:10 PM CST

Title: CutOut Wheel

Date: 11/5/2022

Content by: Rachel Krueger

Present: Rachel Krueger

Goals: Outline the result of 3D printing new part with modifications

Content:

1. Wheel is smaller - not ideal for a surgeons hand to grip
2. Tab coming off of chimney needs to be larger to keep the intuitiveness of the device
3. Punch out below tabs may be problematic
    1. Wire could get stuck/begin coming out of the tabs
4. Able to be injection molded based off of criteria from protolabs
5. Modifications:
    1. Make larger
    2. Make punch outs smaller
    3. bring wall to plate as end of every punchout (see image)

Conclusions/action items: Make modifications and reprint.

RACHEL KRUEGER - Nov 15, 2022, 12:12 PM CST

Download

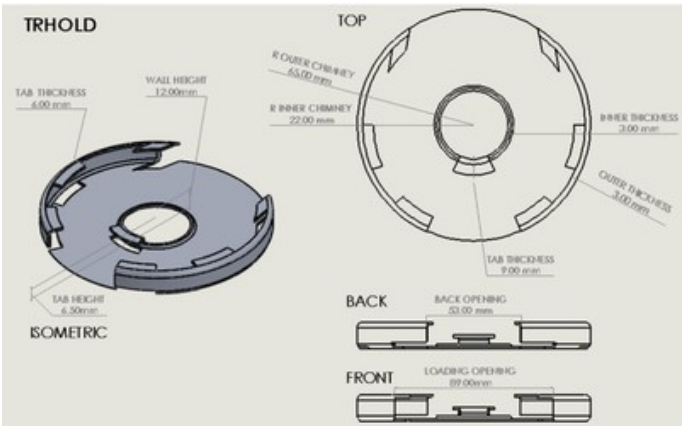
wall_to_plate.jpg (1.63 MB) Figure 1: Showing where wall to plate modification needs to be.

RACHEL KRUEGER - Nov 15, 2022, 12:12 PM CST

Download

cutout.jpg (1.9 MB) Figure 2: CutOut design.

RACHEL KRUEGER - Dec 11, 2022, 2:46 PM CST



Download

TR_Solidworks.jpg (108 kB) Figure 3: TRHold Solidworks File (CutOut)

12/1 Data From Testing

RACHEL KRUEGER - Dec 11, 2022, 2:41 PM CST

Title: Data From Testing

Date: 12/1/2022

Content by: Rachel Krueger

Present: Rachel Krueger

Goals: Outline testing results and conclusions.

Content:

1. I am Member 3.
2. Testing order (wheels):
    1. XtraHold
    2. LHold
    3. XSHold
    4. LGHold
    5. TRHold
    6. ADHold
    7. VHold
3. Process: load wire into wheel - time, rate 0-3. unload wire from wheel - time, rate 0-3.
4. Results:

Design	Member	Trial	Loading Time	Loading Grade	Unloading Time	Unloading Grade
3	3	1	12.07	3	4.04	3
3	3	2	12.25	2	3.2	3
3	3	3	10.07	3	3.26	3
0	3	4	12.25	3	3.65	3
0	3	5	10.93	3	4.13	3
0	3	6	12.5	3	3.53	3
2	3	7	14.5	2	4.26	3
2	3	8	17.96	2	4.07	3
2	3	9	14.48	3	3.73	3
6	3	10	13.46	2	5.5	3
6	3	11	12.72	3	4.43	3
6	3	12	18.14	2	5.46	2
4	3	13	19.48	1	5.23	2
4	3	14	18.5	0	4.01	2
4	3	15	18	0	6.13	2
5	3	16	16.3	2	3.82	2
5	3	17	16.91	3	4.08	3
5	3	18	12.31	3	3.72	3
1	3	19	9.94	3	4.54	3
1	3	20	11.06	3	3.56	3
1	3	21	10	3	3.41	3

1. Conclusions:
    1. TRHold had mistrials or had low ratings for all trials of loading. The tabs and cutouts caused the wire to get stuck (see image)
    2. ADHold was most realistic in terms of injection molding and feasibility
    3. Previous iterations (non-injection moldable) worked well, not feasible for next steps

Conclusions/action items: Eliminate TRHold from future iterations. Use aspects from previous iterations into devices that can be injection molded.

RACHEL KRUEGER - Dec 11, 2022, 2:42 PM CST

Download

TRHold.jpg (3.39 MB) Figure 1. TRHold mistrial example.

12/11 Evaluation of LGHold

RACHEL KRUEGER - Dec 11, 2022, 2:49 PM CST

Title: Evaluation of LGHold

Date: 12/11.2022

Content by: Rachel Krueger

Present: Rachel Krueger

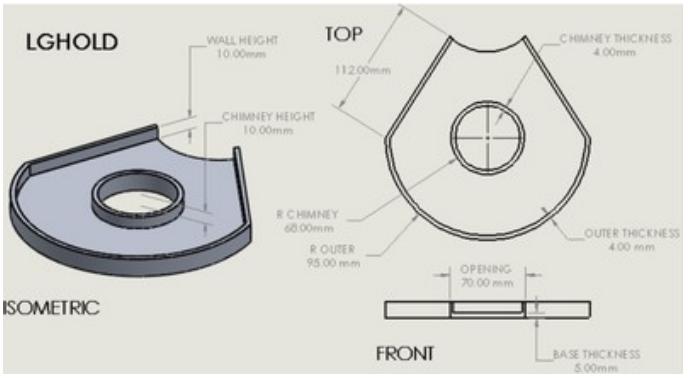
Goals: Outline pros and cons of LGHold

Content:

1. Pros:
    1. Able to be injection molded
    2. Simple design (lower cost of manufacturing)
    3. Chimney helps smoother unloading
    4. Angled walls hold the wire in place so it doesn't pop out of device
2. Cons:
    1. Nothing holding the wire inside the wheel (can pop out easily)
    2. Thick & heavy (easy fix)
    3. Angled walls could cause kinks in stiffer wires

Conclusions/action items: Make any modifications necessary to be able to accommodate for all kinds of wire stiffness.

RACHEL KRUEGER - Dec 11, 2022, 2:45 PM CST



Download

LGHold.jpg (91 kB) Figure 1: LGHold Solidworks File

12/11 Evaluation of ADHold

RACHEL KRUEGER - Dec 11, 2022, 2:53 PM CST

Title: Evaluation of ADHold

Date: 12/11/2022

Content by: Rachel Krueger

Present: Rachel Krueger

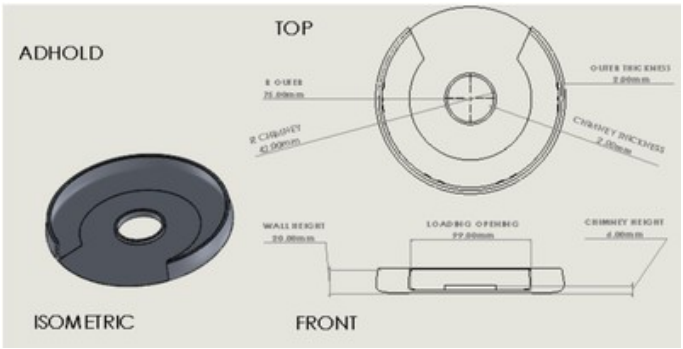
Goals: Outline pros and cons of ADHold

Content:

1. Pros:
    1. Able to be injection molded
    2. Simple design (lower cost of manufacturing)
    3. Light curvature holds the wire within the wheel
    4. Can hold wires of varying stiffness
2. Cons:
    1. Stiffer wire may be more likely to pop out
        1. To fix, need smaller diameter which could then cause kinks in the wire (lose/lose)

Conclusions/action items: Make any modifications necessary to allow for manufacturing efficiently while maintaining integrity of device.

RACHEL KRUEGER - Dec 11, 2022, 2:46 PM CST



Download

ADHold.jpg (77.8 kB) Figure 1: ADHold Solidworks File

12/11 End of Semester/Future Work

RACHEL KRUEGER - Dec 11, 2022, 2:55 PM CST

Title: End of Semester/Future Work

Date: 12/11/2022

Content by: Rachel Krueger

Present: Rachel Krueger

Goals: Outline goals for next semester

Content:

1. Modify current designs to create one final design
    1. use diameter of XSHold for ADHold - will help hold the wire in place more firmly
    2. incorporate chimney from XSHold into ADHold - will keep the wire from springing out during unloading (more neat)
2. Get new quote from protolabs after modifications are made
3. finalize material
    1. biocompatible
    2. injection moldable
    3. FDA approved for operating room environments
4. Injection mold!

Conclusions/action items: Use this outline to guide beginning of next semester.

Copy - 3/14/2021 Biosafety and Chemical training

RACHEL KRUEGER - Mar 24, 2021, 8:42 PM CDT

Title: Biosafety and chemical training

Date: 3/14/2021

Content by: Rachel Krueger

Present: Rachel Krueger

Goals: Show documentation of completed trainings.

Content:

See attachments for proof of training completion.

Conclusions/action items:

Continue to be trained in other sections throughout this course and in the BME department to expand my knowledge and abilities.

RACHEL KRUEGER - Mar 24, 2021, 8:43 PM CDT

University of Wisconsin-Madison

This certifies that RACHEL KRUEGER has completed training for the following course(s):

Course Name	Curriculum or Quiz Name	Completion Date	Expiration Date
BIOSAFETY 105: BIOSAFETY CABINET USE	BIOSAFETY 105: BIOSAFETY CABINET USE QUIZ	11/13/2020	
BIOSAFETY 106: AUTOCLAVE USE	BIOSAFETY 106: AUTOCLAVE USE: SAFETY AND EFFICACY - VERIFICATION QUIZ	11/13/2020	
BIOSAFETY 107: CENTRIFUGE SAFETY	BIOSAFETY 107: CENTRIFUGE SAFETY VERIFICATION QUIZ	11/13/2020	
BIOSAFETY REQUIRED TRAINING	BIOSAFETY REQUIRED TRAINING QUIZ	11/14/2020	
CHEMICAL SAFETY: FUME HOOD SAFETY TRAINING	FUME HOOD FINAL QUIZ	11/13/2020	

Data Effective: Sat Nov 14 11:25:00 2020
Report Generated: Fri Mar 12 13:14:14 2021

Download

Training.JPG (157 kB) Training documentation to show completion of required trainings.

RACHEL KRUEGER - Apr 29, 2021, 1:03 PM CDT

University of Wisconsin-Madison

This certifies that RACHEL KRUEGER has completed training for the following course(s):

Course Name	Curriculum or Quiz Name	Completion Date	Expiration Date
BIOSAFETY 105: BIOSAFETY CABINET USE	BIOSAFETY 105: BIOSAFETY CABINET USE QUIZ	11/13/2020	
BIOSAFETY 106: AUTOCLAVE USE	BIOSAFETY 106: AUTOCLAVE USE: SAFETY AND EFFICACY - VERIFICATION QUIZ	11/13/2020	
BIOSAFETY 107: CENTRIFUGE SAFETY	BIOSAFETY 107: CENTRIFUGE SAFETY VERIFICATION QUIZ	11/13/2020	
BIOSAFETY REQUIRED TRAINING	BIOSAFETY REQUIRED TRAINING QUIZ	11/14/2020	
CHEMICAL SAFETY: FUME HOOD SAFETY TRAINING	FUME HOOD FINAL QUIZ	11/13/2020	
CHEMICAL SAFETY: THE OSHA LAB STANDARD	FINAL QUIZ	4/15/2021	

Data Effective: Thu Apr 15 19:25:01 2021
Report Generated: Fri Apr 16 14:20:22 2021

Download

Capture.JPG (169 kB) Updated chemical safety training

Copy-Green Permit

RACHEL KRUEGER - Feb 20, 2021, 12:51 PM CST

Download

Green_Permit.PNG (148 kB)

RACHEL KRUEGER - Mar 25, 2021, 1:01 PM CDT

Image caption: Image showing proof of obtaining a green permit.

RACHEL KRUEGER - Feb 20, 2021, 12:52 PM CST

Title: Green Permit

Date: 2/20/2021

Content by: Rachel Krueger

Present: Rachel Krueger

Goals: Show proof of documentation of green permit.

Content:

Reference attachment

Conclusions/action items:

Obtain any other permits I made need in the future to complete my project.

WARF Presentation 3/10

RACHEL KRUEGER - Mar 10, 2022, 11:47 AM CST

Title: Warf Presentation

Date: 3/10/22

Content by: Rachel Krueger

Present: N/A

Goals: Describe how my design might have intellectual property.

Content:

My team and I could file a patent for the device design which can then be trademarked under the name of our device along with a logo. We would need to define prior art - competing devices - in order to make a case as to why our invention is worthy of being patented.

Conclusions/action items:

Consider the patent process more when our design is finalized.

4/1/2022 Tong Lecture

RACHEL KRUEGER - Apr 01, 2022, 12:48 PM CDT

Title: Tong Lecture

Date: 4/1/22

Content by: Rachel Krueger

Present: N/A

Goals: Listen and gain information from the tong distinguished lecture series.

Content:

1. TITLE: bio entrepreneurship: transforming intent into impact
2. Intent: treating complex skin defects. Goal: reduce or eliminate the need for donor site scarring. Impact: StrataGraft skin substitute
3. only 14 cell and gene products that are approved by the FDA
4. What makes an entrepreneur: innovation, management, opportunity, risk-tolerance (financial, professional, personal).
5. find a mentor, be a mentor

Conclusions/action items:

It will be helpful to use this information in the future.

Biomedical problem to be solved from 2/3/22

RACHEL KRUEGER - Feb 28, 2022, 10:04 PM CST

Title: Biomedical problem to be solved

Date: 2/3/22

Content by: Rachel Krueger

Present: N/A

Goals: Understand problem/project

Content:

1. Surgeons must use multiple guidewires during a single procedure.
2. Guidewires are hard to manage - they get tangled and disorderly very easily. This increases time in surgery and sterilization procedures
3. Client wants us to design a device that serves to increase procedure efficiency and safety - do so by decreasing time to load and unload the wires and making the device easy to use.
4. Must be easy to remove the wire while in the operating room.
5. Device will consist of two parts - wheel and stand
6. Current wheel design is provided by the client - we need to finalize and determine dimensions that maximize efficiency

Conclusions/action items:

Make a plan to solve these problems given our resources and available time

Engineering Principles and Math

RACHEL KRUEGER - Feb 28, 2022, 10:09 PM CST

Title: Engineering Principles and Math

Date: From 2/7/22

Content by: Rachel Krueger

Present: N/A

Goals: Brainstorm different math techniques and principles to solve the problem

Content:

1. Using solidworks for designing on a 3D software.
2. will be using some sort of statistical analysis to prove effectiveness of device - options include p test, t test, etc.
3. Calculating time it takes to load and unload the wire while also considering how a person gets better at a procedure the more times they do it - possibly be able to quantify that?
4. Use problem solving, brainstorming, collaboration to solve the problem.

Conclusions/action items:

Use various techniques to complete the project.

Biology, Physiology, Chemistry

RACHEL KRUEGER - Feb 28, 2022, 10:13 PM CST

Title: Biology, physiology, chemistry

Date: 2/4/22

Content by: Rachel Krueger

Present: N/A

Goals: Apply science related ideas to device

Content:

Since this project has been continued from last semester, the initial in depth research into guidewires, storage devices, and biocompatibility are stored in the previous lab archives. The team members who were on the project last semester briefed the new members on what they had learned.

Conclusions/action items:

Apply the knowledge of previous team members to progress the project.

Codes and Standards

RACHEL KRUEGER - Mar 01, 2022, 12:59 PM CST

Title: Codes and Standards

Date: 3/1/22

Content by: Rachel Krueger

Present: N/A

Goals: Outline codes and standards to consider

Content:

ISO 11070:1998(E) tests help medical device manufacturers to ensure that products such as guidewires are safe for use (see testing guidewires entry in design ideas for citation).

ISO 25539-2:2020 - Cardiovascular implants, endovascular devices, vascular stents

FDA-16007 - Coronary, peripheral, and neurovascular guidewires

Citation: “Trackability,” *ViVitro Labs*, 09-Aug-2021. [Online]. Available: https://vivitrolabs.com/testing-services/trackability/. [Accessed: 01-Mar-2022].

Conclusions/action items:

Consider these important standards and codes when we get closer to patent applications.

Why do we need to solve this problem?

RACHEL KRUEGER - Mar 01, 2022, 3:03 PM CST

Title: Why do we need to solve this problem?

Date: 3/1/22

Content by: Rachel Krueger

Present: N/A

Goals: Understand why we need to solve the problem

Content:

1. surgeons need to keep a sterile field - gets broken if wire falls on ground (towel and cath clip)
2. surgeons need to use many in a single surgery
    1. if they need to reuse the same wire it needs to be easily accessible, organized, and readily available
    2. being able to store 3 wires at once decreases disorganization
3. current methods are unreliable - could be greatly improved
4. decreasing time it takes in surgery by increasing efficiency will save the patient money

Conclusions/action items:

Aim to incorporate these considerations into the final design

Oliver Catheter and Guidewire Dispenser

RACHEL KRUEGER - Mar 01, 2022, 12:29 PM CST

Title: Oliver Catheter and Guidewire Dispenser

Date: 3/1/22

Content by: Rachel Krueger

Present: N/A

Goals: Highlight key aspects of current designs

Content:

Citation: “Catheter & Guidewire dispensers,” *Oliver Healthcare Packaging*. [Online]. Available: https://www.oliverhcp.com/products/catheter-and-guidewire-dispensers. [Accessed: 01-Mar-2022].

1. Can be sterilized via EtO and gamma irradiation
2. Benefits:
    1. clipless
    2. dual hoop option for multiple size devices in one system
    3. easily contains related procedural components
    4. increased convenience for end users
    5. reduced end user time and cost
    6. reduces puncture risk
3. Awarded winner of packaging design of the year by healthcare asia medtech awards 2021
4. cons:
    1. can bend in device if too much force is applied
    2. device is not see-through, can't see what it is getting stuck on
    3. walls may increase resistance when loading
    4. increased loading and unloading time

Conclusions/action items:

Consider the benefits of this device when finalizing design

RACHEL KRUEGER - Mar 01, 2022, 12:30 PM CST

Download

oliver_dispenser_.jpg (40.5 kB) Figure: Picture of Oliver device

Cath clip design

RACHEL KRUEGER - Mar 01, 2022, 12:37 PM CST

Title: Cath clip design

Date: From 2/10/22

Content by: Rachel Krueger

Present: N/A

Goals: Understand the cath clip current competing design

Content:

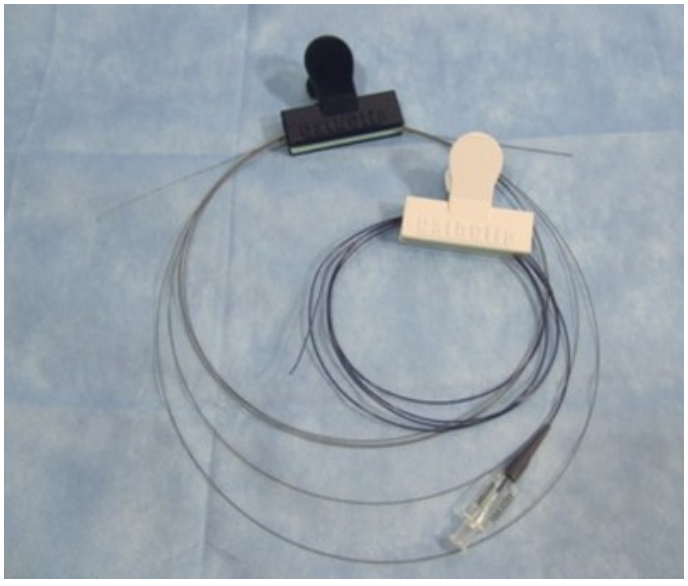
Citation: “The cathclip solution,” *CathClip*. [Online]. Available: https://www.cathclip.com/the-cathclip-solution1.html. [Accessed: 10-Feb-2022].

1. securely and gently holds any type of flexible elongated medical device
2. small, so many can fit in the sterile field and even in saline-filled bowl
3. foam is a lint-free, dimensionally stable polyurethane which does not release lint, thereby eliminating the risk of intra- and post-procedure embolization due to lint.
4. Reduced material cost and waste
5. CathClip is the only universal, easily adopted, quick to use, and economical solution to holding any guidewire, catheter, or balloon between uses during procedures, safely and securely.
6. comes in two colors (white & blue) - the different colors are to aid in organization only (there is no functional difference).
7. pays for itself in materials cost savings
8. efficiency and safety benefits

Conclusions/action items:

Consider using less material like the cath clip to minimize waste

RACHEL KRUEGER - Mar 01, 2022, 12:38 PM CST



Download

cath_clip_design.jpg (32 kB) Figure: Cath clip competing design

RACHEL KRUEGER - Mar 01, 2022, 12:38 PM CST

Flexible tube

RACHEL KRUEGER - Mar 01, 2022, 3:15 PM CST

Title: Flexible tube competing device

Date: From 2/17/22

Content by: Rachel Krueger

Present: N/A

Goals: Outline the competing device

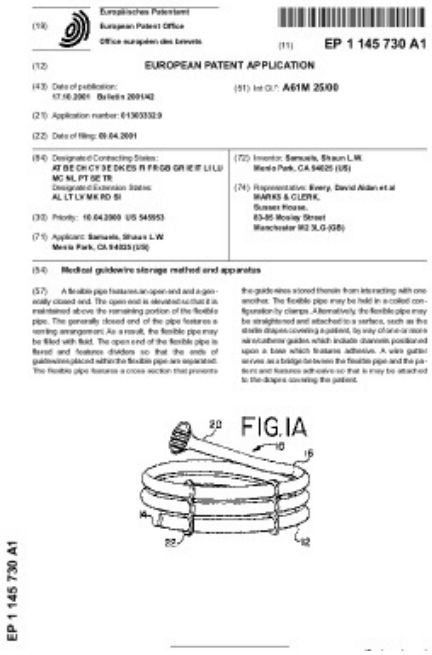
Content:

See attachments for pdf of article.

1. has a very similar purpose
2. Is associated with a patent
3. the external portion of a guidewire is wound about itself in such a way as to "lock" the wire from springing into its naturally straight configuration
4. The wound portion of the guidewire is then placed into a large bowl containing a sterile saline solution so as to keep the wire wet.
5. The saline solution also promotes the dissolution of any clots which may have formed on the guidewire after it is removed from the patient and placed in the bowl
6. Wound guidewires also have a tendency to straighten once unlocked
7. provide a method and apparatus for storing medical guidewires that maintains them submersed in liquid
8. provide a method and apparatus for storing medical guidewires that allows for their easy introduction into a patient and removal
9. provide a method and apparatus for storing medical guidewires that prevents their contact with non-sterile portions of the procedure room

Conclusions/action items:

Possibly use some ideas from here that can increase the effectiveness of our device.



Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 145 730 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
17.10.2001 Bulletin 2001/42

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(30) Priority: 10.04.2000 US 545953

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Manchester M2 3LG (GB)

(54) Medical guidewire storage method and apparatus

(57) A flexible pipe features an open end and a generally closed end. The open end is elevated so that it is maintained above the remaining portion of the flexible pipe. The generally closed end of the pipe features a nesting arrangement. As a result, the flexible pipe may be filled with fluid. The open end of the flexible pipe is flared and features dividers so that the ends of guidewires placed within the flexible pipe are separated. The flexible pipe features a cross section that prevents the guidewires stored therein from interacting with one another. The flexible pipe may be held in a coiled configuration by clamps. Alternatively, the flexible pipe may be straightened and attached to a surface, such as the sterile drapes covering a patient, by way of one or more skin/catheter guides which include channels positioned upon a base which features adhesive. A wire gutter serves as a bridge between the flexible pipe and the patient and features adhesive so that it may be attached to the drapes covering the patient.

FIG.1A

EP 1 145 730 A1

[Download]

Competing_Device-_Flexible_tube.pdf (345 kB)

Design Constraints

RACHEL KRUEGER - Feb 28, 2022, 10:23 PM CST

Title: Design Constraints

Date: 2/28/22

Content by: Rachel Krueger

Present: N/A

Goals: Outline realistic constraints

Content:

1. Time. This is obviously a constraint given it is a semester long project. However, the project should not be rushed simply to complete it in the semester. If desired, the client may choose to continue it for another semester.
2. Budget. Although the client didn't give us a true budget, it is important to consider any money spent as to not create an overly expensive device. The device needs to be able to be produced for the market, so being able to design and produce a device that is affordable is important.
3. Makerspace. We plan to 3D all of the pieces for the protype we will be presenting to our client. Some of the 3D printing is not entirely accurate and can result in incorrect dimensions produced. The team will need to make adjustments after seeing how the variation in dimensions affects the performance of the device.
4. 3D printing. Along with number 3, we need to consider how the performance of the prototype will compare to the device that will be presented to the market. The difference in material depending on sterilizability and biocompatibility may alter the performance of the device so our testing and analysis should mention that.
5. Quantifying results. We need to be able to quantitatively measure the performance of the device in order to produce statistical results.

Conclusions/action items:

See how we can work around design constraints to meet the requirements for our client.

Testing Guidewires

RACHEL KRUEGER - Mar 01, 2022, 12:13 PM CST

Title: Testing Guidewires

Date: From 2/28/22

Content by: Rachel Krueger

Present: N/A

Goals: Understand current guidewire testing method

Content:

Citation: [1] S. L. | M. 14, “Putting guidewires to the test,” *mddionline.com*, 25-Aug-2017. [Online]. Available: https://www.mddionline.com/testing/putting-guidewires-test. [Accessed: 28-Feb-2022].

1. ISO 11070:1998(E) tests help medical device manufacturers to ensure that products such as guidewires are safe for use
2. set of relatively quick and uncomplicated methods with which to evaluate different materials, manufacturing means, and engineering configurations in order to optimize the final product
3. general requirements for the four devices covered under ISO 11070 include sterilization, biocompatibility, surface, corrosion resistance, and radio detectability, as well as information to be supplied by the manufacturer.
4. Corrosion test: subjects the specimen to a five-hour soak in a 0.15 mol/L saline solution at 22°C, followed by 30 minutes of boiling in water, cooling to 37°C, and finally maintaining the 37°C soak for 48 hours. After drying, the guidewire is inspected for signs of corrosion.
5. Guidewire fracture test: The guidewire is wrapped around the cylinder in relation to the OD of the wire for eight complete turns, after which the device is unwrapped and inspected for any signs of fracture. In the case of coated guidewires, the coating is also inspected for signs of flaking.
    1. This could be useful because we need to finalize the dimensions of wheel to ensure we are not damaging the wire
6. Guidewire flexing test: repeated bending and straightening of the device followed by an inspection for any damage and defects
    1. performed for 20 cycles
7. tensile test: addresses the union of the coil and core wire of the guidewire or that of the coil and the safety wire

Conclusions/action items:

Consider the guidewire fracture test and flexing test in testing protocol.

3D printing materials

RACHEL KRUEGER - Mar 01, 2022, 12:53 PM CST

Title: 3D Printing Materials

Date: From 2/21/22

Content by: Rachel Krueger

Present: N/A

Goals: Outline possible 3D printing materials

Content:

Link: 3D Printers – UW Makerspace – UW–Madison (wisc.edu)

1. Different types of 3D printers we are considering:
    1. Ultimaker - prosumer printer, efficient and economical
    2. Formlabs - standard and engineering resins for small and intricate parts
2. Possible choice of materials:
    1. PLA: high stiffness, high strength, translucent
    2. nylon: tough, wear resistant, low friction
    3. PETG: tough, chemical resistant, temperature resistant, wear resistant

Conclusions/action items:

Decide on what materials and printer will give us the best quality device

Testing Effectiveness of Device

RACHEL KRUEGER - Mar 01, 2022, 2:41 PM CST

Title: Testing effectiveness of device

Date: 3/1/22

Content by: Rachel Krueger

Present: N/A

Goals: Outline how the team can test the device

Content:

1. place 3 guidewire wheels on the stand (currently UHold) with 1 guidewire of a set stiffness in each wheel
2. start timer
3. operator (someone on team) will unload 1 guidewire from the top wheel
4. once fully unloaded, stop timer and record time
5. begin timer
6. same operator will reload the guidewire back onto the top wheel
7. stop timer and record once successfully loaded
8. repeat 5 times for each operator, test at least 5 operators
9. analyze results using a statistical analysis (not yet decided)

Conclusions/action items:

Use this general testing plan to write a more professional one

Dr. Y current design

RACHEL KRUEGER - Mar 01, 2022, 2:46 PM CST

Title: Dr. Y current design

Date: From 2/12/22

Content by: Rachel Krueger

Present: N/A

Goals: Watch Dr. Y use his current device.

Content:

See files attached for a video of Dr. Y using his current prototype as well as some competing designs.

Conclusions/action items:

Reference when using our device.

RACHEL KRUEGER - Mar 01, 2022, 2:49 PM CST

Download

Dr._Y_performance.mov (277 MB LA S3) Figure: Video of Dr. Y using wheel and stand prototype

Dr Y provided STL files

RACHEL KRUEGER - Mar 01, 2022, 3:06 PM CST

Title: Dr. Y provided STL files - design idea

Date: 2/9/22

Content by: Rachel Krueger

Present: N/A

Goals: Provide STL files from Dr. Y

Content:

See attachments for designs.

Conclusions/action items:

Print and modify these files when considering designs

RACHEL KRUEGER - Mar 01, 2022, 3:07 PM CST

Download

DYSpool.stl (900 kB) Figure: STL files of possible prototypes

RACHEL KRUEGER - Mar 01, 2022, 3:07 PM CST

Download

DYWheel.stl (736 kB) Figure: STL files of possible prototypes

RACHEL KRUEGER - Mar 01, 2022, 3:07 PM CST

Download

ShortSpout.STL (359 kB) Figure: STL files of possible prototypes

Current wheel design

RACHEL KRUEGER - Mar 01, 2022, 3:19 PM CST

Title: Current wheel design

Date: 3/1/22

Content by: Rachel Krueger

Present: N/A

Goals: Show current design and dimensions

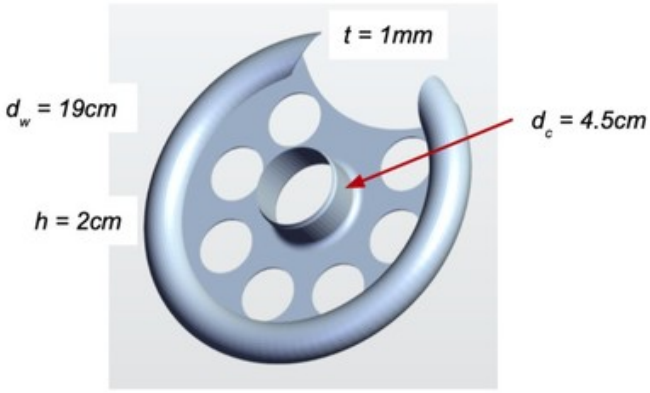
Content:

See attachments.

Conclusions/action items:

Edit current design as needed.

RACHEL KRUEGER - Mar 01, 2022, 3:19 PM CST



Download

current_wheel_design.jpg (35.7 kB)

Testing Code From 4/6/22

RACHEL KRUEGER - Apr 30, 2022, 11:52 AM CDT

Title: Testing Code Round 1

Date: 4/30/22

Content by: Rachel Krueger

Present: N/A

Goals: Outline code used in Matlab for testing analysis of first round of testing

Content:

```
figure(1);

subplot(1,2,1);

xD = [0 1 2 3];

yD=[0 0 1; 0 2 2; 5 2 5; 5 6 2];

bar(xD, yD);

xlabel('Rating Number');

ylabel('Number of Occurences for Each Rating');

title('Ratings of Loading Different Wheel Designs');

legend('DY Wheel', 'Short Spout', 'U Wheel');


subplot(1,2,2);

xD = [0 1 2 3];

yD=[1 0; 2 2; 9 3; 3 10];

bar(xD, yD);

xlabel('Rating Number');

ylabel('Number of Occurences for Each Rating');

title('Ratings of Loading Different Wheel Designs');

legend('Stiff Guidewire', 'Flexible Guidewire');


figure(2);

subplot(1,2,1);

timeD=[12.51 15.56 15.94; 12.00 13.3 17.95; 16.31 13.15 20.76; 18.22 23.16 23.95; 16.55 19.29 19.05; 17.47 17.31 0.00; 25.19 22.02 34.92; 22.9 20.65 21.44; 12.06 15.64 24.12; 14.04 13.2 18.37];

boxplot(timeD);

designs = {'DY Wheel'; 'Short Spout'; 'U Wheel'};
```

```
set(gca, 'xtick', [1:3], 'xticklabel', designs);

xlabel('Design Type');

ylabel('Time to Load');

title('Time to Load Different Designs');



subplot(1,2,2);

timeG=[12.51 12.00; 15.56 13.3; 16.31 18.22; 17.47 16.55; 25.19 22.9; 12.06 14.04; 15.56 13.3; 13.15 23.16; 17.31 19.29; 22.02 20.65; 15.64 13.20; 15.94 17.95; 20.76 23.95; 0.00 19.05; 34.92 21.44; 24.12 18.37];

boxplot(timeG);

guidewires = {'Stiff'; 'Flexible'};

set(gca, 'xtick', [1:2], 'xticklabel', guidewires);

xlabel('Guidewire Type');

ylabel('Time to Load');

title('Time to Load Different Guidewires')
```

Conclusions/action items: Use similar code for round 2 testing.

Testing Code From 4/25/22

RACHEL KRUEGER - Apr 30, 2022, 11:54 AM CDT

Title: Testing Code From 4/25/22

Date: 4/30/22

Content by: Rachel Krueger

Present: N/A

Goals: Outline code from second round of testing (done in Matlab)

Content:

```
figure(1);

subplot(1,2,1);

xD = [0 1 2 3];

yD=[0 1 1; 8 8 1; 7 7 14; 17 16 14];

bar(xD, yD);

xlabel('Rating Number');

ylabel('Number of Occurences for Each Rating');

title('Ratings of Loading Different Wheel Designs');

legend('DY Wheel', 'Cut Chimney', 'Curve Spout');


subplot(1,2,2);

xD = [0 1 2 3];

yD=[0 2; 5 12; 9 19; 33 14];

bar(xD, yD);

xlabel('Rating Number');

ylabel('Number of Occurences for Each Rating');

title('Ratings of Loading Different Guidewires');

legend('Stiff Guidewire', 'Flexible Guidewire');


figure(2);

subplot(1,2,1);

timeD=[15.3 22.46 24.8; 24.13 32.76 25.99; 21.88 23.59 24.67; 36.73 27.61 24.55; 31.67 21.54 22.29; 25.53 0.00 0.00; 19.84 15.52 17.39; 17.41 14.99 21.56; 26.00 20.76 20.45; 29.76 30.88 21.78; 17.55 19.80 11.66; 18.81 25.06 11.88; 13.13 10.08 13.56; 18.10 15.54 13.28; 21.98 16.99 22.12; 19.80 20.58 16.32; 10.90 23.06 17.16; 14.13 21.66 39.91; 18.48 16.55 14.60; 21.33 20.99 28.95; 9.63 16.35 17.56; 11.46 21.19 15.03; 15.83 15.18 17.73; 20.73 20.01 18.62; 17.31 16.79 20.6; 14.77 18.65 24.32; 17.23 14.73 18.71; 27.12 20.49 22.99; 15.6 15.82 16.09; 19.3 19.29 27.93];

boxplot(timeD);
```

```
designs = {'DY Wheel'; 'Cut Chimney'; 'Curve Spout'};

set(gca, 'xtick', [1:3], 'xticklabel', designs);

xlabel('Design Type');

ylabel('Time to Load');

title('Time to Load Different Designs');



subplot(1,2,2);

timeG=[26.00 29.76; 17.55 18.81; 13.13 18.10; 21.98 19.8; 10.90 14.13; 18.48 21.33; 9.63 11.46; 15.83 20.73; 17.31 14.77; 17.23 27.12; 15.60 19.30; 18.63
17.41; 22.46 32.76; 23.59 27.61; 21.54 0.00; 15.52 14.99; 20.76 30.88; 19.80 25.06; 10.08 15.54; 16.99 20.58; 23.06 21.66; 16.55 20.99; 16.35 21.19; 15.18
20.01; 16.79 18.65; 14.73 20.49; 15.82 19.29; 14.81 19.35; 24.8 25.99; 24.67 24.55; 22.29 0.00; 17.39 21.56; 20.45 21.78; 11.66 11.88; 13.56 13.28; 22.12 16.32;
17.16 39.91; 14.60 28.95; 17.56 15.03; 17.73 18.62; 20.60 24.32; 18.71 22.99; 16.09 27.93];

boxplot(timeG);

guidewires = {'Stiff'; 'Flexible'};

set(gca, 'xtick', [1:2], 'xticklabel', guidewires);

xlabel('Guidewire Type');

ylabel('Time to Load');

title('Time to Load Different Guidewires')
```

Conclusions/action items: Use code for testing analysis - plots and graphs.

Preliminary Loading Graphs 4/6/22

RACHEL KRUEGER - Apr 30, 2022, 11:58 AM CDT

Title: Preliminary Loading Graphs From 4/6/22

Date: 4/30/22

Content by: Rachel Krueger

Present: N/A

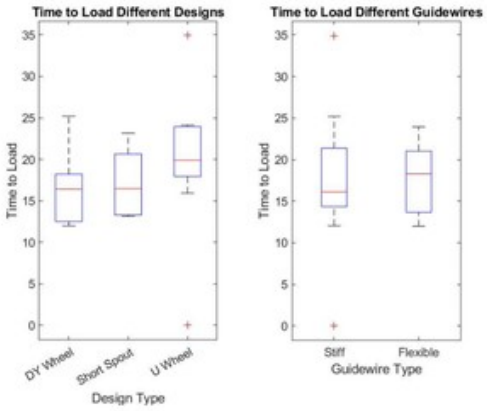
Goals: Provide visual representation of preliminary testing results.

Content:

See attachments.

Conclusions/action items: Do same analysis for final testing round.

