Summer Internship

at

Integral Enterprises

Auroville

Project Report

Submitted on: July 8th 2013
Submitted by: Deepanwita Ghosh|126130009
IDC, IIT-Bombay

Table of Contents

Acknowledgement

I would like to thank Prof. R.Sandesh, IDC, IIT-B for suggesting we go to Auroville for our internship. Without his input, I would have been unaware of such an opportunity.

I would also like to thank Mr.Chandresh Patel of Integral Enterprises, and Mr. Samvit Blass of Light-Fish Product Design for the amazing opportunity they gave me to work with them through this work term. They were very supportive and guided me through my internship. I thank them for all the facilities and resources they provided me with during my stay.

I thank my colleagues and friends – Avinash Jayakumar and Avinash Prabhune for their invaluable company during this trip. I would also like to thank both Saehan Lenzen and Alexandra Sierra for their company during and after a tiring work day.

It was a fabulous learning experience, and one I will never forget.

Introduction

About Auroville

Auroville (City of Dawn) is situated along the coast of Tamil Nadu and was founded in 1968 by Mirra Alfassa, a disciple of Shri Aurobindo Ghosh. The township was designed by architect Roger Anger.

[Reference for Images: www.auroville.org | www.treekaya.wordpress.com| 1st July 2013 @ 2:00 pm]

About Auroville

Auroville has a number of small scale industries that are heavily based on traditional arts & crafts. Units associated with the Auroville foundation design, manufacture and distribute products such as scented candles, incense sticks, soaps and natural cosmetics, pottery and ceramic ware, gemstone jewelery, wooden furniture, food products such as cheese and baked goods,etc. There is also a presence in the leather products industry, with a major brand such as Hidesign being based close to Auroville.






Background

The opportunity to work in Auroville sprung from old contacts found at the IDC Office. Previously, some of our alumni had worked with Integral Enterprises on an electric motorcycle project. Mr. Chandresh Patel, the head of Integral Enterprises jumped at the chance to work with IDC students again, and was kind enough to provide us with a chance to work with him.

The team from IDC was joined by two junior student interns from the University of Dayton, USA, and two junior engineering interns from SRM University. Being the senior students, my colleagues and me were put in-charge of managing junior students -assigning them tasks, and guiding them. This gave us a chance to hone more than just our design skills, as we also learned the skills of project management and human resource management.

About LiGHT-FiSH

Light-Fish product design in primarily a one person operation run by Mr. Samvit Blass, a product designer educated at the Massachusetts College of Arts, USA. Although he does general product design as well, his primary interests lie in lighting and interior design. Mr. Blass was the lead designer under contract with Integral Enterprises for the Wee Dryer project.

Project- Wee Dryer

Objectives

The main aim of the project was to provide a cost effective means to completely dry small articles of clothing. The product was to be able to dry clothing such as undergarments in a short amount of time, removing the need for drying such articles of clothing publicly (externally) or even openly in the house.

Drying times can be significantly higher during monsoon seasons in India, because of the moisture in the air. This can lead to potentially unhygienic situations for consumers that have a high turnover of dirty clothes – such as families with small children, students in hostels, travelers in hotels, etc. that don't necessarily have access to commercial dryers in India.

1 kg of wet clothes

15 min.

Energy Efficient

Cost effective

Market Study

Most households in India do not have commercially available clothes dryers due to a few important factors. Firstly, dryers are generally expensive, and also occupy a lot of space in tight urban settings. They also use a lot of power with the average North American dryer using 5-7kW of power. This brute force method of drying is unnecessary for small loads.

Thus, households will definitely benefit from a product that can dry small amounts of clothes in a short time - as well be compact and easy to store.

[Reference for Images: www.ehow com/ 1st July 2013 @ 3:10 pm]

Market Study

Existing market products include compact spin dryers, compact heat dryers, and compact Airers. Compact spin dryers are small capacity spin drums that rotate at very high speeds (2000-3000 RPM). This causes the water in the wet clothes to fly outwards due to centrifugal force and the clothes are dried this way. But the problem with this method is that the clothes still need to be dried completely on a line after this spin-dry as there is some residual water that remains.

