Design Document

Team: Deaf Kids Code

Project: DCC

Date: July 29, 2019

1 Table of Contents

2 Revision History

Date	Author	Revisions Made
7/31/2019		

3 Design Status

Phase 6: Service / Maintenance	**Status:** To be done **Semester:** *following*

Phase 5: Delivery	**Status:** To be done **Semester:** *summer 2019*

Phase 4: Detailed Design	**Status:** In Process **Semester:** *summer 2019*

Phase 3: Conceptual Design	**Status:** Completed **Semester:** *summer 2019*

Phase 2: Specification Development	**Status:** Completed **Semester:** Fall 2018

Phase 1: Project Identification	**Status:** Completed **Semester:** Spring 2018 / Fall 2018

***Note:** Identify which of the three (Completed/ In Process/ To be done) your project is in.

4 Project Charter

4.1 Description of the Community Partner

Our Project Partner, Blake Widmer, founded "Deaf Can! Coffee" (DCC), an on-campus coffee shop located at the Caribbean Christian Centre for the Deaf in Kingston, Jamaica and is operated by deaf and hard of hearing (DHH) student employees. Widmer and some of the students started off making coffee as a hobby, and it has since grown into a business. They now have a mobile coffee shop where they train students the art of being a barista. It is their goal to train the students to become baristas, thereby providing a way for the students to provide for themselves in an otherwise tough environment. Our project is to create a coffee bean huller to remove the hull from coffee beans. Designing this huller will remove the timely manual labor required to remove the parchment by hand, thus allowing more time spent improving other areas in the coffee making process. This project is specifically designed for Widmer and DCC, but small-scale farmers may also be interested in a cost effective and efficient small-scale coffee bean huller.

4.2 Stakeholders

Primary stakeholders –

- Deaf Can! Coffee Student Employees
  - The DCC student employees will be the direct users of the coffee bean huller. The huller will be operated daily by deaf and hard of hearing (DHH) employees. Increasing production rate and eliminating manual labor allows for more time allocated towards learning about coffee and perfecting the coffee brewing process.
- Project Partner, Blake Widmer
  - Blake Widmer is the project partner specifying the project needs. Widmer is the direct contact and his wants are placed at the forefront of the coffee bean huller design according to the coffee shop and student needs

Secondary stakeholders –

- DCC Customers
  - With a dramatic increase rate of production of hulled coffee beans, DCC has the possibility of decreasing costs of coffee with reduced manual labor and increased efficiency, impacting customers.
- Purdue University EPICS, DKC-DCC
  - Purdue University EPICS' DKC-DCC team is the designer of the coffee bean huller. When the product is delivered, the team is responsible for whether the coffee bean huller works or not, as well as

any changes necessary moving forward. The DCC team serves as larger representatives of Purdue University.

- Caribbean Christian Centre for the Deaf – Kingston, Jamaica

  - DCC is located at the Caribbean Christian Centre for the Deaf in Kingston Jamaica. With DCC increasing production rate and automating the coffee bean hulling process, the school is affected by the coffee produced, profit, and prospective DCC full-time coffee shop.

- Small-scale farmers

  - With the development of a cost efficient yet effective small-scale coffee bean huller, small-scale farmers may be interested as one does not yet exist.

4.3 Project Objectives

The DCC team's objective is to design and construct a cost efficient yet effective friendly small-scale coffee bean huller to remove the hull from the coffee beans and sort the removed hull from the hulled beans.

As of January 2019, Deaf Can! Coffee currently pulps coffee cherries at a rate of 150 lbs/hr. The next step after coffee cherries are pulped is to dry the core. Then, the coffee beans need to be hulled. DCC's current means of hulling beans is unconventional and inefficient. The hulling rate is inconsistent and not practical enough for DCC to regularly hull their own beans. DCC hopes to hull beans in 16 lbs. per hour batches.

The following specifications are defined by the needs of the project partner:

- The system will be used minimally before roasting season, i.e. the system will not be used on a daily basis.
- The system must hull beans at a minimum hulling rate of 70%
- The system must not exceed 1m x 1m x 1m
- The system must produce a minimum of 16 lbs./hr. of hulled beans
- The system will be operated indoors from an electric power source.
- The system must be small and portable.
  - The system must be able to fit in the trunk of a vehicle, e.g. minibus.

4.4 Outcomes/Deliverables

The outcome of this project is a cost efficient yet effective automated small-scale coffee bean huller that is transportable and deaf and hard of hearing (DHH) friendly. The completed project will be delivered to Deaf Can! Coffee in Kingston, Jamaica.

4.5 Expected Semester Timeline

The Summer 2019 DCC team is the fourth iteration of this project. The spring 2019 semester has provided elaborate design ideas and prototypes. As a result, we are continuing to develop the project from where the team left off. The needs of the coffee bean huller have been defined based on information provided by the project partner, and we are currently in the process of working on the first prototype based on the latest specification provided by the project partner. However, that is contingent on completing of prototypes, success of hulling, and project partner feedback.

Major milestones for the Spring 2019 semester are as follows:

- Conceptual Design Phase
    - Brainstorm several solutions
    - Gather feedback
    - Evaluate feasibility of solutions
    - Choose best solution
- Detailed Design Phase
    - Development of component designs
    - Develop design specification
    - Prototyping of project, sub-modules and/or components

5 Semester Documentation (current semester)

5.1 Team Members

Name	Role	Responsibility
Abdulrahman Alsalem	Design Lead	*Oversees the project and helps members with their roles*
Mohammed Alhazmi	Project Partner Liaison	*Keeps in contact with Blake, and checks if we are meeting his needs*
Riyadh Alghamdi	Project Archivist	*Keeps documentation of the work in check.*
Safi Khayyat	Member	*Work and help other members of the team in their roles*
Khalid Alothman	Member	*Work and help other members of the team in their roles*