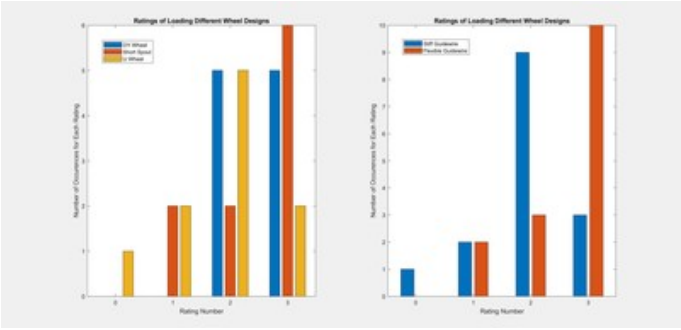
RACHEL KRUEGER - Apr 30, 2022, 11:59 AM CDT



Download

Box_and_Whisker_Loading.jpg (172 kB) Bar chart for loading ratings. Box and Whisker for loading times.

RACHEL KRUEGER - Apr 30, 2022, 11:59 AM CDT



Download

Bar_Chart_Loading.jpg (333 kB) Bar chart for loading ratings. Box and Whisker for loading times.

Final Loading Graphs From 4/25/22

RACHEL KRUEGER - Apr 30, 2022, 12:00 PM CDT

Title: Final Loading Graphs From 4/25/22

Date: 4/30/22

Content by: Rachel Krueger

Present: N/A

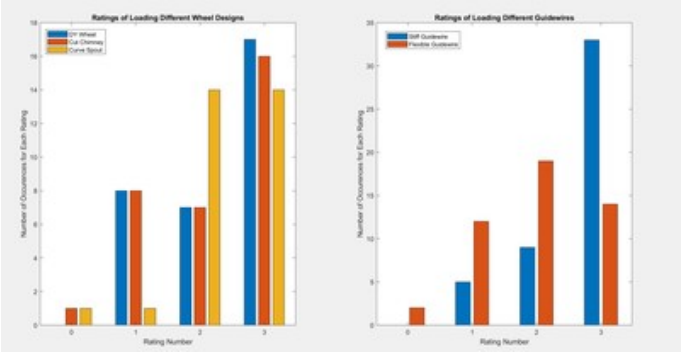
Goals: Show results from second round of testing (subjects not from our team)

Content:

See attachments.

Conclusions/action items: Perform analysis of these results (ANOVA)

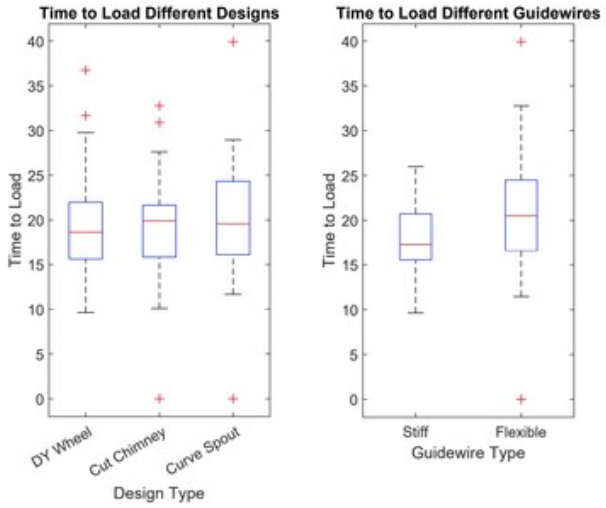
RACHEL KRUEGER - Apr 30, 2022, 12:01 PM CDT



Download

loadinground2testing.jpg (324 kB) Bar chart for loading ratings. Box and Whisker for loading times.

RACHEL KRUEGER - Apr 30, 2022, 12:01 PM CDT



Download

boxandwhiskerround2.jpg (180 kB) Bar chart for loading ratings. Box and Whisker for loading times.

ANOVA Test Research From 4/25/22

RACHEL KRUEGER - Apr 30, 2022, 12:11 PM CDT

Title: ANOVA Test Research From 4/25/22

Date: 4/30/22

Content by: Rachel Krueger

Present: N/A

Goals: Determine if ANOVA test will be useful for our testing,

Content:

1. ANOVA - Analysis of Variance.
2. Analyze difference between means of two groups
3. One way: Uses one independent variable
4. Two way: Uses two independent variables
5. Statistical test:

$$F = \frac{\Sigma n_j (\bar{X}_j - \bar{X})^2 / (k-1)}{\Sigma\Sigma (X - \bar{X}_j)^2 / (N-k)}$$

6. Critical value is determined.
7. If the null hypothesis is true, the F statistic will be small
8. If the null hypothesis is false, the F statistic will be large
9. Hypothesis Testing - Analysis of Variance (ANOVA) (bu.edu)

Conclusions/action items: Would be useful to use to determine if there is a statistical difference between the devices

09SEP2022 Past Project Research

LILY GALLAGHER - Sep 21, 2022, 10:38 PM CDT

Title: Review of Final Report

Date: 09/21/2022

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To gain a better understanding of the scope and the steps that have gotten the project to the point it is at

Content:

Introduction:

- During endovascular procedures, the guide wire used often becomes tangled and disorganized when it is being stored

- Leads to lost of time and destruction of the guide wire

- endovascular device market is over $2 billion

- surgeons often use multiple guide wires during an endovascular surgery

- guidewires vary in stiffness and diameter and have different purposes

-guidewire is inserted and removed (once a catheter is fed to the area)

-guidewire must be stored incase it needs to be used again

Competing designs:

1. Cath Clip

- reduces the time spent operating by 80%

- lint free

- CONS:

    - can lead to disorganization, the guide wires are not separated

    - The open end allows for the guide wire to still be kinked or damaged

    - limited stability

2. Medical guidwirie storage method and apparatus

* PATENT PENDING

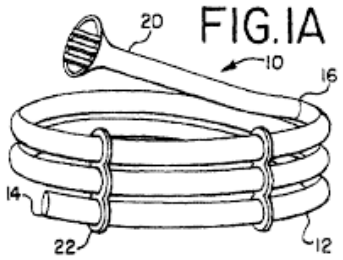
- holds up to 4 guide wires

- separates each individual guide wire

- openings that allow fluid to sterilize

CONS:

- must feed the guide wire in, takes too much time



Spring 2022 Design:

- initial design provided by the client

-Printed at the maker space

- Ultimaker S5

- Ultimaker PLS and PVA for inner supports (Ease of use, high strength, high stiffness, cost effective and efficient)

- Design was iterated and the wheel dimensions and characteristics were modified

- loads guide wires of varying stiffnesses and diameters (0.014, 0.018, 0.035 inches)

- holds three separate guide wires and allows for individual removal

SHOULD NOT EXCEED $200

Proposed Designs:

- DYWheel

Team moved forward with testing of this wheel

Deep inner cavity allowing the guide wire to be held in place

-CutChimney

Similar to DYWheel

Semicircular (inner chimney) allows it to slide off the stand after guide wire is unloaded

-CurveSpout

-DYStand

-UHold

-Door

Conclusions/action items:

26SEP2022 Injection Molding

LILY GALLAGHER - Oct 04, 2022, 7:01 PM CDT

Title: Injection Molding

Date: 26SEP2022

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To gain a better understanding of the criteria for injection molding

Content:

Wrapping your head around injection moulded parts:

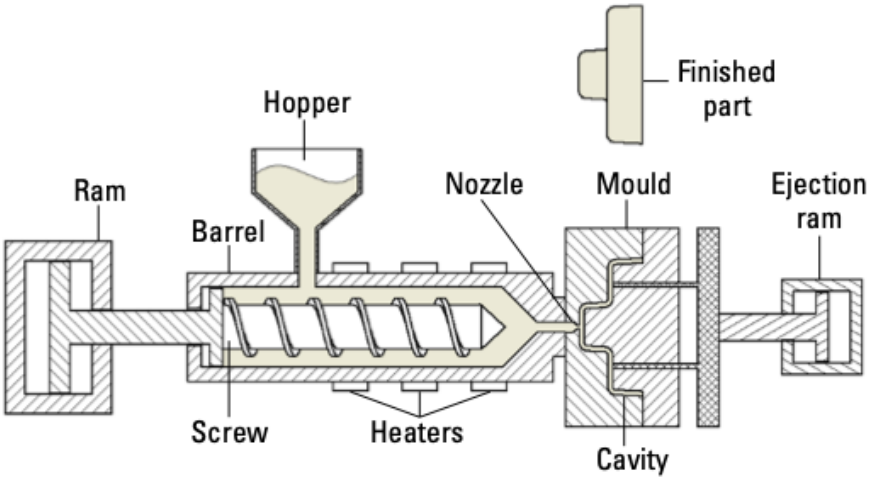


Figure 1-1: Schematic of a typical injection moulding machine.

Steps to injection molding:

1. Melt the plastic pellets

- Load them into the hopper

- melts by the combination if heat and pressure(by screw)

2. Inject the melted plastic into the mould

- Ram pushed the screw forward into a cavity within the mold

3. Let the mould cool

- once the mold is all injected

4. Eject the finished part out of the mould

- mould is opened and part is ejected

Mould Criteria:

Straight pull mould

- centres on a work piece made of at least two pieces of steel or aluminum

- held together with mechanical clamps or hydraulic pressure (when plastic injected)

- Pulled straight apart when cooled

* you can add pieces called "side actions" that create openings in sides of parts to create more complex features

CORE & CAVITY:

* at the center of the mould assembly there are two haves that create the hollow area where the melted plastic goes

Core: usually the interior or non cosmetic side

- contains the ejection mechanism to push the completed part out of the mould

Cavity: The void inside the mould that the molten plastic fills

- pastic enters the mould from the cavity side and forms the final shape

- usually forms the cosmetic side of the part

SEE IMAGE TO THE RIGHT

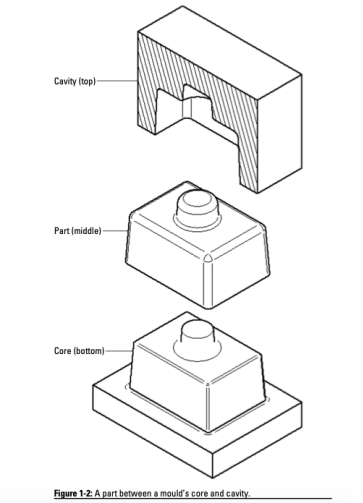


Figure 1-2: A part between a mould's core and cavity.

The Runner:

- The runner system has to make sure that the mould can fill

- Not too fast, not too slow

- Attached to the gates (part that controls the flow of plastic into the cavity)

Gates

- Edge: plastic flows into the cavity through the edge of the part

-Tunnel: Inject the plastic into the cavity from a port thats cut into the core side of the mould and comes back up into a portion of the part

- Post: Allow the plastic to be shot into the back of the mould via the paths of ejector pins

- Hot tips: gates that connect the sprue directly to the part

- a tip is placed in the part's cavity and heated so that the part doesn't stick to it but has a dimple added to allow the plastic to flow out of it properly

Part size and configuration:

-limit size of mould

- limit how much plastic you put in it

Choose a material:

- Mechanical properties of the part

- Characteristics of resins

- Special considerations

- Cost

Properties of common Resins:

Table 2-1 Properties of Common Resins

Resin Type	Strength	Impact Resistance	Dimensional Accuracy	Capability to Fill Small Features	Performance at High Mould Temperatures	Cost
Acetal	Medium	Medium	Fair	Fair	Fair	Medium
Acrylic	Medium	Low	Good	Fair	Good	Medium
Acrylonitrile butadiene styrene (ABS)	Low to medium	High	Good	Fair	Good	Low
High-density polyethylene (HDPE)	Low	High	Fair	Excellent	Good	Low
Polycarbonate (PC)	Medium	High	Good	Fair	Good	Medium to high
Polycarbonate/ ABS alloy (PC/ABS)	Medium	High	Good to excellent	Fair	Good	Medium
Polypropylene (PP)	Low	High	Fair	Excellent	Good	Low
Polystyrene (PS)	Low to medium	Low	Good	Good	Good	Low

- You can combine resins to create a blend

Conclusions/action items:

Look for a injection moulding expert on campus that we can schedule a meeting to discuss our design and possibility of creating a mould that could be injected to create our part

LILY GALLAGHER - Sep 28, 2022, 12:13 PM CDT

Citation:

Tremblay, *Injection Moulding Part Design for Dummies*. Protolabs, 2012.

https://www.protolabs.co.uk/media/1011290/im-for-dummies-en.pdf

02OCT2022 Thermoforming VS injection molding

LILY GALLAGHER - Oct 12, 2022, 9:31 AM CDT

Title: injection molding vs Thermoforming Manufacturing

Date: 02OCT2022

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To gain a understanding of the differences between injection molding and thermoforming

Content:

Injection molding VS thermoforming:

Thermoforming:

Heating a plastic sheet to glasswork transition and then compressing it over a mold

- Works best for basic, large parts

Cost:

- Tooling investment is less expensive ($)
    - “Up front” cost
- Per piece is more expensive ($$)

Lead time:

- January to march, 0-8 weeks

Size:

- Max size is 10’ by 11’

Injection Molding:

- Injection moulding involves a high pressure injection of a polymer into a mould where it is shaped.

- Injection molding scored the highest for production efficiency as it is the most common and time-efficient process used to mass produce parts

- Depending on the size of the desired product, the injection molding process can take two seconds to two minutes to produce a part

- Injection molding is ranked the highest as it is compatible with a wide range of thermoplastic, thermosets, or elastomers

- accommodate tolerances +/- .005 mm

Cost:

- Tooling investment ($$$)
    - Mould design is a key factor in determining the quality of the finished product. The strength, durability, shape and size all rely on the type of mould that is used. The mould must be sturdy and be able to withstand the pressures involved during the injection process. The polymer must also be able to flow properly along the mould. The mould must also be carefully designed to allow heat transfer to control the cooling process.
- Per piece is less expensive

Lead time:

- January to July 12-16 weeks

Size:

- 4’ by 4’

"The cycles of the injection moulding process," Automatic Plastics, 22-Apr-2020. [Online]. http://www.automaticplastics.com/the-cycles-of-the-injection-moulding-process/

"Thermoforming vs. injection molding," 3 Space, 10-Dec-2021. [Online]. Available: https://3space.com/thermoforming-vs-injection-molding/.

"What is injection molding?," KEYENCE. [Online]. https://www.keyence.com/ss/products/measure-sys/machining/injection-molding/about.jsp.

"Injection molding vs. thermoforming - how to choose?: Productive plastics," *Productive Plastics Inc*, 18-Jan-2021. [Online]. Available: https://www.productiveplastics.com/injection-molding-vs-thermoforming/

"Injection molding vs. thermoforming: What's The difference," Thomasnet® - Product Sourcing and Supplier Discovery Platform - Find North American Manufacturers, Suppliers and Industrial Companies. [Online]. https://www.thomasnet.com/insights/injection-molding-vs-thermoforming-what-s-the-difference/.

Conclusions:

Begin to make Design matrix comparing and contrasting thermoforming and injection molding

Injection molding is obviously the best choice for mass production of our product based on material compatibility, cost per part, production efficiency, and the complex geometry of our part

10OCT2022 Materials

LILY GALLAGHER - Oct 19, 2022, 3:09 PM CDT

Title: Material in Operating Rooms

Date: 10OCT2022

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To gain a better understanding of the type of material options for our design

Content:

Material selection guidelines and suggestions
Specialized engineering thermoplastics, developed specifically for healthcare applications, offer powerful tools for optimizing products, increasing speed to market, and improving product function. For example, today there are options for flexible applications – traditional vinyl, nonphthalate vinyl, thermoplastic polyurethane (TPUs), TPEs, co-polyesters, and ethylene-vinyl acetate (EVA). In terms of innovation, the latest materials are biomaterials that feature property enhancements unavailable in the past.

Plastics in the operating room
Respirator bulbs can be molded from vinyl, which still makes up a significant portion of medical plastics used today. Vinyl products display excellent clarity and chemical resistance, are easily processed, and can be formulated in a range of colors and durometers. They are sterilizable in steam, gamma radiation, and ethylene oxide (EtO) and provide an economical option. For this reason, they are used in many fluid container applications, from IV and dialysis fluids to blood storage bags. In these bags, the low oxygen permeability and good clarity makes vinyl ideal. Medical vinyl compounds are also used in a broad range of tubing, such as wound and chest drainage tubes, catheters, and endotracheal tubing.

***Thermoplastic parts** designed for healthcare applications can help reduce the spread of infection and germs.

In the OR, formulated polymer systems can be used in reusable versions of formerly disposable items. There are now materials that have the temperature and mechanical performance properties required for multiple uses and sterilizations. Materials such as polyphenylsulfone and polyether ether ketone (PEEK) can withstand over 1,000 steam sterilization cycles, making them useful in surgical and dental instruments or in sterilization trays. Not only are these material resilient in steam sterilization, but their excellent chemical resistance extends to many common hospital disinfectants, giving longer life for these multiple use applications.

Conclusions:

Overall injection molding is comparable with almost to all thermoplastics. Once we meet with Prolabs/ possible vendors we can further investigate what type of thermoplastics are available for fabrication and we can investigate those plastics further.

L. W. Johnson, “Select the right plastic material when designing medical products,” *Design World*, 19-Sep-2011. [Online]. Available: https://www.designworldonline.com/select-the-right-plastic-material-when-designing-medical-products/. [Accessed: 10-Oct-2022].

Title: Material Research

Date: 19OCT2022

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To gain a better understanding of the material samples we are being sent

Content:

Overall: Silicone rubbers are characterized principally by the following properties...

- Outstanding low-temperature flexibility and high-temperature resistance
- excellent compression set
- high resistance to chemicals and environmental influences
- water-repellent surface
- high transparency, almost no limits on pigmentation
- good mechanical properties
- good flame resistance, non-toxic combustion products in the event of a fire
- neutral taste and odor
- easy to process
- can be adjusted from electrically insulating to semiconducting
- good radiation resistance
- ELASTOSIL® LR 3003 series are paste-like, easily-pigmentable two-component compounds with short curing times. Their vulcanizates are noted for their high transparency and excellent mechanical and electrical properties.

Elastosil 3003/40 A/B (Clear Silicone)

- Hardness range from 38 to 44 Shore A (41 ± 3 Shore A).

-used within a temperature range of - 55 °C to + 210 °C.

- Good for; Food-contact, general purpose, and reduced volatile content

- 5 minute cure time

- Density= 1.13 g/cm^3 (ISO 37 type 1)

- Tear strength = 30 N/mm (ASTM D 624 B)

- Rebound resilience = 57% (ISO 4662)

Elastosil 3003/50 A/B (Clear Silicone)

- Narrow Shore hardness range from 47 to 53 Shore A (50 ± 3 Shore A).

- This product can be used within a temperature range of - 55 °C to + 210 °C.

- Good for; Food-contact, general purpose, and reduced volatile content

- 5 minute cure time / 165 degrees C

- Density= 1.13 g/cm^3

- tear strength 26 N/mm

Elastosil 3003/60 A/B (Clear Silicone)

- hardness range from 57 to 63 Shore A (60 ± 3 Shore A).

- Good for; Food-contact, general purpose, and reduced volatile content

- Tear strength 27 N/mm

- Rebound resilience 67% ISO 4662

- Density 1.13 g/cm³ (DIN EN ISO 1183-1 A)

Product	Further characteristics	Hardness Shore A ISO 48-4	Specific gravity [g/cm³] ISO 1183-1A	Tensile strength [N/mm²] ISO 37 Typ 1	Elongation at break [%] ISO 37 Typ 1	Tear resistance [N/mm] ASTM D 624 B	Compression set [%] (22 h/175 °C) DIN ISO 815-1	Food contact – BfR[1]	Food contact – FDA[2]	Flame retardancy – UL 94 Listing	Cure system	Appearance	Typical applications
LR 3004/40		40	1.13	9.1	610	29	10	X	X	HB (1.5 mm)	Platinum (1:1 A/B)	Transparent	Production of molded parts, e.g. seals, O-rings, valves, gaskets, membranes
LR 3004/50		50	1.13	10.0	480	27	15	X	X	HB (1.5 mm)	Platinum (1:1 A/B)	Transparent	Production of molded parts, e.g. seals, O-rings, valves, gaskets, membranes
LR 3004/60		60	1.13	9.6	380	25	18	X	X	HB (1.5 mm)	Platinum (1:1 A/B)	Transparent	Production of molded parts, e.g. seals, O-rings, valves, gaskets, membranes

Versaflex OM 1060X-1 (Natural TPE)

- Thermoplastic elastomer

- Soft touch, good surface aesthetics, rubbery feel, soft touch

-Overmolding

- consumer, packaging and healthcare markets

- Hardness 60 (Shore A)

Injection Speed: 1 to 3 in/sec
1st Stage - Boost Pressure: 300 to 900 psi

2nd Stage - Hold Pressure: 30% of Boost

Hold Time (Thick Part): 3 to 10 sec
Hold Time (Thin Part): 1 to 3 sec

Conclusions:

There is not much variability between these materials, it is hard to say if one material is better suited for our application because they are so similar. We could preform testing on the wheel to determine how much force is applied to the wheel. I am worried about the rubbery feel/ flexibility of this material at the thickness of our design. These are the material samples that protolabs is sending us so we will be able to test out how flexible the material is and determine if we want to move forward with an elastomer.

- I would like to compare the cost of an elastomer with thermoplastics

“ELASTOSIL® LR 3003 Liquid silicone rubber (LSR): Wacker Chemie AG,” *WACKER Website*.

https://www.wacker.com/h/en-us/silicone-rubber/liquid-silicone-rubber-lsr/elastosil-lr-300340-ab/p/000014137.

LILY GALLAGHER - Oct 19, 2022, 4:58 PM CDT

WACKER

CREATING TOMORROW'S SOLUTIONS

ELASTOSIL® LR 3003/40 A/B

Liquid Silicone Rubber (LSR)

Properties

Specific features

- Food-contact
- General purpose
- Reduced volatile content

Download

ELASTOSIL-LR-300340-AB-en-2021.07.01-v6.pdf (47.7 kB)

LILY GALLAGHER - Oct 19, 2022, 4:58 PM CDT

WACKER

CREATING TOMORROW'S SOLUTIONS

ELASTOSIL® LR 3003/50 A/B

Liquid Silicone Rubber (LSR)

Properties

Specific features

- Food-contact
- General purpose
- Reduced volatile content

Download

ELASTOSIL-LR-300350-AB-en-2022.06.17.pdf (47.9 kB)

LILY GALLAGHER - Oct 19, 2022, 4:58 PM CDT

WACKER

CREATING TOMORROW'S SOLUTIONS

ELASTOSIL® LR 3003/60 A/B

Liquid Silicone Rubber (LSR)

Liquid silicone rubbers of the ELASTOSIL® LR 3003 series are paste-like, easily-pigmentable two-component compounds with short curing times. Their vulcanizates are noted for their high transparency and excellent mechanical and electrical properties.

Properties

Narrow Shore hardness range from 57 to 63 Shore A (60 ± 3 Shore A).
This product can be used within a temperature range of - 55 °C to + 210 °C. The addition of heat stabilizers at service temperatures of more than 180 °C is recommended. Further information to improve the heat stability by use of specific ELASTOSIL® Color Pastes FL can be obtained from the Technical Information Sheet "ELASTOSIL® Color Pastes FL".

Specific features

- Food-contact
- General purpose
- Reduced cyclic content

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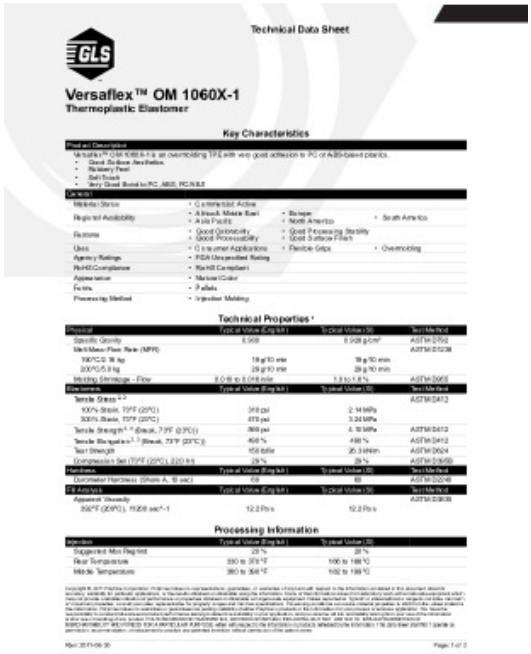
ELASTOSIL-LR-300360-AB-en-2022.06.28.pdf (47.9 kB)

LILY GALLAGHER - Oct 19, 2022, 4:58 PM CDT



Technical Data Sheet

GLS

Versaflex™ OM 1060X-1

Thermoplastic Elastomer

Key Characteristics

Technical Properties

Processing Information

Download

Versaflex_OM_1060X-1_Natural_TPE_.pdf (102 kB)

14NOV2022 Collapsible Core Injection Molding

LILY GALLAGHER - Dec 13, 2022, 11:01 AM CST

Title: Collapsible Core Injection Molding Specialized Companies

Date: 14NOV2022

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To gain a better understanding of the type of material options for our design

Content:

Company #1 UpMold

Collapsible core injection molding used for plastic injection molding and extrusion

- For the parts what inner cavity dimension is bigger than outer dimension

Collapsible core technology characteristic:

1.
2. Ingenious structure, moving and demoulding in limited space
3. High precision and consistency for components
4. Cool machining technology for material with high hardness
5. Security & reliable mechanical structure for multi-cavities injection mold, and make the tooling size smaller.

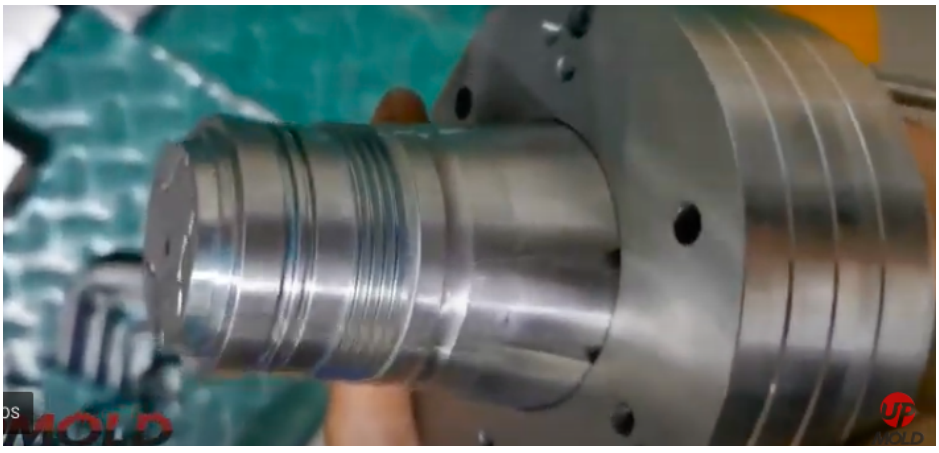
The collapsible core having a straight pin improved stability of the collapsible core segments improving the dimensional accuracy of the molded part. The pin diameter matches the inside diameter of the segments and by being contained by a stripper or containment ring matched to the outside of the segments the pin and the segmented sleeves are self-centering and extremely accurate.

Shorter and spring-loaded segments reduce the possibility of injection pressure opening the segments.

- Reduces the time for injection and reduces cycle time.

- The increased contact area between the pin and the collapsible core segments improves mold cooling allowing for faster cycle times.

- The change of shape of the contact area between the segments and the pin, rounded surfaces moving across flat surfaces, reduces wear allowing for less maintenance.



Collapsed to remove and eject part (Smaller outer diameter of the part)

Company #2 DME

THE DME S-CORES CAN BE MANUFACTURED IN DIFFERENT VERSIONS.

The DME S-Cores can be manufactured in multiple versions depending on part geometry.

6 Segments

Three (3) large and three (3) small slide segments each. Provides sufficient collapse for undercuts up to 600mm.

Ready to Mold Collapsed for Ejection

8 Segments

Four (4) large and four (4) small slide segments each. Used for intermediate (medium) undercuts.

DME S-Core's can be designed in Oval and Square shapes to compensate for part deformation/shrink.

Ready to Mold Collapsed for Ejection

12 Segments

The smallest possible collapsible core available.
Design optimized for producing undercuts on diameters as small as 6mm.

Ready to Mold Collapsed for Ejection

CONS:

More expensive

Conclusion:

Reach out to UpMold and DME and get a quote estimate on our part

Citations:

1. “Collapsible Core Mold Design: Internal Undercut Injection Molding - UPMOLD.” *Upmold Technology Limited*, 19 Feb. 2022, https://upmold.com/Product/collapsible-core-mold-design/.

2. S-Core Collapsible Cores - DME. https://www.dme.net/s-core/.

26SEP2022 LINDAR Thermoformed Medical Equipment

LILY GALLAGHER - Sep 26, 2022, 4:35 PM CDT

Title: LINDAR Thermoformed Medical Equipment: Guidewire packaging

Date: 26SEP2022

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To gain a better understanding of competing devices that are in the market

Content:

Lindar is a thermoformed and medical plastics manufacturer.

Product: LINDAR Coil Pack guide wire medical tray and cover

Size:

16.7 x 16.7 x 2.5 (Coil pack tray)

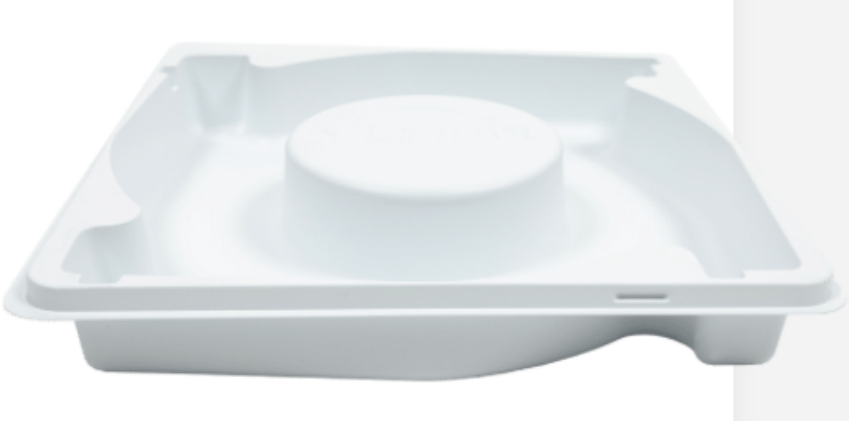
16.7 x 16.7 x .5 (Coil pack Lid)

Pros:

- Durable
- Reusable?
- Packaging
- Cost
    - For 30: $8.50 per tray, $5.40 per lid
    - For 3600: $3.49 per tray, $2.16 per lid
    - See attach quote below

Cons:

- Used for handling between internal processing (most likely does not go into OR)
    - Seems like it is used for packaging, shipping, and storage
- Not customizable
- Depending on what it's used for it can be reused



Conclusions/action items:

Overall, this device has a slightly different use than what we are designing, however I think the general ideas are very similar, this product is just more of a storage package. I like the simplicity of the design and thing we could benefit from playing around with something with a lid.

- Look into criteria / materials used in thermoforming

- We were talking about how injection molding our prototype might be difficult because it has an overhang, maybe we can look into a lid mechanism so that we don't need that overhang.

LILY GALLAGHER - Sep 26, 2022, 4:37 PM CDT

Coil Pack Tray and Lid

#00671 COIL PACK TRAY

#00670 COIL PACK LID

PRICE LIST

QUANTITY	PRICE/TRAY
30	$ 8.50
60	$ 7.52
120	$ 6.38
240	$ 5.89
360	$ 5.49
480	$ 5.18
1 PALLET 600	$ 4.58
2 PALLETS 1200	$ 3.76
4 PALLETS 2400	$ 3.65
6 PALLETS 3600	$ 3.49

QUANTITY	PRICE/LID
30	$ 5.40
60	$ 4.77
120	$ 4.34
240	$ 4.09
COMBINED 1 PALLET 360	$ 3.90
480	$ 3.54
600	$ 3.27
1 PALLET 900	$ 2.93
2 PALLETS 1800	$ 2.56
4 PALLETS 3600	$ 2.16

9001:2015 ISO CERTIFIED

MANUFACTURED IN USA

7789 HASTINGS ROAD, BAXTER MN 56425 (218) 829-3457 www.lindarcorp.com

Download

COIL_PACK_TRAY_and_LID_PRICING_7-2021.pdf (470 kB) LINDAR's quote for Coil Pack Tray and Lid

LILY GALLAGHER - Sep 26, 2022, 4:41 PM CDT

Citation: https://lindarcorp.com/consumer-products/medical-guidewire-trays-and-lids/

26SEP2022 MEDLINE Guidewire Bowl

LILY GALLAGHER - Sep 26, 2022, 5:04 PM CDT

Title: Medline Guidewire Bowls

Date: 26SEP2022

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To gain a better understanding of competing devices that are in the market

Content:

Guidewire bowl to provide a secure location for guide wires while preparing for a procedure

Characteristics:

-2 sizes

1. 8.5" Diameter, 2,500 mL capacity
2. 11" Diameter, 5,000 mL capacity

- Has a lid

- 5 tabs that ensure the wire stays in place

- sterile

- fits multiple wires

Cons:

- pre roll the wire

- don't see a opening/ to pull the guide wire

- seems like multiple wires would get tangled

Conclusion/action items:

This design is very different from our prototype design, this one does not seem very functional. I want to see how it is loaded/unloaded.

LILY GALLAGHER - Sep 26, 2022, 5:05 PM CDT

Citation:

https://punchout.medline.com/product/Guidewire-Bowls/Safety/Z05-PF157858#mrkDocumentation

19OCT2022 Frisbee Injection Mold

LILY GALLAGHER - Oct 24, 2022, 9:28 AM CDT

Title: Frisbee Injection mold

Date: 19OCT2022

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: Gain a better understand on how we will create a injection mold for our design with the complex geometry of the overhang

Content:

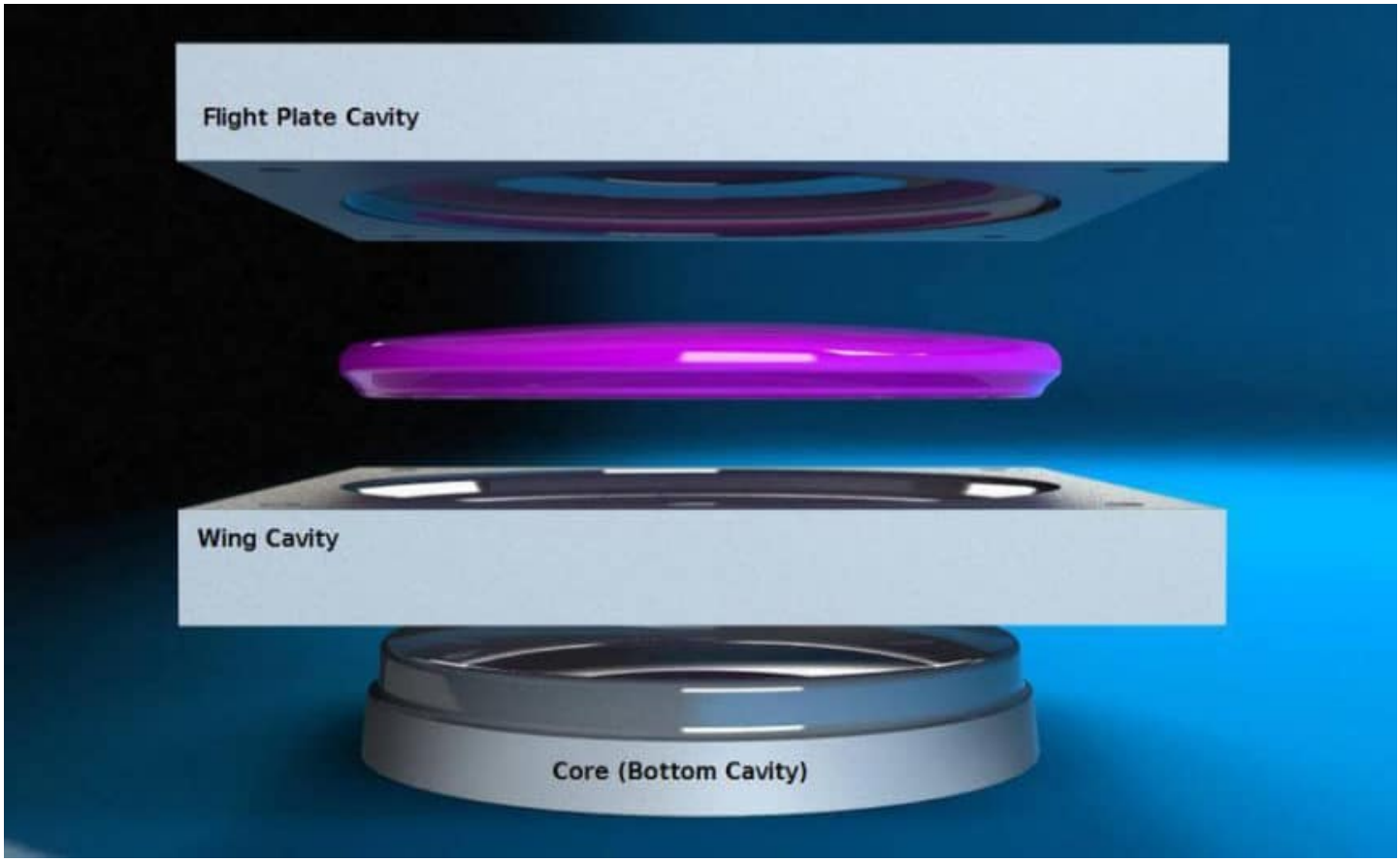
- Multicavity mold to create the overhang of a frisbee without additional welding or separation of the top and bottom

- Similar geometry to our wheel design, circular shape with an a overhang and an inner cavity

- The bottom cavity is inside of the wing cavity which makes the underside profile

- Our design also has the inner ring in the middle of the wheel design

- When injection molding this mold starts off as two moving pieces but during the processes, these pieces are compressed to one piece as the plastic is injected

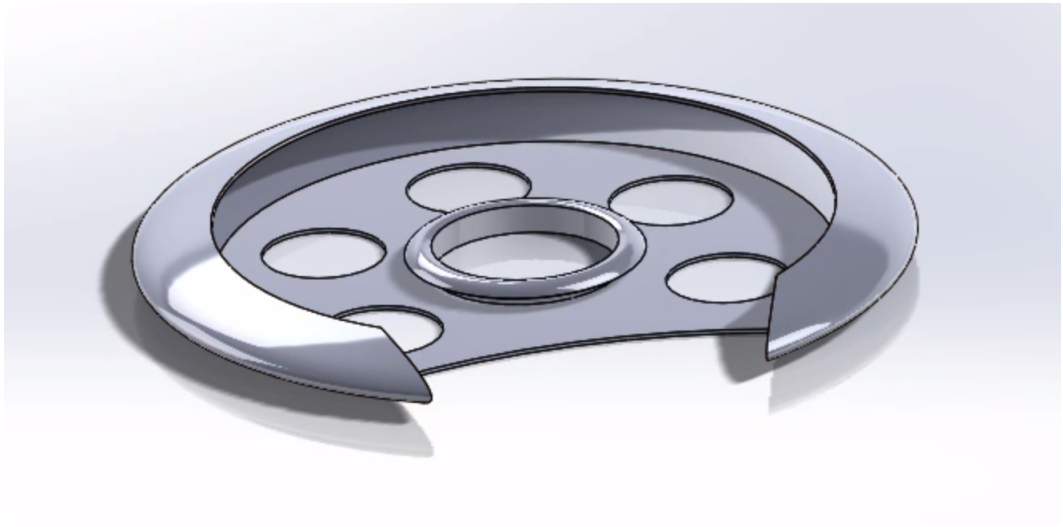


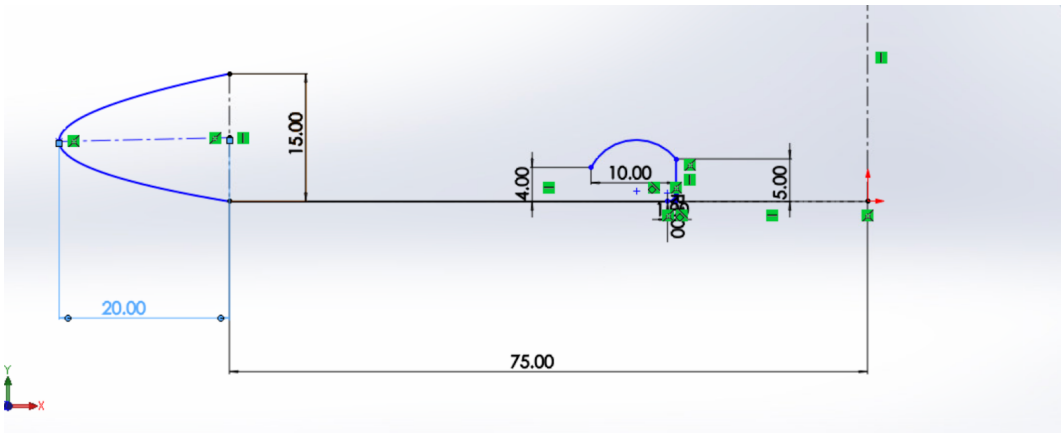
Inconsistencies:

A general rule for injection molding parts is that the entire part should have consistent wall thicknesses. Thicker plastic will take more time to solidify, resulting in possible shrinkage or cosmetic defect called "sink".