Compact heat dryers are available in the market that use existing hair-dryers to dry clothing. The drawback in this is that only one piece of cloth can be dried at a time, and this becomes cumbersome to use. Compact airers have a very gimmicky appearance, and fragile construction. They also require assembly and disassembly, otherwise they occupy too much space.

The drawbacks of each of these products prove the need for a robust solution to this problem, creating a need for a product such as the Wee Dryer.

Compact 'Airers'

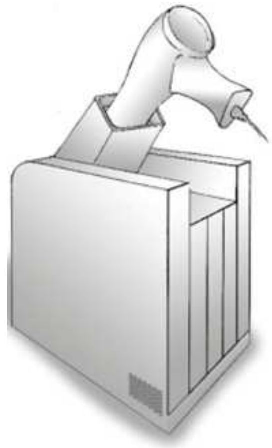
Compact Spin Dryers

Compact Heat Dryers

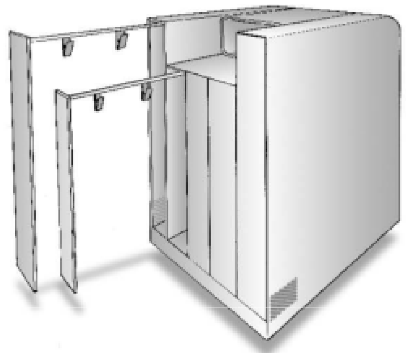
[Reference for Images: www.applianceonline.co | www.automaticwasher.org | 1st July 2013 @ 3:20 pm]

Development History

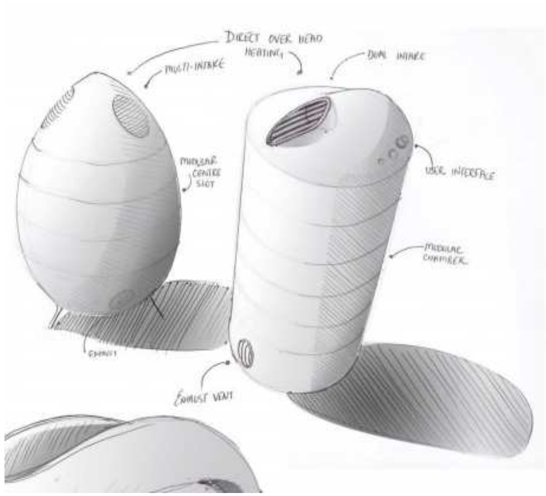
Ideation Concepts



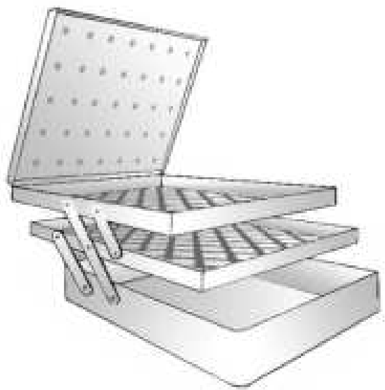
Drawer/Hanger Concept: Vertical Sliding racks with hooks to hold clothes, and a hot air source such as a hair dryer providing dry heated air to flow through the racks.



Existing Idli-Steamer Concept: Modular containers with clothes in them with the heated air 'steaming' the clothes similar to an idli cooker or dumpling steamer.