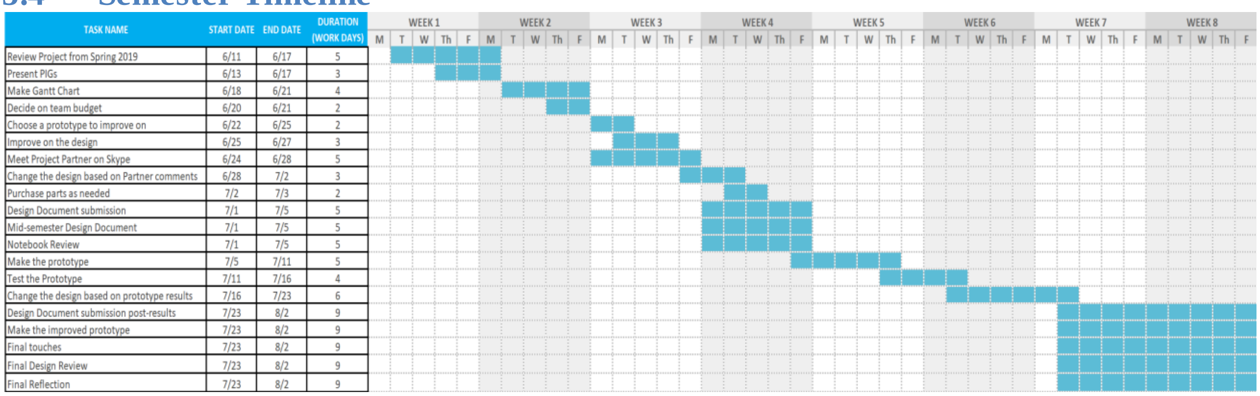
5.2 Current Status and Location on Overall Project Timeline

After making a decision matrix (see 6.5), we chose concept design 3 (see 6.4.3). After that, we started prototyping. We had two things two work on, which were the space between the plates and a material to put on the disks. These changes are important so that the beans do not get damaged. Currently, we found a way to manipulate the spacing between the plates, and we found a very good type of material that is both durable and soft enough so that it doesn't break the beans.

5.3 Goals for the Semester

The goal for this semester is to design a coffee huller that could be automated. The huller should be fully automated, less than 1 m^3 in volume, has a production rate of 16 lbs./hr., has a separation system, has a 70% hulling rate, and able to hull different bean sizes without damaging them. After designing the huller, we are going to make different prototypes to ensure that the hulling mechanism is working. Our goals for this semester do not include automating the product.

5.4 Semester Timeline



TASK NAME	START DATE	END DATE	DURATION (WORK DAYS)
Review Project from Spring 2019	6/11	6/17	5
Present PIGs	6/13	6/17	3
Make Gantt Chart	6/18	6/21	4
Decide on team budget	6/20	6/21	2
Choose a prototype to improve on	6/22	6/25	2
Improve on the design	6/25	6/27	3
Meet Project Partner on Skype	6/24	6/28	5
Change the design based on Partner comments	6/28	7/2	3
Purchase parts as needed	7/2	7/3	2
Design Document submission	7/1	7/5	5
Mid-semester Design Document	7/1	7/5	5
Notebook Review	7/1	7/5	5
Make the prototype	7/5	7/11	5
Test the Prototype	7/11	7/16	4
Change the design based on prototype results	7/16	7/23	6
Design Document submission post-results	7/23	8/2	9
Make the improved prototype	7/23	8/2	9
Final touches	7/23	8/2	9
Final Design Review	7/23	8/2	9
Final Reflection	7/23	8/2	9

5.5 Semester Budget

5.5.1 Concept idea 2 cost:

Item	Price ($)
Fan	20
Rubber sheet	5
Ply wood	10
Motor	100
PVC tube	20
Electric wires	7
Funnel	15
Total	**177**

5.5.1 Concept idea 3 cost:

Item	Price ($)
Corn grinder	25
Rubber sheet	10
Motor	100
Electric wires	7
Fan	20
Total	**162**

Note: We are currently working on concept idea 3. If the prototype is successful, we can dismiss the budget of concept idea 2.

5.6 Transition Report

5.6.1 Summary of Semester Progress / Comparison of Actual Semester Timeline to Proposed Semester Timeline

We have thus far made significant progress in the design process. We began the semester with a conversation with Blake Widmer, our project partner, to establish the objective of the project as well as basic design requirements. Doing so has helped us redefine design requirements and has, in fact, provided different project partner needs. Moving forward, with the new parameters that we were handed we tried to further improve the Lazy Suzan, the first prototype of the last semester. We took the essence of the idea and then we tried to make it more efficient in terms of the mechanical aspect. That was achieved by increasing the distance of two plates of a corn grinder; thus, we have changed the purpose of the grinder from grinding corn to hulling coffee. We also experimented on several different materials to help in improving the hulling and limit the amount of the coffee beans breaking.

At the end of Summer 2019, we can conclude that we have followed the proposed timeline we have provided in the beginning of the semester. We have made a prototype and we would have finished testing it in different cases.

5.6.2 Draft Timeline for (next semester) and Relationship to Overall Project Timeline

We recommend the next team to analyze our prototype and understand how it works. The two major steps that the next team needs to implement are a separation mechanism, to separate the hull from the beans, and complete automation. They are expected to automate the device so that it takes an input of coffee beans (with hulls) and outputs beans without hulls. Finally, they can start turning it into a deliverable product.

<table>
<tr><th colspan="7">Draft Timeline for Fall 2019 Semester</th></tr>
<tr><td>Week 1</td><td>Week 2</td><td>Week 3</td><td>Week 4</td><td>Week 5</td><td>Week 6</td><td>Week 7</td></tr>
<tr><td colspan="3">Implement hull removal mechanism</td><td colspan="4">Design automation mechanism</td></tr>
<tr><td>Week 8</td><td>Week 9</td><td>Week 10</td><td>Week 11</td><td>Week 12</td><td>Week 13</td><td>Week 14</td></tr>
<tr><td colspan="4">Develop concept design 3 into an actual product</td><td colspan="3">Delivery and final presentation</td></tr>
</table>

6. Current Design

6.1 System Specifications

- System must be within a 1 meter cubed volume.
- The system must output the parchment and hulled beans.
- The system must separate the parchment and hulled beans.
- The LED must display green when the system is on and motors are running.
- The system must be portable, i.e. a maximum of 23 kg.
- The system must hull beans at a minimum of 16 lbs./hr.
- The system must hull beans at a minimum hulling rate of 70%

6.2 Research

As a prerequisite for commencing the project, we conducted research about coffee processing. Below, Figure 1 shows the process of coffee making from the plant to the stores. One process we are concerned about as well as our stakeholders is the hulling process.