- We need to make sure our design has a consistent thickness

With the frisbee mechanics, it is not possible for the walls to have the same thickness so when designing the mold it is important that the plastic flows from a thicker section to a thinner section to maintain consistent pressure

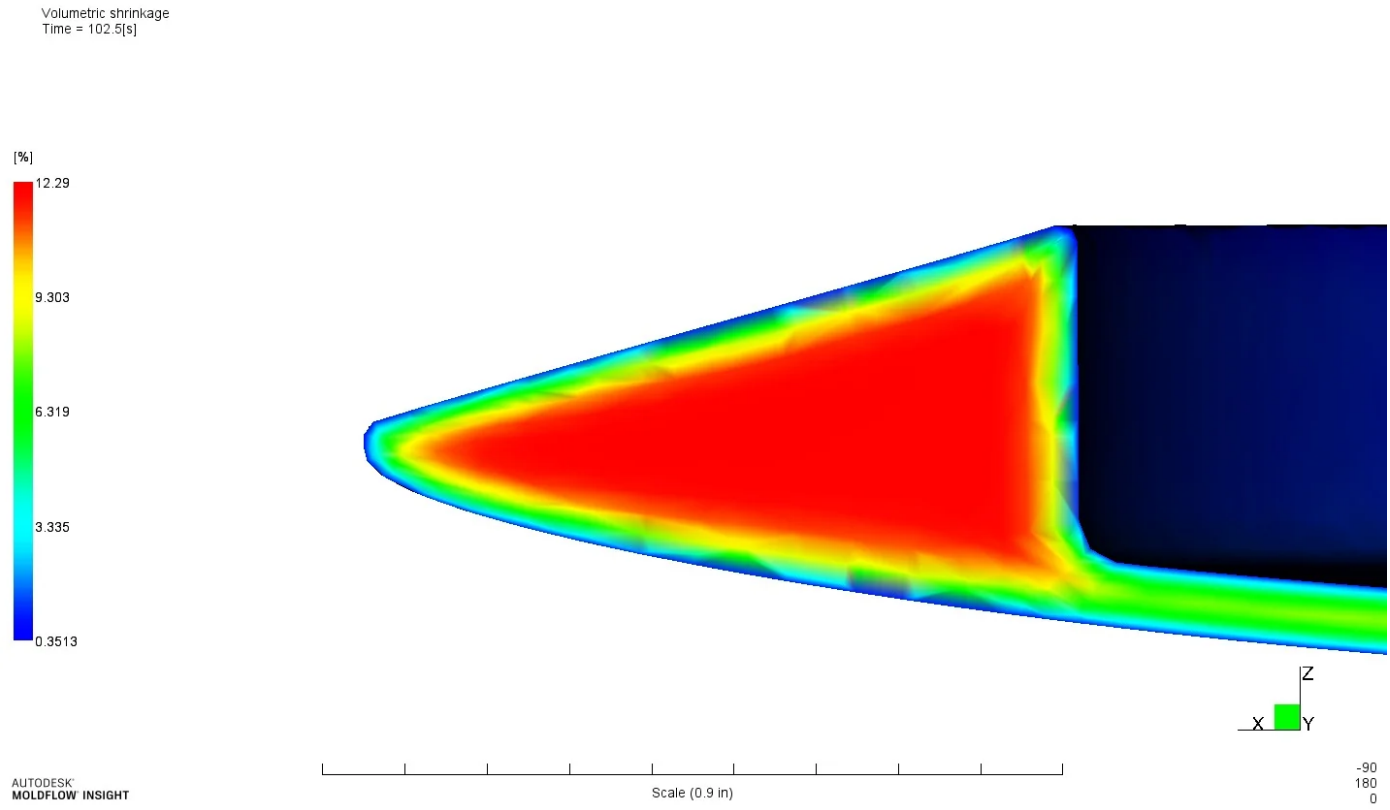




- Volumetric shrinkage profile

- The core of the wing wants to shrink twice as much as the rest of the disc

- extra force wants to pull in the surrounding walls, resulting in a concave shape



Example of how the mold can become deformed:

Conclusions/action items:

- Our design is different than a frisbee but there are similarities with the overall structure and outer wall and cavity. We can keep this information and inconsistencies in the design to further improve/understand how our part will be molded.

A. Hynkel, “Injection molding and disc inconsistencies: Part 2,”

https://www.reddit.com/r/discgolf/comments/avumch/injection_molding_and_disc_inconsistencies_part_2/

02NOV2022 Design Modification

LILY GALLAGHER - Nov 18, 2022, 2:39 PM CST

Title: Design Modifications

Date: 03/11/2022

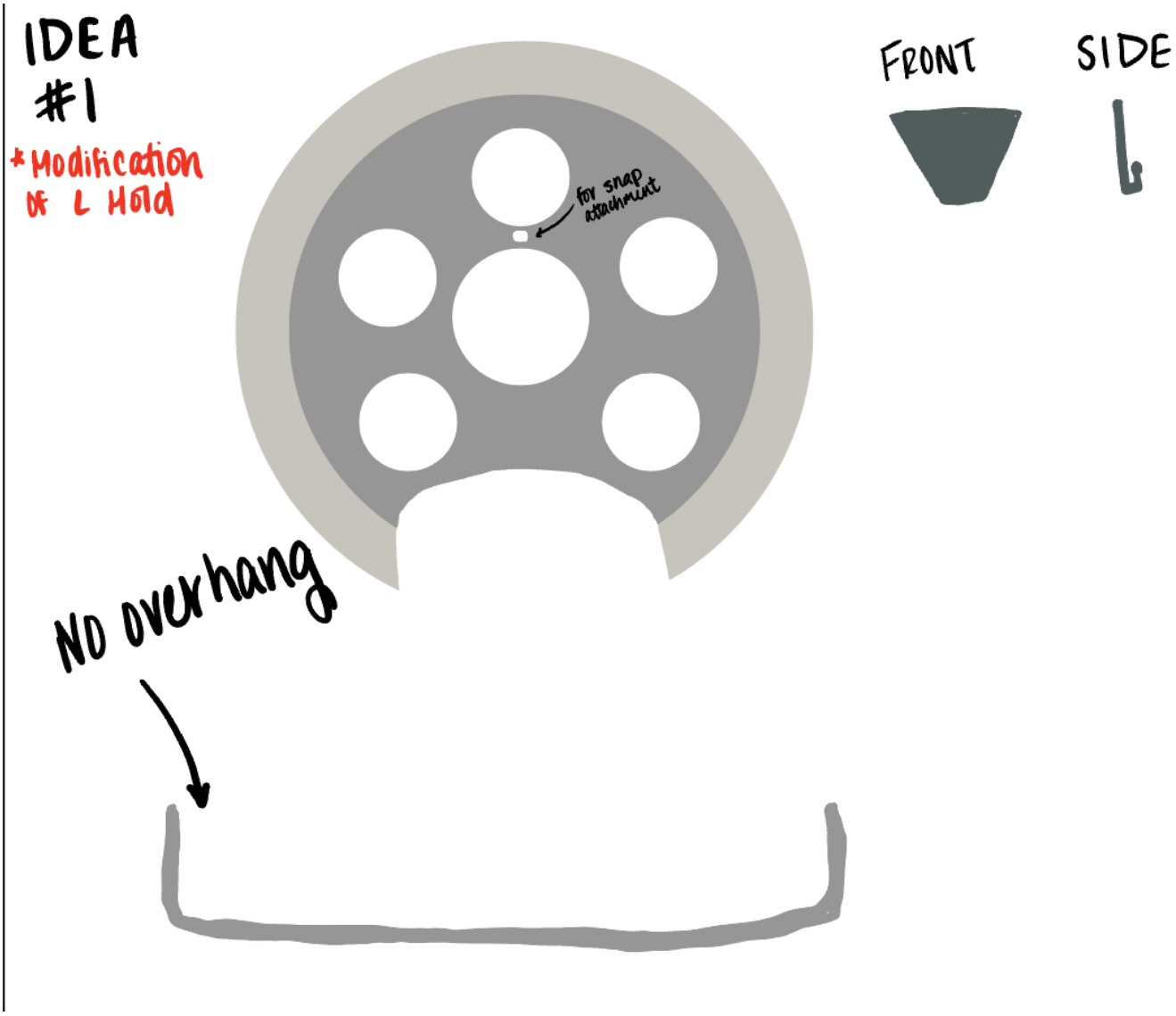
Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To modify our design so that a mold can be created

Content:

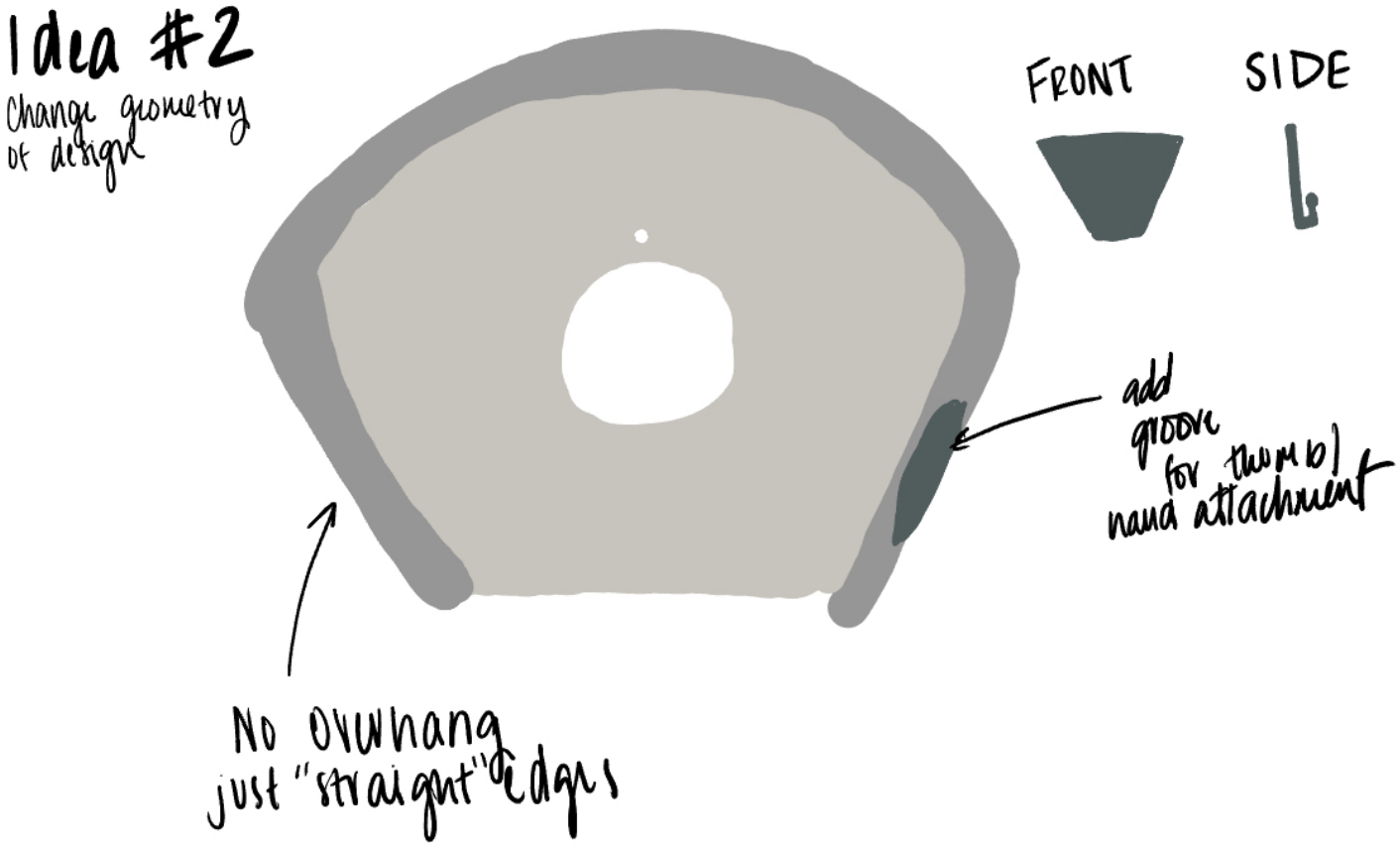
First design is a modification of LHold. The med students and our client really liked this design, they explained that it worked well and was intuitive to load the guidewire. This design modification separates the wheel and the extrusion/clip that is used to keep the wire wound and in place. This makes the wheel design easier to injection mold. An additional modification would be to modify the overhang/cavity of the wheel. The geometry of the overhang is what is making our design so difficult to injection mold. A part of the injection mold process includes ejecting the solidified mold, however, this over hang makes it so the part cannot be injected once it has solidified (why we are only able to use elastic materials). if there was no overhang, this part would be easily injection molded.



Clip snap mechanism:

Type of design \ Shape of the cross section	A Rectangle	B Trapezoid	C Ring segment	D Irregular cross section
(Permissible) deflection 1 Cross section constant Over the length	$y = 0.67 \cdot \frac{\varepsilon \cdot l^2}{h}$	$y = \frac{a + b_{(1)}}{2a + b} \cdot \frac{\varepsilon \cdot l^2}{h}$	$y = K_{(2)} \frac{\varepsilon \cdot l^2}{r_2}$	$y = \frac{1}{3} \cdot \frac{\varepsilon \cdot l^2}{c_{(2)}}$
(Permissible) deflection 2 All dimensions in direction y, e.g., h or Δt, decrease to One-half	$y = 1.09 \cdot \frac{\varepsilon \cdot l^2}{h}$	$y = 1.64 \cdot \frac{a + b_{(1)}}{2a + b} \cdot \frac{\varepsilon \cdot l^2}{h}$	$y = 1.64 \cdot K_{(2)} \cdot \frac{\varepsilon \cdot l^2}{r_2}$	$y = 0.55 \cdot \frac{\varepsilon \cdot l^2}{c_2}$
(Permissible) deflection 3 All dimensions in direction z, e.g., b and a, decrease to one-quarter	$y = 0.86 \cdot \frac{\varepsilon \cdot l^2}{h}$	$y = 1.28 \frac{a + b_{(1)}}{2a + b} \cdot \frac{\varepsilon \cdot l^2}{h}$	$y = 1.28 \cdot K_{(2)} \cdot \frac{\varepsilon \cdot l^2}{r_2}$	$y = 0.43 \cdot \frac{\varepsilon \cdot l^2}{c_{(2)}}$
Deflection force 1,2,3	$P = \overbrace{\frac{bh^2}{6}}^{Z} \cdot \frac{E_z \varepsilon}{l}$	$P = \overbrace{\frac{h^2}{12} \cdot \frac{a^2 + 4ab_{(1)} + b^2}{2a + b}}^{Z} \cdot \frac{E_z \varepsilon}{l}$	$P = Z_{(4)} \cdot \frac{E_z \varepsilon}{l}$	$P = Z_{(4)} \cdot \frac{E_z \varepsilon}{l}$
Subscript numbers in parenthesis designate the note to refer to.				

In this design, the geometry of the "wheel" is changed so it resembles more of a baseball plate. If we were to remove the overhang, there is nothing that would be keeping the wire in place. This geometry of the semi circle and straight edges would help keep the wire down.



Conclusions/action items:

Meet with the team to show them the designs.

LILY GALLAGHER - Nov 09, 2022, 9:02 PM CST

Title: SolidWorks design

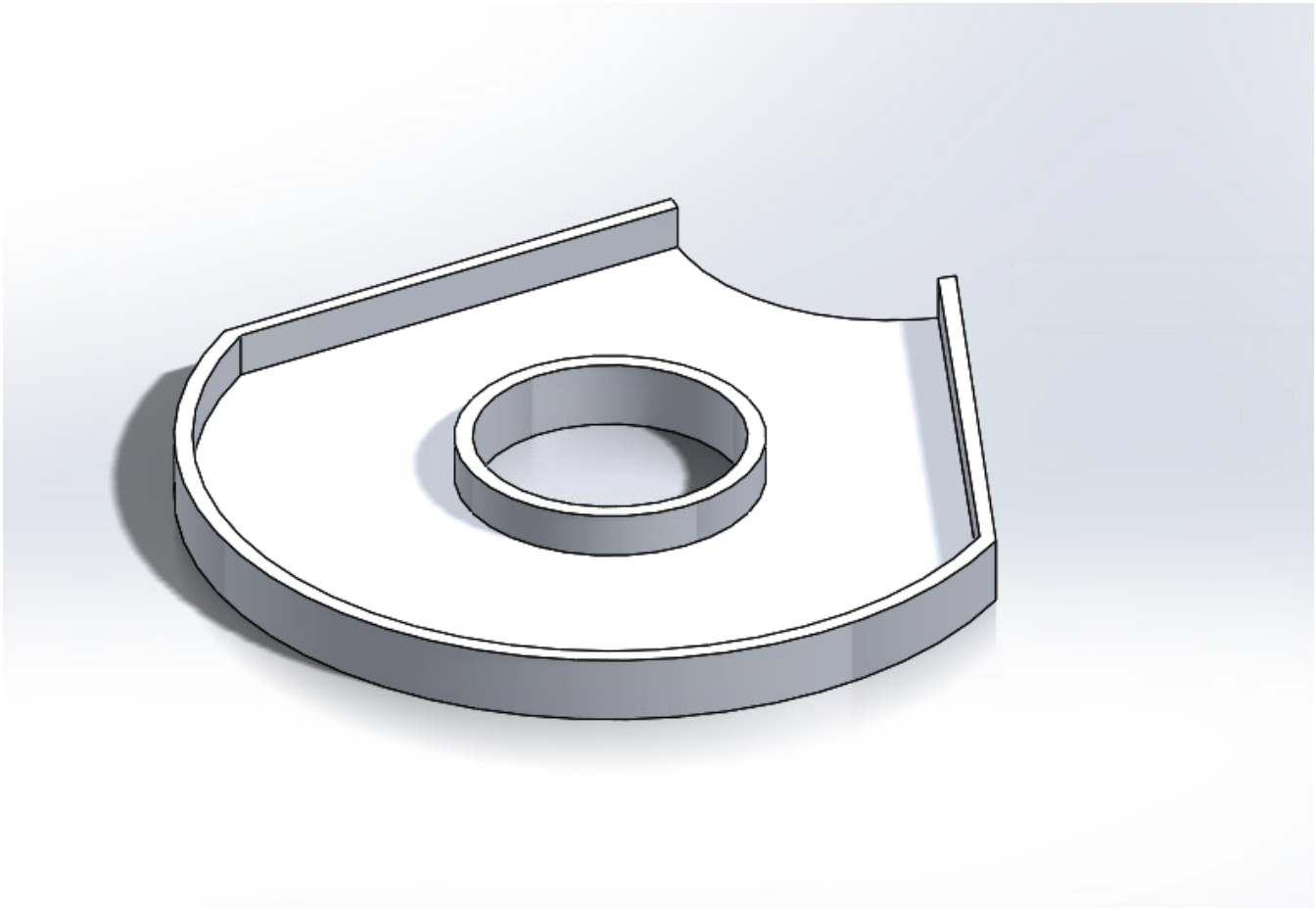
Date: 11/09/2022

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To create one of the design variations in SolidWorks

Content:



Conclusion:

Show team the design, get feedback on the dimensions and add a draft to the straight edge.

04DEC2022 Testing Notes

LILY GALLAGHER - Dec 13, 2022, 4:52 PM CST

Title: Testing Notes

Date: 04DEC2022

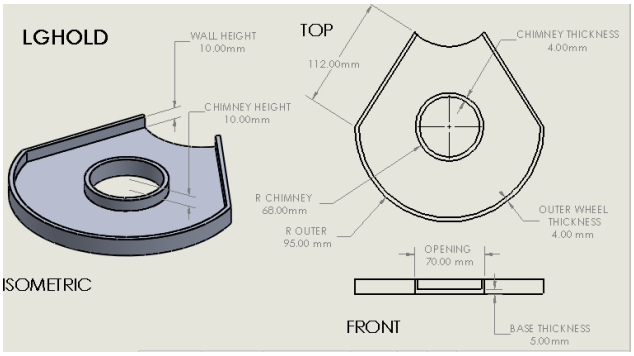
Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To analyze each of the 7 prototypes to get a better understanding of what needs to change for future iterations

Content:

LHold:



Likes:

- Simple design, easily Injection Moldable

- Angled straight walls did help to keep the guidewire organized when loading and unloading

Dislikes:

- Too thick and clunky

- The radius of the semi circle was too big, the wires had more room than needed to expand

- The wires did not stay inside of the wheel once you let go of the guidewire

    - Had to use hand to initially push the wire down

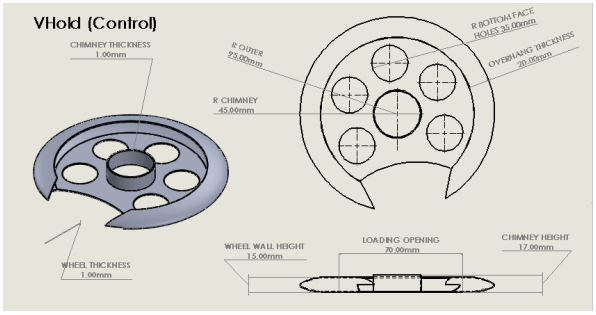
Changes:

- Smaller thickness of the material (currently is 4mm while other prototypes were 1-2mm thick)

- Smaller semi circle radius (currently is 95mm, could make 75mm to be similar in size as the XSHold)

- Possibly change the angle of the straight edges to see if a smaller angle would be more effective

- Add a slight draft to the inside walls like in ADHOLD, in hopes to keep the wire to stay within the wheel better

Vhold: 

Likes:

- Easy to load,

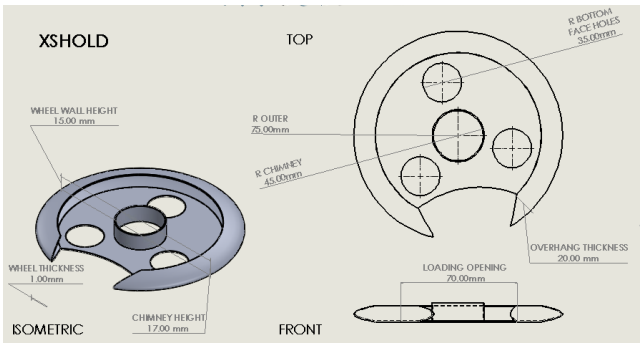
- Increased height of the chimney is functional when loading the guidewire, you can more easily release the wire when loading

Dislikes:

- Too big, the wire did not need that much space - caused issues of the guidewire popping out when unloading

- Couldn't unload as fast, guide wire had too much space (could change diameter of the inner chimney)

- Not injection moldable

XSHold: 

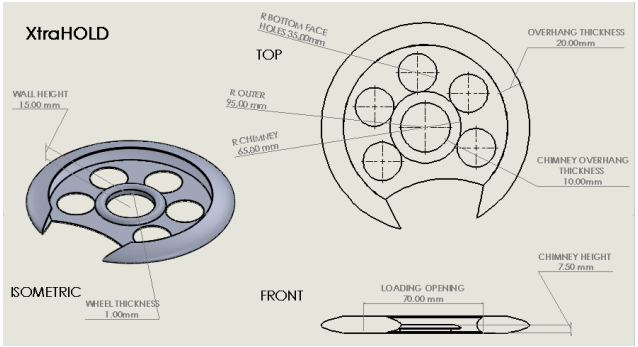
Likes:

- Size of the outer wheel, the guidewire was able to expand more controlled because there was less space for it to pop out when both loading and unloading

Dislikes:

- Not injection moldable

- Change chimney to the clip, the circular chimney doesn't "grab" and secure the wire as well as the clip attachment

XtraHold (3): 

Likes:

- Similar likes to VHold and XSHold

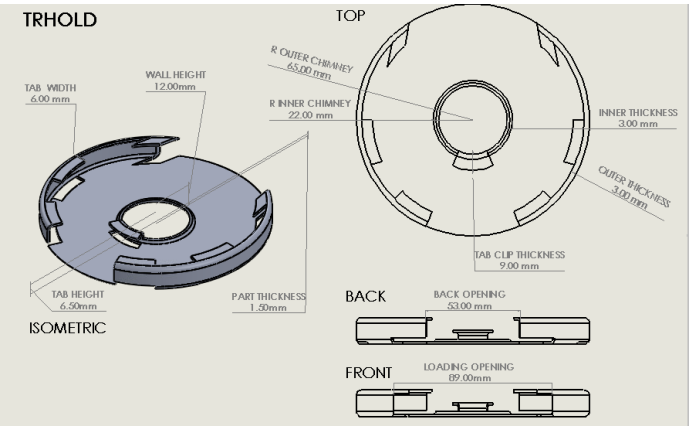
Dislikes:

- the middle overhang did not keep the wire down when unloading

- The chimney so low made it difficult to load the wire because your hand had to get so close to the inside (obstruction)

- Smaller wheel diameter/radius

TRHold:



Likes:

- Injection moldable

Dislikes:

- The opening at top made it hard to load the wire

- The wire got stuck in the gaps when pulling it out

- Confusion on which side to load the guidewire initially

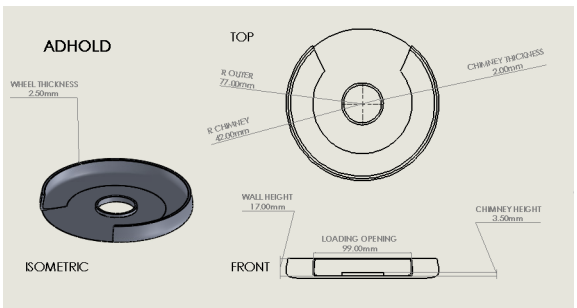
- Too small

- Too bulky with all of the tabs jetting outwards

Changes:

- Play around with the side of the tabs and holds - try to make it so there is less space for the wire to get stuck when loading/unloading

ADHold:



Likes:

- Injection moldable

- Simple design

- Smaller wheel measurements made it easier to load/unload

- Wire stayed within the wheel very well, it did not need extra securing when loading

Dislikes:

- The wire just popped out when unloading because nothing was keeping the wire in place (the clip middle would be helpful)

Changes:

- I would really like to try this design with a better chimney, either the clip attachment or just a taller chimney

Conclusion:

- XS hold was clearly the best iteration we have currently, however it is not injection moldable. I thought that ADHold worked very well being our first iteration of this design. I think we need to change the chimney to be taller or have the clip attachment on it.

04DEC2022- Data From Testing

LILY GALLAGHER - Dec 13, 2022, 5:11 PM CST

Title: Personal Data from Testing

Date: 04DEC2022

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To update my testing results

Content:

1. I am Member 6.
2. Wheel Configurations:

Design	Design #
LHold	0
VHold	1
XSHold	2
XtraHold	3
TRHold	4
ADHold	5
LGHold	6

3. Process: 21 Trials total for the 7 wheel variations
    1. Loading: Start time, wrap wire into a circle shape, load wire into wheel, end time
        1. Rate 0-3 on loading
    2. Unloading: Start time, find the end of the guidewire, pull out wire 100% out of the wheel, end time
        1. Rate 0-3 on loading
    3. Repeat for three trials
4. Notes:
    1. I was really bad at wrapping the guidewire up into a neat circular shape to load the wheel but throughout the 21 trials I had gotten better (why some of my times are dramatically different)
5. Results:
    1. I had a lot of issues with TRHold (4) and LGHold (6)
    2. I had the best ratings for XSHold (2), XtraHold (3), ADHold (5), LHold(0), and Vhold(1)

Design Number:	Member Number:	Trial Number:	Loading Time:	Loading Grade (0-3):	Unloading time (not on stand):	Unloading Grade (0-3)
4	6	1	8.33	2	6.79	1
4	6	2	13.1	1	5.07	3
4	6	3	14.2	1	5.75	2
2	6	4	15.69	3	5.41	3
2	6	5	13.9	3	5.75	3
2	6	6	13.4	3	6.2	3
6	6	7	14.32	1	3.9	2
6	6	8	14	2	4.4	2
6	6	9	16.66	2	9	3
3	6	10	15.3	3	6.5	3
3	6	11	13.45	3	6.3	2
3	6	12	15.9	3	9.36	2
5	6	13	15.35	3	7.28	1
5	6	14	13.92	3	7.59	1
5	6	15	12.98	3	5.6	1
0	6	16	14.46	3	6.43	3
0	6	17	13.07	3	6.31	3
0	6	18	9.35	3	7.38	3
1	6	19	14.61	3	5.9	3
1	6	20	11.96	3	7.37	3
1	6	21	14.01	3	5.74	3

Conclusion:

Personally, i liked ADHold and XSHold the best, even though I also had the same ratings for XtraHold, LHold and VHold.

- I thought the wheel diameters of XSHold and ADHold made it more efficient to load and unload. I often saw with the larger diameter wheels, XtraHold, LHold and VHold, that you had to unload slower and controlled in order for the guidewire to stay in (too much space in the wheel for the wires to move and expand)

- I think that we need to think about adding a finger dent or something so that the medical professionals have something the hold/orientate their hands with.

- See document with extensive notes on each of the wheels

10DEC2022 Prototype Dimensions

LILY GALLAGHER - Dec 13, 2022, 10:43 AM CST

Title: SolidWorks Design Drawings

Date: 10DEC2022

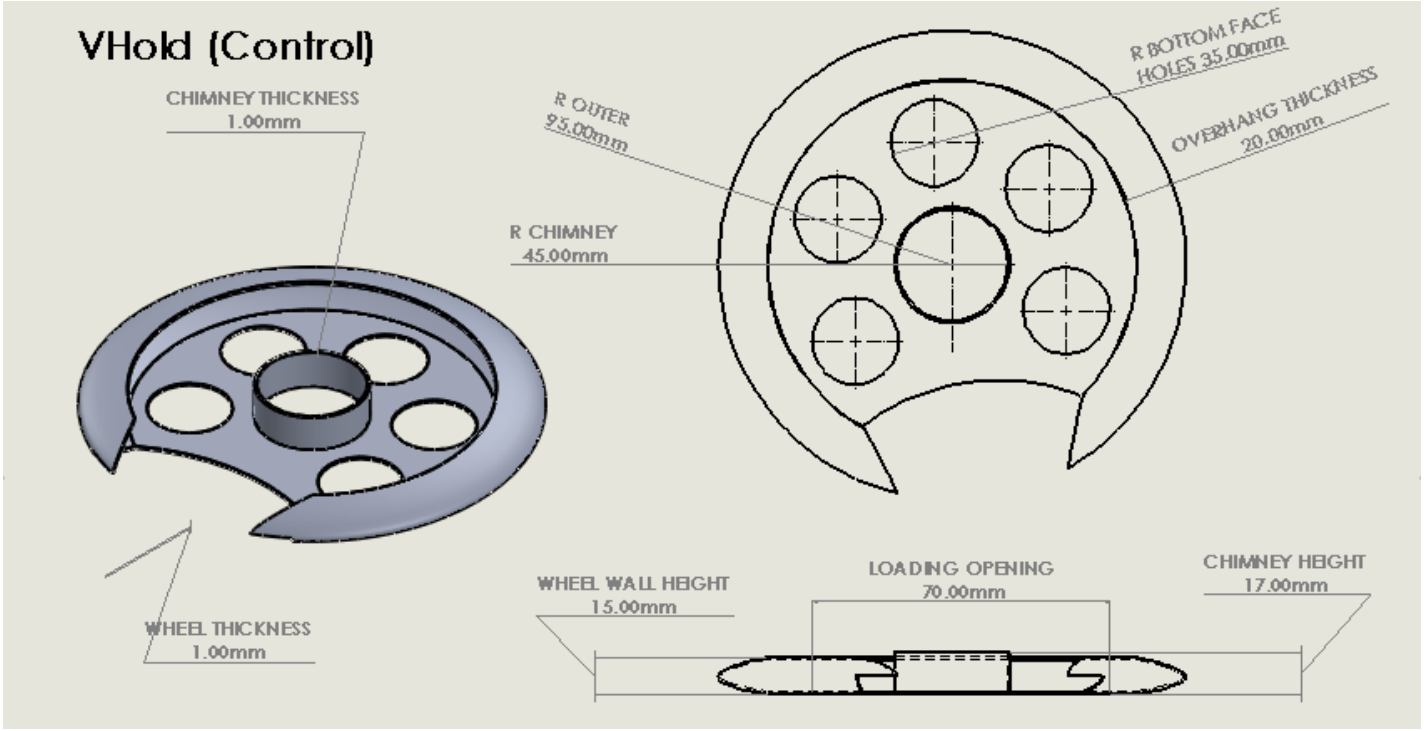
Content by: Lily Gallagher

Present: Lily Gallagher

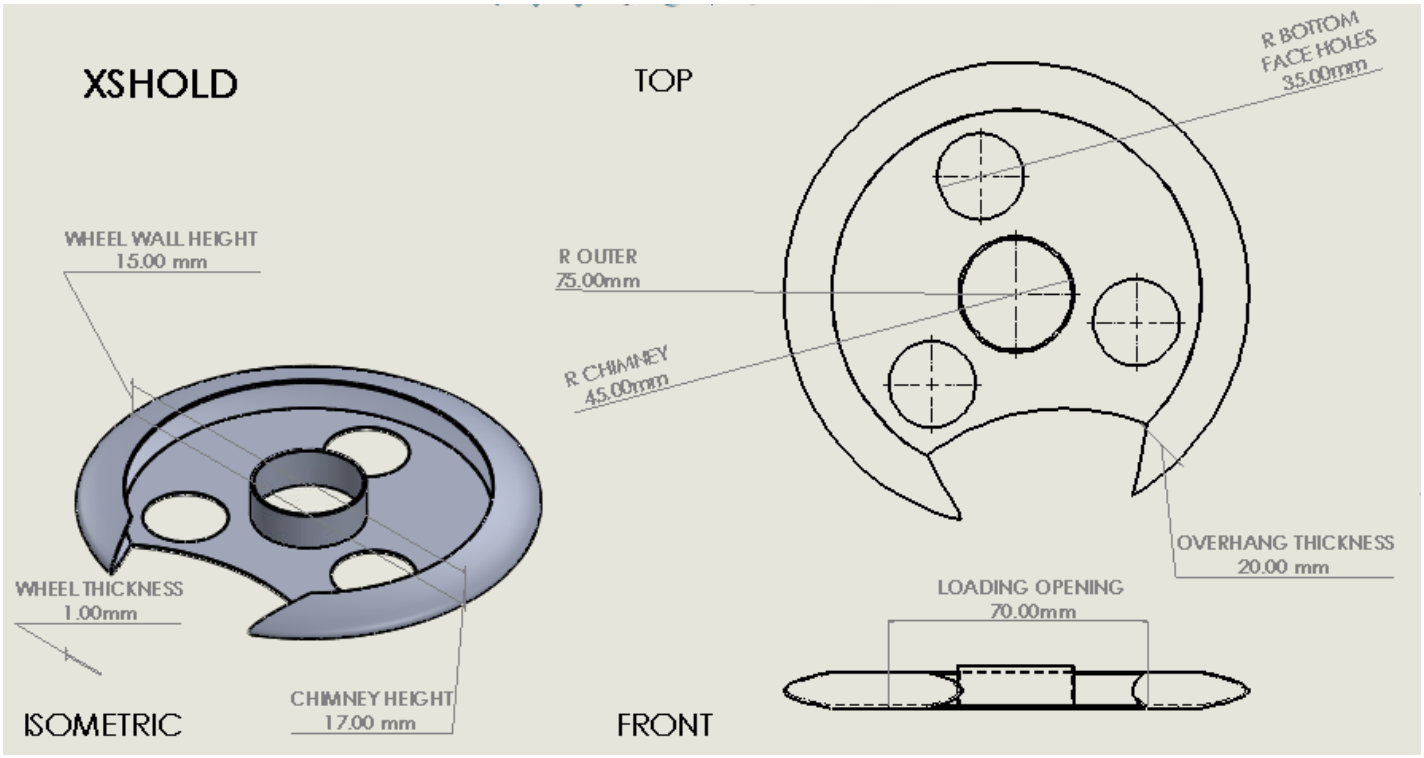
Goals: To create dimensional drawings for all of our designs