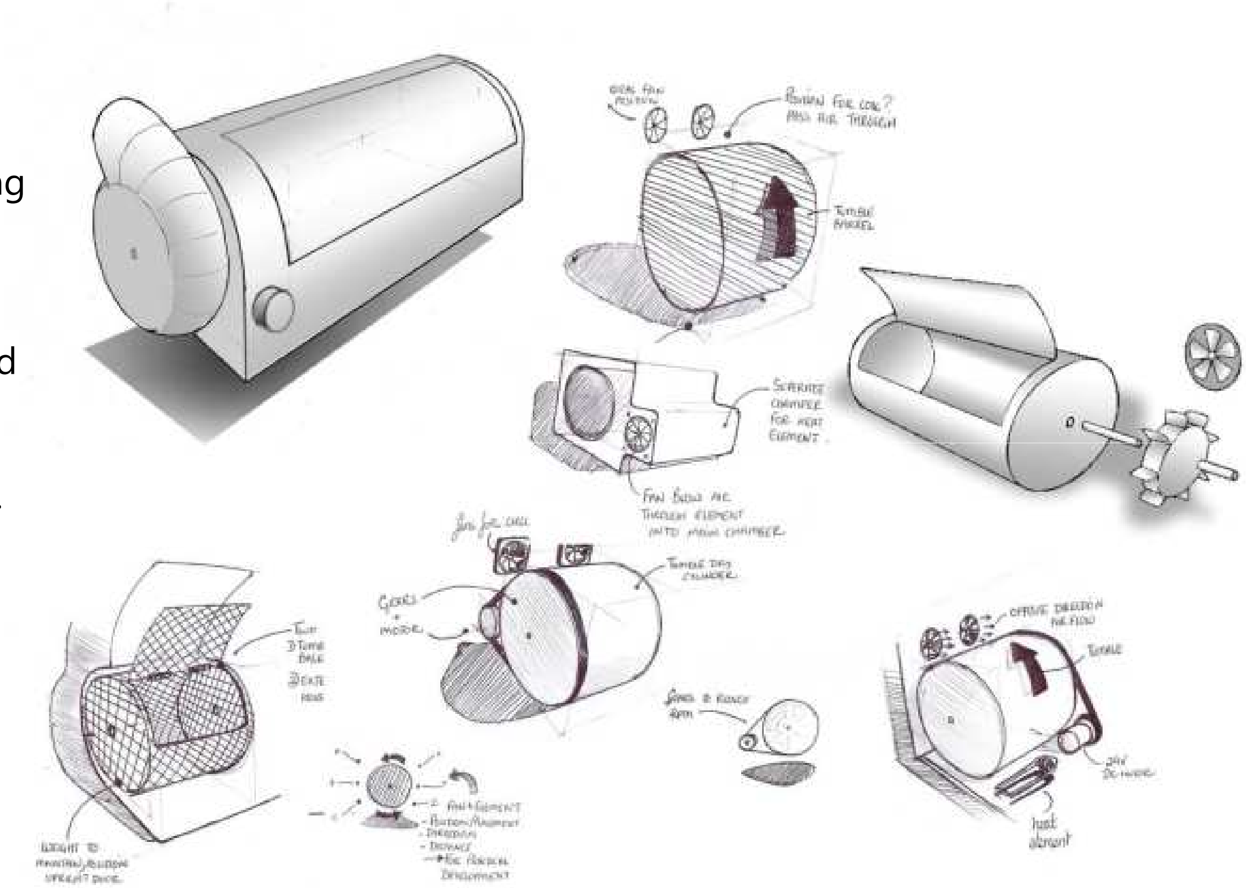
Steam Tray Concept: Horizontal meshed trays to hold clothes, with the mesh allowing hot air to pass through and dry the clothes.