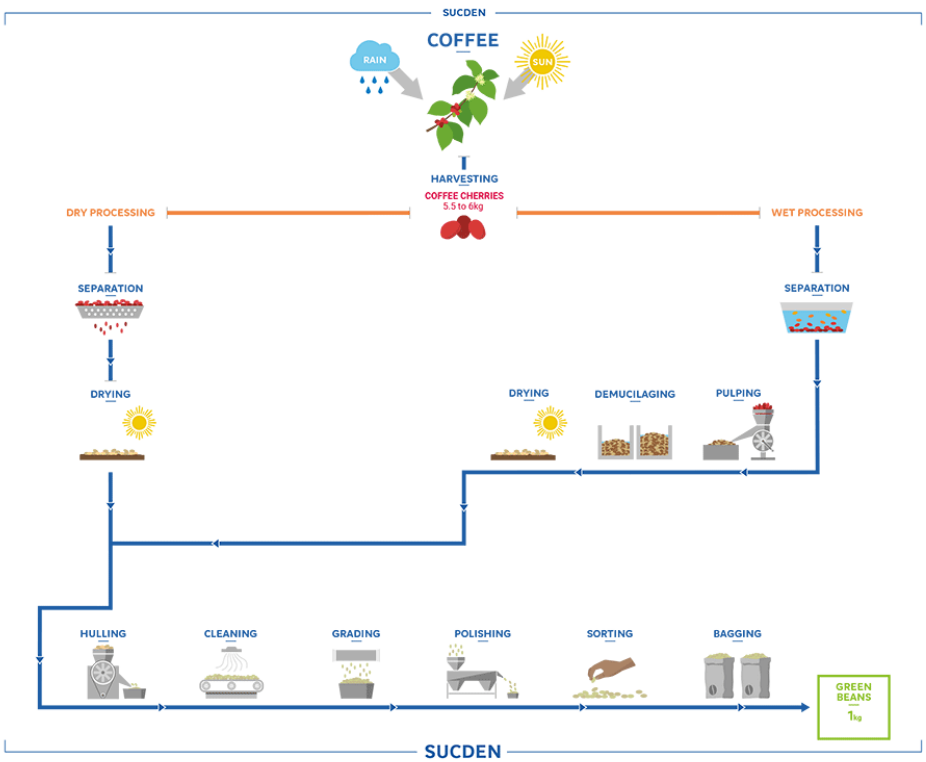


Figure 1: Coffee Process Flowchart[1]

[1] https://www.sucden.com/en/products-and-services/coffee/process-flowchart/

To hull is "to remove the covering or the stem and leaves from some fruits, vegetables, and seeds."[2] To learn more about hulling, we watched the following videos:

- Hulling Green Coffee Beans from Parchment Coffee
- Coffee de Huller (Official video)
- Parchment Coffee Huller S200 - Coffee processing for husks and dry cherries

As for the existing hullers that are already in the market, we have looked at Tables 1 through 4 from the Design Document of the previous team[3]. Those tables highlight the existing hullers, their prices, their weights, volumes, production rates, and their power consumption. They also highlight the scores from the decision matrix as well as the pros and cons of those hullers. The benchmarking for those hullers can be found in Figure 2 below.

Figure 2: Bench-marking of the existing hullers, benchmarked by the previous team[4]

[2] https://dictionary.cambridge.org/us/dictionary/english/hulling

[3] https://purdue0.sharepoint.com/sites/epics/dkc/Shared%20Documents/Project%20Documentation/DCC/Design%20Document/Spring2019_DCC_Midterm_DesignDocument.pdf

[4] https://purdue0.sharepoint.com/sites/epics/dkc/Shared%20Documents/Project%20Documentation/DCC/Design%20Document/Spring2019_DCC_Midterm_DesignDocument.pdf

6.3 Previous Team Designs

The previous team has done a lot of brainstorming and prototyping until they came up with three different designs along with their proof-of-concept prototypes. These prototypes along with their benchmarking can be found in their Design Document paper[5]. In figure 3, you can find the summary of the pros and cons of those three designs. The prototypes in are Lazy Susan, Pinwheel, and Pepper Grinder respectively to figure 3.

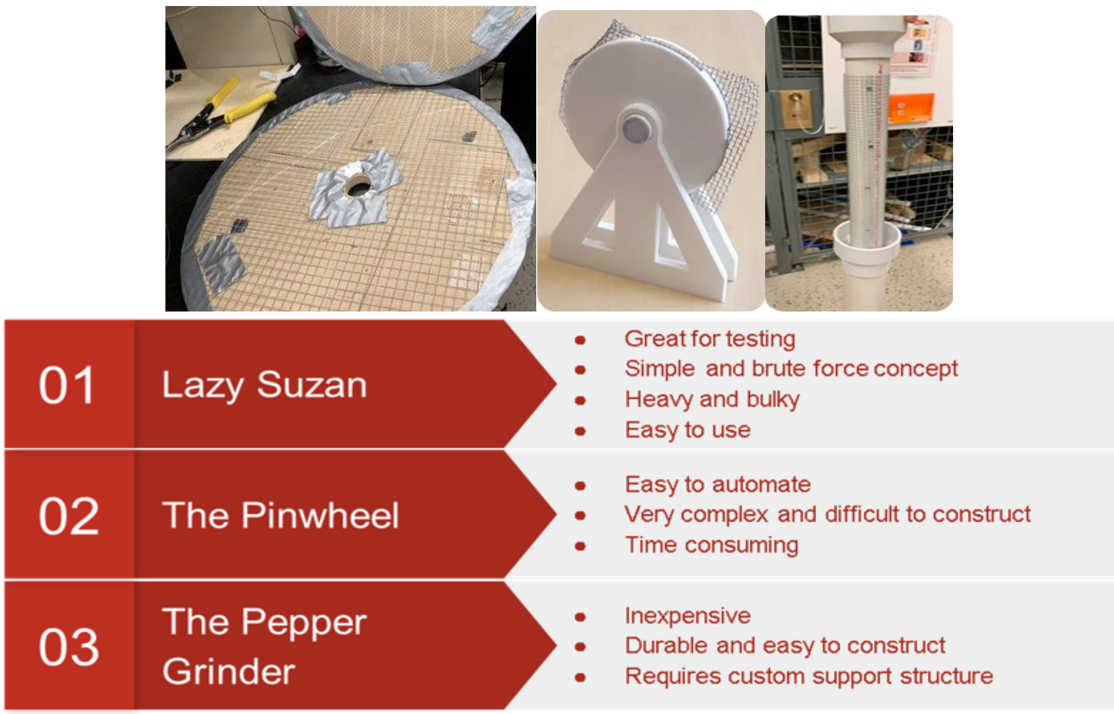


Figure 3: Pros and cons of the three prototypes of the previous team[6]