Content:

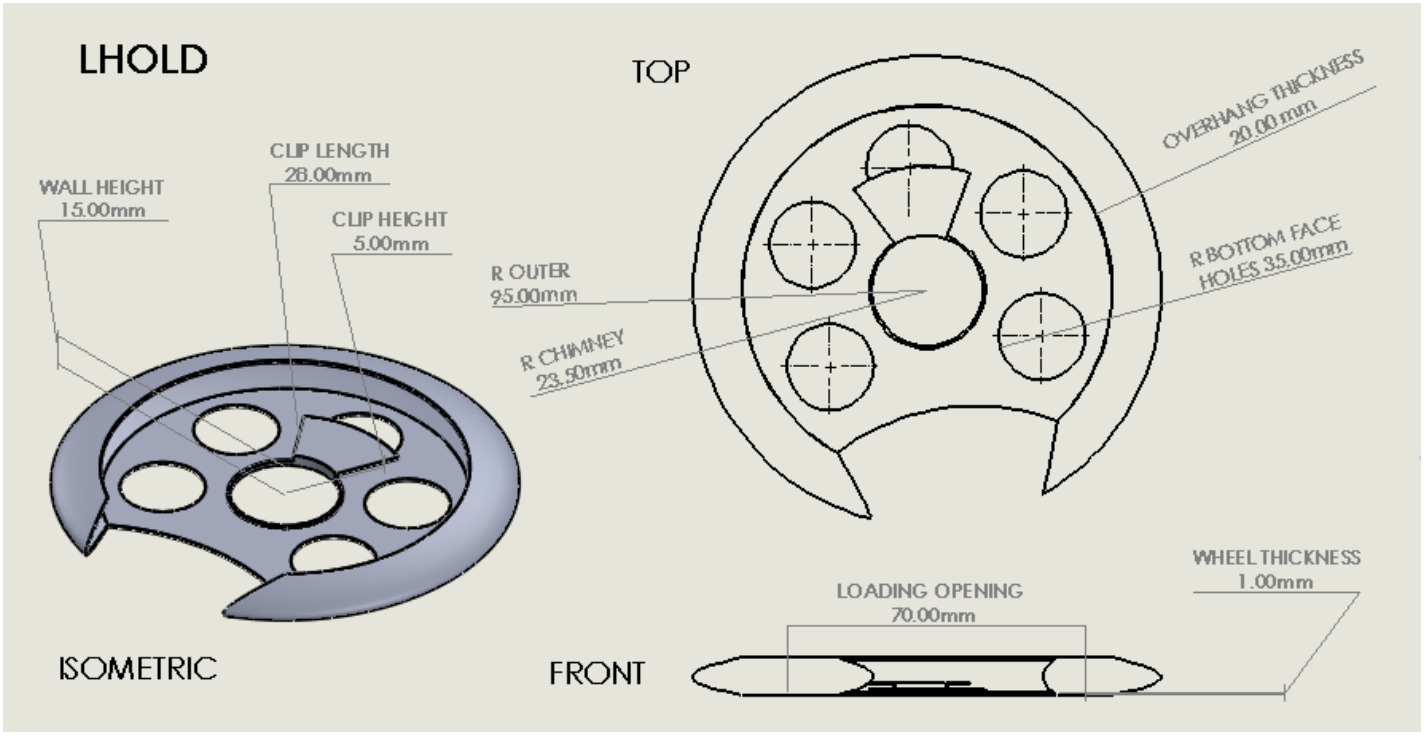
VHOLD:



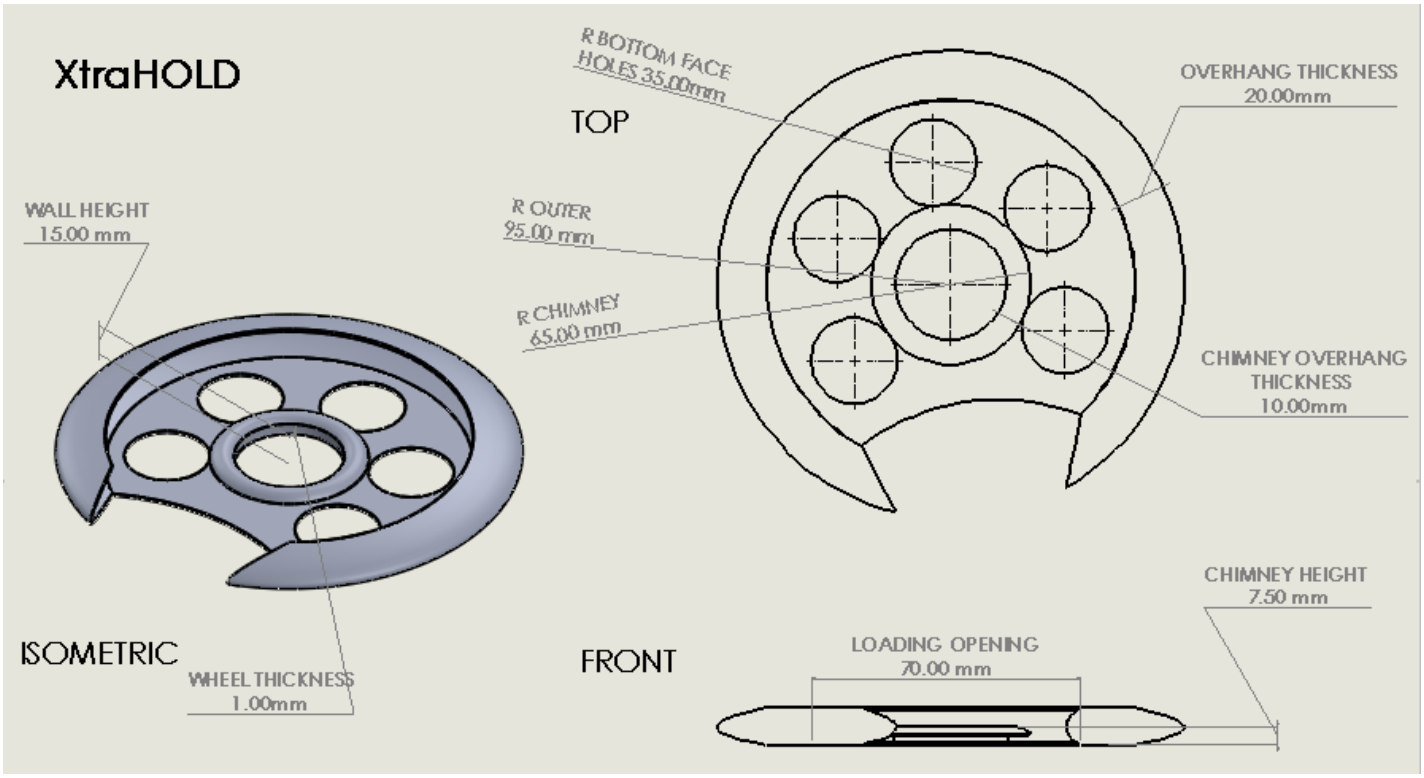
XSHOLD:



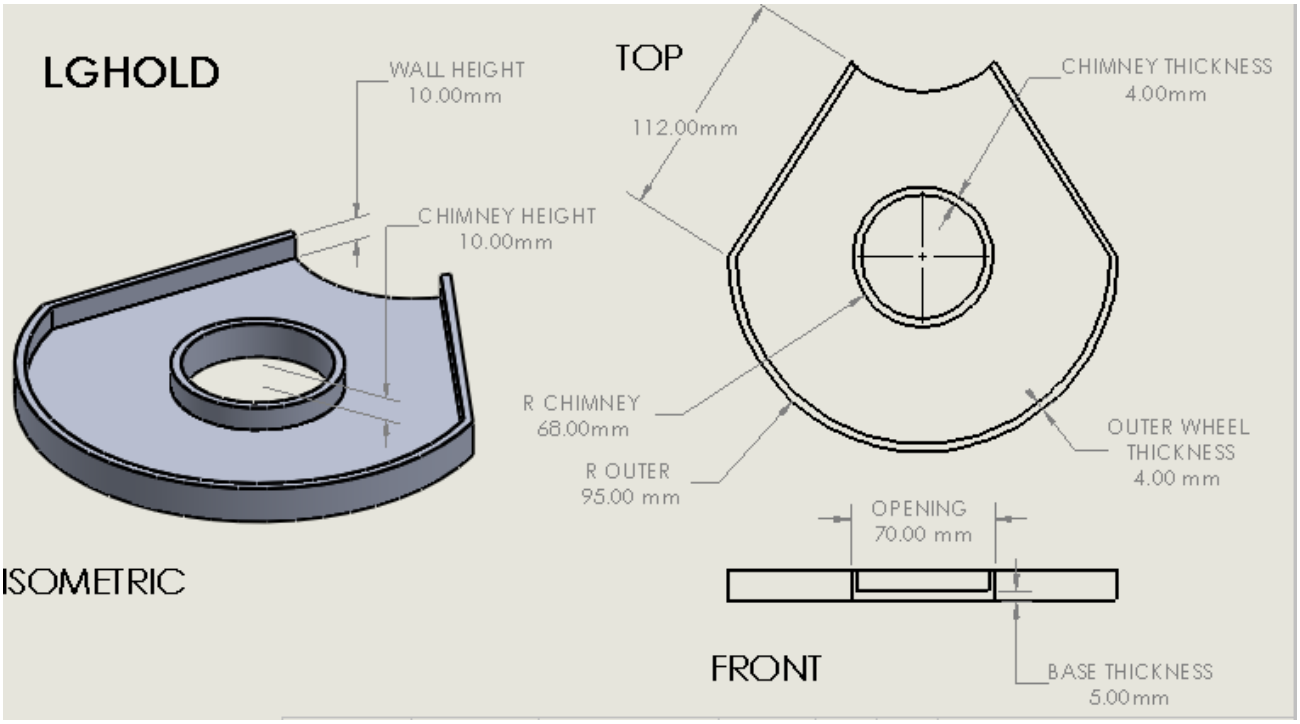
LHOLD:



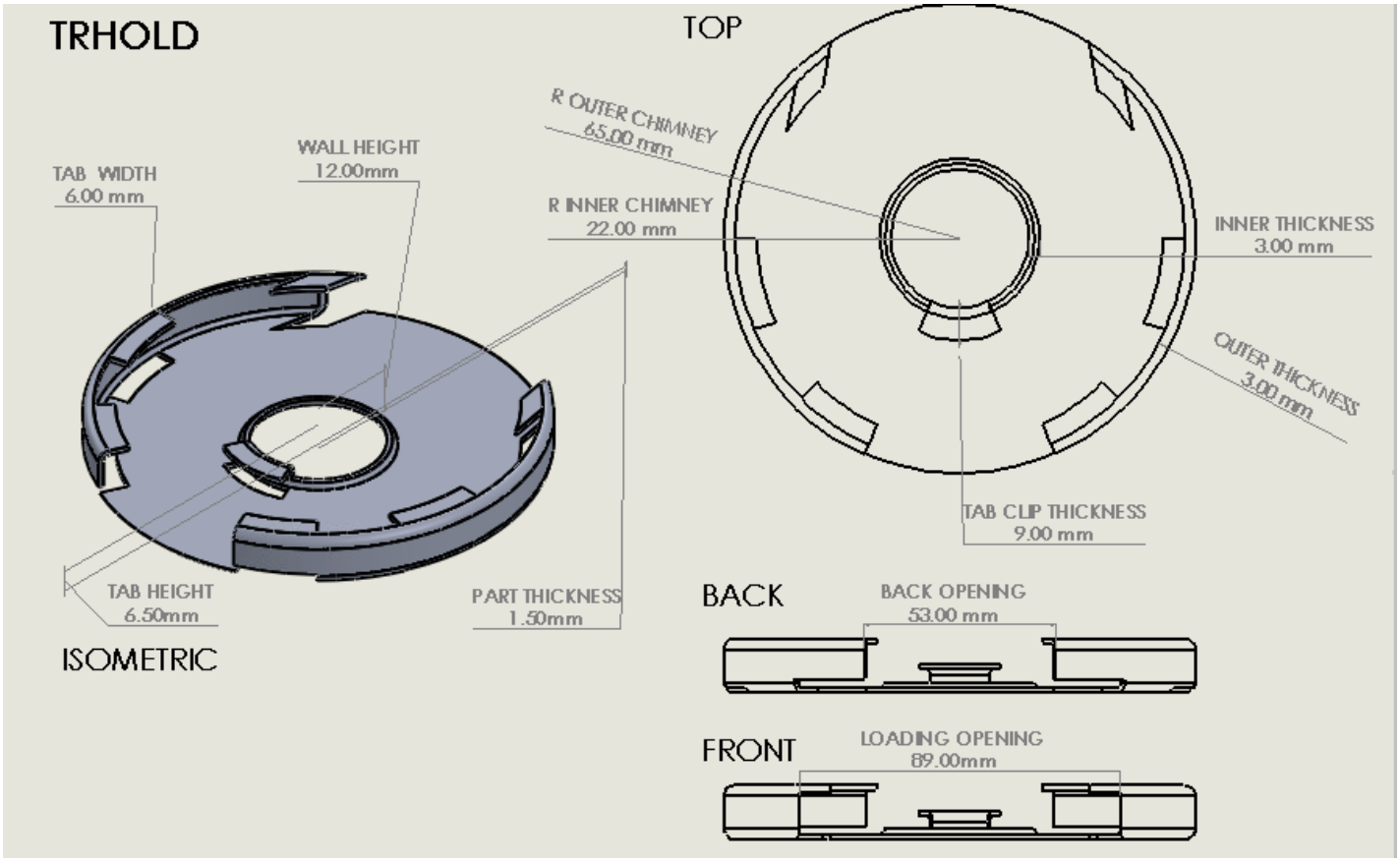
XTRAHOLD:



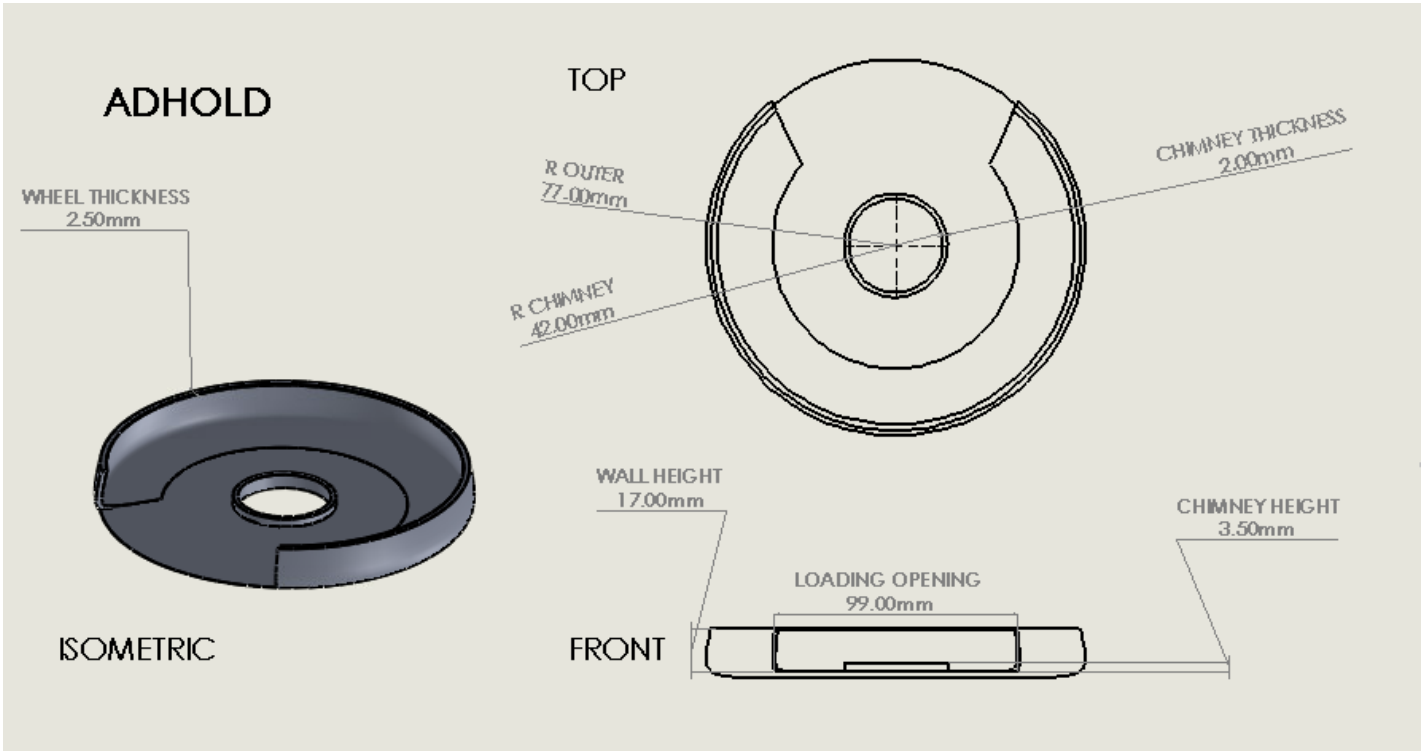
LGHOLD:



TRHOLD:



ADHOLD:



Conclusions/action items:

Add to final report

9/15/22 Past Project Research

Ben Smith - Oct 03, 2022, 11:44 PM CDT

Title: Past Project Research

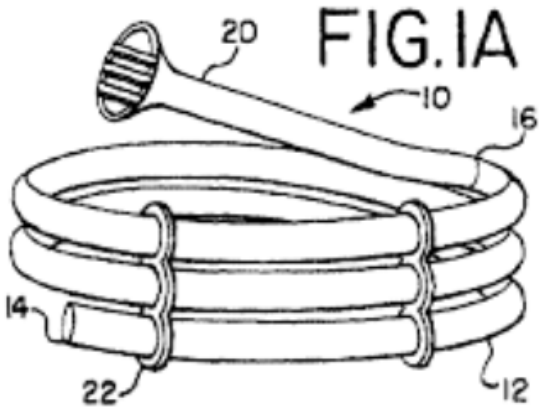
Date: 9/15/22

Content by: Ben Smith

Goals: Become familiar with the previous work of the team.

Content:

Source: BME 301 Final Report "Guidewire Organizer for Endovascular Procedures"

- The team's project was to create a guidewire organizer and stand for use in operating rooms during surgical procedures that require use of guidewires and catheters
- It is super easy for guidewires to tangle and become disorganized after use in catheters
    - This is bad because guidewires have bodily fluids on them and you want to keep the operating room as sterile as possible
- Competitors:
    - Cath Clip
        - Single use
        - Still have open wire that can get tangled with other wires
        - Acts like a "chip clip"
        - 
        - **Figure 1:** Cath Clip holding guidewire in place
    - Medical Guidewire Storage Method
        - Flexible tube holds 4 guidewires
        - Can be filled with saline to sterilize
        - 

        - **Figure 2:** Medical Guidewire Storage Method drawing
- 3 main initial designs for the wheel:
    - DYWheel
        - Deep inner cavity to place guidewire in
        - Long neck for stand
    - CutChimney
        - Semicircle chimney to easily slide off stand
    - Curvespout
        - Cut off base for easily loading of guidewire
- 3 main initial stands:
    - DYStand
        - Simple with long chimney in the middle cut into two parts
    - UHold
        - No holes, long solid chimney with a half-wall surrounding the base
    - Door
        - Features a removable top, door allows guidewire organizers to be removed in any order
- UHold is the final proposed stand, but the wheel design is the main priority
- Testing for unloading and loading times was done to determine the best wheel design
- The team will further optimize the design of the wheel in the future
- Future goals include mass manufacturing of the product to be brought into industry

Conclusions/action items:

There is a clear path forward and I am excited to start researching for the team.

9/29/22 Injection Molding Resources

Ben Smith - Oct 05, 2022, 12:08 AM CDT

Title: Injection Molding Resources

Date: 9/29/22

Content by: Ben Smith

Goals: Gather and reach out to several contacts in the injection molding industry.

Content:

Protolabs

Contact Name: Sydney Darkow

Email: sydney.darkow@protolabs.com

Title: Account Manager for UW-Madison

- I reached out to Protolabs and **Sydney** introduced herself to me
- **Sydney** gave me this resource for more information about the injection molding capabilities at Protolabs
- I also requested a quote for our control model VHold to get general cost assumptions for injection molding (see below for quote)
    - Notice HIGH mold cost but very small cost to actually injection mold 25 parts ($2.88/part)
- Design modification is needed before we can move forward with the quote
- **Sydney** will be a good contact to keep in touch with at Protolabs as we continue to investigate the best options to mass manufacture our product

Morgridge Fablab

Contact Name: Professor Kevin Eliceiri

Email: eliceiri@wisc.edu

Title: Investigator, Morgridge Institute for Research

- Upon reaching out to **Dr. Puccinelli** for other injection molding resources, he put in me contact with **Prof. Kevin Eliceiri**
- **Prof. Kevin Eliceiri** then introduced me to his collaborator **Dr. Tom Turng**

Contact Name: Dr. Tom Turng

Email: turng@engr.wisc.edu

Title: Co-Director, Polymer Engineering Center

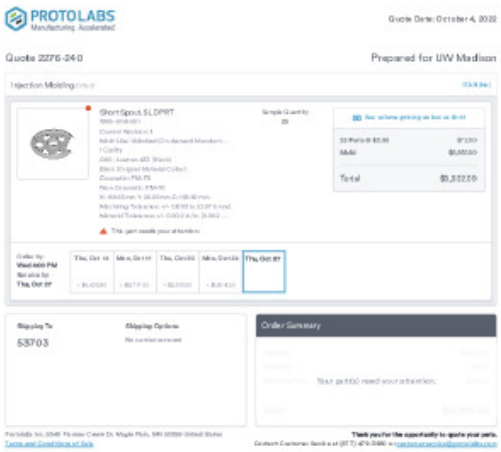
- **Dr. Turng** reached out to us to introduce himself and ask what our group had in mind
- **Dr. Turng's** group has been working on injection molding for over two decades at UW-Madison

- I reached out to set up a meeting to discuss our design with him
    - We are looking at how to optimize our design to be compatible with injection molding
    - We are also looking to compare injection molding options and see where we can mass manufacture our product for the cheapest price along with most efficiency
- The team agreed to meet on October 5th at 10:50am with **Dr. Turng** to inquire about our design, learn more about his expertise, and overall learn more about injection molding, overmolding, and molds in general

Conclusions/action items:

The team is excited with the resources we have already came into contact with in the injection molding industry. We will learn more about our design and how we can modify it to most easily/efficiently mass manufacture it using injection molding on Oct. 5th in our meeting with Dr. Turng.

Ben Smith - Oct 04, 2022, 11:51 PM CDT



Download

Quote_2276-240.pdf (273 kB)

10/11/22 Snap Fit Research

LILY GALLAGHER - Nov 18, 2022, 2:38 PM CST

Title: Snap Fit Research

Date: 10/11/22

Content by: Ben Smith

Goals: Learn about snap fit connections and brainstorm how we could incorporate them into our own design

Content:

References:

[1] “Snap fit design: Types of snap fits and best practices: RapidDirect blog,” *rapiddirect*, 02-Aug-2022. [Online]. Available: https://www.rapiddirect.com/blog/snap-fit-design/. [Accessed: 11-Oct-2022].

Notes:

Background

- using snap fits can save time and money in production
- Injection molding has proven viable for producing snap joints
- What is a snap joint?
  - " a snap joint is a small protrusion that can be a stud, hook, or bead. The deflection of this protrusion occurs during assembly. " [1]
- Usually no need for other types of fasteners when integrating snap fits into a design
- How does it work?
  - "the protruded part of a component may deflect while joining. Then, it catches a feature that is present in the mating component." [1]
  - The snap fit piece creates a locking mechanism when catching on to a ledge in the mating component
- Depending on how the snap fit is designed, the connection made between the two parts can by permanent or temporary
  - If we use snap fits, we would likely want it to be permanent
- Important to keep in mind the amount of displacement the snap fits would experience
- Snap fits should be flexible
  - Choose a plastic with a "reasonable level of strain and elasticity" [1] to avoid breakage of snap fits
- When designing snap fits, try to minimize the amount of displacement they experience when in a joined state
  - Otherwise stress is placed on the plastic which over time can lead to breakage
- There are industry standards and specific design requirements

Types of Snap Fit Joints

Cantilever Snap Joints

- Most common snap fit joints in manufacturing

- Easy to calculate strain experienced on snap fit while joining parts
- Features extruded cantilever beam with a tapered hook at the tip to match into a recess on the other part, as seen in **Figure 1**
    - The tapered hook allows the beam to bend until the piece is joined correctly into place, where it is then undeformed
- Can be permanent or releasable
- Can be made with "U" and "L" shaped cantilevers as well

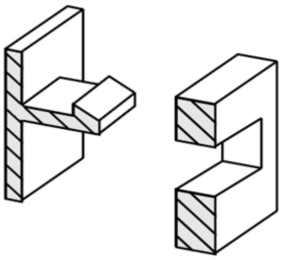


Figure 1: Cantilever Snap Joint

Torsion Snap Joints

- Deflect beams by twisting a bar
- Rocking arm makes for easy opening of joining piece
- Easily releasable by "pushing the beam's free end to life the hook and release the joint" [1]

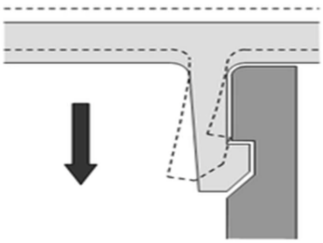


Figure 2: Torsion Snap Joint

Annular Snap Joints

- This type is usually used for circular or elliptic parts
    - ex. pen caps or container lids
- Comes with a ridge at the circumference of one component that locks into the groove on the partner piece
- Bending, tensive, and compressive hoop stresses may occur while assembling
- These can be challenging to design as they contain multiaxial stresses
- These feature a circumference that can compress and stretch
- These are usually easy to lock and release
- Usually allow rotation
    - We would not want this in our design

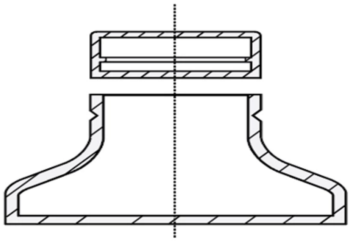


Figure 3: Annular Snap Joint

Calculations

Shape of the cross section / Type of design	A Rectangle	B Trapezoid	C Ring segment	D Irregular cross section
(Permissible) deflection 1 Cross section constant Over the length	$y = 0.67 \cdot \frac{\varepsilon \cdot l^2}{h}$	$y = \frac{a + b_{(1)}}{2a + b} \cdot \frac{\varepsilon \cdot l^2}{h}$	$y = K_{(2)} \frac{\varepsilon \cdot l^2}{r_2}$	$y = \frac{1}{3} \cdot \frac{\varepsilon \cdot l^2}{c_{(2)}}$
(Permissible) deflection 2 All dimensions in direction y, e.g., h or Δr, decrease to One-half	$y = 1.09 \cdot \frac{\varepsilon \cdot l^2}{h}$	$y = 1.64 \cdot \frac{a + b_{(1)}}{2a + b} \cdot \frac{\varepsilon \cdot l^2}{h}$	$y = 1.64 \cdot K_{(2)} \cdot \frac{\varepsilon \cdot l^2}{r_2}$	$y = 0.55 \cdot \frac{\varepsilon \cdot l^2}{c_2}$
(Permissible) deflection 3 All dimensions in direction z, e.g., b and a, decrease to one-quarter	$y = 0.86 \cdot \frac{\varepsilon \cdot l^2}{h}$	$y = 1.28 \frac{a + b_{(1)}}{2a + b} \cdot \frac{\varepsilon \cdot l^2}{h}$	$y = 1.28 \cdot K_{(2)} \cdot \frac{\varepsilon \cdot l^2}{r_2}$	$y = 0.43 \cdot \frac{\varepsilon \cdot l^2}{c_{(2)}}$
Deflection force 1,2,3	$P = \overbrace{\frac{bh^2}{6}}^{Z} \cdot \frac{E_s \varepsilon}{l}$	$P = \overbrace{\frac{h^2}{12} \cdot \frac{a^2 + 4ab_{(1)} + b^2}{2a + b}}^{Z} \cdot \frac{E_s \varepsilon}{l}$	$P = Z_{(4)} \cdot \frac{E_s \varepsilon}{l}$	$P = Z_{(4)} \cdot \frac{E_s \varepsilon}{l}$

Subscript numbers in parenthesis designate the note to refer to.

Figure 4: Table to help carry out effective calculations needed based on what snap fit design you are carrying out

- y = permissible deflection
- b = width at root
- c = center of gravity (i.e., distance between outer fiber and neutral fiber)
- E as absolute value = percentage/100
- E = permissible strain in the outer fiber at the root
- l = length of arm
- K = geometric factor
- h = thickness at root
- Es = secant modulus
- P = permissible deflection force
- Z = section modulus
- Z = I c; where I = axial moment of inertia

Other Considerations

- Creep is a common occurrence in plastics when the material is put under stress
- Fatigue/failure can occur after repetitive loading
    - This will not be an issue as our device is a single-use device and we want our snap fits to be permanent
- Tolerance issues can cause pieces to fit together improperly
    - Consider this when designing our own snap fits
- Add fillets to base of cantilever snap joints to distribute force
    - recommended fillet radius = 0.5x thickness of the base

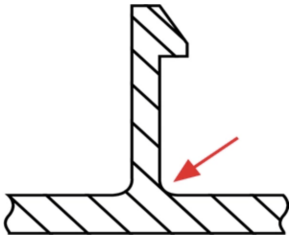


Figure 5: Fillet on a cantilever snap joint

- Taper the cross section of cantilever beam to save material and further distribute stress
- Increase width of clip to increase strength and stiffness of cantilever beam
    - Should be at least 5mm

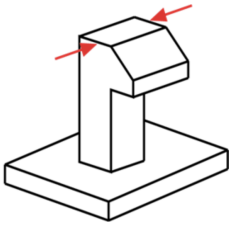


Figure 6: Width that should be increased for more strength on cantilever snap joint

- Add lugs to parts to help with alignment and distribution of shear force throughout parts

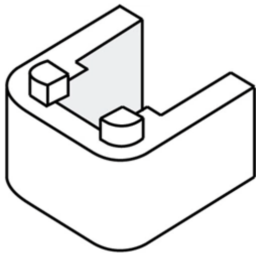


Figure 7: Lugs on part

Conclusions/action items:

Snap fits offer a really interesting way to potentially reduce the cost of mass manufacturing our device. By cutting our device along the equator, we can have a top and bottom have that can connect via snap joints to eliminate some of the design's complexity during injection molding. Next steps are to continue discussions with injection molding companies to see if our design needs to be furthered optimized, and then consider if snap fit joints are the way to do so.

10/11/22 Protolabs Injection Molding Guide

Ben Smith - Oct 11, 2022, 11:17 PM CDT

Title: Protolabs Injection Molding Guide

Date: 10/11/22

Content by: Ben

Goals: Learn about Protolabs' injection Molding Capabilities

Content:

References:

[1] “Guide: Im definitive guide,” *Home*. [Online]. Available: https://view.highspot.com/viewer/63344b9fd4b6e4a7b108939a?iid=6254b00f5850cc38dc97e017. [Accessed: 11-Oct-2022].

Notes:

- Protolabs has a Consultation Design Service
  - Can consult with them when designs don't meet guidelines
  - "Helps you update your CAD model to address the manufacturability feedback" [1]
    - This would be helpful to us since we got feedback in our quote that we needed to redesign our model
- 8 Moldability Mistakes to Avoid
  - Add sufficient draft to parts
  - Avoid non-uniform wall thickness
  - Transition Gradually from Thick to Thin Areas
  - Consider carefully your CAD file format
  - Use radii wisely
  - be careful with parting lines
  - Eliminate undercuts if possible
  - Determine if cosmetic finishes are necessary

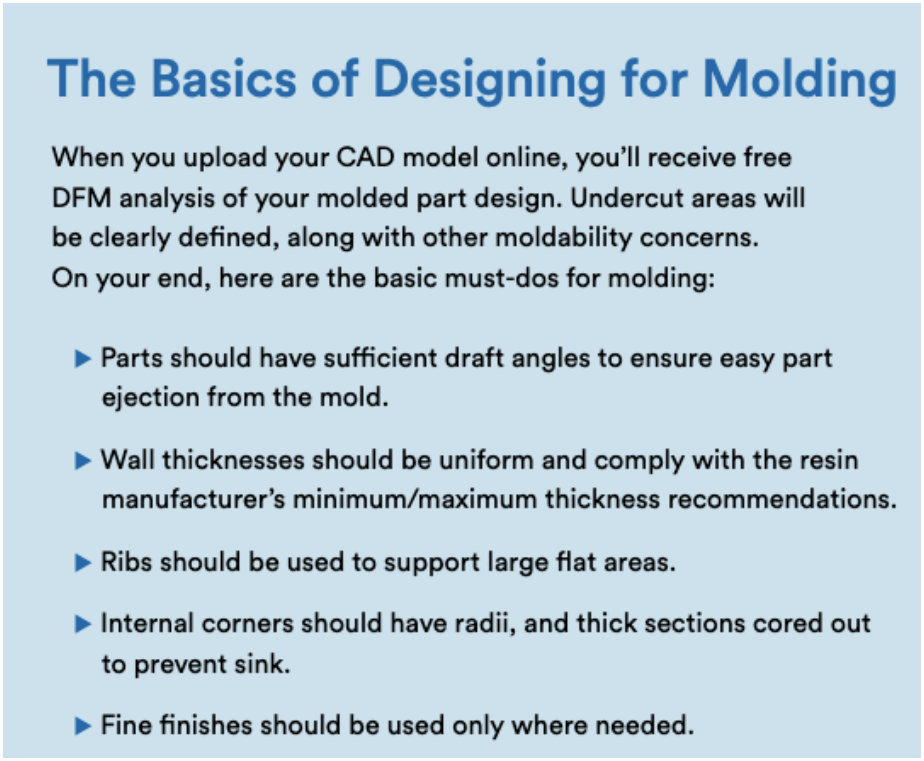


Figure 1: The Basics of Designing for Molding

Resin Type	Benefits	Applications	Considerations
POM (Polyoxymethylene) or Acetal	Tough, stiff, hard, and strong. Good lubricity and resistance to hydrocarbons and organic solvents. Good elasticity, slippery. Low creep. Great fatigue properties	Gears, pumps and pump impellers, conveyor links, soap dispensers, fan and blower blades, automotive switches, electrical switch components, buttons, and knobs	Due to shrink, you need uniform wall thickness. Painting, coating, and achieving high-cosmetic finish difficult.
PMMA (Polymethyl Methacrylate) or Acrylic	Good optical properties, high gloss, scratch resistant. Low shrink. Less sink in geometries with thin and thick sections	Light pipes, lenses, light shades, optical fibers, signs	Can be brittle. PC is a good alternative. Draft always required, sometimes twice as much as other materials. Poor chemical resistance
ABS (Acrylonitrile butadiene styrene)	Tough, impact- and chemical-resistant, low shrink, high dimensional stability, inexpensive	Cosmetic parts, handheld devices, housings, and moldings for electrical tools, remote controls, computers, telephone components	Show knit lines and can have sink and voids in thick areas. Reduce sink with switch to ABS/PC blend
HDPE (High-density polyethylene)	Tough, impact- and chemical-resistant, high shrink, low dimensional stability, inexpensive, density less than water (floats)	Lawn furniture, totes, containers, toys, gas cans	High shrink, low surface energy
PC (Polycarbonate)	Strong, extremely impact resistant, low shrink, good dimensional stability and heat resistance, accepts high cosmetic finishes well	Lenses, indoor and outdoor lighting, cell phone housings, electrical components, medical devices, bulletproof glass	Possible sensitivities in thick sections of parts could cause voids, bubbles, and sink. Poor chemical resistance. An ABS/PC blend is a good alternative for opaque parts with these issues. Acrylic another option for parts with thick geometries
ABS/PC	Strength, heat and low-temperature resistance, improved processing	Automotive, electronic, telecommunications	Improved thick molding and mechanical properties compared to just ABS or PC. Lower cost than PC
PP (Polypropylene)	Inexpensive, higher impact resistance in some grades, PP homopolymer can be brittle in cold. Wear resistant, flexible with high elongation. Resistant to acids and bases. Density less than water (floats)	Integral hinges or living hinges, fans, snap-over lids (e.g., shampoo bottle tops), medical pipette tubing	Thick sections in part geometry can void or show sink marks. Shrink and warp possible. If the part has living hinges that require higher stiffness, K-Resin a good alternative
Polystyrene (PS)	High optic clarity, good electric insulator	Plastic utensils, containers, optics, toys	Brittle, poor UV resistance, very susceptible to hydrocarbon solvents
PEEK (Polyether Ether Ketone)	High-temperature, high-performance, flame retardant; excellent strength and dimensional stability, good chemical resistance	Bearings, piston parts and pumps; cable insulation; compatible with ultra-high vacuum applications	High-performance material, very expensive. Ultem is a slightly less-costly option, and PPSU is worth considering if price a concern

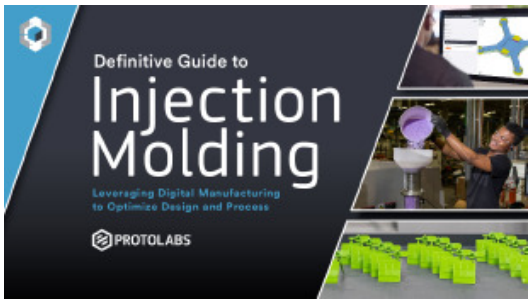
PEI (Polyetherimide) or Ultem	High-temperature, high-performance, flame retardant, excellent strength and dimensional stability, good chemical resistance	Medical and chemical instrumentation; tableware and catering; HVAC and fluid handling; electrical and lighting	Very expensive, though not as costly as PEEK. PPSU possible alternative
PPSU (Polyphenylsulfone)	High-temperature tolerance, dimensionally stable, high toughness. Resistance to radiation sterilization, as well as alkalis and weak acids	Medical instrument components, sterilization trays, automotive fuses, interior aircraft parts, hot water fittings, sockets, and connectors	Thick sections could result in voids, bubbles or sink. Organic solvents and hydrocarbons can also attack PPSU. Colorant cannot be added to Protolabs-supplied PPSU resins
PA (Aliphatic Polyamides)	Wide variety. High strength and temperature tolerance when reinforced. Chemically resistant except to strong bases or acids	Thin-walled features, combs, spools, gears and bearings, screws, structural parts (with glass), pump parts, under-hood components, cameras	Some nylons can be susceptible to warp due to non-linear shrink. Absorbs moisture
PPA (Semi-aromatic Polyamides)	Less susceptible to moisture than aliphatic polyamides	Automotive housings, modules, valves, sports equipment	Susceptible to warp
PBT (Polybutylene Terephthalate)	Good electrical properties for power components and works well for automotive applications. Moderate to high strength depending on glass fill. Unfilled grades are tough and flexible. Good resistance to fuels, oils, fats, and many solvents. Doesn't absorb flavors. Low creep	Slide bearings, gears and cams; coffee makers and toasters; hair dryer nozzles; vacuum cleaners; handles and knobs for electrical cookers	Glass-filled PBT resins are prone to warp, and have poor resistance to acids, bases, and hydrocarbons. Thin parts hard to fill with PBT. Nylons good alternatives
PET (Polyethylene Terephtalate)	Similar to PBT, but stiffer and higher melting point	Similar to PBT	Similar to PBT
LCP	Very easy flowing, good chemical resistance, high upper use temp, good electrical properties, low thermal expansion	Connectors, plugs, PCBs, sports equipment	Anisotropic properties and shrinkage, expensive
PPO	Good electrical insulator, hot water/steam resistance	Sensor housings, pumps, connectors	Susceptible to stress cracking
PPS	Very good chemical resistance, high upper use temp, great electrical properties	Electric components, automotive intakes, pumps, valves, sensor encapsulation	Desirable properties such as chemical resistance rely heavily on proper crystallization during molding

Figure 2: Materials used for injection molding at Protolabs

Conclusions/action items:

This is a useful guide to the injection molding capabilities at Protolabs. This will be helpful moving forward and help facilitate our future discussions with Protolabs.