Ideation Concepts

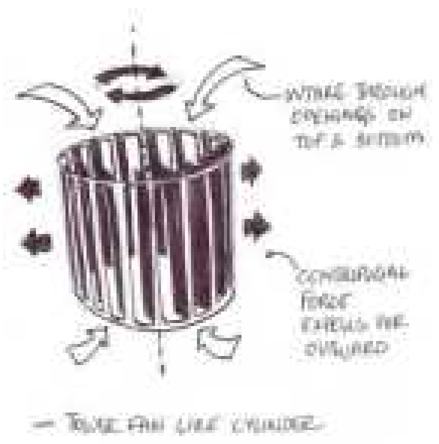
Cylindrical Drum Concept

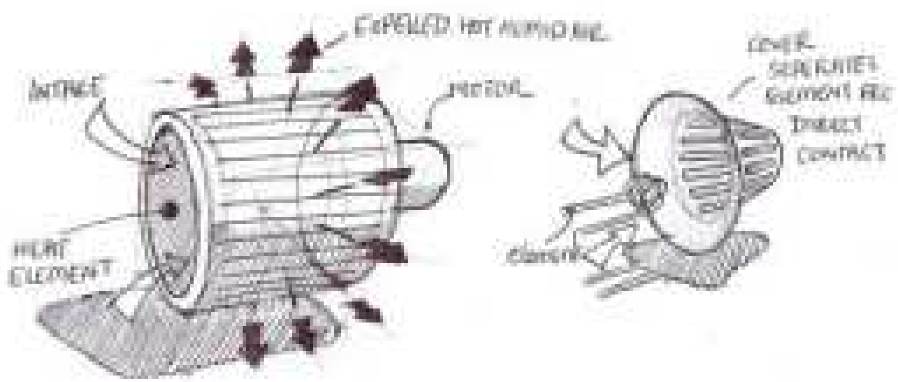
Cylindrical Drum concept: The idea is based on drum containing the wet clothes, and a heater in the back of the drum. Air flows through the drum as it rotates and tumbles, similar to a conventional front-load washing machine / dryer.



Ideation Concepts

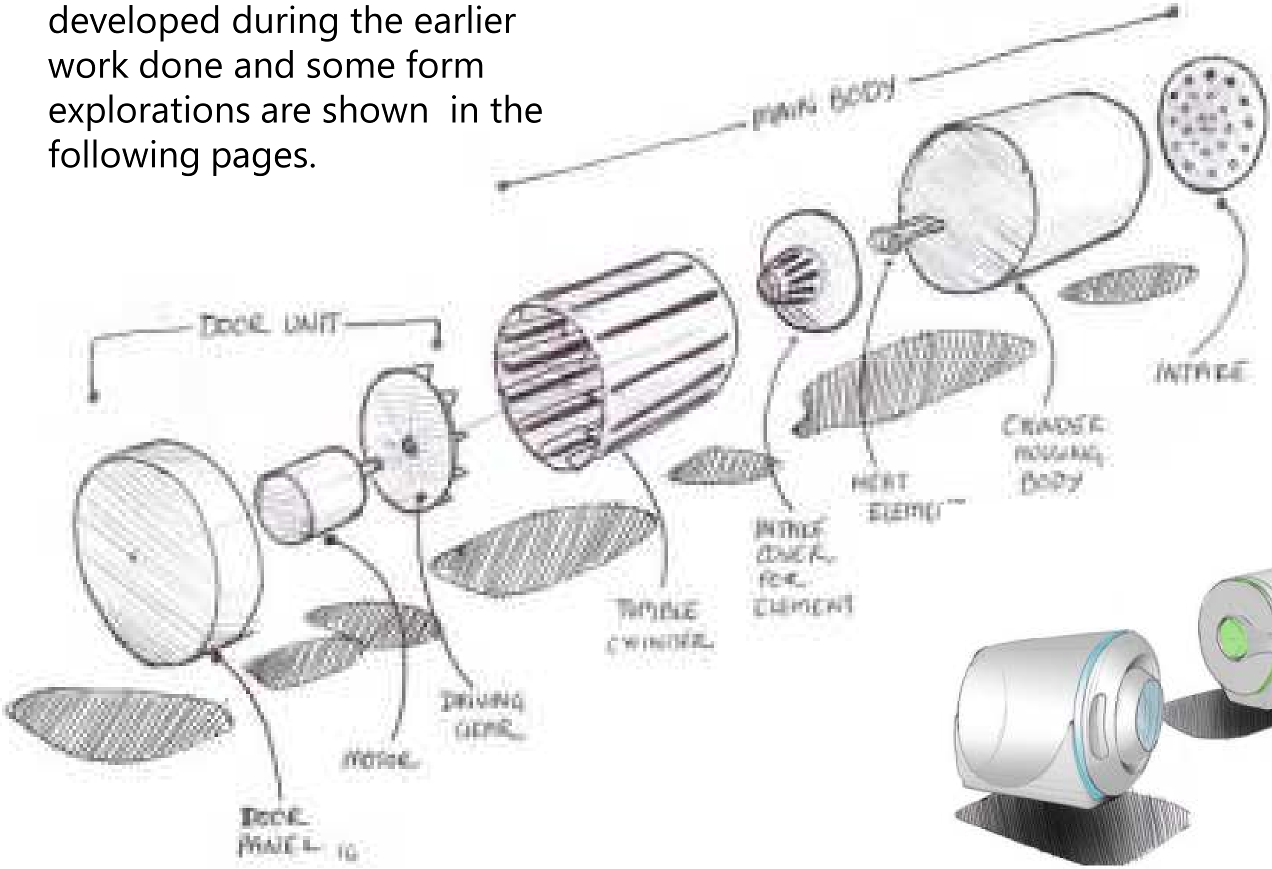
This concept was further explored by associates at Light-Fish during early stages, and the use of blades on the drum was developed. The blades act like the blades in a centrifugal fan, similar to what is used in hair dryers and split air conditioners to force air outwards, and have an intake at the ends. A heater was plumbed into the line, following the CFL-bulb style of coil. This heater element was protected by a metal grill that prevented direct contact between the clothes and the heater. When the drum was spun, air was drawn into the drum over the heater, and thus hot air theoretically entered the drum chamber.