[5] https://purdue0.sharepoint.com/sites/epics/dkc/Shared%20Documents/Project%20Documentation/DCC/Design%20Document/Spring2019_DCC_Midterm_DesignDocument.pdf

[6] https://purdue0.sharepoint.com/sites/epics/dkc/Shared%20Documents/Project%20Documentation/DCC/Design%20Document/Spring2019_DCC_Midterm_DesignDocument.pdf

6.4 Concept Designs

Current conceptual designs have been documented and made into a decision chart before proof-of-concept prototyping.

6.4.1 Concept Design 1

When we learned about the hulling process, we remembered a similar device that does a similar job, which is the grater. We thought that a grater might be used to hull instead of grate. Therefore, the following idea was generated: input unhulled coffee beans, then rotate grater against a surface, then output beans with their hulls.

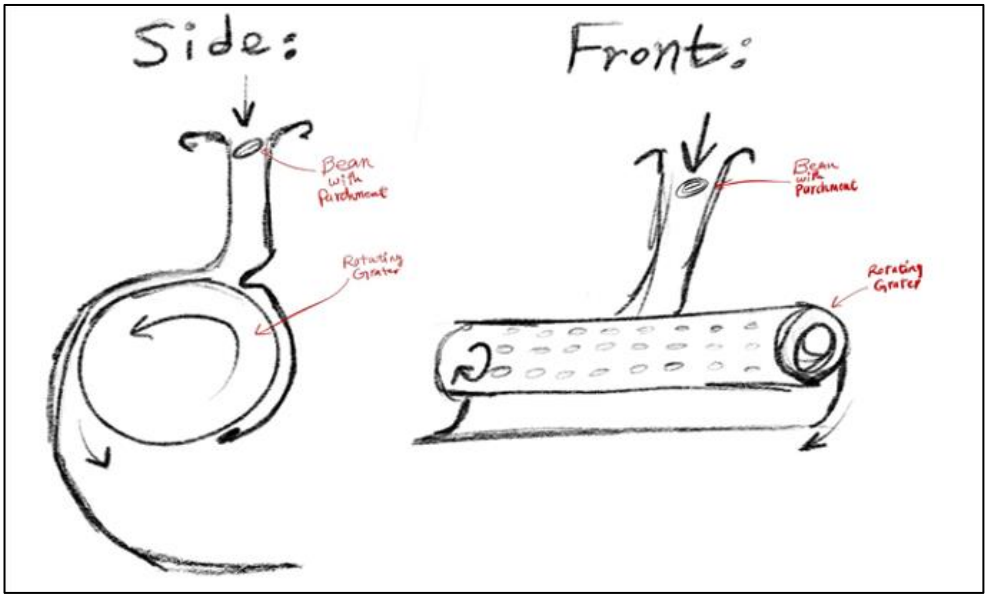


Figure 4: Concept idea 1, a grater that hulls beans against a surface

6.4.2 Concept Design 2

We have seen many videos of coffee hullers for inspiration. A video that we have been inspired by is rice huller building instructions. This video gave us the idea of having two cylinders that roll both clockwise and counterclockwise against each other. With a soft material on the exterior of the cylinders, the coffee beans won't be crushed, instead they will be slowly exposed to pressure and friction in order to get hulled. As a separation mechanism, we think of utilizing a fan that can separate the hulls due to their light weight. This concept design can have both automation and input/output. Below is figure 5 showing the concept art of the design.

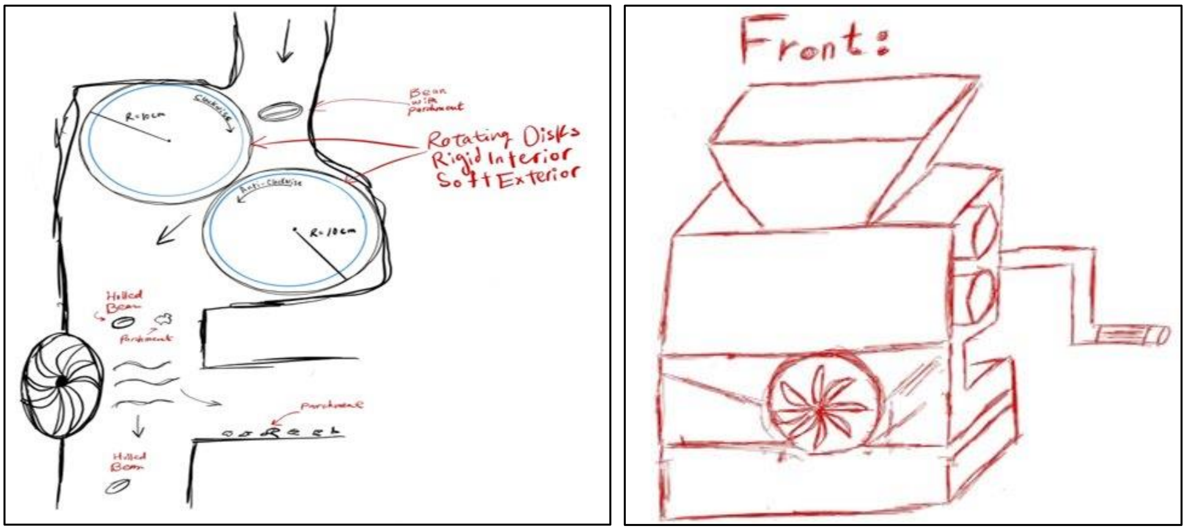


Figure 5: a side and front view of concept design 2, two cylinders rotating against each other hulling beans

6.4.3 Concept Design 3

As a team, we have checked the stash and the lockers in the lab. We have come into possession of a corn grinder after checking the inventory. Figure 6 shows the picture of a corn grinder.