Ben Smith - Oct 11, 2022, 11:17 PM CDT



Download

GUIDE-_IM_Definitive_Guide.pdf (3.26 MB)

12/5/22 Additional Press/Snap Fit Research

Ben Smith - Dec 13, 2022, 6:11 PM CST

Title: Additional Press/Snap Fit Research

Date: 12/5/22

Content by: Ben Smith

Goals: Continue research on press/snap fits to potentially be incorporated in our design.

Content:

References:

[1] C. Brown, “Too tight or perfect fit? when to use press fits in your assemblies,” *Fictiv*. [Online]. Available: https://www.fictiv.com/articles/too-tight-or-perfect-fit-when-to-use-press-fits-in-your-assemblies. [Accessed: 13-Dec-2022].

Notes:

- Press fits aren't necessarily needed/the right mechanism for ALL mechanisms [1]
- Certain press fit designs should never be used in plastics
  - "Press fits rely on constant stress and friction" [1]
  - Plastics undergo cold creep over time that decreases friction and ability to hold into place
  - Plastics under constant strain lose stress over time due to this cold creep
  - This contradicts the goals of the team as we want to incorporate press fits as well as a plastic material
- Interferences:
  - One can calculate exactly how tight the interference should be
  - The pin (male part) is trying to expand radially outward while the hole (female part) is pressing radially inward towards its initial diameter --> these forces are what holds the press fit components into place
  - Small interference results in a large amount of force
  - Never use more than two interference fits per assembly
    - This is good to know as the current design with interference fits has four
- If you need to use plastic materials, use locating pins for alignment and snap fits for assembly [1]

$$P = \frac{\delta}{\frac{r}{E_h}(1+\nu_h)+\frac{r}{E_p}(1-\nu_p)}$$

Where P is pressure, *r* is the nominal radius , E is Young’s modulus (sub h = hole; sub p = pin), v is Poisson’s Ratio, and δ is the radial interference (half the diametrical interference).

Figure 1: Pressure between parts in an interference fit.

Nominal size	Nominal pin diameter	Pin diameter, A						Point diameter, B		Crown height, C	Crown radius, R	Range of preferred lengths, bL	Single shear load, for carbon or alloy steel (Calculated in lbs)	Suggested press fit hole diameter	
		Standard Series Pins			Oversize Series Pins										
		Basic	Max	Min	Basic	Max	Min	Max	Min	Max	Min			Max	Min
1/16	0.0625	0.0627	0.0628	0.0626	0.0635	0.0636	0.0634	0.0580	0.0480	0.0200	0.0080	3/16 - 3/4	400	0.0625	0.0620
5/64 a	0.0781	0.0783	0.0784	0.0782	0.0791	0.0792	0.0790	0.0740	0.0640	0.0260	0.0100	...	620	0.0781	0.0776
3/32	0.0938	0.0940	0.0941	0.0939	0.0948	0.0949	0.0947	0.0890	0.0790	0.0310	0.0120	5/16 - 1	900	0.0937	0.0932
1/8	0.1250	0.1252	0.1253	0.1251	0.1260	0.1261	0.1259	0.1200	0.1100	0.0410	0.0160	3/8 - 2	1600	0.1250	0.1245
5/32 a	0.1562	0.1564	0.1565	0.1563	0.1572	0.1573	0.1571	0.1500	0.1400	0.0520	0.0200	...	2500	0.1562	0.1557
3/16	0.1875	0.1877	0.1878	0.1876	0.1885	0.1886	0.1884	0.1800	0.1700	0.0620	0.0230	1/2 - 2	3600	0.1875	0.1870
1/4	0.2500	0.2502	0.2503	0.2501	0.2510	0.2511	0.2509	0.2400	0.2300	0.0830	0.0310	1/2 - 2 1/2	6400	0.2500	0.2495
5/16	0.3125	0.3127	0.3128	0.3126	0.3135	0.3136	0.3134	0.3020	0.2900	0.1040	0.0390	1/2 - 2 1/2	10000	0.3125	0.3120
3/8	0.3750	0.3752	0.3753	0.3751	0.3760	0.3761	0.3759	0.3650	0.3500	0.1250	0.0470	1/2 - 3	14350	0.3750	0.3745
7/16	0.4375	0.4377	0.4378	0.4376	0.4385	0.4386	0.4384	0.4240	0.4090	0.1460	0.0550	7/8 - 3	19550	0.4375	0.4370
1/2	0.5000	0.5002	0.5003	0.5001	0.5010	0.5011	0.5009	0.4860	0.4710	0.1670	0.0630	3/4, 1-4	25500	0.5000	0.4995
5/8	0.6250	0.6252	0.6253	0.6251	0.6260	0.6261	0.6259	0.6110	0.5950	0.2080	0.0780	1 1/4 - 5	39900	0.6250	0.6245
3/4	0.7500	0.7502	0.7503	0.7501	0.7510	0.7511	0.7509	0.7350	0.7150	0.2500	0.0940	1 1/2 2 - 6	57000	0.7500	0.7495
7/8	0.8750	0.8752	0.8753	0.8751	0.8760	0.8761	0.8759	0.8600	0.8400	0.2930	0.1090	2, 2 1/2 - 6	78000	0.8750	0.8745
1	1.0000	1.0002	1.0003	1.0001	1.0010	1.0011	1.0009	0.9800	0.9600	0.3330	0.1250	2, 2 2/5, 6	102000	1.0000	0.9995

Figure 2: Table of values for pin diameter max and mins based on how much force you want the interference fit to hold

Conclusions/action items:

There is an important difference between a tolerance fit and a snap fit. A tolerance fit uses pins of different dimensions to create a radial force in the connection which keeps two pieces together, and a snap fit utilizes something like a cantilever beam to snap two pieces into place. Tolerance fits can be tough to use with plastic as most plastics can and will deform over time, so we might want to look more into and keep our focus on snap fits if this is the approach we want to take.

10/11/22 Snap Fit Design

Ben Smith - Oct 11, 2022, 10:37 PM CDT

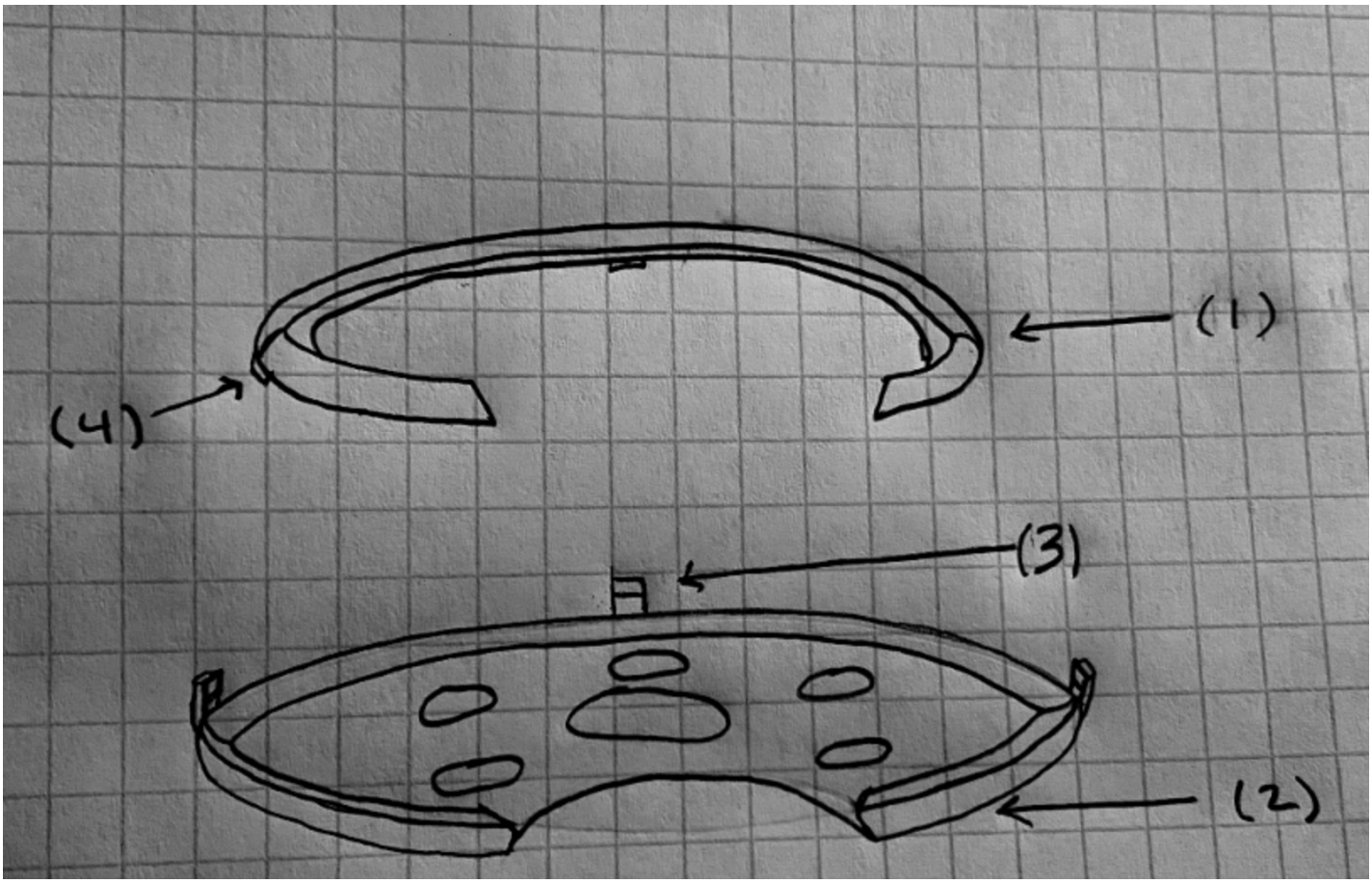
Title: Snap Fit Design

Date: 10/11/22

Content by: Ben

Goals: Implement snap fittings into our current design

Content:



- This design cuts our current VHold design in half along the equator to allow for snap fittings
  - This also makes the design less complicated for injection molding
    - This would, however, require two molds
      - Would this be cheaper than one big complicate mold?

Components

(1) Top half of outer wall

(2) Bottom half of outer wall plus base of device

(3) Cantilever Snap Joint on bottom half of device

(4) Connection for Cantilever Snap Joint on top half of device

Conclusions/action items:

This is a possible design to include snap fits and simplify the design for mass manufacturing. After more discussion with injection molding companies about design optimization, we can decide to move forward with the redesign or stick with one of the current design variations.

11/8/22 Press Fit Solidworks File

Ben Smith - Nov 09, 2022, 5:13 PM CST

Title: Press Fit Solidworks File

Date: 11/8/22

Content by: Ben

Goals: Create a design on Solidworks implementing snap fits

Content:

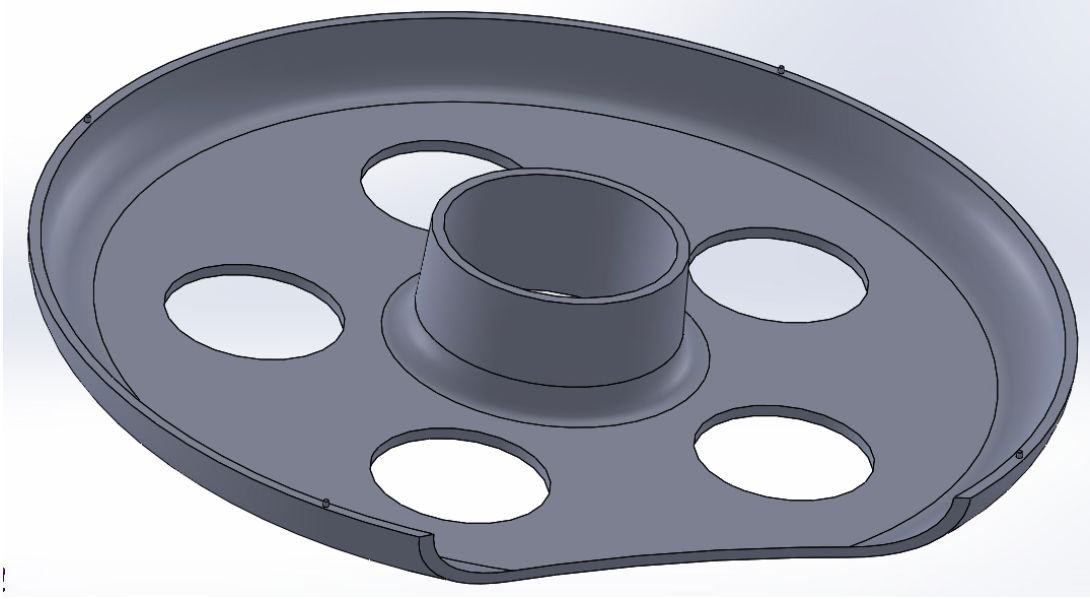


Figure 1: Bottom half of new design with male parts of the press fit mechanism

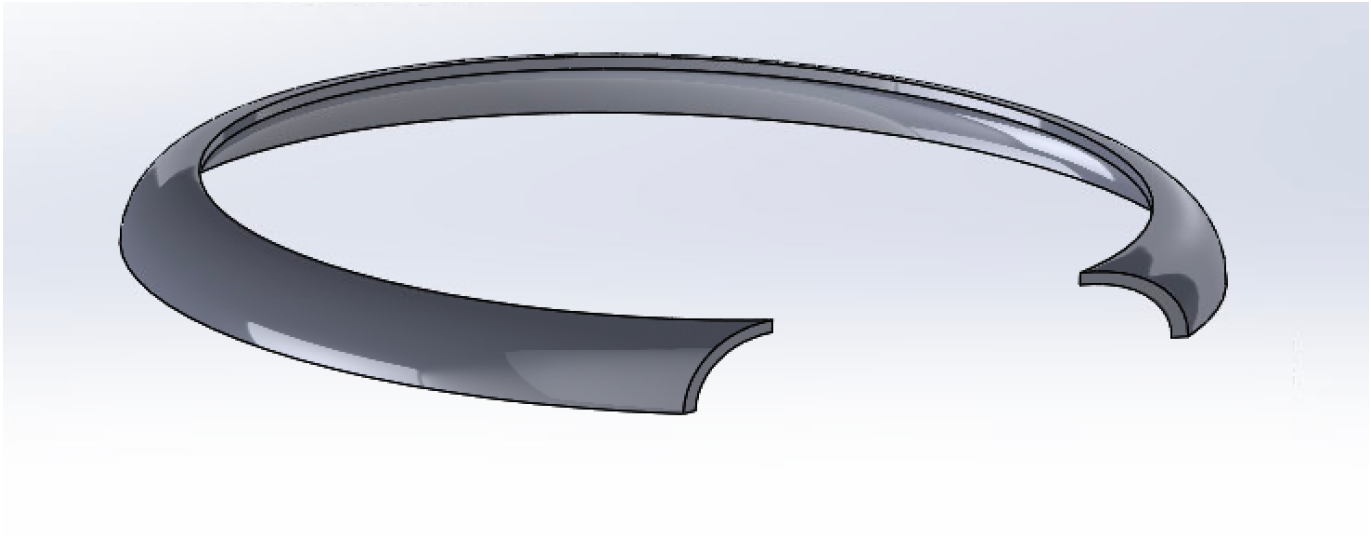


Figure 2: Top half of new design with female parts of the press fit mechanism

Conclusions/action items:

This design cuts our previous design in half so they can be injection molded. Next steps are to verify the press fit mechanism works.

Ben Smith - Nov 09, 2022, 5:16 PM CST

Download

V2_Bottom2.0.SLDPRT (167 kB)

Ben Smith - Nov 09, 2022, 5:16 PM CST

Download

V2_Top.SLDPRT (123 kB)

11/9/22 Press Fit Sample

Ben Smith - Nov 09, 2022, 5:20 PM CST

Title: Press Fit Sample

Date: 11/9/22

Content by: Ben

Goals: Create a piece to test a press fit

Content:

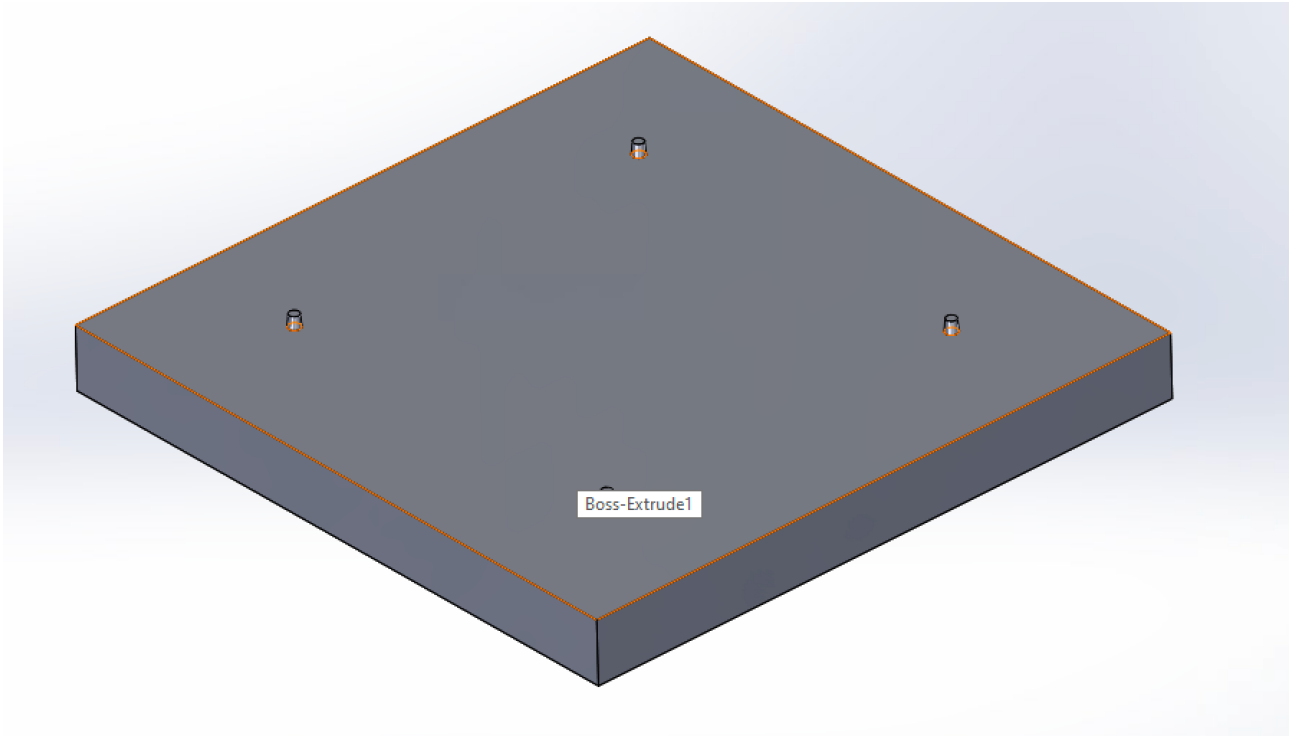


Figure 1: Press Fit Sample Bottom

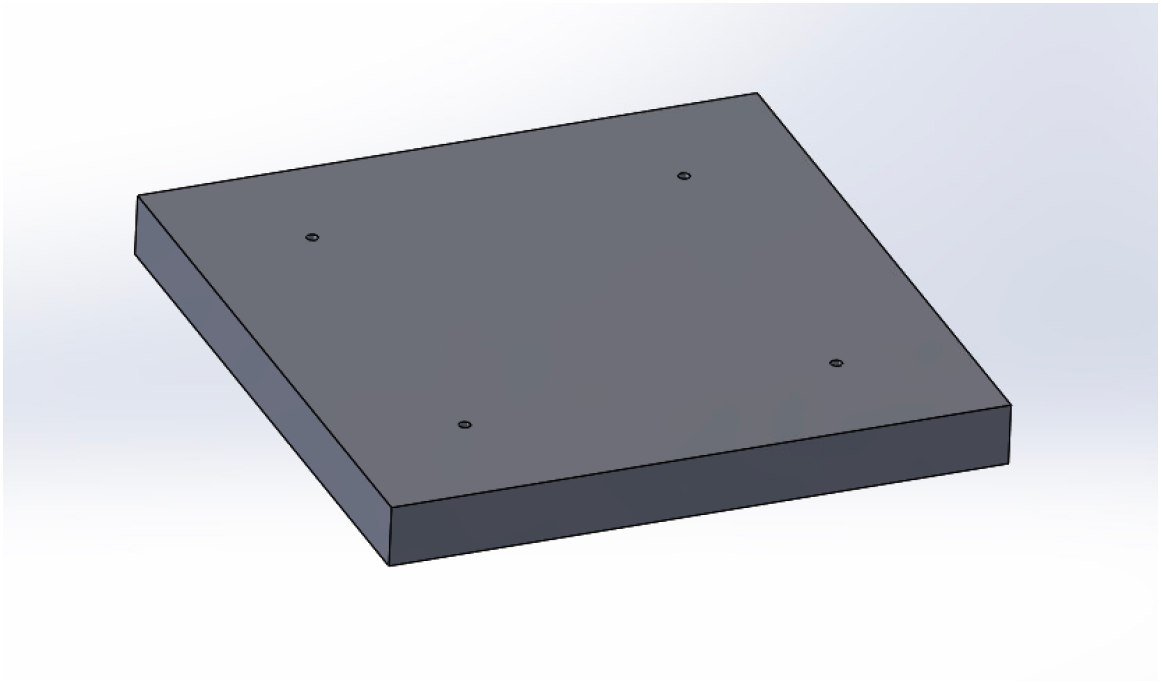


Figure 2: Press Fit Sample Bottom

Conclusions/action items:

Print these pieces to test 1 version of the press fit mechanism

Ben Smith - Nov 09, 2022, 5:20 PM CST

Download

Snap_Fit_Sample_Top.SLDPRT (66.4 kB)

Ben Smith - Nov 09, 2022, 5:20 PM CST

Download

Snap_Fit_Sample_Bottom.SLDPRT (69.8 kB)

11/9/22 Press Fit Sample 2.0

Ben Smith - Nov 09, 2022, 5:26 PM CST

Title: Press Fit Sample 2.0

Date: 11/9/22

Content by: Ben

Goals: Create another way to test a press fit mechanism with different dimensions

Content:

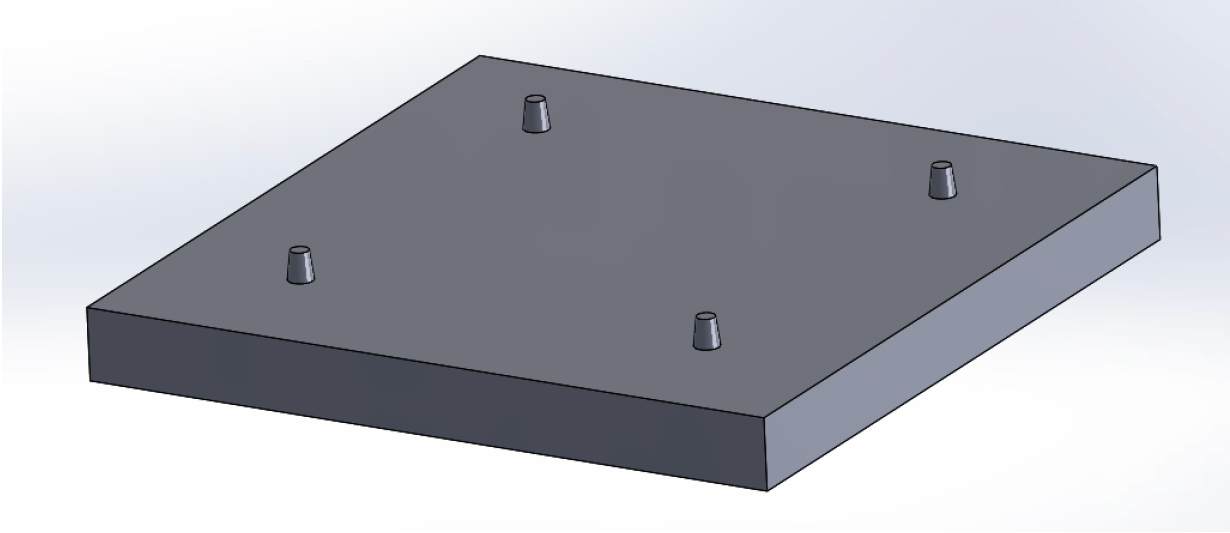


Figure 1: Press Fit Sample 2.0 Bottom

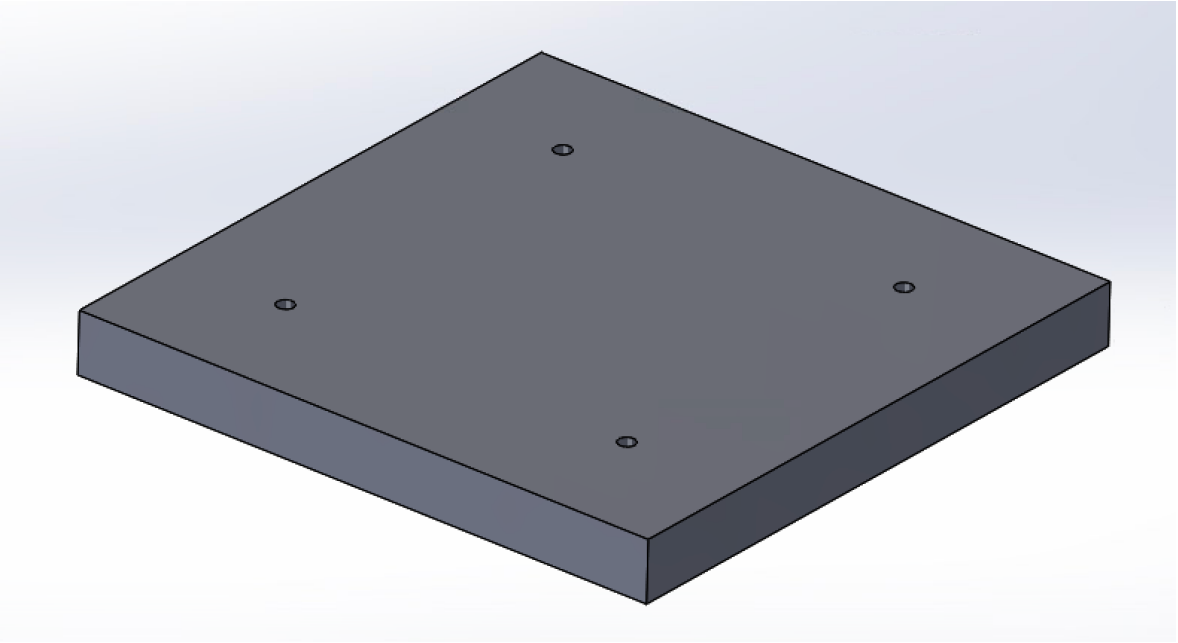


Figure 2: Press Fit Sample 2.0 Top

Conclusions/action items:

3D print these pieces to test different dimensions for a press fit mechanism

Ben Smith - Nov 09, 2022, 5:26 PM CST

Download

Snap_Fit_Sample_Bottom_2.0.SLDPRT (84.2 kB)

Ben Smith - Nov 09, 2022, 5:26 PM CST

Download

Snap_Fit_Sample_Top_2.0.SLDPRT (79.9 kB)

11/9/22 Cantilever Snap Fit Sample

Ben Smith - Nov 09, 2022, 5:29 PM CST

Title: Cantilever Snap Fit Sample

Date: 11/9/22

Content by: Ben

Goals: Create a set of pieces to test a cantilever snap fit mechanism

Content:

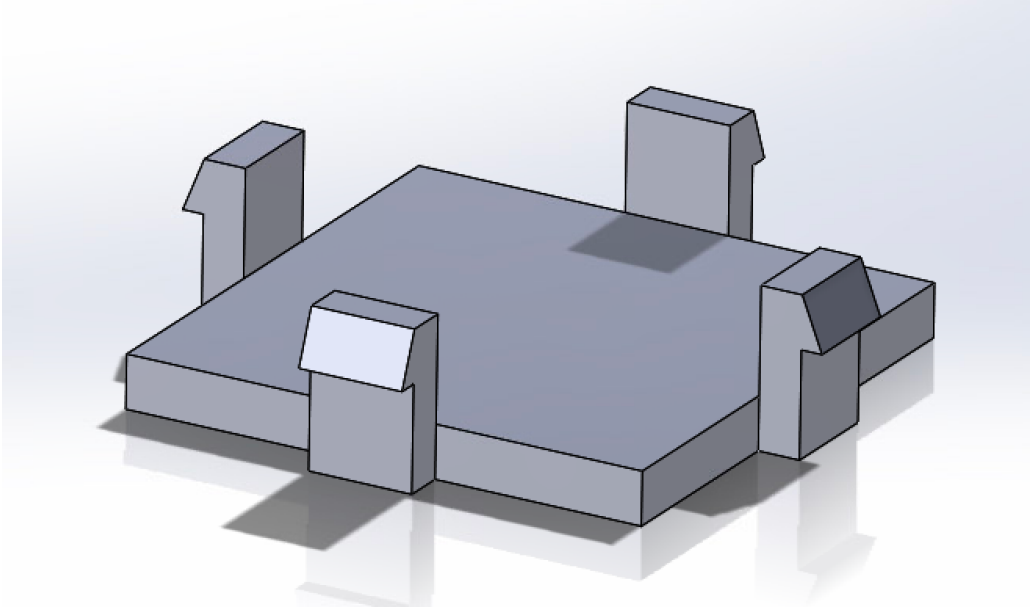


Figure 1: Cantilever Snap Fit Sample bottom

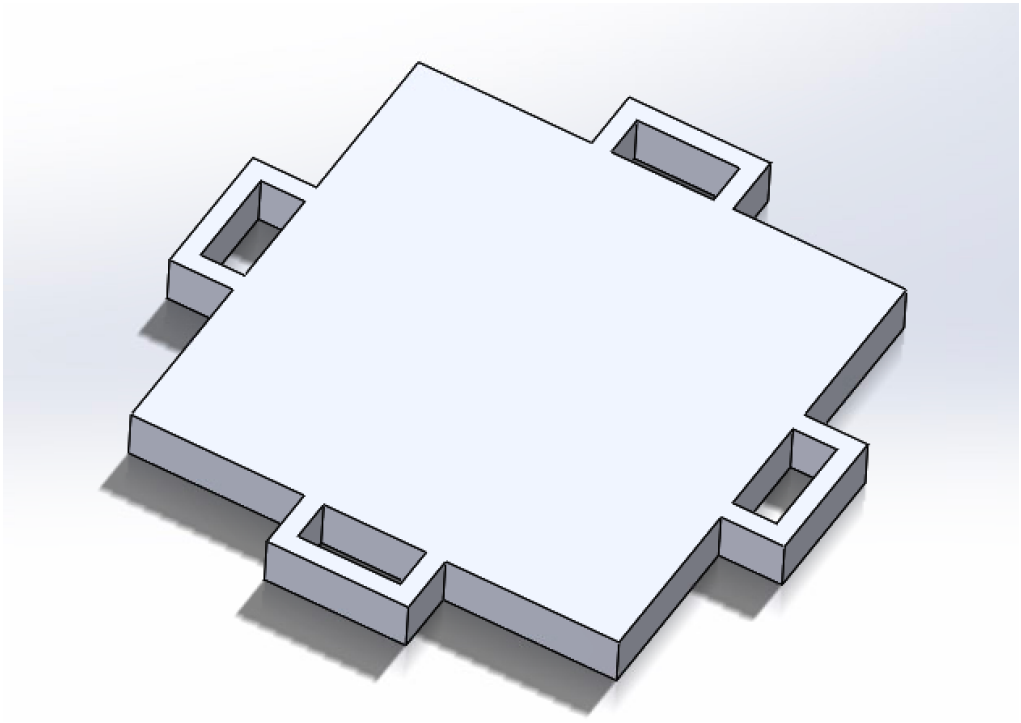


Figure 2: Cantilever Snap Fit Sample top

Conclusions/action items:

3D Print each piece to test first version of a cantilever snap fit mechanism

Ben Smith - Nov 09, 2022, 5:30 PM CST

Download

Cantilever_Fit_Sample_Bottom.SLDPRT (134 kB)

Ben Smith - Nov 09, 2022, 5:30 PM CST

Download

Cantilever_Fit_Sample_Top.SLDPRT (138 kB)

11/18/22 Protolabs Quote 2 Parts

Ben Smith - Dec 12, 2022, 8:50 PM CST

Title: Protolabs Quote 2 Parts

Date: 11/18/22

Content by: Ben Smith

Goals: Get a manufacturing analysis and quote for 2 part design

Content:

This Protolabs manufacturing analysis comes in two parts: one part is the top of the device and the other part is the bottom of the device

Bottom of Device:

- As it is currently designed, the bottom piece of this device is injection moldable, however there are several design suggestions/changes to consider in order to get the most accurate, undeformed part
- Notable changes suggested to make:
  - At least 3 degrees of draft added to flat surfaces (inner portion of rings) and chimney in center
  - The male part to the snap fit is too thin to be moldable
  - Bottom of the chimney is too thick and could result in deformity (not a huge concern, but potential source of error in molding)
  - At least 1 degree of draft in certain areas to help with ejection
  - Male snap fit parts are too small to be polished

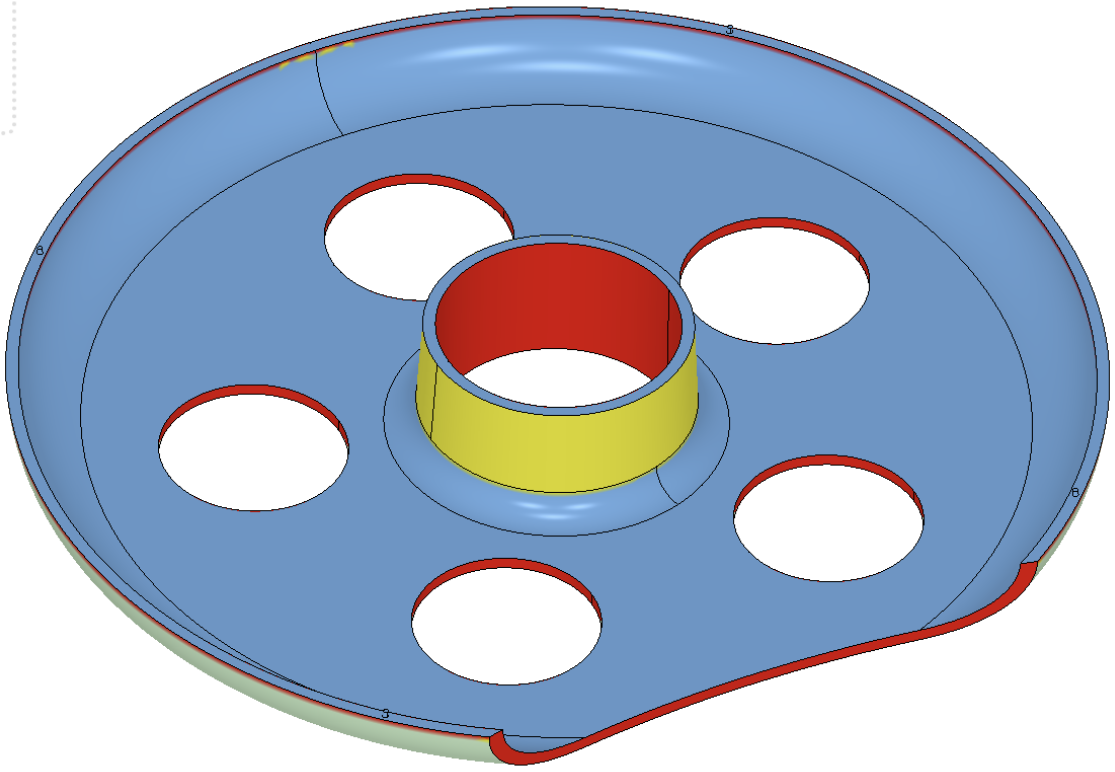


Figure 1: Manufacturing analysis of bottom piece. Areas highlighted red and yellow are areas where addition of a draft angle suggested