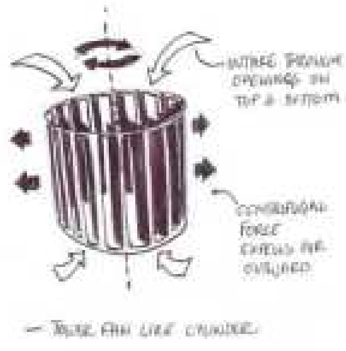


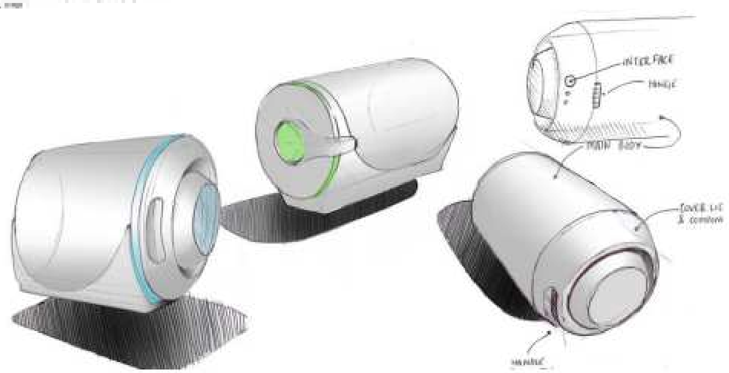


Ideation Concepts

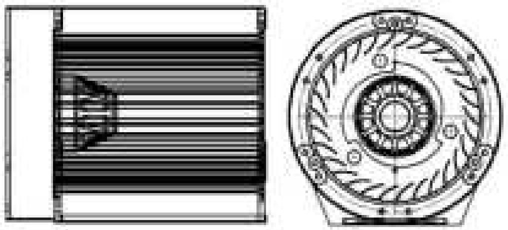
A compact package was developed during the earlier work done and some form explorations are shown in the following pages.