Figure 6: A picture of the corn grinder found in our inventory

The corn grinder gave us many insights from its mechanism alone. One insight we gained is the way the corn grinder is attachable and detachable from any surface, which is a plus toward portability. Another insight we gained is the input hopper that holds the corn as it goes inside the grinder conveyor belt. Speaking of which, the conveyor belt has given us an insight into moving the beans/grains around just by rotating the crank. A final insight was that corn is crushed using two sharp teeth plates made of cast iron with minimum distance from each other.

That gave us the idea that if we increase the distance between the two plates, found in figure 7 and changed the material from cast iron to a material that is even softer like rubber, maybe we could turn the corn grinder into a coffee huller.

Figure 7: Two plates with sharp teeth made of cast iron with almost no distance between them

6.5 Decision Matrix

Taking into consideration the previous team's prototypes along with our own concept ideas, we have articulated a decision matrix in Table 1.

Table 1: Weighted Decision Matrix done in MS Excel to show the different aspects and their weights to score concept ideas and prototypes

Weighted Decision Matrix													
Critera:	Weighting:	OPTIONS											
		Lazy Susan		Pinwheel		Pepper Grinder		Idea 1: Grater		Idea 2: Cylinders		Idea 3: Corn Grinder Hybrid	
cost	5	5	25	2	10	4	20	2	10	2	10	3	15
efficiency	4	4	16	0	0	2	8	2	8	4	16	4	16
portability	4	3	12	2	8	4	16	2	8	2	8	3	12
size	4	1	4	1	4	1	4	2	8	2	8	3	12
automation	3	0	0	1	3	2	6	3	9	3	9	3	9
separation	3	0	0	1	3	0	0	2	6	3	9	3	9
TOTAL			57		28		54		49		60		73
0 = costly, 5 = cheap													
0 = inefficient, 4 efficient													
0 = bulky and heavy, 4 lightweight and portable													
0 = exceeds $1m^3$, 4 = small													
0 = cannot be automated, 3 = can be automated													
0 = can't have separation system, 3 = can separate													

As can be seen from Table 1 above, the highest score by a long shot goes to the corn-grinder hybrid, which agrees with our theoretical analysis. Therefore, our team opted to further go with the Corn Grinder Hybrid design and make a proof-of-concept prototype to get the green-light from our partner.

6.6 Issues Faced When Prototyping

After trying the grinder and initiating the process of turning it into a huller we stumbled upon two major problems. The first problem was that the beans got consistently crushed by the proximity of the two metal serrated plates. The second problem is even after separating the two metal disks their edges continued to break the beans.

6.6.1 Plate Spacing

After much research and deliberation, we found three key points where we can attach washers to increase the distance between the plates. In Figure 8 are shown the three trial locations.

Figure 8 The locations of washers' trials

More washers mean more space between the plates. In theory, putting washers in any of the above locations in figure 8 will increase the space, though in practice we had tried implementing the washers in every location. Two of the locations failed to work. The location that works is the one in the middle in figure 8, inside the grinder around the worm screw. Each additional washer increases the gap by 0.2 inches as can be seen in figure 9. The needed distance, however, is still unknown and further testing needs to be done on different bean sizes.

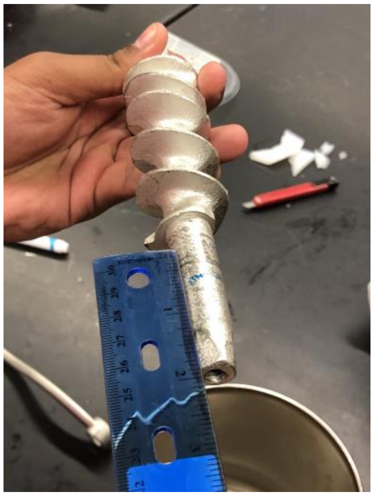


Figure 9 Worm screw marked when more washers are added

6.6.2 Plate Material

As for the plate materials, we have decided the plates need to be changed for their too serrated teeth. Three materials have been thought of that could potentially hull without grinding. Silicon Sheets were considered for their availability, ease of application, and ease of removal. A Liquid Rubber Mold was considered for its ease of removal, but it had two main setbacks. First setback was time; making a Liquid Rubber Mold takes approximately two to three days. In addition, after drying out the Liquid Rubber Mold it needs to be cut-out of the mold. The final material we considered were Rubber Sheets. Rubber Sheets were considered for their sturdiness and their ability to withstand pressure.

6.7 Solutions for Prototype

First, we installed the silicon sheets, as seen in figure 10, on the metal cast disks by gluing them using simple glue. However, they were not fit because they did not adhere to the disks well and did not have the proper padding to safely hull the beans without breaking them.

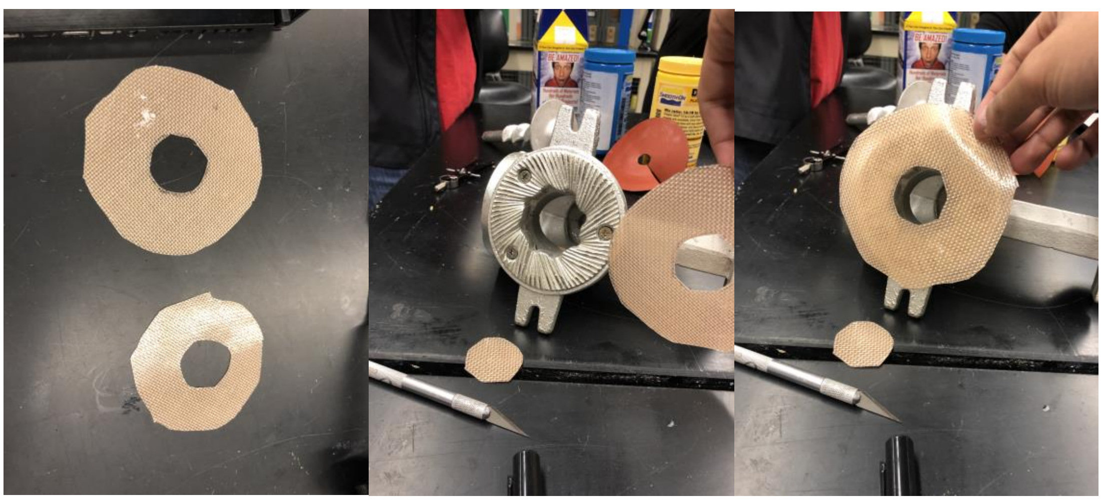


Figure 10 Silicone sheets have been used as a plate material.