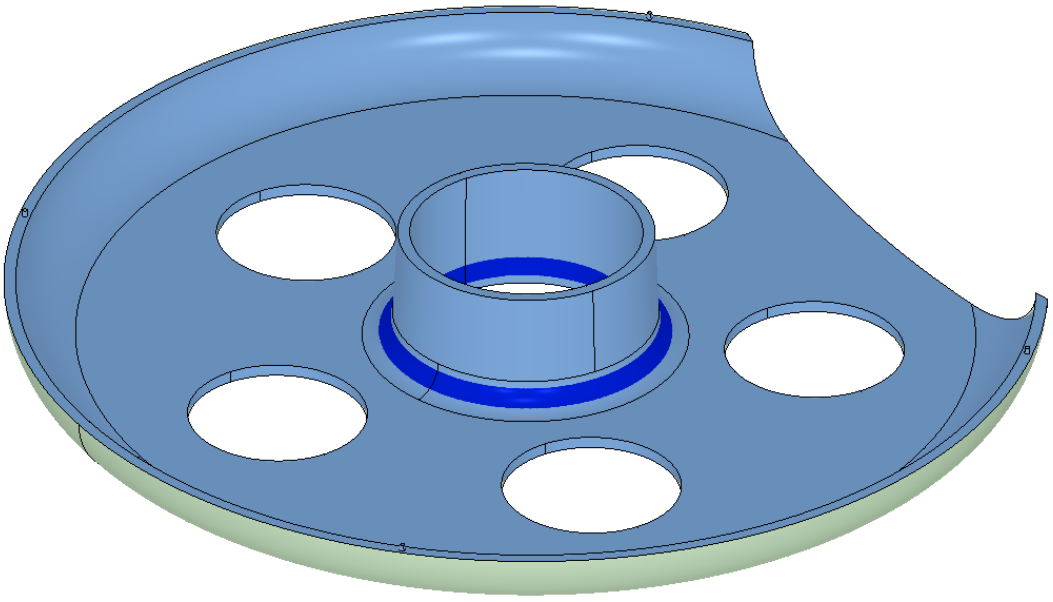


Figure 2: Manufacturing analysis of bottom piece. Areas highlighted blue are potentially too thick and could be deformed while molding

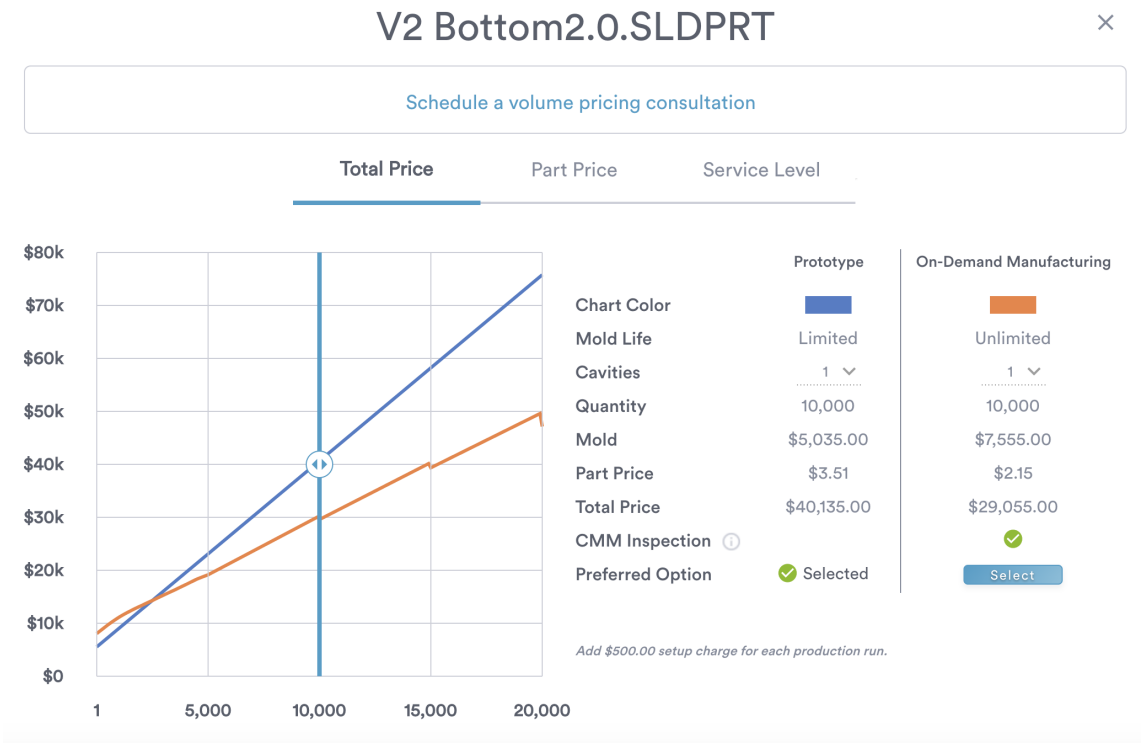


Figure 3: Quote for 10,000 bottom pieces to be injection molded. Note the cost of the mold for just the bottom part ($5035.00)

Top of the device:

- As it is currently designed, the top piece of this device is not injection moldable,and there are several design suggestions/changes to consider in order to get the most accurate, undeformed part that is injection moldable
- Notable changes needed to make:
  - Female parts of snap fits are too small to be injection molded
  - Flat inner edges require draft of at least 3 degrees
  - Small female parts of snap fit could result in deformation

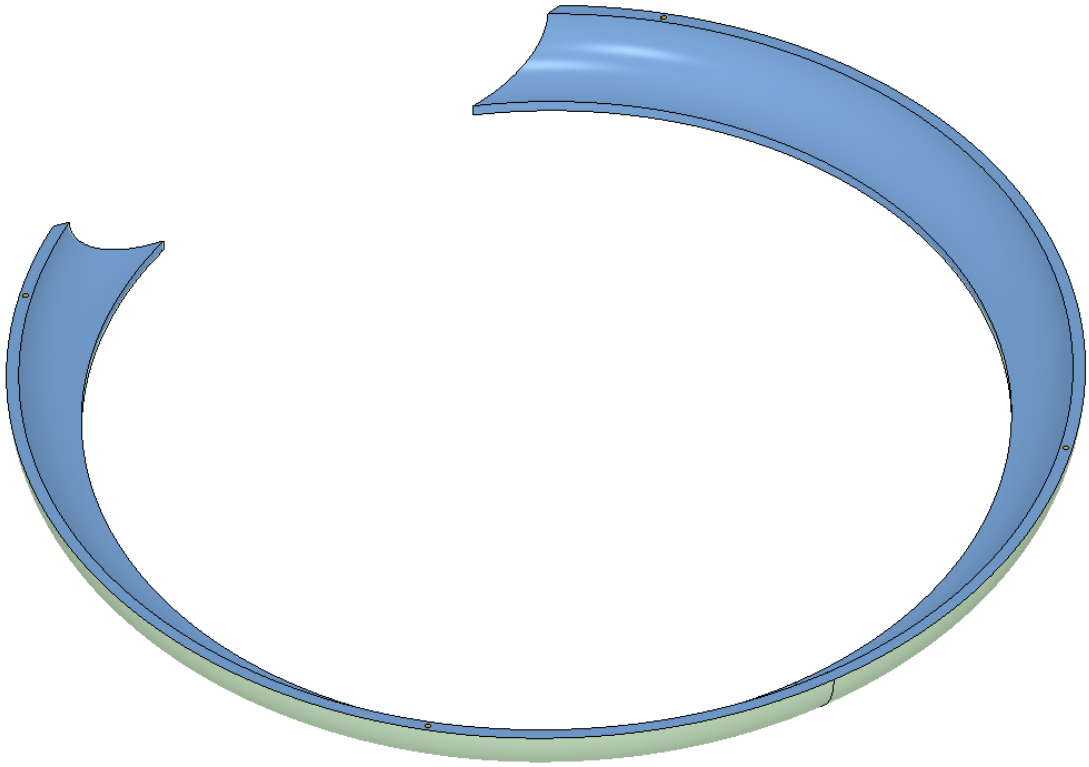


Figure 4: Manufacturing analysis of top piece. Areas highlighted yellow are too small to be injection molded

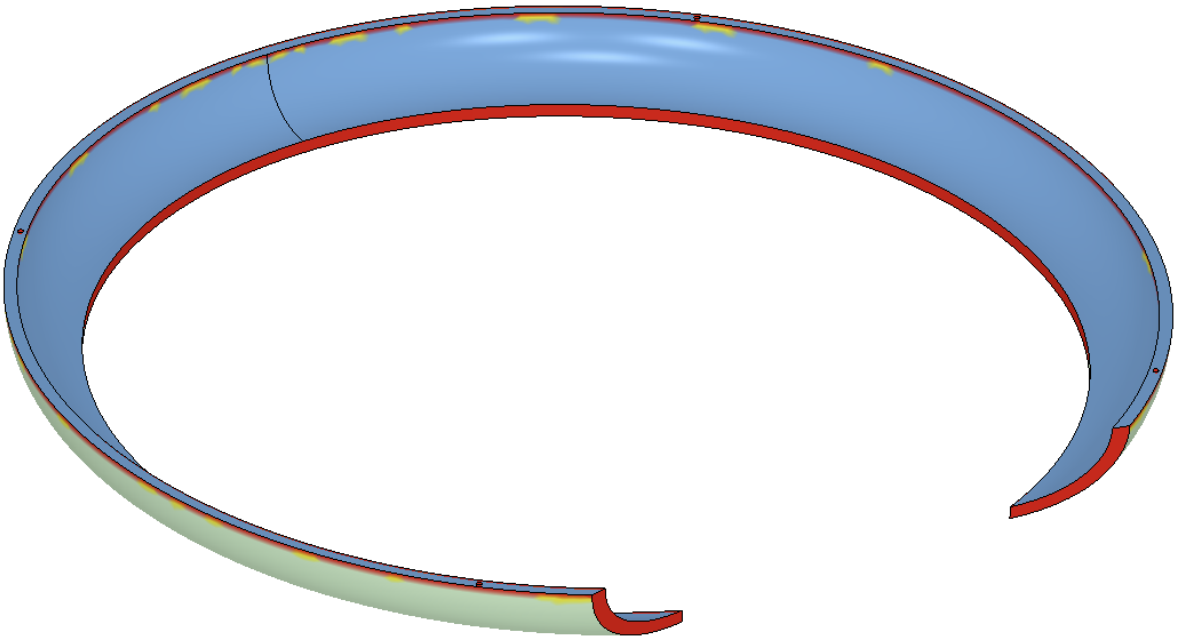


Figure 5: Manufacturing analysis of top piece. Areas highlighted yellow and red require at least 3 degrees of draft to be ejected from mold

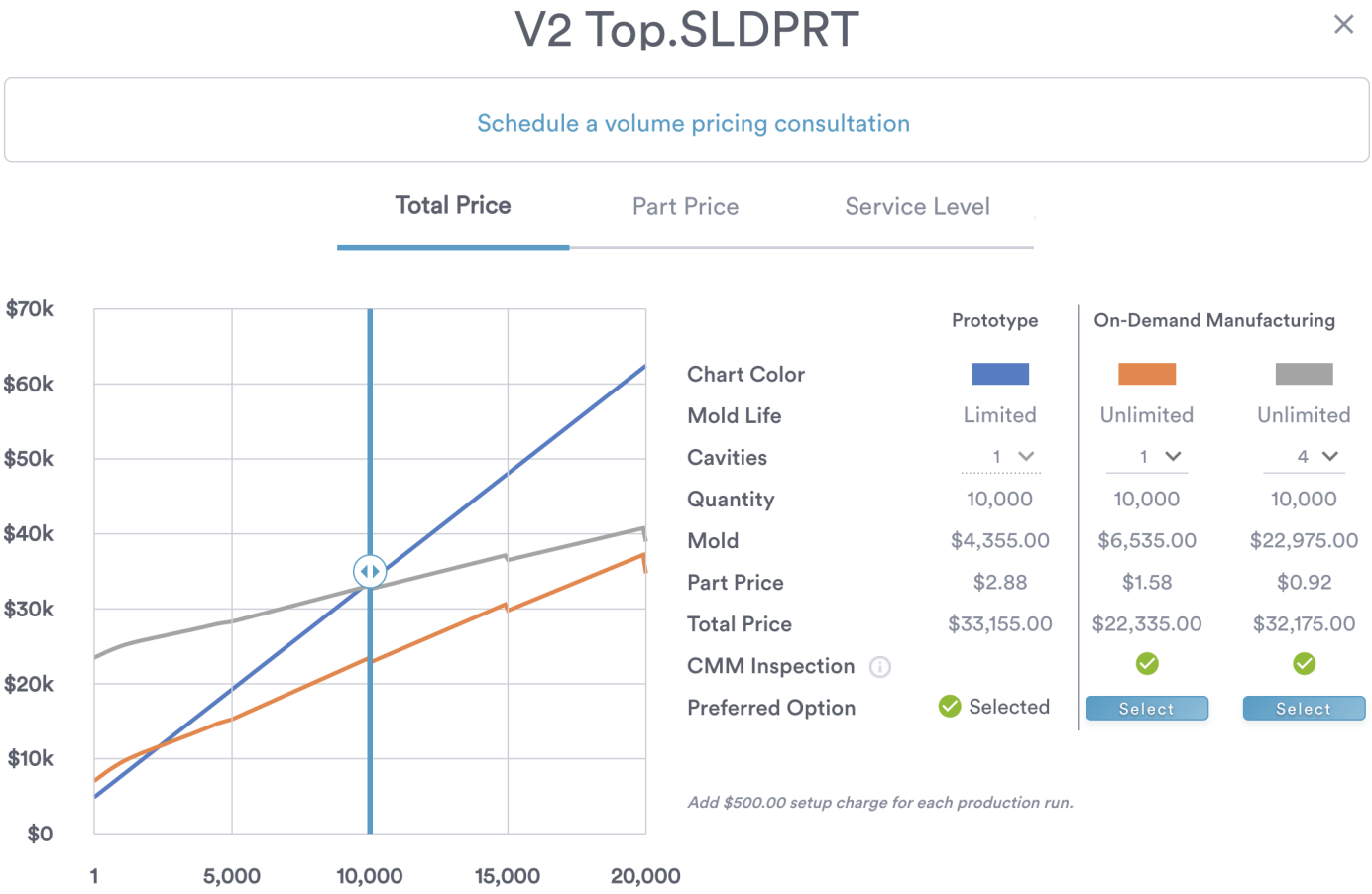


Figure 6: Quote for 10,000 top pieces to be injection molded. Note the cost of the mold for just the top part ($4,355.00)

Total cost for both molds: $9,390.00

Conclusions/action items:

As it stands, the bottom piece of the device is manufacturable and the top part needs to be revised before it can be manufacturable. While minor changes are necessary, they are needed before we can proceed with this design.

Ben Smith - Dec 12, 2022, 8:30 PM CST

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Quote_9682-866.pdf (461 kB)

12/1/22 Protolabs Quote Cutout

Ben Smith - Dec 12, 2022, 8:52 PM CST

Title: Protolabs Quote Cutout

Date: 12/1/22

Content by: Ben Smith

Goals: Evaluate the manufacturing analysis and quote for the Cutout design

Content:

As it is currently designed, the device is not injection moldable, and there are several design suggestions/changes to consider in order to get the most accurate, undeformed part that is injection moldable.

- Notable changes needed to make:
  - There are undercut regions that need to be changed
    - Several areas of overhanging walls are causing the undercut regions
  - At least 3 degrees of draft is required in certain areas to avoid mold damage
  - Certain areas are too thin
  - Outer wall needs at least 1 degree of draft to avoid damage during ejection
  - Certain areas are too deep or too small to be polished during finishing

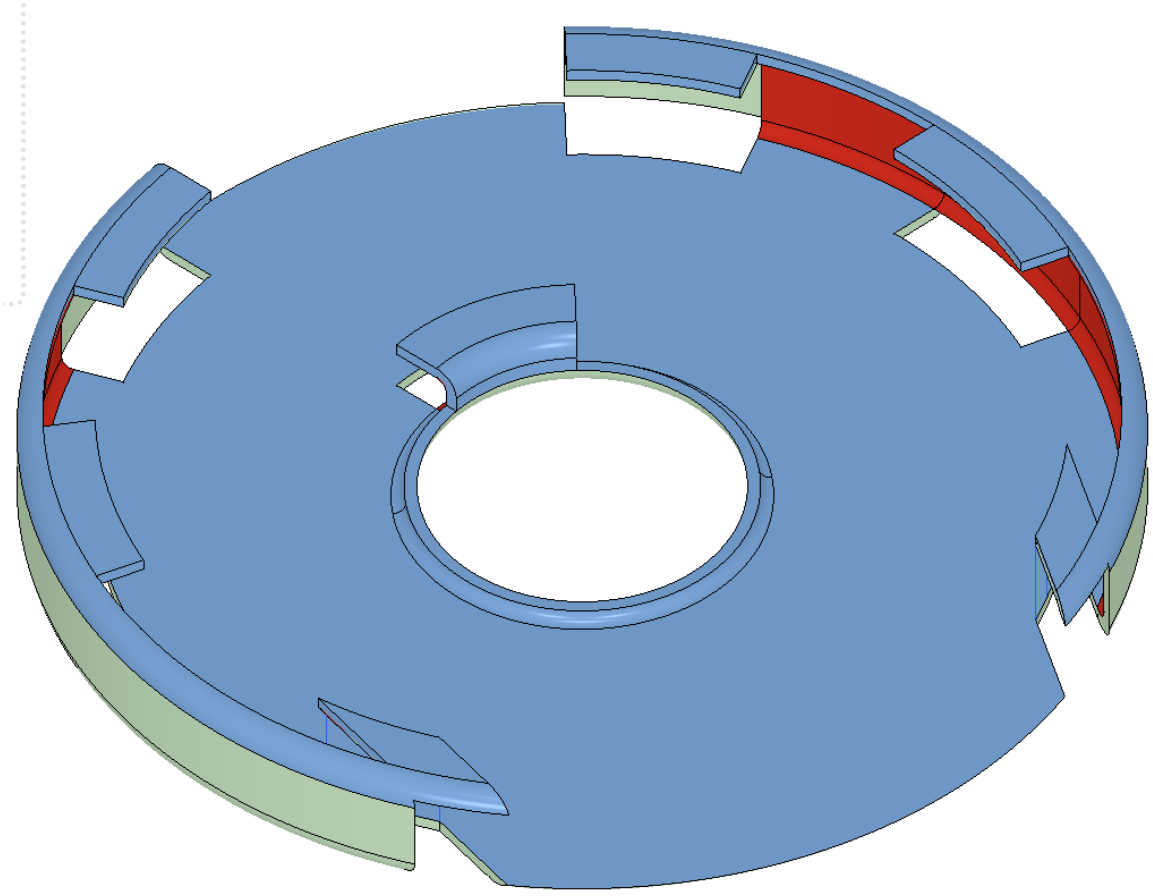


Figure 1: Manufacturing analysis. Areas highlighted red are areas where an undercut is present, prohibiting injection molding.

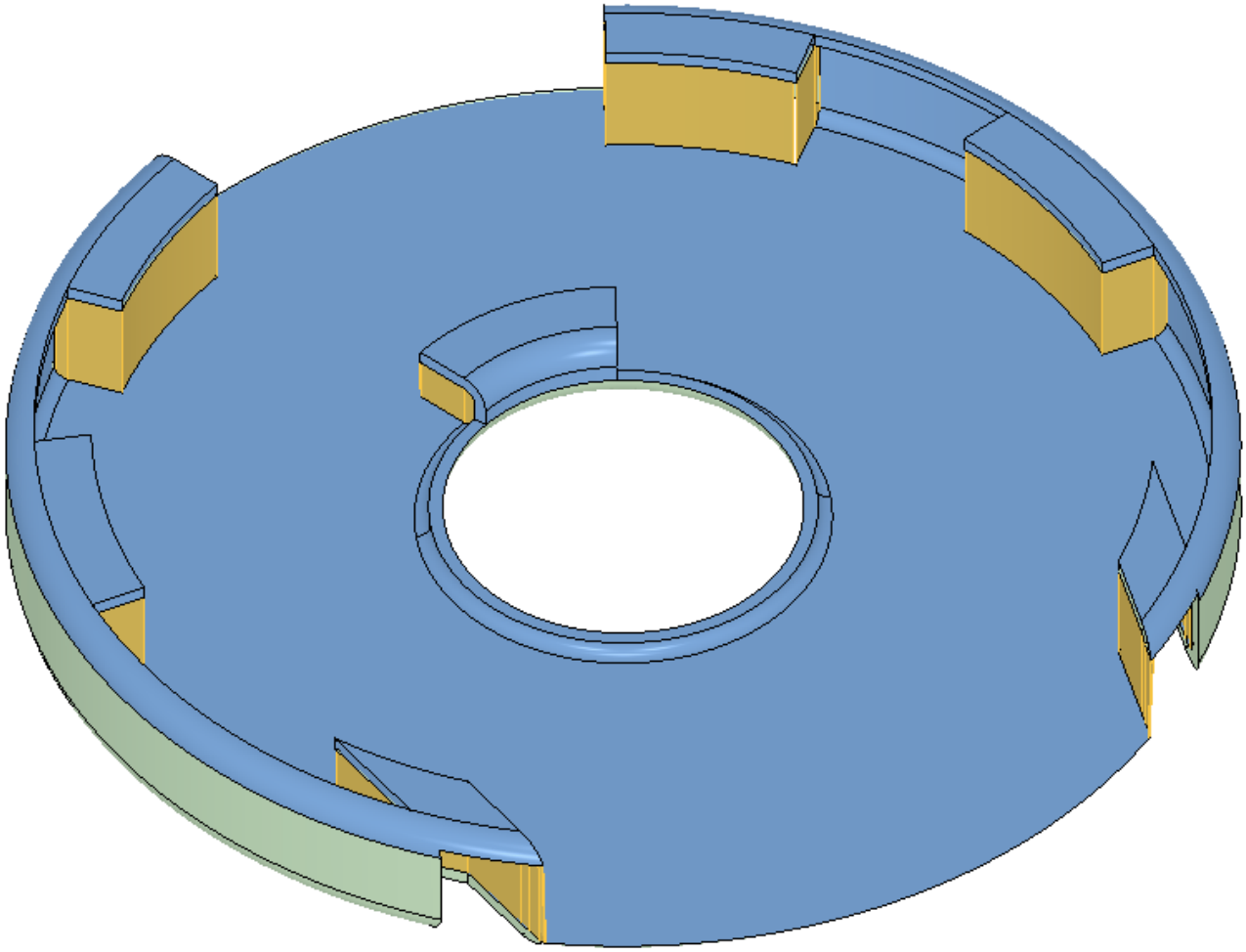


Figure 2: Manufacturing analysis. Areas highlighted yellow require at least 3 degrees of draft to avoid mold damage.

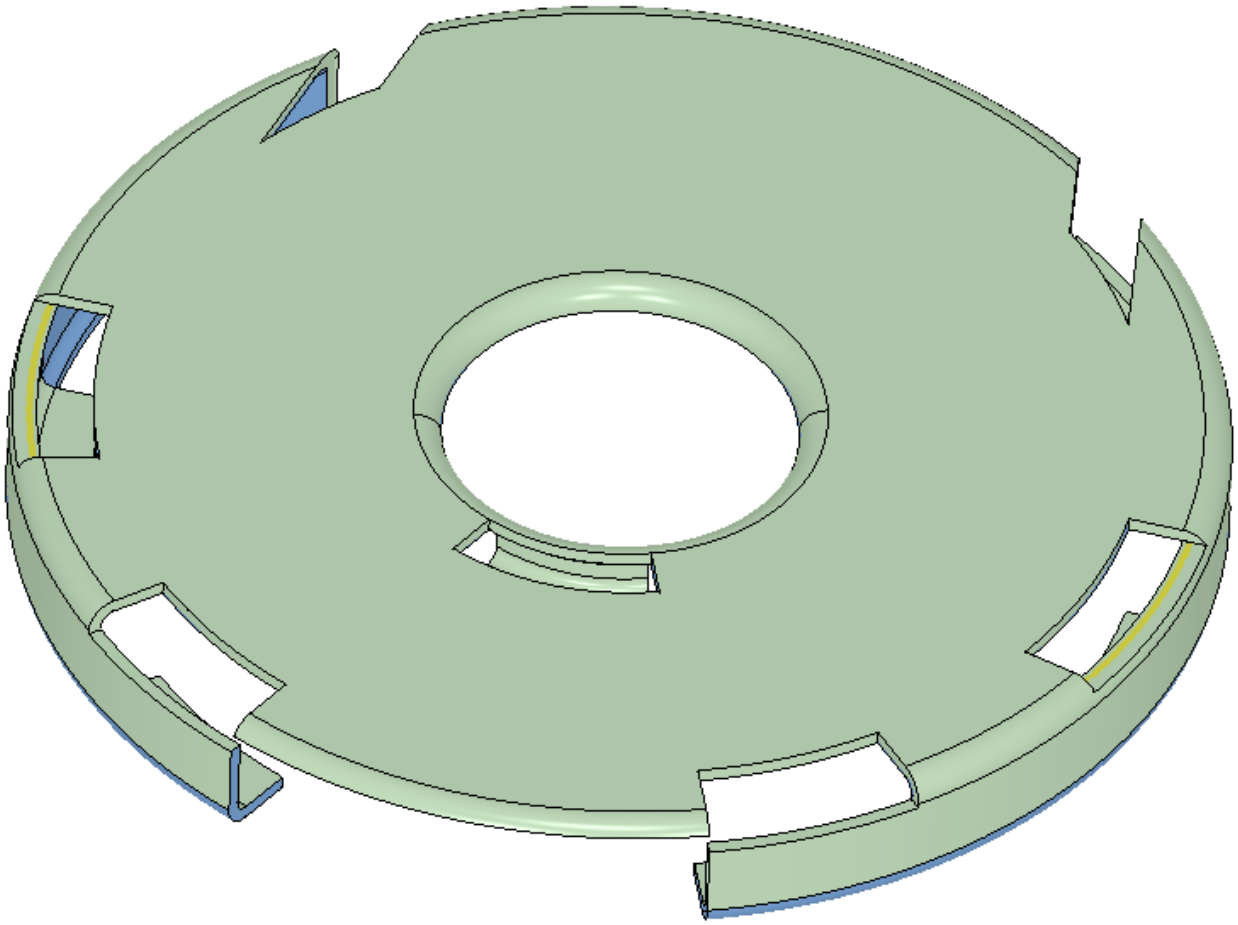


Figure 3: Manufacturing analysis. Areas highlighted yellow are too thin and may be unformed during molding.

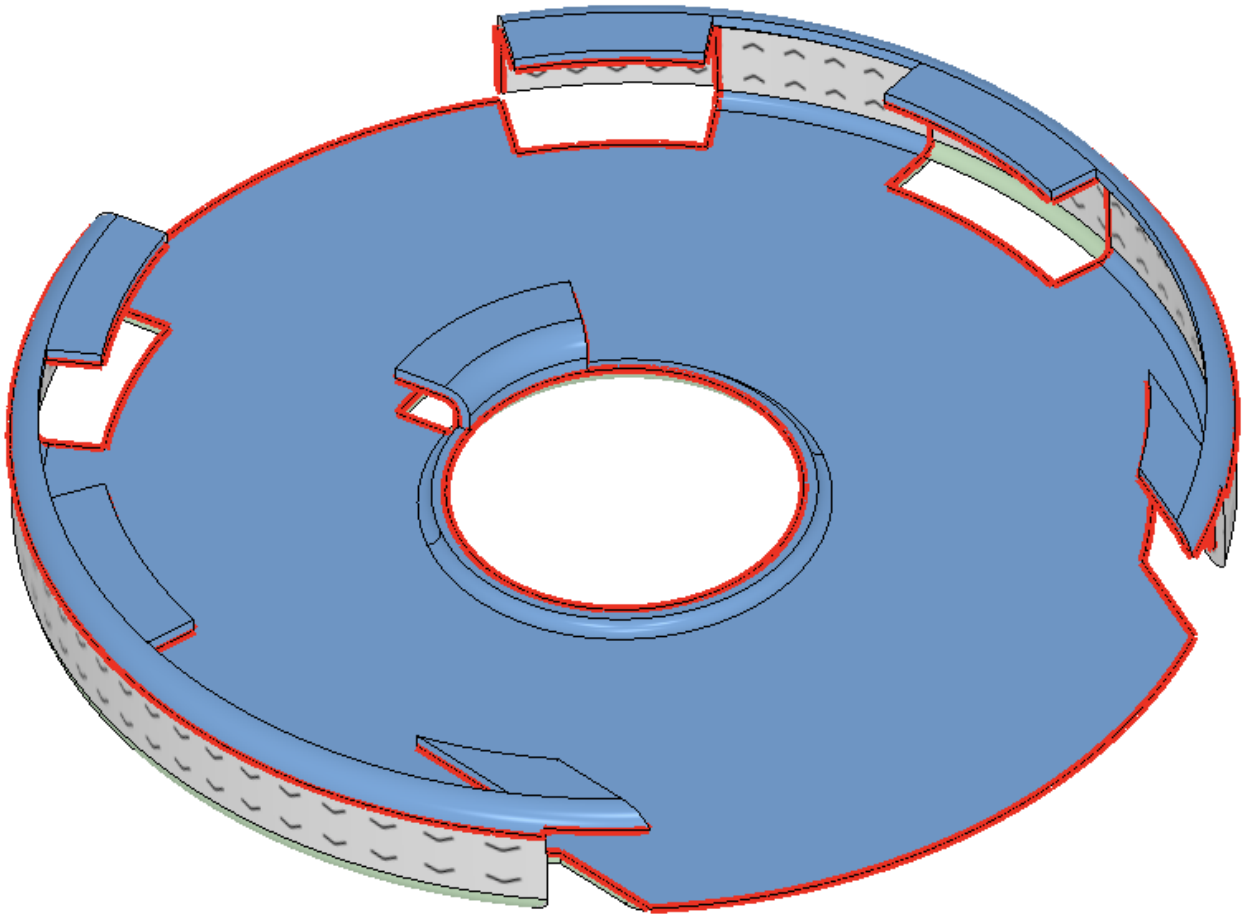


Figure 4: Manufacturing analysis. Areas highlighted red require at least 1 degree of draft to ensure easy ejection of device from mold.

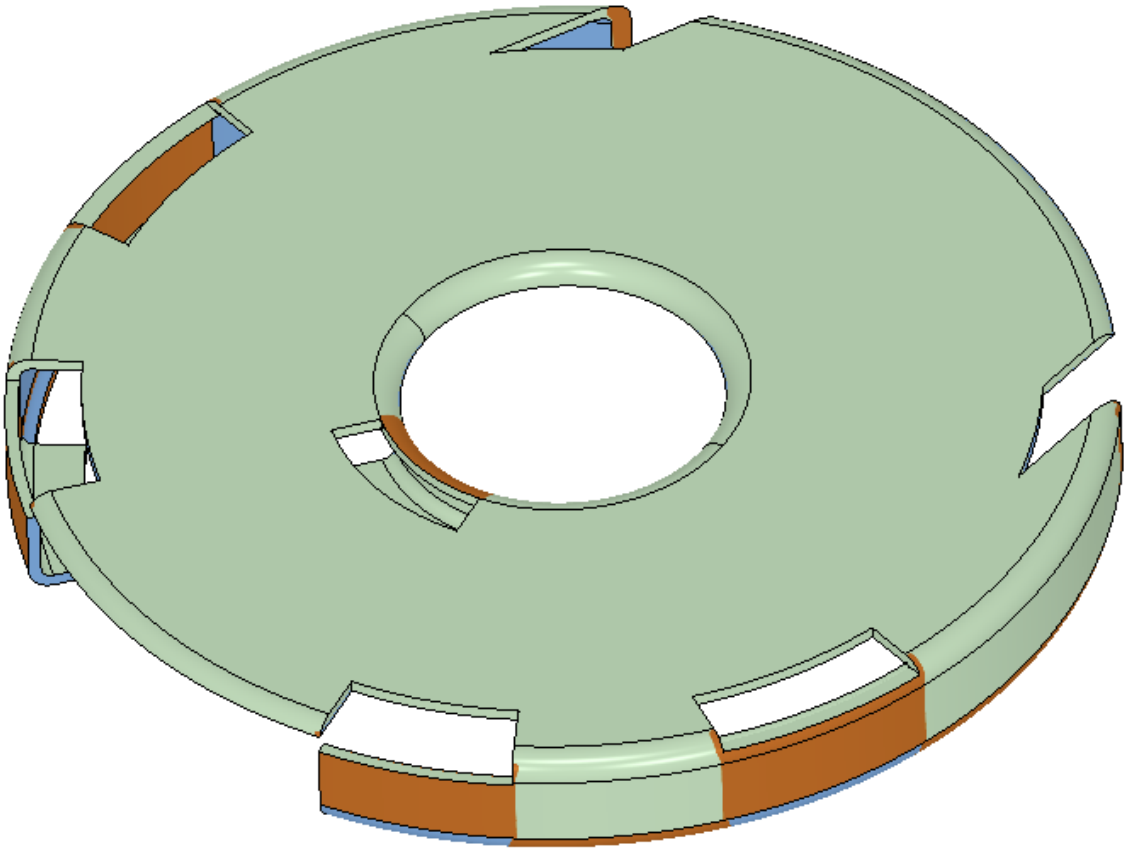


Figure 5: Manufacturing analysis. Areas highlighted orange are either too deep or too small to be polished during finishing.

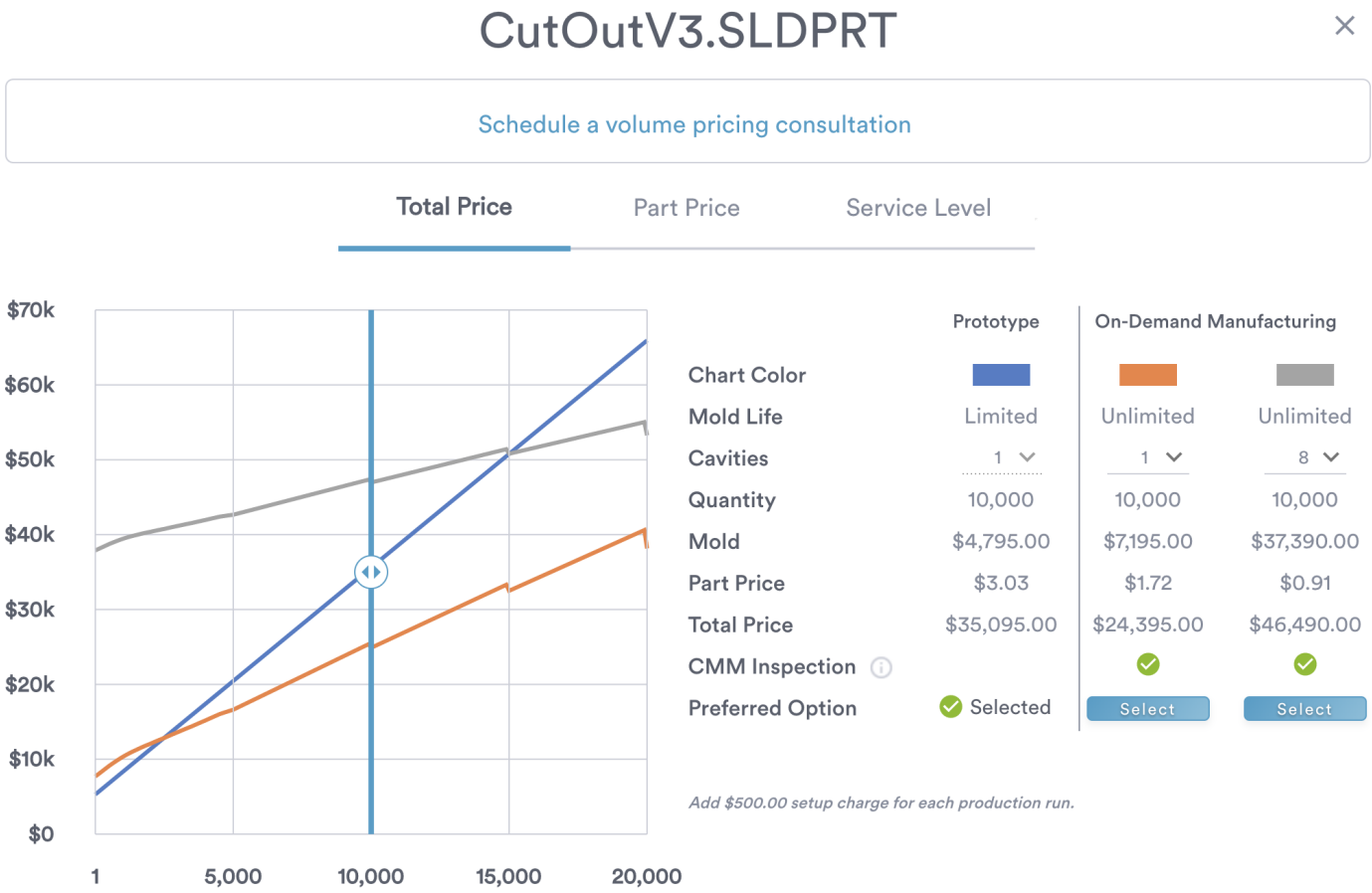
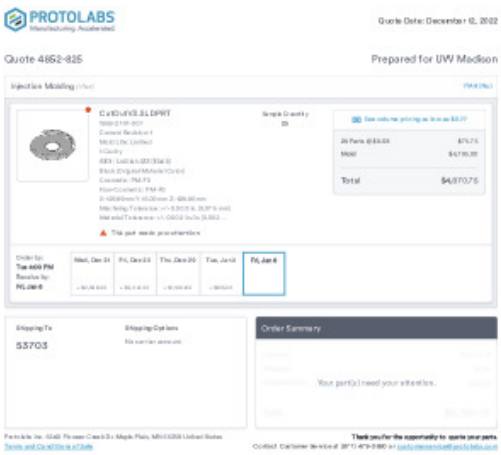


Figure 6: Quote for 10,000 pieces to be injection molded. Note the cost of the mold ($4,795.00)

Conclusions/action items:

As it is currently designed, this version of the wheel is not injection moldable and needs to consideration several design revisions in order to be injection moldable.