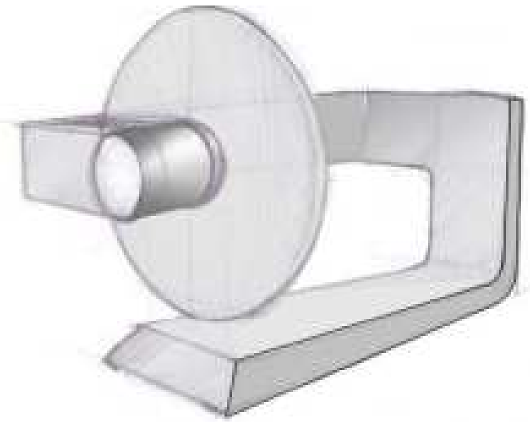


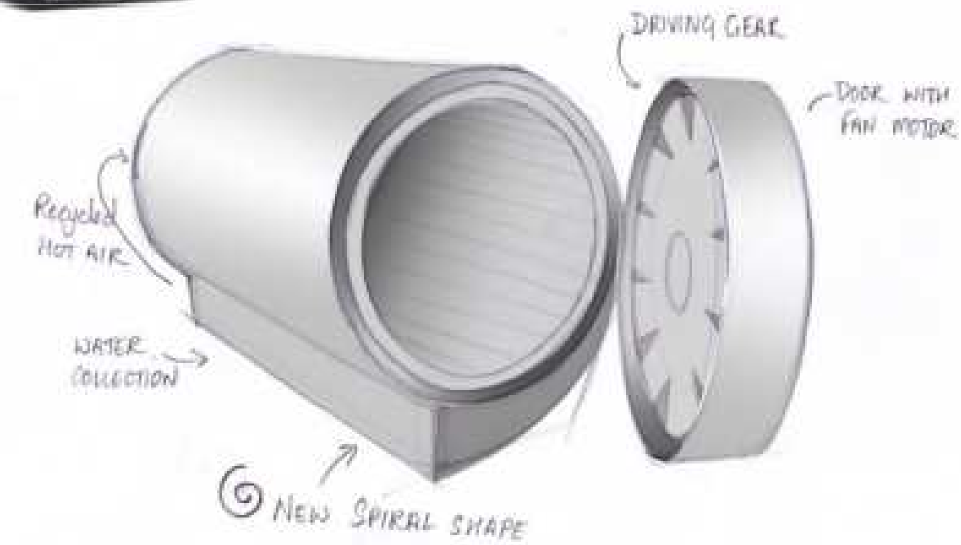




Ideation Concepts





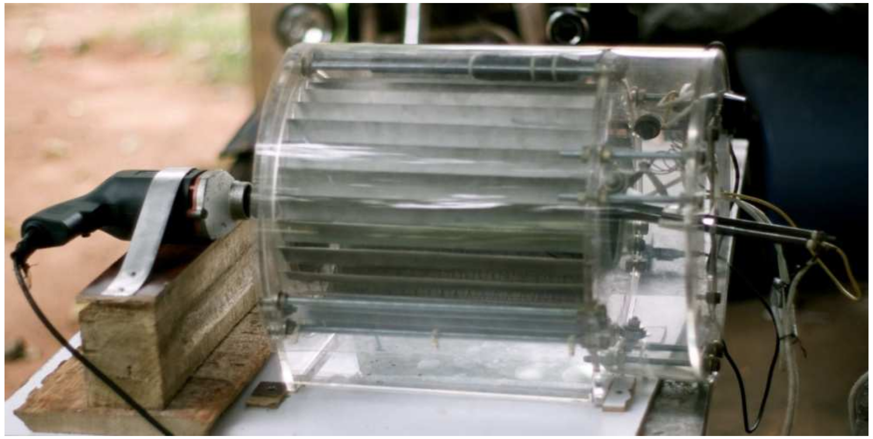


Cylindrical Drum Concept

The current prototype was not meeting the required performance standards and we conducted some testing to fully understand the functioning and problems that existed with the prototype. Some test set-ups are shown below:







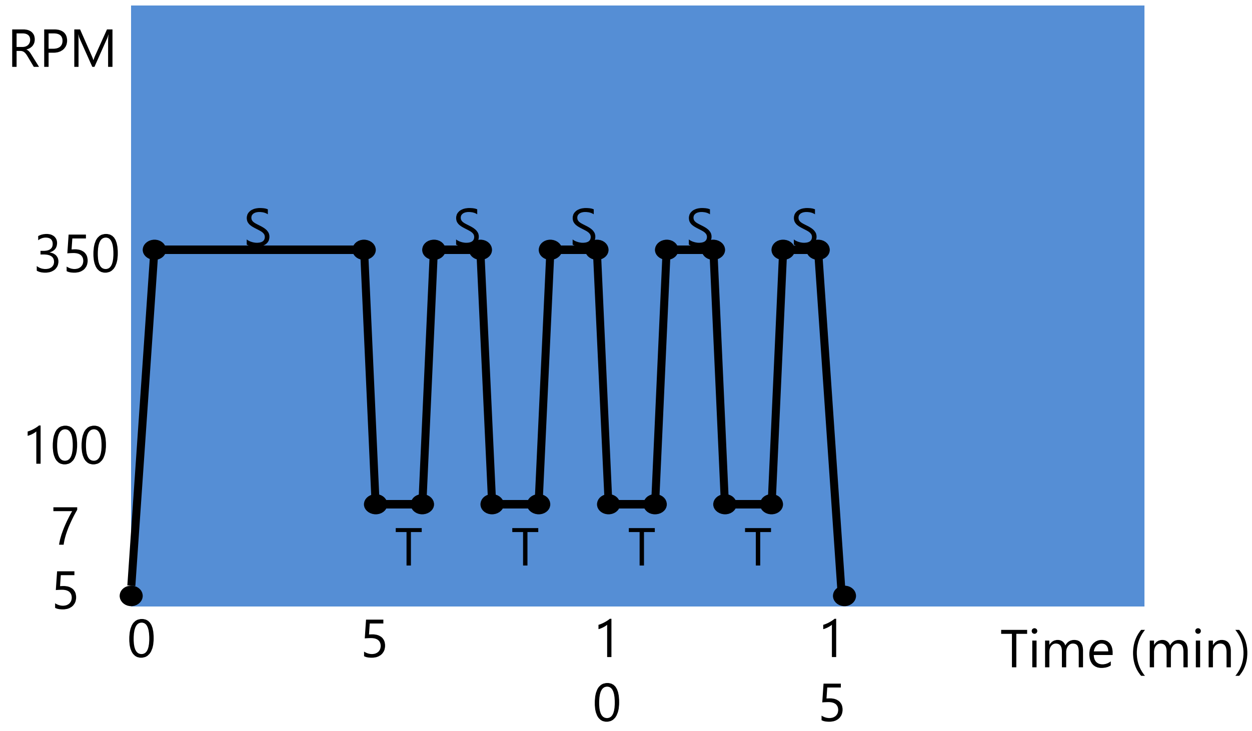
Testing and Validation

Basic Test Cycle

The basic test cycle carried out was simple. 1 Kilo of wet clothes were prepared for testing, and weighed on a scale to know the exact weight.

The target of 15 minutes was split into a five minute spin cycle at high speed. This would remove a lot of the water through centrifugal force.

The heater would be turned on during the start of the test. After the initial five minute spin, the speed of the drum was reduced to spin much slower, causing the clothes to start tumbling within the drum.



After a few minutes the drum speed was again increased to improve air circulation. This tumble-spin pattern was repeated until the full 15 minutes were up. At the end of the test cycle, the semi-dry clothes were weighed again to find out how much water was removed from clothes.

Several test cycles were conducted to understand the behavior of the drying process. During these tests the chamber temperature and Relative Humidity percentage were measured to understand the build-up of humidity in the chamber air. Spin speeds and tumble-spin cycle times were varied to understand their effects on drying time.

Finally, forced airflow over the clothes was examined, using an externally powered computer fan that was placed in-line with the heater, so as to forcefully blow hot air into the drum, and not just rely on the natural draw of air caused by drum rotation.