Secondly, we made a liquid rubber mold on the disk, as shown in figure 11, and then we carved the disks out. Yet, we faced a few problems concerning of how the rubber fits the plates. So, we tried to fix these problems by applying heat on the rubber and then checking if the fit will tighten or not. Yet, heat did not resolve our problem, but the rubber burned instead. So, the loose rubber liquid rubber did not solve our problem.

Figure 11 Liquid Rubber being cast onto the plates as plate material.

Lastly, we ended up using rubber sheets for their optimal padding, as shown in figure 12. However, the problem was adhering the material to the plate. So, we used super glue and clamped the material to the disk. Unfortunately, if needed, removing the material would prove to be rather troublesome. However, at the end they gave us the needed result.

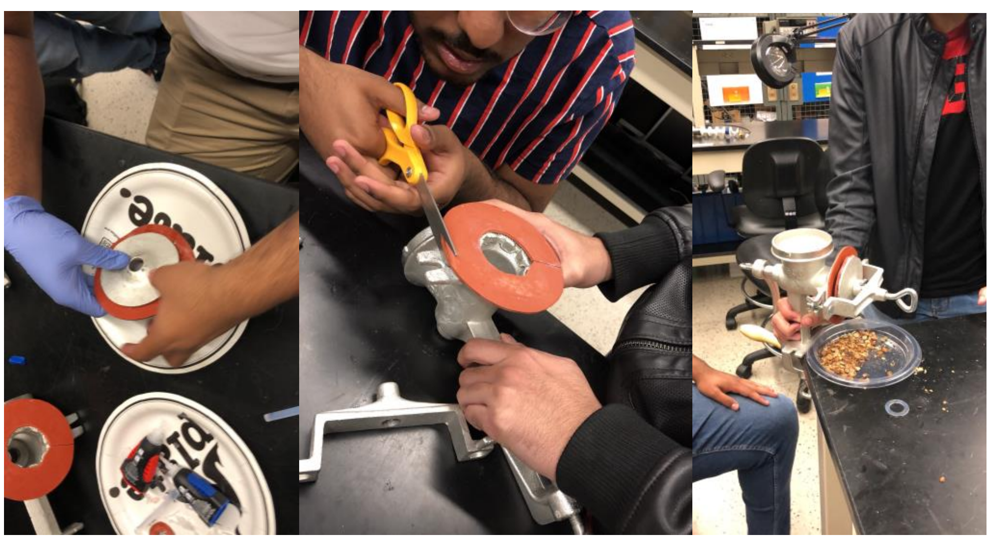


Figure 12 The rubber sheets being applied and experimented with.

Appendix A: Past Semester Archive

A.1 Spring 2019

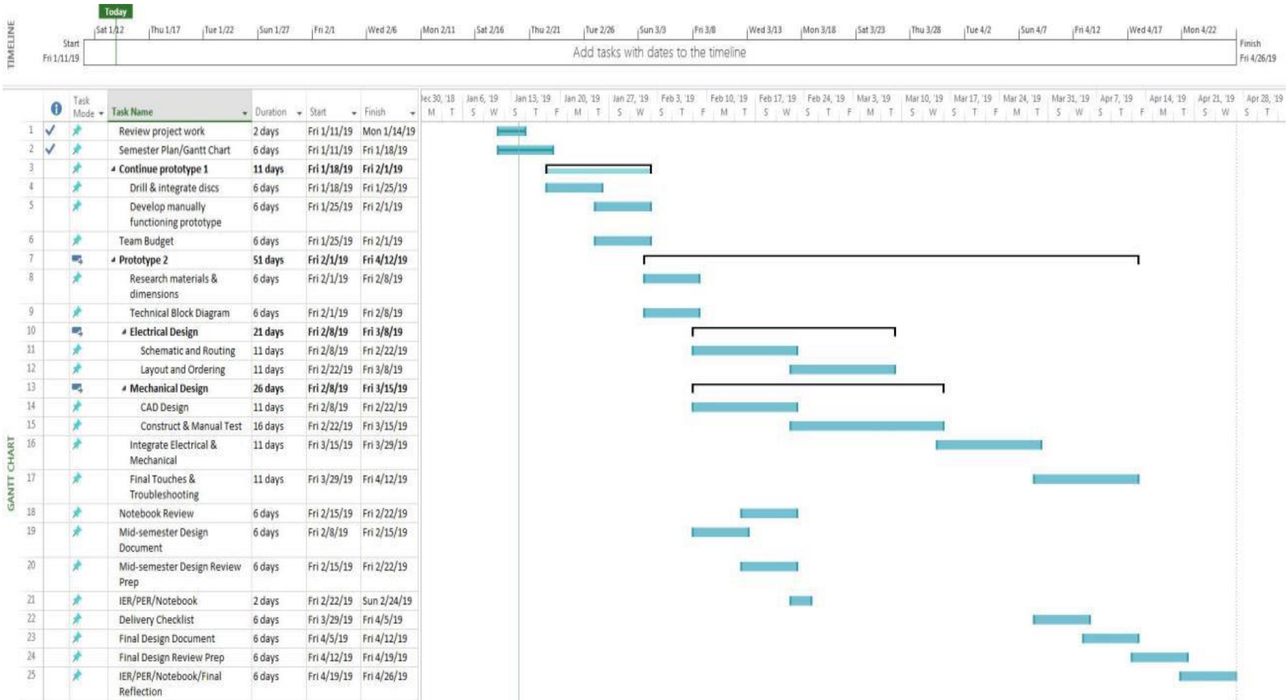
A.1.1 Past Team Members

Nick Rentsch – Design Lead
(No email found in Purdue directory.)
• Ensure completion of project tasks
• Digital mechanical component design o Define technical specifications
o CAD design in Venture and CATIA
• Physical mechanical component design