Ben Smith - Dec 12, 2022, 8:55 PM CST



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Quote_4852-825.pdf (272 kB)

9/19/22 - Average Hand Sizes

VICTORIA HEILIGENTHAL - Sep 19, 2022, 7:57 PM CDT

Title: Average Hand Sizes

Date: 9/19/22

Content by: Victoria

Present: N/A

Goals: To present average hand sizes to determine the appropriate diameter of the wheel

Content:

The wheel must have a diameter that will be optimized for the average person so the ease of loading and unloading the wire will be maximized.

Assessing the Importance of Surgeon Hand Anthropometry on the Design of Medical Devices | J. Med. Devices | ASME Digital Collection

- It could be most important to investigate the hand sizes of surgeons, since either themselves for techs in the OR will be loading and unloading the wheel
- This study looked at the size of 58 surgeon's hands (50 males, 8 females) to get average values of multiple variables
- Males
  - Avg hand circumference: 21.35 +/- 0.95 cm
    - General population: 21.39 +/- 0.98 cm
  - Avg grip diameter: 5.05 +/- 0.32 cm
    - Smaller than general population
    - General population: 5.20 +/- 0.43 cm
- Females
  - Avg hand circumference: 18.95 +/- 1.03 cm
    - General population: 18.65 +/- 0.86 cm
  - Avg grip diameter: 4.63 +/- 0.40 cm
    - 4.80 +/- 0.31 cm
    - Slightly smaller than general population
- General population data is from 1003 men and 1304 women
  - Hand Anthropometry of U.S. Army Personnel (dtic.mil)
  - Greiner, T. M., 1991, Hand Anthropometry of U.S. Army Personnel, U.S. Army Natick Research, Development & Engineering Center, Natick, MA.
- All data was collected using anthropometry methods
- Potentially split the difference between the general and surgeon population data?

-Image of variables tested in study on hand

Conclusions/action items: With this information, the team can decide what dimensions would be best to meet the needs of the general population and surgeons. The team must also decide how to finalize the diameter based on gender differences.

9/19/22 - Law and Entrepreneurship Clinic

VICTORIA HEILIGENTHAL - Sep 19, 2022, 11:19 AM CDT

Title: Law and Entrepreneurship Clinic

Date: 9/19/22

Content by: Victoria

Present: N/A

Goals: To provide information on how the team could start looking into patents for the device

Content:

Law & Entrepreneurship Clinic | University of Wisconsin Law School

- Law students aid entrepreneurs and small business owners with legal services
  - Other guidance from faculty and private attorneys
- Offices at UW Law School
  - Have to sign up for office hours to meet
  - entrepreneurhelp@law.wisc.edu
- Need to apply for legal advice through website
- Law Series Video #1: Overview of Trademarks and Copyrights - YouTube
  - Good video to watch made by the clinic that provides basic information on trademarking
  - Could apply similar concepts to patenting

Conclusions/action items: Having this resource on campus will be very useful for the team later in the semester/year if we are ready to start applying for patents and putting this device on the market.

Injection Molding Materials - 10/8/22

VICTORIA HEILIGENTHAL - Oct 08

Title: Injection Molding Materials

Date: 10/8/22

Content by: Victoria

Present: N/A

Goals: To provide information on the materials we want to use for injection molding

Content:

The team would ideally like to use either nylon or polyester for injection molding since these materials are already used in endovascular procedures. If the team moved forward with these mat process would be shortened. If the team decides to use Protolabs for injection molding, they have many different nylon and polyester materials available.

Manufacturing Materials Comparison Guide (protolabs.com)

- Nylon
  - Nylon 66 - general nylon
    - Datasheet - http://catalog.ides.com/Datasheet.aspx?I=43838&FMT=PDF&E=50979
  - Protolabs offers many different nylon materials, so asking them what the main differences are between them and which one they think will be be our design will be important
- Two kinds of PET (polyesters offered)
- Rynite 530 has higher tensile modulus and stress, but lower flexural modulus
  - We will probably want a material with a higher flexural modulus, so it is not brittle and doesn't break during loading and unloading of the guidewi
-

	Tensile Modulus	Tensile Stress (Break)	Flexural Modulus	Rockwell Hardness (R-Scale)	Melting Point	Data S
Test Method	**ISO 527**	**ISO 527**	**ISO 178**	**ISO 20390**	**ISO 11357**	
Rynite 530 (30% Glass Filled)	11,000 MPa	158 MPa	8,950 MPa	120	252°C	VIEW PDF
Rynite 935 (35% Glass Filled)	10,200 MPa	85.0 MPa	9,100 MPa	115	252°C	VIEW PDF

Conclusions/action items: When the team meets with Protolabs, we should ask them which material they think would be best to use for injection molding the wheel design

Silicon Rubber - 10/13/22

VICTORIA HEILIGENTHAL - Oct 13, 2022, 9:04 AM CDT

Title: Silicone Rubber

Date: 10/13/22

Content by: Victoria

Present: N/A

Goals: To understand silicone rubber properties and see if it would work as a material for the team

Content:

After the Protolabs design meeting, the people at Protolabs suggested that we look into using silicone rubber for injection molding the wheel. This would allow for easy removal of the wheel from the mold without having to make too many design changes.

- Properties and features
  - flexible over wide ranges of temps
  - Good resistance to compression
  - Used for many medical applications
    - Balloon catheters, tubing for feeding and draining, seals, stoppers
  - Biocompatibility
    - Very high biocompatibility, low tissue response
    - Do not grow bacterial, meet FDA requirements
  - Temperature Resistance
    - -75-500 F
    - Can be sterilized with steam autoclaving and other typical methods
  - Mechanical
    - High tensile strength (1500 psi)
    - High flexibility

Silicone Rubber for Medical Device Applications (mddionline.com)

Conclusions/action items: With this information, I think the team could move forward with using silicon rubber to injection mold the wheel. My only concern is that it will be too flexible, making it difficult to load and unload the guidewires.

Protolabs Materials Samples for Injection Molding - 10/19/22

VICTORIA HEILIGENTHAL - Oct 19, 2022, 9:58 PM CDT

Title: Protolabs Materials Samples for Injection Molding

Date: 10/19/22

Content by: Victoria

Present: N/A

Goals: To understand the properties of the different material samples being sent to the team for injection molding the wheel from Protolabs

Content:

- Elastosil 3003/40 A/B
  - **1 - 57768cf50046b6f358b2d2a11af90b9a_57768cf50046b6f460697534ea7e3eec (protolabs.com)**
  - Liquid silicone rubber, paste-like
  - -55-210 C temperature range
  - Hardness 55A
  - Tensile strength: 10,000 N/m^3
  - Tear strength: 33 N/m
- Elastosil 3003/50 A/B
  - **ELASTOSIL® LR 3003/50 A/B | Liquid Silicone Rubber (LSR) | Wacker Chemie AG**
  - Liquid silicone rubber, paste-like
  - -55-210 C temperature range
  - Hardness 47-53A
  - Tensile strength: 10.3 N/mm^2
  - Tear strength: 26 N/m
- Elastosil 3003/60 A/B
  - **Microsoft Word - 00000000000004329351_1341586806250.rtf (protolabs.com)**
  - Liquid silicone rubber, paste-like
  - -55-210 C temperature range
  - Hardness: 60 A
  - Tensile strength: 9.4 N/mm^2
  - Tear strength: 27 N/m

All three have similar tear and tensile strengths and similar hardness values

- Versaflex OM 1060X-1
  - **Data Sheet (protolabs.com)**
  - Good adhesion to PC or ABS
  - Rubbery, soft
  - Hardness: 60 A
  - Tensile strength: 4.1 MPa
  - Tear strength: 26.3 kN/m

Much higher tensile and tear strength, same hardness

Conclusions/action items: By knowing these properties, it will be helpful when the team receives the samples so we can decide which wheel design to injection mold.

Materials - Present to Team

VICTORIA HEILIGENTHAL - Oct 31, 2022, 9:33 PM CDT

Title: Materials- Present to team

Date: 10/31/22

Content by: Victoria

Present: N/A

Goals: To list materials available that might be best for each modification

Content:

- Previous materials

The team was originally using PLA with PVA supports to print the wheel designs from the Makerspace. Although the team is no longer using 3D printing for mass manufacturing, a material that is similar to PLA would be the goal to use for mass manufacturing.

-Ultimaker PLA properties

Ultimaker PLA material: Highly versatile, easy to print

- Flexural strength (103 MPa)
- Impact strength (Izod tested to 5.1 kJ/m²)
- Hardness (83 Shore D)
- Melting temperature (from 145 °C)

Ideally, finding a material that has similar properties to these that can be used for manufacturing is the team's goals.

- Injection molding
  - Design modifications
    - Class I FDA approved materials at Protolabs
    - Medical Device Material Safety Summaries | FDA
    - Manufacturing Materials Comparison Guide (protolabs.com)
      - PEEK, PP
      - Could be good to use since already FDA approved
        - PP would most likely be better due to its properties
      - PS is another material similar to PLA that is available at Protolabs
        - Flexural strength: 61 MPa
        - Impact strength (notched): 107 J/m.
  - Material modifications
    - If the design is not changed, the team will opt towards using an elastomer type of material similar to what Protolabs sent so the wheel can pop out of the mold
- Thermoforming

Thermoforming could be done at the UW Makerspace initially to get first prototypes of the wheel. Makerspace has Formech and FTM thermoforming machines

- Formech
  - Formech | Vacuum Forming Machines | Vacuum Forming Plastic
  - High Impact Polystyrene (HIPS) (blackwellplastics.com)
  - Offers HIPS, ABS, PETG

        - HIPS (High impact polystryene) :
            - Melting temp- 98.9 C
            - Flexural strength: 3.18 x10^7 Pa (31.8 MPa)
            - Impact strength: 2.2 ft-lb/in
        - ABS
            - Flexural strength: 75 Mpa
            - Melting temp - 200 C
        - PETG
            - Flexural strength: 57 Mpa
            - Melting temp - 260 C
        - ABS is most similar to PLA
- Alternate materials
    - Material similar to frisbee - allows for rigid structure with slight flexability
        - Very similar properties to PP
- Would be helpful to talk to protolabs or other experts on whatever manufacturing method we go with based on the design

Conclusions/action items: The team can discuss material options once the manufacturing process and design is finalized

9/15/22 - Alternative Methods to 3D Printing

VICTORIA HEILIGENTHAL - Nov 09, 2022, 12:41 PM CST

Title: Alternative Methods to 3D Printing

Date: 9/15/22

Content by: Victoria

Present: N/A

Goals: To provide alternative methods that could be used to create the device

Content:

- Injection molding
  - Injecting melted plastics into a specific mold, followed by cooling for solidification
  - Used with plastics
  - Could be a good alternative since our design is simple and hollow
  - The outline of injection molding (polyplastics.com)
- Using a more advanced 3D printer
  - Formlab printers in MakerSpace
  - SLA Technology
  - Can also create good molds
  - 3D Printers – UW Makerspace – UW–Madison (wisc.edu)
- Discuss further options with what client 's goal is for final printing

Conclusions/action items: Discuss goals of final printing/prototyping of device with client

Injection Molding - 10/1/22

VICTORIA HEILIGENTHAL - Oct 01, 2022, 8:52 PM CDT

VICTORIA HEILIGENTHAL - Oct 01, 2022, 9:03 PM CDT

Title: Injection Molding

Date: 10/1/22

Content by: Victoria

Present: N/A

Goals: To understand the process of injection molding

Content:

Injection molding steps - [Injection Molding Process | Xcentric Mold & Engineering]

1. Material enters barrel
2. Merial melts and mixes
3. Sizes of material gets shot into the barrel
4. Mold closes
5. Plastic is injected into mold
6. Melted plastic cools
7. Mold opens
8. Part gets removed

- Thermoplastic materials and polymers
  - ABS, PC, PP
- Plastic Injection Molding | Custom Low-Volume Plastic Parts (protolabs.com)

Conclusions/action items: By understanding the injection molding process more, the team can move forward with this for manufacturing

Injection Molding in Madison - 10/1/22

VICTORIA HEILIGENTHAL - Oct 01, 2022, 9:11 PM CDT

Title: Injection Molding in Madison

Date: 10/1/22

Content by: Victoria

Present: N/A

Goals: To get contacts of companies in Madison that do injection molding

Content:

- Xometry
  - Location is in Milwaukee
  - Injection Molding Services Service for Madison, Wisconsin | Xometry
- OBT Plastics
  - Madison
  - Plastic Injection Molded Parts Manufacturers China | OBT (obt-eng.com)
- Engineering Industries
  - Verona
  - Home - Engineering Industries, Inc

Conclusions/action items: With these locations and more, the team could consider manufacturing the prototypes there

Thermoforming at Makerspace-11/9/22

VICTORIA HEILIGENTHAL - Nov 18, 2022, 2:40 PM CST

Title: Thermoforming at Makerspace

Date: 11/9/22

Content by: Victoria

Present: N/A

Goals: To understand the process of thermoforming at the Makerspace to see if the team could use it as an alternative manufacturing methods

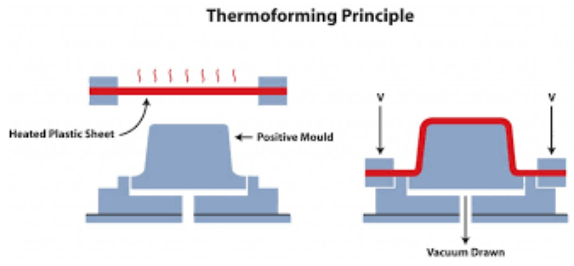
Content:

Thermoformer – UW Makerspace – UW–Madison (wisc.edu)

- Two machines
  - Formech
  - FTM Inc
- Mold
  - Wood, clay, plastic, metal, concrete, 3d printed part
- Materials
  - acrylic, polystyrene, and PETG
    - PS would most likely be best option based on previous research

Thermoforming research

- Heat plastic sheet and fit to mold
- Can mass produce for affordable cost
- Process
  - Many processes, but the Thermoformers at the Makerspace use vacuum forming
    - Vacuum shapes plastic sheet
    - First, sheet is heated
    - Vacuum machine pulls air out, pushing the sheet against the mold
    - Cost-effective and fast
- Mold
  - High-temp resistant
  - Cooling channels
  - Ventilation holes
  - 3D printing would be best option
    - Resin material
- Cost
  - Cheaper than injection molding
- Short production time



Conclusions/action items: By using this information, the team could consider using thermoforming instead

Professor Turng Meeting - 10/5/22

VICTORIA HEILIGENTHAL - Oct 05, 2022, 12:36 PM CDT

Title: Professor Turng Meeting for Injection Molding

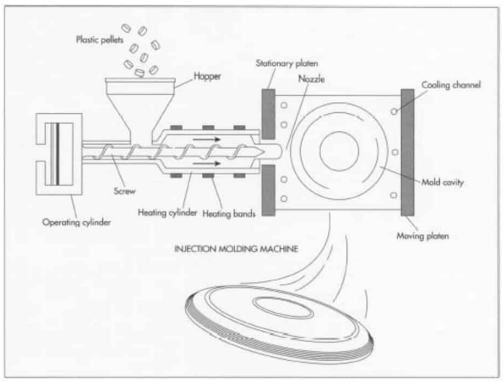
Date: 10/5/22

Content by: Victoria

Present: Victoria, Rachel, Ben. Lily

Goals: To better understand how we might need to modify our design for injection molding

Content:

- We may not have to change our design
  - Might just need to use a specific mold type
    - Collapsible mold?
- Could also look into alternative materials that are a little more flexible so the wheel can be popped out of the mold
  - Showed us PLA, but could explore other options
- Also could consider using a snap-fit if we wanted to explore that as an injection molding option
  - Would have to injection mold 2 pieces and snap together
- Recommended researching how a frisbee is injection molded because it is similar to our design
  - Could use a similar mold for the outer ring portion
  - 

- Recommended reaching out to Evco Plastic to see what their injection molding options were
- He did not think we had to modify our designs and wasn't concerned with the manufacturing of our designs

Conclusions/action items: The team needs to contact Protolabs or another injection molding company to see if they can make a mold for us that will develop the wheel or if they have specific changes they will require to the wheel.

Show and Tell -11/15/22

VICTORIA HEILIGENTHAL - Nov 15, 2022, 10:06 PM CST

Title: Show and Tell

Date: 11/15/22

Content by: Victoria

Present: N/A

Goals: To recap the show and tell

Content:

Since I wasn't present at the show and tell, I wanted to give a summary of my thoughts of the feedback. I think a lego mechanism could be a really interesting way to print the wheel into two parts. However, the stability of the device would concern me because I feel like it could easily come apart. If we could design it so its like a snap-fit/lego mechanism, I think that could be an interesting way to piece the wheel together. The anchor mechanism that was mentioned was also interesting, but I do not think it would be feasible for this design. I think the wheel could easily come apart and that is obviously something we want to avoid. Moving forward, I think the team needs to finalize what material/method for manufacturing we want to use.

Conclusions/action items: the team needs to finalize what material/method for manufacturing we want to use. **These suggestions from others are helpful**

Semester Designs - 12/13/22

VICTORIA HEILIGENTHAL - Dec 13, 2022, 10:17 AM CST

Title: Semester Prototype Designs

Date: 12/13/22

Content by: All

Present: N/A

Goals: To document the team's wheel prototype designs throughout the semester

Content:

The team's prototype designs can be found in Tatum, Addie, Ben and Lily's folder

Conclusions/action items:

MATLAB Code - 12/5/22

VICTORIA HEILIGENTHAL - Dec 05, 2022, 8:38 PM CST

Title: MATLAB Code

Date: 12/5/22

Content by: Victoria

Present: N/A

Goals: To document the code that was used to analyze testing results

Content:

I wrote the MATLAB code to analyze the gradings of loading and unloading the guidewires, the times to load and unload the guidewires, and the statistics that were calculated based on the data. The code counts the number of occurrences of each grade for each wheel design tested for load/unloading, then plots a bar graph. The unload/loading times are plotted as box plots to show the variations in timing. The statistic calculations show the p-values across all wheels and between wheel designs. Additional calculations, like means and standard deviations, are also provided.

Conclusions/action items: This code can be used to analyze the testing data and can be adapted and changed in the future.

VICTORIA HEILIGENTHAL - Dec 05, 2022, 8:38 PM CST

```
%% Fall 2022
clear
clc
close all

%% Load data
[ dataFile, dataDir ] = uigetfile( '*.xlsx', 'Select excel file containing your
study data') ;
wheelData = xlsread( dataFile ) ;
designNum = wheelData( :, 1 ) ;
memberNum = wheelData( :, 2 ) ;
trialNum = wheelData( :, 3) ;
loadTime = wheelData( :, 4 ) ;
loadGrade = wheelData( :, 5 ) ;
unloadTime = wheelData( :, 6) ;
unloadGrade = wheelData( :, 7 ) ;


wheel0 = find(designNum == 0);
wheel0 = wheelData(wheel0,:);

wheel1 = find(designNum == 1);
wheel1 = wheelData(wheel1,:);

wheel2 = find(designNum == 2);
wheel2 = wheelData(wheel2,:);

wheel3 = find(designNum == 3);
wheel3 = wheelData(wheel3,:);

wheel4 = find(designNum == 4);
wheel4 = wheelData(wheel4,:);

wheel5 = find(designNum == 5);
wheel5 = wheelData(wheel5,:);

wheel6 = find(designNum == 6);
wheel6 = wheelData(wheel6,:);

%Getting number of occurences of each rating for loading
[rOW, COl] = size(wheelData);
loadGRTable = cell(row+1, 3);
for x = 0:6
    designRun = find(designNum == x);
    designRun = wheelData(designRun,:);
    xLOAD = unique(designRun(1:15,5)); %Change when run everything
    NLOAD = numel(xLOAD);
    countLoad = zeros(NLOAD,1);
        for k = 1:NLOAD
            countLoad(k) = sum(designRun(1:15,5)==xLOAD(k)); %Change when ran
everything
        end
    emptyData = cellfun(@isempty, loadGRTable);
    emptyRows = find(emptyData(:,1)==1);
    nextRow = emptyRows(1);
    occurLoad =  [xLOAD(:),countLoad ];
    occurLoad = num2cell(occurLoad);
    numRep = repmat([x], height(occurLoad), 1);
    loadGRTable(nextRow:nextRow+height(occurRun)-1, 3) = numRun; %Change nextrow
with all data
    loadGRTable( nextRow:nextRow+height(occurLoad) -1 ,1) = occurLoad(1:end,1);
%Rate is first
    loadGRTable( nextRow:nextRow+height(occurLoad)-1 ,2) = occurLoad(1:end,2);
```

Download

Endo_guideF22.m (10.8 kB)

Results from Testing-12/5/22

VICTORIA HEILIGENTHAL - Dec 05, 2022, 8:53 PM CST

Title: Results from Testing

Date: 12/5/22

Content by: Victoria

Present: N/A

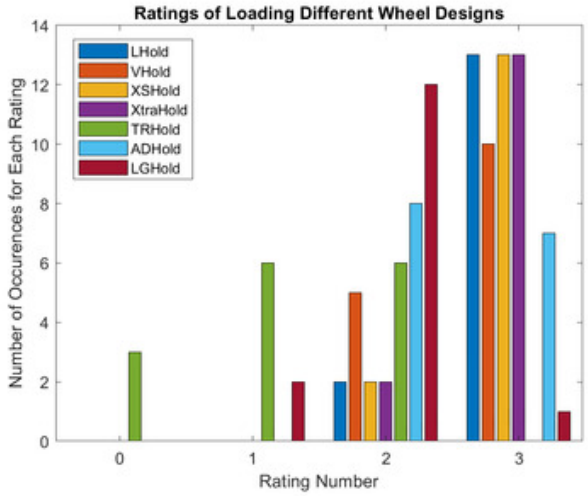
Goals: To present the results from testing

Content:

- XSHold has fastest average loading time (12.29 +/- 2.53s)
- LHold was close behind with loading time (12.45 +/- 2.47 s) and so was XtraHold (12.58 +/- 2.53)
- TRHold has worst loading ratings
- LHold, XSHold, XtraHold all tied for the highest loading ratings
    - Unloading the device is not considered as important right now since the main focus of the device is load it with guidewires
- No significant difference between XHold and ADHold (p = 0.473)
- Significant difference between XSHold and TRHold & LGHold (p = 0.028, p = 0.036)

Conclusions/action items: Additonal test results can be found by running the MATLAB code, however, these are most important takeaways

VICTORIA HEILIGENTHAL - Dec 05, 2022, 8:53 PM CST



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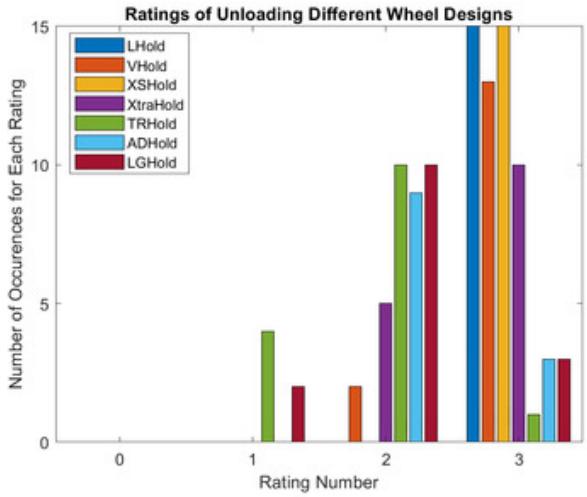
400_grade_load.png (45 kB)

VICTORIA HEILIGENTHAL - Dec 05, 2022, 8:53 PM CST



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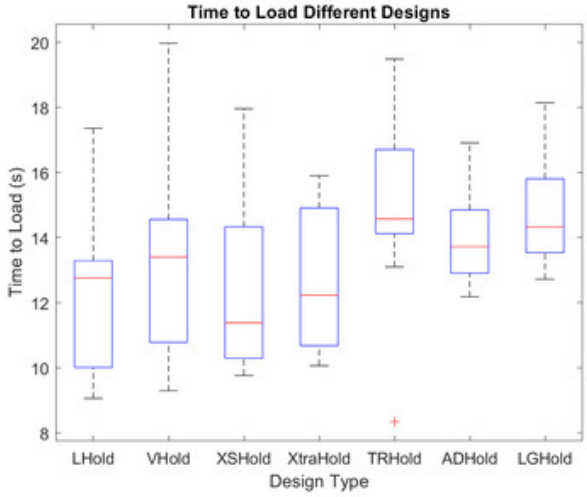
400_grade_unload.png (43 kB)

VICTORIA HEILIGENTHAL - Dec 05, 2022, 8:53 PM CST



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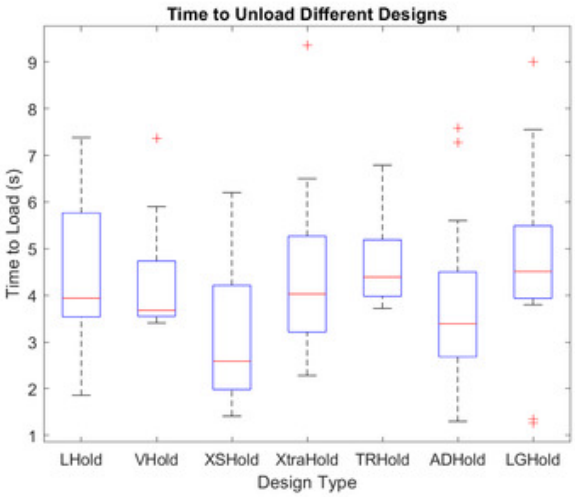
400_load_times.png (32.5 kB)

VICTORIA HEILIGENTHAL - Dec 05, 2022, 8:53 PM CST



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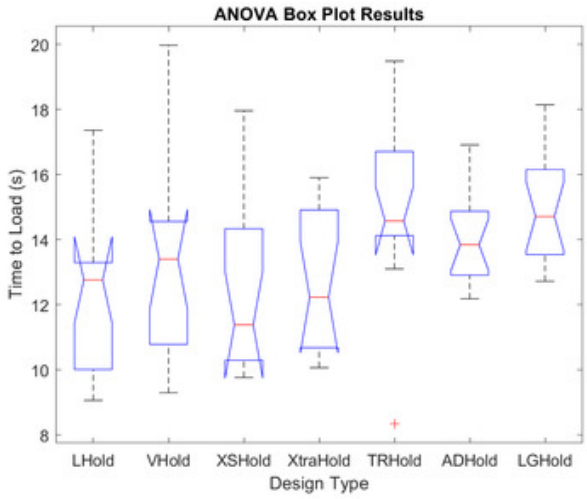
400_unload_times.png (32.1 kB)

VICTORIA HEILIGENTHAL - Dec 05, 2022, 8:53 PM CST



Download

ANOVA_alll.png (41.3 kB)

ANOVA Test results -12/8/22

VICTORIA HEILIGENTHAL - Dec 08, 2022, 8:45 PM CST

Title: ANOVA Test results

Date: 12/8/22

Content by: Victoria

Present: N/A

Goals: To document the ANOVA test results

Content:

Design 1	Design 2	P-value
1	2	0.93506
1	3	0.999996
1	4	0.999999
1	5	0.047204
1	6	0.599838
1	7	0.060217
2	3	0.867164
2	4	0.967624
2	5	0.446063
2	6	0.99459
2	7	0.505609
3	4	0.999877
3	5	0.027677
3	6	0.473338
3	7	0.035915
4	5	0.069212
4	6	0.694543
4	7	0.087081
5	6	0.848126
5	7	1
6	7	0.887523

Design Number Key:	
1	LHold
2	VHold
3	XSHold
4	XtraHold
5	TRHold
6	ADHold
7	LGHold

This shows the p-value between all combinations of designs to show the data significance of loading times.

Conclusions/action items: The team can further use this during data analyzation

Raw Test Results-12/8/22

VICTORIA HEILIGENTHAL - Dec 08, 2022, 8:51 PM CST

Title: Raw Test Results

Date: 12/8/22

Content by: Victoria

Present: N/A

Goals: To document all test results

Content:

All results from testing are shown below.

Design Number:	Member Number:	Trial Number:	Loading Time:	Loading Grade (0-3):	Unloading time (not on stand):	Unloading Grade (0-3)
1	4	1	10.69	3	3.63	3
1	4	2	14.27	2	3.47	3
1	4	3	19.97	2	3.42	3
0	4	4	16.35	3	4	3
0	4	5	12.76	2	2.76	3
0	4	6	9.06	3	1.86	3
2	4	7	10.29	3	3.45	3
2	4	8	10.25	3	1.42	3
2	4	9	10.3	3	1.9	3
3	4	10	12.23	3	3.4	3
3	4	11	10.06	3	4.03	2
3	4	12	13.75	3	4.32	3
4	4	13	15.69	2	4.35	2
4	4	14	14.47	1	3.97	2
4	4	15	14.82	2	3.72	2
5	4	16	13.28	2	2.96	2
5	4	17	13.84	2	3.39	2
5	4	18	12.88	3	3.13	3
6	4	19	15.97	2	4.51	2
6	4	20	15.32	2	1.34	1
6	4	21	14.71	2	3.8	2
2	1	1	10.52	3	2.36	3
2	1	2	10.31	3	2.11	3
2	1	3	10.03	3	1.94	3
5	1	4	12.42	2	1.3	2
5	1	5	13.72	2	2.78	2
5	1	6	12.18	3	2.43	2
6	1	7	13.32	2	4.59	2
6	1	8	13.76	2	4.04	2
6	1	9	13.33	2	1.26	1
1	1	10	13.4	2	3.78	3
1	1	11	9.29	3	3.99	3
1	1	12	11.86	2	3.55	2
3	1	13	10.66	3	3.27	2
3	1	14	10.2	3	2.67	3
3	1	15	10.73	3	2.28	3
4	1	16	16.89	1	4.64	1
4	1	17	14.57	2	3.92	1
4	1	18	14.12	2	4.39	2
0	1	19	13.15	3	3.94	3
0	1	20	13.34	3	3.47	3
0	1	21	9.45	3	3.56	3
3	3	1	12.07	3	4.04	3
3	3	2	12.25	2	3.2	3
3	3	3	10.07	3	3.26	3
0	3	4	12.25	3	3.65	3

KEY:		Number of Trials
Member	**Member #**	
Addie (R)	1	21
Ben (R)	2	0
Rachel (L)	3	21
Tatum (R)	4	21
Victoria (R)	5	21
Lily (R)	6	21
Design	**Design #**	
LHold	0	15
VHold	1	15
XSHold	2	15
XtraHold	3	15
TRHold	4	15
ADHold	5	15
LGHold	6	15

Design Number:	Member Number:	Trial Number:	Loading Time:	Loading Grade (0-3):	Unloading time (not on stand):	Unloading Grade (0-3)
0	3	5	10.93	3	4.13	3
0	3	6	12.5	3	3.53	3
2	3	7	14.5	2	4.26	3
2	3	8	17.96	2	4.07	3
2	3	9	14.48	3	3.73	3
6	3	10	13.46	2	5.5	3
6	3	11	12.72	3	4.43	3
6	3	12	18.14	2	5.46	2
4	3	13	19.48	1	5.23	2
4	3	14	18.5	0	4.01	2
4	3	15	18	0	6.13	2
5	3	16	16.3	2	3.82	2
5	3	17	16.91	3	4.08	3
5	3	18	12.31	3	3.72	3
1	3	19	9.94	3	4.54	3
1	3	20	11.06	3	3.56	3
1	3	21	10	3	3.41	3
4	6	1	8.33	2	6.79	1
4	6	2	13.1	1	5.07	3
4	6	3	14.2	1	5.75	2
2	6	4	15.69	3	5.41	3
2	6	5	13.9	3	5.75	3
2	6	6	13.4	3	6.2	3
6	6	7	14.32	1	3.9	2
6	6	8	14	2	4.4	2
6	6	9	16.66	2	9	3
3	6	10	15.3	3	6.5	3
3	6	11	13.45	3	6.3	2
3	6	12	15.9	3	9.36	2
5	6	13	15.35	3	7.28	1
5	6	14	13.92	3	7.59	1
5	6	15	12.98	3	5.6	1
0	6	16	14.46	3	6.43	3
0	6	17	13.07	3	6.31	3
0	6	18	9.35	3	7.38	3
1	6	19	14.61	3	5.9	3
1	6	20	11.96	3	7.37	3
1	6	21	14.01	3	5.74	3
1	5	1	18.76	3	3.6	2
1	5	2	14.4	3	4.8	3
1	5	3	16.45	2	3.68	3
3	5	4	15.34	3	4.43	3
3	5	5	15.37	2	2.75	3
3	5	6	11.3	3	5.55	2
4	5	7	16.15	0	4.63	1
4	5	8	14.12	2	3.88	2

Design Number:	Member Number:	Trial Number:	Loading Time:	Loading Grade (0-3):	Unloading time (not on stand):	Unloading Grade (0-3)
4	5	9	13.64	1	4.37	2
2	5	10	11.54	3	2.59	3
2	5	11	11.38	3	2.4	3
2	5	12	9.76	3	1.87	3
6	5	13	16.21	2	7.55	2
6	5	14	17.95	1	5.81	2
6	5	15	15.02	2	4.72	2
5	5	16	14	2	4.64	2
5	5	17	15.16	2	2.29	2
5	5	18	13.92	2	2.65	2
0	5	19	13.06	3	6.24	3
0	5	20	17.36	2	4.34	3
0	5	21	9.7	3	3.86	3

Conclusions/action items: The team used this data to complete a statistical analysis

Outreach Seminar Make-Up Notes - 9/26/22

VICTORIA HEILIGENTHAL - Sep 26, 2022, 9:49 PM CDT

Title: Outreach Seminar Make-Up Notes

Date: 9/26/22

Content by: Victoria

Present: N/A

Goals: To go over the slides from the outreach seminar and take notes that will be shared out to the team

Content:

Presentation Notes

- BME Outreach is a program that teaches kids in the Madison community about what engineering is, what you can do with engineering, and what engineering at UW is like
- Want to share the opportunities in engineering to the youth and to continue to build diversity within the field
- Outreach activity
    - Set up meeting with Dr. P
    - Creative, fun, insightful activity

Follow-up Questions

- What is the outreach requirement composed of?
    - Presentation
        - 10 minute introductions/personal stories, defining BME, an activity
    - Activity
        - 20-40 min fun hands-on activity with clear learning objectives
    - Report
    - Teacher/leader evaluation
- Where do you submit deliverables?
    - http://bmedesign.engr.wisc.edu/outreach/
    - Activity guide due December 14th, 2022
    - Final Outreach Deliverables due April 21st, 2023
- Where should we do the outreach activity (past outreach connections)?
    - Additional locations the outreach activity could take place could be in smaller group settings or clubs that kids might be apart of like Boy Scouts and Girl Scouts. This would allow us to connect better with kids and they can interact with the activity more since there wouldn't be as many kids. We could also make it more personalized or tailored to what they are most interested in so we can make a greater impact on them and teach them about engineering.

Conclusions/action items: With this information, the team can decide where they want to complete the outreach activity and what they want to do with the kids.

Last Semester Files-2/8/22

VICTORIA HEILIGENTHAL - Feb 08, 2022, 12:14 PM CST

Title: Last Semester Files

Date: 2/8/22

Content by: Victoria

Present: N/A

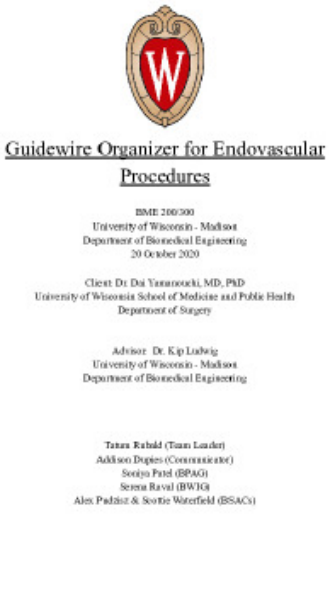
Goals: To document all the presentations and reports created by last semester's team since this project is continuing from last semester

Content:

ATTACHMENTS BELOW

Conclusions/action items: By having all the documents in one spot, it makes it easy to refer back to what was done last semester. As a new team member to this project, it also helps be to better understand the project.

VICTORIA HEILIGENTHAL - Feb 08, 2022, 12:15 PM CST



Guidewire Organizer for Endovascular Procedures

BME 200/300
University of Wisconsin - Madison
Department of Biomedical Engineering
20 October 2020

Client: Dr. Dai Yamamoto, MD, PhD
University of Wisconsin School of Medicine and Public Health
Department of Surgery

Advisor: Dr. Kip Ludwig
University of Wisconsin - Madison
Department of Biomedical Engineering

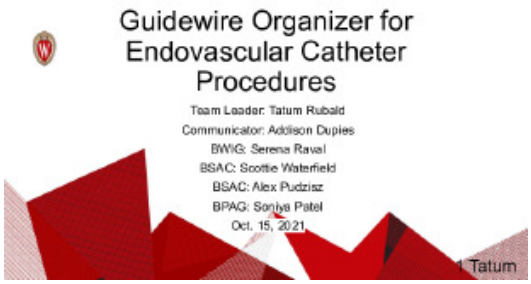
Tatum Rehfeld (Team Leader)
Addison Dupies (Communicator)
Soniya Patel (BPAG)
Serena Raval (BWIG)
Alex Paddisz & Scottie Waterfield (BSACs)

1

Download

endo_cath_Preliminary_Report.pdf (1.95 MB)

VICTORIA HEILIGENTHAL - Feb 08, 2022, 12:15 PM CST



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Preliminary_Presentation.pdf (1.18 MB)

VICTORIA HEILIGENTHAL - Feb 08, 2022, 12:15 PM CST

Product Design Specifications
Date of Last Revision: 09/21/2021

Title: Guidewire Organizer for Operation Room
Client: Dr. Dai Yamamouchi
Advisor: Dr. Kip Ludwig
Team: Tatum Rubald, Addison Dupies, Serena Raval, Scottie Waterfield, Alex Pudzisz, Soniya Patel

Function:
In many endovascular catheter related surgeries, surgeons must use multiple guidewires during a single procedure. These guidewires are hard to manage as they can get tangled and disorderly. This product aims to increase procedure efficiency and safety and decrease the time it takes for surgeons to organize the wires.