Erika Lin – Project Archivist
lin941@purdue.edu
• Design documentation writing
o Ensure thorough project/design documentation
• Project planning – Gantt chart
• System diagrams and specifications
• Physical mechanical component design
• Electrical component design
o Power management
o Visual feedback

Lauren Risany – Project Partner Liaison
lrisany@purdue.edu
• Direct contact for Project Partner
• Keep Project Partner updated throughout the design process
• Digital mechanical component design
Assist in CAD design
• Physical mechanical component design

A.1.2 Past Timeline



	Task Name	Duration	Start	Finish
1	Review project work	2 days	Fri 1/11/19	Mon 1/14/19
2	Semester Plan/Gantt Chart	6 days	Fri 1/11/19	Fri 1/18/19
3	**Continue prototype 1**	**11 days**	**Fri 1/18/19**	**Fri 2/1/19**
4	Drill & integrate discs	6 days	Fri 1/18/19	Fri 1/25/19
5	Develop manually functioning prototype	6 days	Fri 1/25/19	Fri 2/1/19
6	Team Budget	6 days	Fri 1/25/19	Fri 2/1/19
7	**Prototype 2**	**51 days**	**Fri 2/1/19**	**Fri 4/12/19**
8	Research materials & dimensions	6 days	Fri 2/1/19	Fri 2/8/19
9	Technical Block Diagram	6 days	Fri 2/1/19	Fri 2/8/19
10	**Electrical Design**	**21 days**	**Fri 2/8/19**	**Fri 3/8/19**
11	Schematic and Routing	11 days	Fri 2/8/19	Fri 2/22/19
12	Layout and Ordering	11 days	Fri 2/22/19	Fri 3/8/19
13	**Mechanical Design**	**26 days**	**Fri 2/8/19**	**Fri 3/15/19**
14	CAD Design	11 days	Fri 2/8/19	Fri 2/22/19
15	Construct & Manual Test	16 days	Fri 2/22/19	Fri 3/15/19
16	Integrate Electrical & Mechanical	11 days	Fri 3/15/19	Fri 3/29/19
17	Final Touches & Troubleshooting	11 days	Fri 3/29/19	Fri 4/12/19
18	Notebook Review	6 days	Fri 2/15/19	Fri 2/22/19
19	Mid-semester Design Document	6 days	Fri 2/8/19	Fri 2/15/19
20	Mid-semester Design Review Prep	6 days	Fri 2/15/19	Fri 2/22/19
21	IER/PER/Notebook	2 days	Fri 2/22/19	Sun 2/24/19
22	Delivery Checklist	6 days	Fri 3/29/19	Fri 4/5/19
23	Final Design Document	6 days	Fri 4/5/19	Fri 4/12/19
24	Final Design Review Prep	6 days	Fri 4/12/19	Fri 4/19/19
25	IER/PER/Notebook/Final Reflection	6 days	Fri 4/19/19	Fri 4/26/19

A.2 Fall 2018

A.2.1 Past Team Members

Nick Rentsch – Design Lead
(No email found on Purdue directory.)

- Ensure completion of project tasks
- Research coffee bean huller design
- Mechanical component design
  - o Define technical specifications

Erika Lin – Project Archivist
lin941@purdue.edu

- Completely revise design document
- Ensure thorough project/design documentation
- Research coffee bean huller design
- Project planning – Gantt chart
- System diagrams
- Electrical component design
  - o Power management
  - o Visual feedback

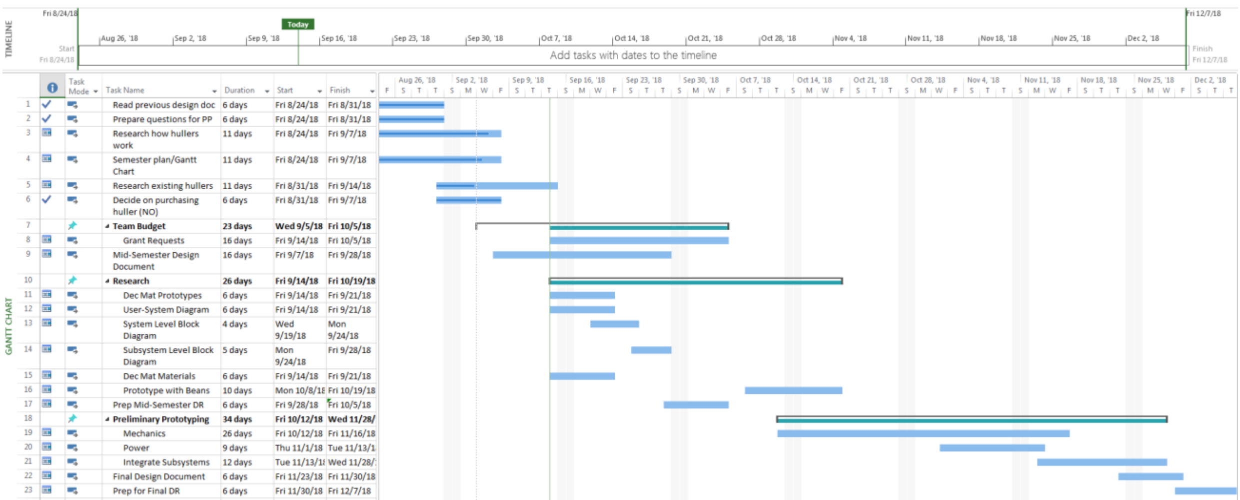
Austin Faust – Project Partner Liaison
faust7@purdue.edu

- Direct contact for Project Partner
- Keep Project Partner updated throughout design process
- Research coffee bean huller design

- Preliminary design mock-ups

Shawn Prosky – Webmaster
sprosky@purdue.edu
- Update DKC Twitter account with frequent updates
- Research coffee bean huller design
- Mechanical component design

A.2.2 Past Timeline



A.3 Spring 2018

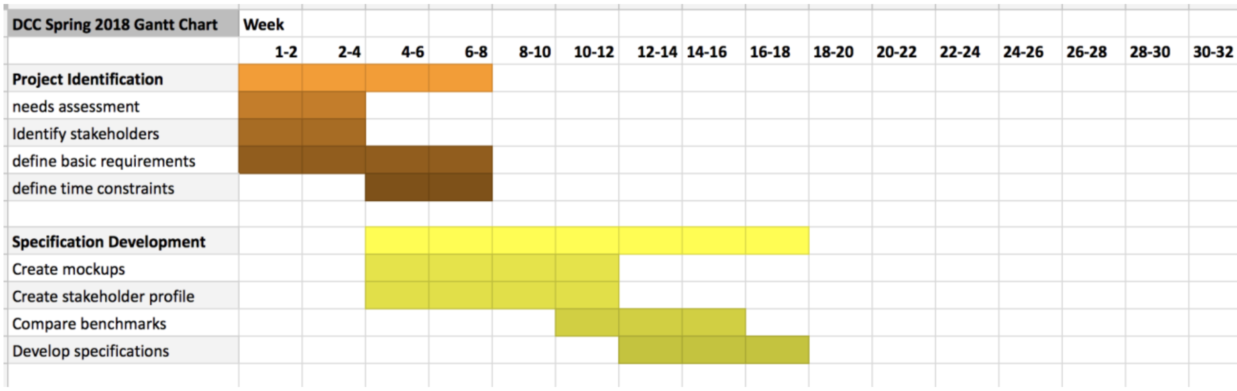
A.3.1 Past Team Members

Brendan Donahue
donahueb@purdue.edu
Brendan is co-design lead, and is in charge of ensuring the completion of project tasks. Brendan is working on finding benchmarks for hullers, and creating a Gantt chart for the project. In addition, Brendan is also the project partner liaison.

Michael Simons
simons7@purdue.edu
Michael is co-design lead, and is in charge of ensuring the completion of project tasks. Michael is also the project archivist and is therefore in charge of updating SharePoint and the design document. He is also working on the decision matrix and specifications of our project

Dingye Zhang
zhan1263@purdue.edu
Dingye is webmaster when DCC eventually establishes a webpage on DKC's website. He is in charge of keeping it up to date. Dingye is also working on developing a prototype for the huller, and after some more benchmarks and specifications are analyzed he will work on it further.

A.3.2 Past Timeline



Appendix B: Overall Project Design

B.1 Project Identification

Phase 1: Project Identification	Status:	Evidence can be found:
Goal is to identify a specific, compelling need to be addressed		
• Conduct needs assessment (if need not already defined)	Completed	4.3 Project Objectives
• Identify stakeholders (customer, users, person maintaining project, etc.)	Completed	4.2 Stakeholders
• Understand the Social Context	Completed	4.1 Description of the Community Partner
• Define basic stakeholder requirements (objectives or goals of projects and constraints)	Completed	4.2 Stakeholders
• Determine time constraints of the project	Completed	4.5 Expected Semester Timeline

Summary of Project Identification phase of design….

B.2 Specification Development

Phase 2: Specification Development	Status:	Evidence can be found:
Goal is to understand "what" is needed by understanding the context, stakeholders, requirements of the project, and why current solutions don't meet need, and to develop measurable criteria in which design concepts can be evaluated.		
• Understand and describe context (current situation and environment)	Completed	4.1 Description of the Community Partner 4.3 Project Objectives
• Create stakeholder profiles	Completed	4.2 Stakeholders
• Create mock-ups and simple prototypes: quick, low-cost, multiple cycles incorporating feedback	Completed	6.3 Previous Team Designs
• Develop a task analysis and define how users will interact with project (user scenarios)	To be done	
• Identify other solutions to similar needs and identify benchmark products (prior art)	Completed	6.2 Research
• Define customer requirements in more detail; get project partner approval	Completed	4.3 Project objective
• Develop specifications document	To be done	
• Establish evaluation criteria	To be done	

Summary of Specification Development phase of design….

B.3 Conceptual Design

Phase 3: Conceptual Design	Status:	Evidence can be found:
Goal is to expand the design space to include as many solutions as possible. Evaluate different approaches and selecting "best" one to move forward. Exploring "how".		
• Complete functional decomposition	Completed	6.2 Research
• Brainstorm several possible solutions	Completed	6.4 Concept Designs
• Prior Artifacts Research	Completed	6.3 Previous Team Designs
• Create prototypes of multiple concepts, get feedback from users, refine specifications	Completed	6.4 Concept Designs
• Evaluate feasibility of potential solutions (proof-of-concept prototypes)	Completed	6.3 Previous Team Designs
• Choose "best" solution	Completed	6.5 Decision Matrix

Summary of Conceptual Design phase of design….

B.4 Detailed design

Phase 4: Detailed Design	Status:	Evidence can be found:
Goal is to design working prototype which meets functional specifications.		
• Bottom-Up Development of component designs	To be done	
• Develop Design Specification for components	To be done	
• Design/analysis/evaluation of project, sub-modules and/or components (freeze interfaces)	In progress	
• Design for Failure Mode Analysis (DFMEA)	To be done	
• Prototyping of project, sub-modules and/or components	In progress	6.4 Preliminary and Conceptual Design
• Field test prototype/usability testing	In progress	

Summary of Detailed Design phase of design….

B.5 Delivery

Phase 5: Delivery	Status:	Evidence can be found:
Goal is to refine detailed design so as to produce a product that is ready to be delivered! In addition, the goal is to develop user manuals and training materials.		
• Complete deliverable version of project including Bill of Materials	To be done	
• Complete usability and reliability testing	To be done	
• Complete user manuals/training material	To be done	
• Complete delivery review	To be done	
• Project Partner, Advisor, and EPICS Admin Approval	To be done	

Summary of Delivery phase of design….

B.6 Service / Maintenance

Phase 6: Service / Maintenance	Status:	Evidence can be found:
• Evaluate performance of fielded project	To be done	
• Determine what resources are necessary to support and maintain the project	To be done	

Summary of Delivery phase of design….