Client requirements:
- The device must be easy to use and increase organization in the operating room
- The device must consist of a main storing unit (the crate) to house 4-5 guidewire wheels
- The final device must ultimately have biocompatible properties*
- The final device must be sterilizable by autoclave or other alternatives*

*Client's main goal is a successful prototype and proof of concept

Design requirements:
1. Physical and Operational Characteristics
   a. *Performance requirements:* The device will consist of two parts: (1) a divided crate to store (2) 4-5 wheels in which the guidewires will be placed. The wheel must be able to hold guidewires with diameter sizes of 0.014 to 0.035 inches. Additionally, the guidewire must stay organized and unknotted when removed from the wheel; to do this there will be a lip on the edge of the crate for the guidewire to sit on. It must be easy to load and remove the wire into the wheel while in the operating room [1]. The wheels must also be easily placed and removed from the crate.
   b. *Safety:* The device should be able to withstand heavy chemicals such as, glutaraldehyde, formaldehyde, ethylene oxide that are needed to sterilize medical tools in the operating room [2]. Additionally, there should be no risk for the user and all edges must be smooth to prevent the risk of cuts through medical gloves [1].
   c. *Accuracy and Reliability:* In order for the device to comply with the requirements made by the client, it must be able to fit 4-5 catheter guidewires, which ideally fit within the 11.5 inch diameter of each wheel, and each wheel must be able to hold a 0.035, 0.018, 0.014 inch guidewire [1]. In addition to the precision it will take to design the device, it also must be able to undergo surgeries and have the ability to keep the multiple guidewires used during surgery organized so the operating room

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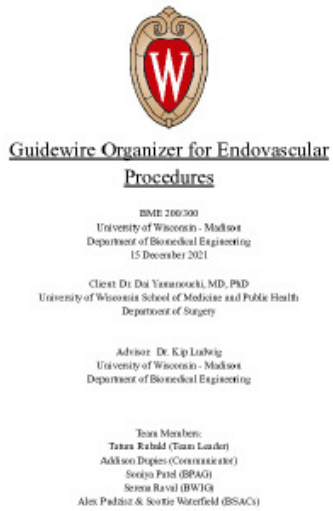
Endo_Cath_PDS.pdf (309 kB)

VICTORIA HEILIGENTHAL - Feb 08, 2022, 12:15 PM CST



Guidewire Organizer for Endovascular Procedures

BME 200/300
University of Wisconsin - Madison
Department of Biomedical Engineering
15 December 2021

Client: Dr. Dai Yamamouchi, MD, PhD
University of Wisconsin School of Medicine and Public Health
Department of Surgery

Advisor: Dr. Kip Ludwig
University of Wisconsin - Madison
Department of Biomedical Engineering

Team Members:
Tatum Rubald (Team Leader)
Addison Dupies (Communicator)
Soniya Patel (BPAG)
Serena Raval (BWIG)
Alex Padzisz & Scottie Waterfield (BSACs)

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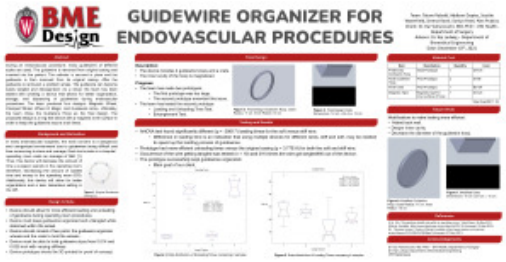
EndoCath_Final_Report.pdf (2.44 MB)

VICTORIA HEILIGENTHAL - Feb 08, 2022, 12:15 PM CST



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Poster_BME_300_-_ENDO_CATH.pdf (547 kB)

Last Semester Overview-2/8/22

VICTORIA HEILIGENTHAL - Feb 08, 2022, 12:16 PM CST

VICTORIA HEILIGENTHAL - Feb 08, 2022, 12:49 PM CST

Title: Last Semester Overview

Date: 2/8/22

Content by: Victoria Heiligenthal

Present: N/A

Goals: To document what the team last semester accomplished with the project

Content:

- Last semester
    - Design criteria
        - Device should allow for loading and unloading or guidewire during OR procedures
        - Device must keep guidewire organized and untangled while stationed within wheel
        - Device should have 2 parts: guidewire organizer wheels and crate to hold wheels
        - Device must hold guidewire sizes from 0.014 to 0.035 in
        - Should be able to be 3D printed
    - Final design
        - 4 guidewire hoops and cate
        - Inner cavity of hoop is magnetized
        - Team developed a prototype that was testing using loading and unloading time tests as well as an entanglement test
        - Cost $110
    - Results
        - Significantly different loading times were found for soft vs stiff wires
            - Indicates multiple devices might need to be produced depending on the wire type
        - Design had better unload times vs the original
        - No tangling and there were organization
    - Future
        - Modify crate
        - Make changes to device

Conclusions/action items: Understanding what the team did last semester is extremely important to know so the team can decide what worked well, what needs to be modified and brainstorm new changes to the device to meet the client's needs

Overview of Guidewires-2/8/22

VICTORIA HEILIGENTHAL - Feb 08, 2022, 12:47 PM CST

Title: Overview of Guidewires

Date: 2/8/22

Content by: Victoria

Present: N/A

Goals: To gain a basic understand and background of guidewires and catheters to know what the device will be used for

Content:

- Uses
  - placing stents into blood vessels to open blocked arteries
  - Guidewire is used with catheter to guide it for insertions
  - Gives access to blood vessels invasively
  - Catheter has needle that is inserted into veins, guidewire is placed through needle and passed into blood vessel
- Benefits
  - Faster recovery and less surgical trauma
- Navigation of guidewires and catheters in the body during intervention procedures: a review of computer-based models (nih.gov)

- Materials
  - Stainless steel
  - Alloy of nickel, titanium, nitinol
  - Coated in Teflon or perylene
  - Either solid or braided
  - Guidewire - an overview | ScienceDirect Topics (wisc.edu)
- Problems
  - Kinking, breakage, loss, knotting of guidewire
  - A lost guidewire (nih.gov)

Conclusions/action items: By understanding the general concepts behind the need for the device, it makes it easier to begin the design brainstorming process.

Endovascular Procedure video-2/28/22

VICTORIA HEILIGENTHAL - Feb 28, 2022, 8:21 PM CST

Title: Endovascular Procedure Video

Date: 2/28/22

Content by: Victoria

Present: N/A

Goals: To better understand the procedures our device will be used for

Content:

- Endovascular: treating blood vessel disorders with balloons, stents and other devices that are placed inside the vessels
  - Increase blood flow
- Less invasive, avoid anesthesia
- Balloon angioplasty
  - Widens blood vessels due to constriction from plaque from breaking the plaque and extending the blood vessel through a balloon
- Stents
  - Support broken plaque during healing
  - Flexible, small delivery system
  - Not always effective
- Endographs: treating aneurisms with stents covered in fabric, similar to endovascular procedures
  - Prevent aneurism rupture
  - Relining the weakened blood vessel

History of Endovascular Surgery - YouTube

Conclusions/action items: By watching this video, I can now better understand the setting and situation that the wheel and stand devices will be used and how they will be beneficial on the market.

Endovascular Procedure-2/28/22

VICTORIA HEILIGENTHAL - Feb 28, 2022, 8:42 PM CST

Title: Endovascular Procedures

Date: 2/28/22

Content by: Victoria

Present: N/A

Goals: To better understand the risks and purposes for endovascular procedures

Content:

Endovascular Surgery | Conditions & Treatments | UCSF Health

Endovascular surgery: less invasive to treat problems that affect the blood vessels

- What does it treat?
  - Blood vessel disorders like aneurysms
- How does it work?
  - A small incision is made close to blood vessels to gain access to them
  - A guidewire is inserted into the incision and pushed through the blood vessel to the point of interest
    - Uses an X-Ray to locate the aneurysm
  - An endovascular graft is inserted into the arteries using a catheter
    - Graft: Fabric tube with stainless steel self-expanding stents
    - Catheter: Long and narrow tube that is flexible
  - The graft expands and seals off aneurysms, preventing blood flow into it
    - Graft is permanent
- Benefits
  - Less invasive than open surgery, which was the old method
  - Shorter recovery period
  - Less discomfort
  - Smaller incisions
  - Low risk
- Risks
  - Blockage of blood flow through graft
  - Infection
  - Leaking of blood around graft
  - Movement of graft away from position
  - Graft breaking

Conclusions/action items: I now understand how the procedures take place as well as the benefits and risks of the procedures.

Aneurysm Information -2/28/22

VICTORIA HEILIGENTHAL - Feb 28, 2022, 8:48 PM CST

Title: Aneurysm Information

Date: 2/28/22

Content by: Victoria

Present: N/A

Goals: To understand the problem that our device will be used to help fix

Content:

What is an Aneurysm? | American Heart Association

Aneurysm: artery wall weakens, causing it to widen or balloon

- Aneurysm types
  - Can occur in any artery
  - Most common in aorta, brain (cerebral), popliteal artery (behind knee), mesenteric artery (blood to intestine) and splenic artery (spleen)
- Symptoms
  - Headache
  - Abdomen or back pain
  - Pulsating abdominal mass
  - Confusion
  - Dizziness
  - Fatigue
  - Blue coloration of lower extremities
- Causes
  - Family
  - Born with
  - Disease or injury
- Treatment
  - Surgery
- Lowering risk
  - Lowering high blood pressure
  - Eating healthy
  - Exercise
  - Not smoking or using tobacco

Conclusions/action items: Since endovascular procedures typically treat aneurysms, it is important that I understand this condition, so I know how our device relates to it.

Math and chemistry-2/28/22

VICTORIA HEILIGENTHAL - Feb 28, 2022, 8:53 PM CST

Title: Math and chemistry

Date: 2/28/22

Content by: Victoria

Present: N/A

Goals:

Content:

The current standing of this project does not require math, statistics or chemistry research.

Conclusions/action items: Alter this entry as project progresses

Vascular Procedures for Executive Summary-4/21/22

VICTORIA HEILIGENTHAL - Apr 21, 2022, 1:01 PM CDT

Title: Vascular Procedures for Executive Summary-

Date: 4/21/22

Content by: Victoria

Present: N/A

Goals: To understand how many vascular procedures are carried out each year

Content:

Predicted shortage of Vascular Surgeons in the United States: Population and workload analysis - ScienceDirect (wisc.edu)

- Predicted that 1,020,067 surgeries would be done in 2020
  - Correct estimation based on other research done by other team members
- Demand for vascular surgeons is increasing

By creating devices to make endovascular surgeries easier, it could allow surgeons from other departments to use them without much additional training.

Cardiac (Heart) Catheterization Procedures | UPMC

- 23,000 vascular surgeries carried out in a year at this center alone
- Shows the demand for vascular surgeries
- Making advancements would help with surgery costs

Conclusions/action items: This information can be used in our executive summary to support our point that the endovascular department of surgeries is increasing and that demands are high for better equpiment.

Guidewire storage devices-2/8/22

VICTORIA HEILIGENTHAL - Feb 08, 2022, 12:45 PM CST

Title: Guidewire storage devices

Date: 2/8/22

Content by: Victoria

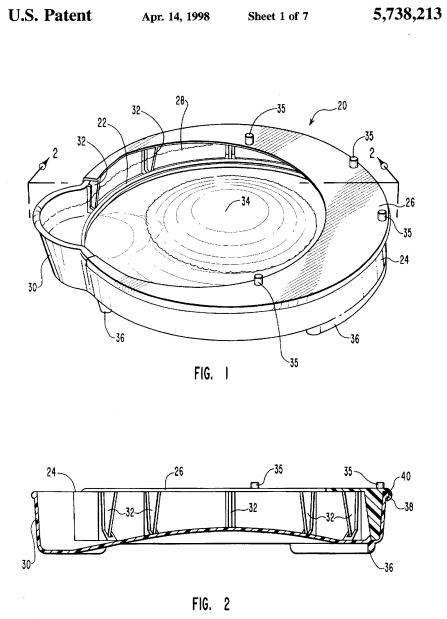
Present: N/A

Goals: To show competing guidewire storage devices

Content:

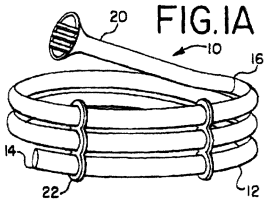
US5738213A - Guidewire holder with easy guidewire access - Google Patents

- Stores and retrieves coil guidewires
- US5738213A

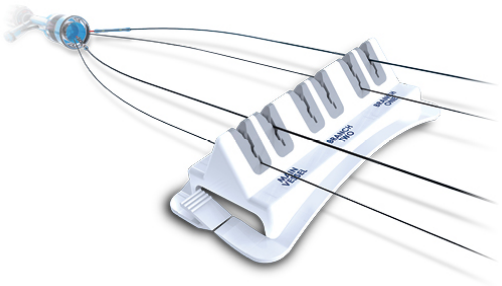
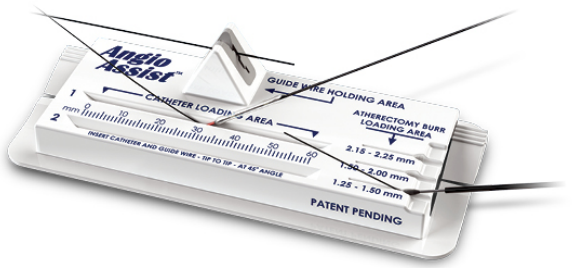


EP1145730A1 - Medical guidewire storage method and apparatus - Google Patents

- Flexible pipe that can be turned or coiled to store guidewires
- One end is open to allow for guidewires to be inserted and take out
- EP1145730A1



Interventional Accessories | US | Teleflex

- Teirstein Edge™ Device Organizer
  - Has 6 slits to organize guidewires and catheters
  - Easy identification of guidewires and minimizes loss of guidewires
  - 
- Angio Assist™ Docking Station
  - Holder for single-operator procedures
  - Has catheter loading area and guidewire holding area
  - 

Conclusions/action items: By researching these devices already on the market, the team can see what has worked well as well as to gain inspiration from when designing the requested device for the client.

CathClip-2/17/22

VICTORIA HEILIGENTHAL - Feb 17, 2022, 7:41 PM CST

Title: CathClip Competing Design

Date: 2/17/22

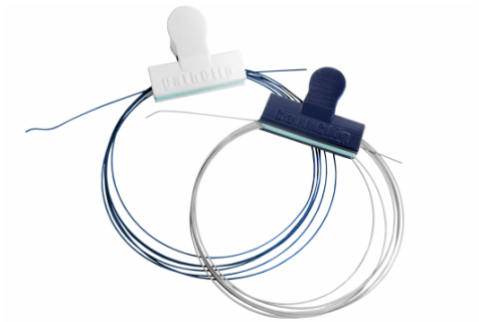
Content by: Victoria

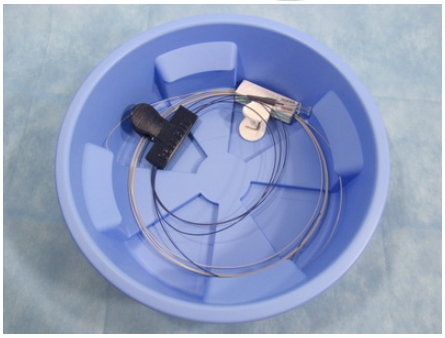
Present: N/A

Goals: To document the primary leading competitor on the market

Content:

CathClip - Device Management Tool to Improve Profitability and Safety/Outcomes - Dropped and damaged devices? CathClip can help.



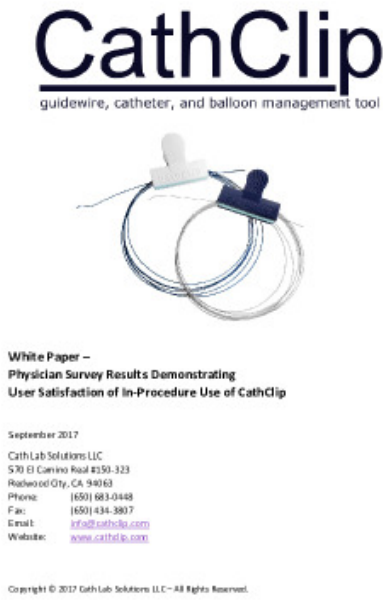


- Functions
  - Simply clips around guidewire loop
  - Dip into saline before use
  - Unclip when ready to use guidewires again
  - Can be reused during procedures, but should be discarded afterwards
  - Fits into standard bowls
- Structure
  - Foam grip pads that are durable and soft to hold any wire without damage
  - Have absorptive gripping pads that remain moist after dipping in the saline solution
  - 2" x 2.25" x 1.25" (palm of hand)
  - Sterile, biocompatible, latex-free
- Benefits
  - Can hold stiffest and most fragile wires
  - Saves a lot of time compared to standard wire techniques like clipping with kelly forceps, wrapping the wire or returning it to the packaging
  - Avoids damage to wires
  - Multiple wires can be held in one bowl
  - Reduces procedure costs

    - Decreases procedure time
    - Easier use for doctors
    - Reduces material costs from damaging wires
    - Reduces risk of infection
- Instructions for use
    - Remove CathClip from sterile packaging.
    - Wet CathClip's gripping pads with saline solution; CathClip is now ready to hold a guidewire, catheter, balloon, or similar flexible elongated device. One CathClip should hold only one flexible elongated device at a time.
    - Discard CathClip at the conclusion of the procedure.
- Testing to show saves time
    - PDF attached
    - Team could use a similar testing method to show quantitative results
    - Tested different wires and compared other techniques to those of the CathClip to show that CathClip worked faster
- Saves Material costs
    - PDF attached
    - Shows how money is saved from not wasting or damaging guidewires
- Physician approval
    - PDF attached
    - Shows that physician approve of the product and say the device is efficient
- Cost
    - Cost not posted

Conclusions/action items: By looking into the CathClip, the team can see how the device was designed, what has worked well, how the device was tested quantitatively and qualitatively, and what improvements could be made. Since this device is the team's top competitor currently on the market, it is important to understand the product so the one developed by the team can be even more efficient.

VICTORIA HEILIGENTHAL - Feb 17, 2022, 7:41 PM CST



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white_paper_-_physician_survey_results_1.pdf (631 kB)

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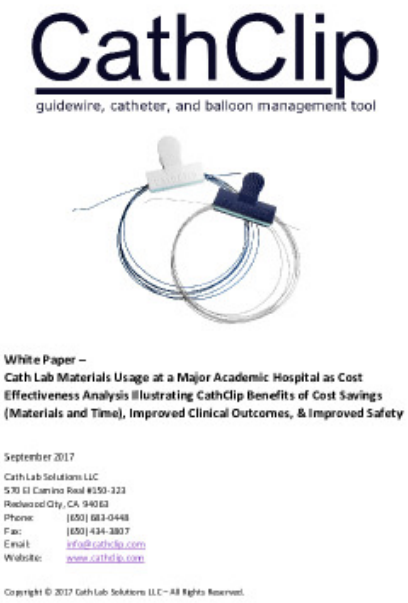
CathClip
guidewire, catheter, and balloon management tool

White Paper –
Cath Lab Materials Usage at a Major Academic Hospital as Cost Effectiveness Analysis Illustrating CathClip Benefits of Cost Savings (Materials and Time), Improved Clinical Outcomes, & Improved Safety

September 2017

Cath Lab Solutions LLC
570 El Camino Real #150-323
Redwood City, CA 94063
Phone: (650) 683-0448
Fax: (650) 434-3807
Email: info@cathclip.com
Website: www.cathclip.com

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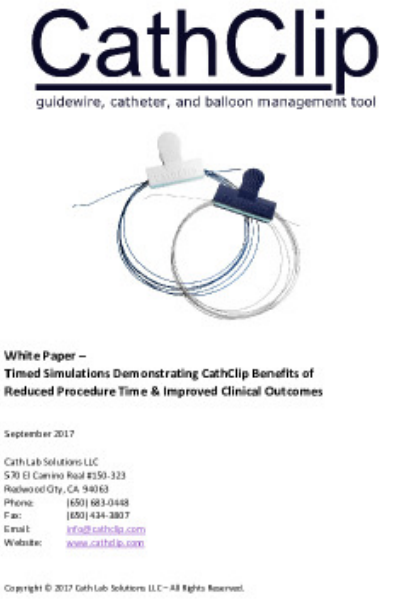
white_paper_-_cath_lab_materials_usage_1.pdf (868 kB)

VICTORIA HEILIGENTHAL - Feb 17, 2022, 7:41 PM CST


CathClip
guidewire, catheter, and balloon management tool

White Paper –
Timed Simulations Demonstrating CathClip Benefits of Reduced Procedure Time & Improved Clinical Outcomes

September 2017

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Materials Alternatives-2/17/22

VICTORIA HEILIGENTHAL - Feb 17, 2022, 11:55 AM CST

Title: Materials Alternatives

Date: 2/17/22

Content by: Victoria

Present: N/A

Goals: Both our client and advisor recommended we look into other materials we could use for the stand other than PLA

Content:

The team originally was planning on using PLA to print the stand, but the client and advisor suggested we look into other options. The first prototype might still be printed with PLA in the case that changes to the design must first be made.

Ultimaker:

- Ultimaker Tough PLA
  - Ultimaker Tough PLA material: Create durable prototypes and tooling
  - Similar strength and higher stiffness than ABS
  - Greater machinability than PLA
  - Creates tough plastic parts, but allows for complex geometries
  - Flexural strength -78 MPA
  - Impact strength (Izod tested to 9 kJ/m²)
  - Hardness (79 Shore D)
  - Melting temperature (151 °C)
  - This material could be a good consideration for the team since it is similar to the original PLA, but it is stronger and more durable while allowing for complex printing patterns. This would allow for the stand to be sturdy and to have each component printed properly.
- Ultimaker PC
  - Ultimaker PC material: Strong, tough, and heat-resistant material
  - Strong, tough and maintains shape in high temps
  - Tensile strength (59.7 MPa at break)
  - Impact strength (Charpy tested to 3.41 J/m)
  - Melting temperature (Mass flow rate at 300 °C: 23 - 26 g/10 min)
  - Glass transition at 112 - 113 ºC
  - This material is another good option, but it might be too strong and stiff for what the team needs. The team also does not need a material that will withstand such high temperatures since it will only be in ORs.
- Ultimaker ABS
  - Ultimaker ABS material: 3D print durable and tough prototypes
  - Good adhesion- might be good when adding weights to bottom of design to prevent tipping
  - Flexural strength (70.5 MPa)
  - Impact strength (Izod tested to 10.5 kJ/m²)
  - Hardness (76 Shore D)
  - Melting temperature (from 225 °C)
  - This could be another very good option. It is durable and strong and is similar to PLA. This is also adhesive, which would be good if weights are adding to the design.

Formlabs:

- Biomed Clear Resin
  - 3D Printing Materials For Healthcare (formlabs.com)
  - Good for medical device and surgical planning tools
  - Good for R&D
  - Biocompatible, short-term skin contact
  - compatible with disinfecting and sterilizing
  - Could be good since the guidewires must also be sterile in the OR
- Rigid Resin
  - Resin Family: Rigid (formlabs.com)
  - Very stiff
  - Very resistant to heat and chemicals
  - Withstand load without bending
  - Another good option for printing
- Tough 1500
  - 3D Printing Materials For Healthcare (formlabs.com)
  - Similar strength and stiffness to polypropylene
  - Good for devices
  - Very resilient and is certified for skin contact
  - Stiff and pliable
  - Could be good since the guidewires must also be sterile in the OR and the stand might need to be a little pliable and flexible

Conclusions/action items: It is important that the team is aware of the material options for 3D printing at the Makerspace that we can consider for the final design.

Team Design Ideas for Stand-2/17/22

VICTORIA HEILIGENTHAL - Feb 17, 2022, 11:27 AM CST

Title: Team Design Ideas for Stand

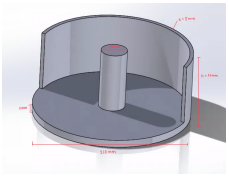
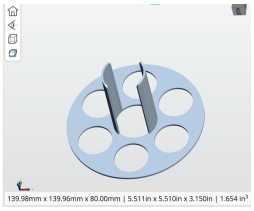
Date: 2/17/22

Content by: Victoria

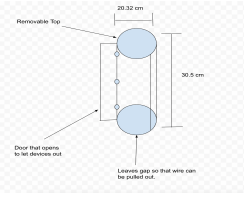
Present: N/A

Goals: To generate design ideas for the stand to use in the team's design matrix

Content:

- UHold Design- Design by Tatum
- 
- This design has similar dimensions to the standard stand created by our client, Dr. Y. This design differs by including a back wall to hold the wheels in the stand, but still allows for easy access as well as being easy to learn how to use. This design seems to be very durable since it is sturdy, and it will be compatible with storing in different ORs and with the use of wheels that contain varying guidewire types, however the back wall could introduce some limitations of wheel size.
- DYStand-Designed by client, Dr. Y
- 

- This stand was design by our client and is serving as the "standard" design that the team is aiming to develop an alternative stand design from. This stand is very similar to the UHold design, just without a back wall and it also contains slits for the middle projection. This slit helps with ease of insertion and removal of the wheels. This design seems durable, but not as durable as the UHold design since it is thinner and doesn't have the back wall component. It will be compatible with storing in different ORs and with the use of wheels that contain varying guidewire types.
- Door Stand- Designed by Alex



This design includes a door design that allows to remove the guidewire wheels. It would be more difficult to learn how to use this design, it might not be as compatible for varying wheels and ORs, and it overall would be more difficult to design.

Conclusions/action items: The different design generated by the team allow the team to assess what the best device is to be the focus of the project.

SolidWorks Files for UHold and wheel - 2/28/22

VICTORIA HEILIGENTHAL - Feb 28, 2022, 8:49 PM CST

Title: SolidWorks Files for UHold and wheel

Date: 2/28/22

Content by: Victoria

Present: N/A

Goals: To include the SolidWorks Files for UHold and wheel devices

Content:

Files attached below

Conclusions/action items: The team can continue to progress through the project.

VICTORIA HEILIGENTHAL - Feb 28, 2022, 8:49 PM CST

Download

DYSpool.stl (900 kB)

VICTORIA HEILIGENTHAL - Feb 28, 2022, 8:49 PM CST

Download

DYWheel.stl (736 kB)

VICTORIA HEILIGENTHAL - Feb 28, 2022, 8:49 PM CST

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ShortSpout.STL (359 kB)

VICTORIA HEILIGENTHAL - Feb 28, 2022, 8:49 PM CST

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UHold.STL (26 kB)

Alternative 3D printing options-3/24/22

VICTORIA HEILIGENTHAL - Mar 24, 2022, 11:44 AM CDT

Title: Alternative 3D printing options

Date: 3/24/22

Content by: Victoria

Present: N/A

Goals: To find alternative locations and material options for 3D printing

Content:

After the team conducted loading and unloading testing of the wheel designs, it was clear that the PLA material used at the MakerSpace was too brittle and was easily breakable, especially compared to the client's design. Due to this, the team must find alternative material options or locations to 3D print the wheel design. Alternative materials can be found in my section of "Materials Alternatives" that show different materials from different types of 3D printers at the MakerSpace. Below are some other locations that the team could 3D print from instead for a sturdier material.

- UPS
  - 3D Printing | 3D Print Services | The UPS Store
  - Regent St location
  - Materials used and prices cannot be found on website
- Stratasys printing
  - Local 3D Printing Services - New (stratasysdirect.com)
  - Located in Madison
  - Materials used and prices cannot be found on website
- Others found on MakerSpace website
  - All external
    - Midwest Prototyping
    - Engman-Taylor
    - Ponoko
    - Shapeways
    - Xcentric
    - Hubs

Conclusions/action items: If an alternative location needs to be found for 3D printing, these could be options.

Executive Summary Video-4/28/22

VICTORIA HEILIGENTHAL - Apr 28, 2022, 8:39 PM CDT

Title: Executive Summary Video

Date: 4/28/22

Content by: Victoria

Present: N/A

Goals: To show the teams Executive Summary Video for the final presentation

Content:

Since I was not going to be able to make it to the final presentations, I recorded the executive summary portion for the team to play at the presentation.

Conclusions/action items: The team can present at final presentations.

VICTORIA HEILIGENTHAL - Apr 28, 2022, 8:39 PM CDT

Download

Executive_summary.mp4 (7.86 MB)

All Designs-4/29/22

VICTORIA HEILIGENTHAL - Apr 29, 2022, 8:26 PM CDT

Title: All team designs

Date: 4/29/22

Content by: Victoria

Present: N/A

Goals: To show the teams designs from the semester

Content:

Tatum's folder shows the designs that the team tested or data analysis.

Conclusions/action items: The team can analyze data from testing

Testing Alternatives-2/17/22

VICTORIA HEILIGENTHAL - Feb 17, 2022, 12:28 PM CST

Title: Testing Alternatives

Date: 2/17/22

Content by: Victoria

Present: N/A

Goals: Our advisor recommended we look into other forms of quantitative testing other than the ones the team has already conducted previously

Content:

Last semester, the team conducted testing where they timed how long it took to load and unload the guidewires into the wheel as well as an entanglement test where the device was walked around to see if entanglement occurred. Results from testing last semester can be found in the files in the "Last Semester" folder. Since this semester will mainly surround around testing the client's wheel prototype, our advisor suggested we come up with other quantitative ways of testing. We will also need to find another doctor, resident or student to test the device to replicate the use in the OR and since if the team members tested it, bias could be included.

Ideas:

- Continue timing-important for design matrix components
- Compare timing from different guidewire types
- Conduct timing across multiple people
- Count number of times entanglement occurred during testing?

Conclusions/action items: The team can continue to investigate and brainstorm different testing ideas as that time approaches

Preliminary Unloading Graphs-4/5/22

VICTORIA HEILIGENTHAL - Apr 05, 2022, 9:35 PM CDT

Title: Preliminary Unloading Graphs

Date: 4/5/22

Content by: Victoria

Present: N/A

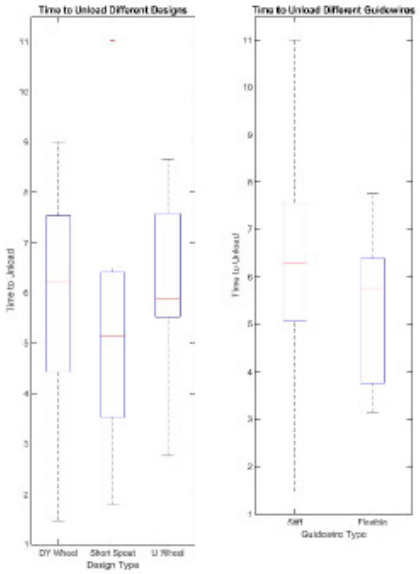
Goals: To show the results from preliminary testing in a visual form

Content:

Attached to this entry are graphs generated for the unloading portion of preliminary testing. The first plot is a bar graph that shows the number of times a rating number was given for each design and for each guidewire type. The second plot is a box plot that show the time of unloading for each design and for each guidewire type.

Conclusions/action items: The team can continue to analyze this data and use it for future testing.

VICTORIA HEILIGENTHAL - Apr 05, 2022, 9:36 PM CDT



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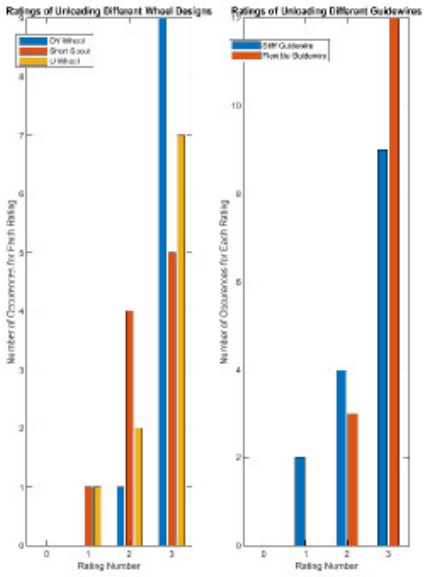
VICTORIA HEILIGENTHAL - Apr 05, 2022, 9:36 PM CDT



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Final Unloading Graphs-4/28/22

VICTORIA HEILIGENTHAL - Apr 28, 2022, 8:36 PM CDT

Title: Final Unloading Graphs

Date: 4/28/22

Content by: Victoria

Present: N/A

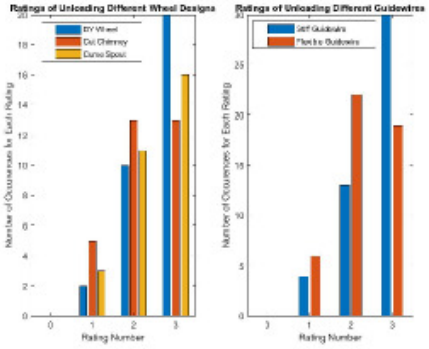
Goals: To show the results from final testing in a visual form

Content:

Attached to this entry are graphs generated for the unloading portion of final testing. The first plot is a bar graph that shows the number of times a rating number was given for each design and for each guidewire type. The second plot is a box plot that show the time of unloading for each design and for each guidewire type.

Conclusions/action items: The team can continue to analyze this data for final presentations

VICTORIA HEILIGENTHAL - Apr 28, 2022, 8:37 PM CDT



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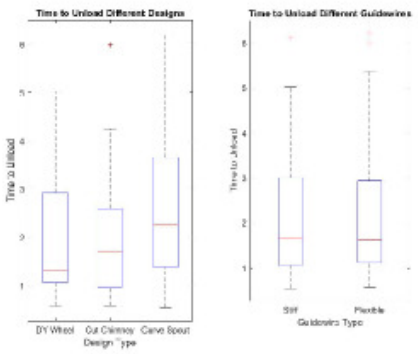
POSTUnload_Bar.pdf (81 kB)



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ANOVA Results-4/29/22

VICTORIA HEILIGENTHAL - Apr 29, 2022, 8:24 PM CDT

Title: ANOVA Results

Date: 4/29/22

Content by: Victoria

Present: N/A

Goals: To show the results from ANOVA tests run on the final unloading and loading data.

Content:

Attached to this entry are files that show the statistics from an ANOVA test run for the unloading and loading data for each of the designs. One of the most important statistical pieces of data of the p-value. Thees results show that the difference between the designs were not significant.

Conclusions/action items: The team can continue to analyze this data for final presentations

VICTORIA HEILIGENTHAL - Apr 29, 2022, 8:24 PM CDT

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ANOVA Table

Source	SS	df	MS	F	Prob>F
Columns	4.431	2	2.36812	1.48	0.2332
Error	174.458	87	1.36319		
Total	185.389	89			

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WARF Lecture-3/19/2022

VICTORIA HEILIGENTHAL - Mar 19, 2022, 8:00 PM CDT

Title: WARF Lecture

Date: 3/19/22

Content by: Victoria Heiligenthal

Present: N/A

Goals: To take notes on the WARF lecture and understand how it relates to our team's project

Content:

- Beginning
  - Patenting and licensing for UW-Madison
  - Patenting innovations on campus for industry
  - Non-profit and separate from university
- Who they Are
  - Provide financial support, managing assets and move innovations into the marketplace
- Cycle of innovation
  - UW research and discovery
  - IP protection (patenting)
    - In the US
  - Licensing's and startups
  - Funding to support research and discovery
    - Grant to university
    - Royalties to inventors
- Protecting innovation
  - Patents
    - machines and devices, compounds, processes and methods, improvements
  - Trademarks
    - Words and phrases, colors, pictures, sound
  - Copyrights
    - Literary works, webpages, software programs
  - Trade secrets are not available for university because mostly presented at the school
- Prior art
  - "references" created before a specific data
    - By inventor: more than a year before filling date of patent application
    - By another: before filling date of patent application
  - Have a grace period
    - Other countries do not have grace period
- Public disclosure and prior art
  - Examples: journal publication, talk or poster, dissertation, description on internet site
  - Sharing innovation to people
- Requirements of patentability
  - eligible, useful, enabled, described, novel, non-obvious
  - Examine and assess innovation
  - Based on requirements and prior art to see if done before or not
  - Time intensive
- WARF's IP process
  - invent and disclose to WARF

    - Disclosure committee meets monthly to review new disclosures
    - Patent application drafting, filing and prosecution
    - Technology marketing
    - Licensing
- Licensing considerations for new disclosures
    - Chance of licensing
    - Timeline for licensing
    - Licensing strategy
    - Plan for next year
    - revenue projections
- Licensing innovation
    - WARF provides exclusive or non-exclusive rights to make, use sell or import
    - Licensee provides development, fees, obligations
    - Timeline varies for licensing
- WARF's accelerator program
    - milestone-based validation funding to speed promising techs to a commercial lease
    - Accelerate prospects for WARF IP
    - Different sectors
    - Results in licenses and money
- Finding a licensee
    - Internal (inventor contacts, meetings, sponsored research) or external (publications, targeting outreach)
- Start-up resources
    - D2P
        - Campus-wide resource for entrepreneurship
        - Innovation funding
    - Innovation roadmap series
- WARF has accepted BME projects

I think our design definitely has intellectual property. Although there are devices on the market that meet the same goal as ours, our device is unique and is more efficient than other devices currently on the market.

Conclusions/action items: If our device is successful, I believe we could file for a patent.

2014/11/03-Entry guidelines

John Puccinelli - Sep 05, 2016, 1:18 PM CDT

Use this as a guide for every entry

- Every text entry of your notebook should have the **bold titles** below.
- Every page/entry should be **named starting with the date** of the entry's first creation/activity, subsequent material from future dates can be added later.

You can create a copy of the blank template by first opening the desired folder, clicking on "New", selecting "Copy Existing Page...", and then select "2014/11/03-Template")

Title: Descriptive title (i.e. Client Meeting)

Date: 9/5/2016

Content by: The one person who wrote the content

Present: Names of those present if more than just you (not necessary for individual work)

Goals: Establish clear goals for all text entries (meetings, individual work, etc.).

Content:

Contains clear and organized notes (also includes any references used)

Conclusions/action items:

Recap only the most significant findings and/or action items resulting from the entry.

2014/11/03-Template

John Puccinelli - Nov 03, 2014, 3:20 PM CST

Title:

Date:

Content by:

Present:

Goals:

Content:

Conclusions/action items:

BME Design - Spring 2022 Notebook

TATUM RUBALD - Sep 13, 2022, 6:45 PM CDT

BME Design-Spring 2022 - TATUM RUBALD
Complete Notebook

PDF Version generated by
TATUM RUBALD
on
Sep 13, 2022 @06:31 PM CDT

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