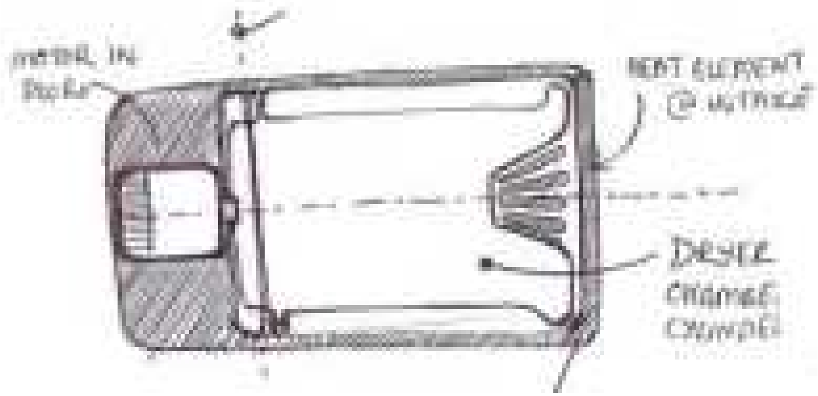
Drying Process

Three main factors affect the drying process – Heat, Airflow and Drum rotation speed. The drum volume also plays an important role in the drying process of clothes.

Based on empirical data obtained from testing by major consumer goods manufacturer Electrolux, the recommended drum volume for drying 1kg of clothes is 25L. At present it was noted that the drum volume in the existing prototype was 15L or 60% of the optimal capacity.

Heat

After the testing a few key observations were noted from the testing. The heat within the drum quickly reached 70 degrees C, which often resulted in the toasting of clothes. A foul odour of burning often emanated from the drum, due to the burning / toasting of clothes. It was also observed that the heat distribution within the drum itself was uneven across the chamber wall. The heater currently projected into the drum because of the CFL style coil and reduced the amount of usable drum volume.

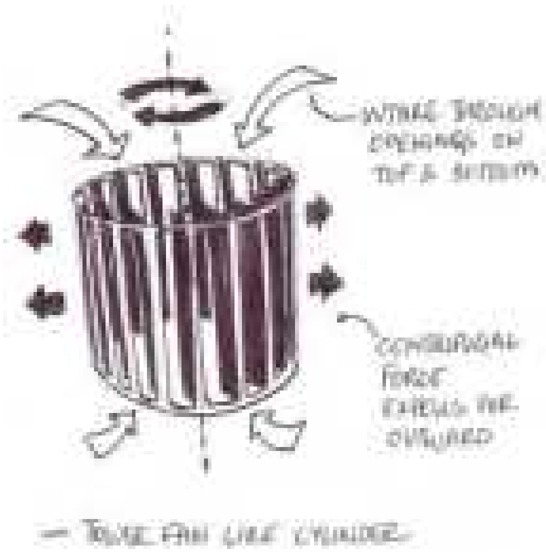


Air Flow (AVINASH JAYAKUMAR – INDIVIDUAL CONTRIBUTION)

During the tumble cycle, it was observed that the airflow within the drum became almost stagnant due to the slow rotation speed, and thus gave the water in the clothes a chance to evaporate into the air. The hot air has a higher capacity to store water vapour in it as a mixture, and thus allowed a lot of water to be drawn into it. However, once the air was saturated with water, the clothes stay damp, due to non movement of air.

Secondly, the design recommendation was to have a different blade profile on the drum blades to push air towards the back of the drum. Fan blades were also to be added to the intake side of the dryer.

Vents were also to be considered on the sides of the dryer so that hot wet air can be dumped if necessary during the high speed.



Drum Rotation AVINASH JAYAKUMAR – INDIVIDUAL CONTIRBUTION

A number called the G-Factor was approximated for the current prototype. The G-Factor is derived from a formula using the diameter of the drum and the square of the RPM. This based on research done by “Miele Appliances”.

Based on calculations the required drum speed was calculated to be at least 900 RPM during the spin cycle, and currently the dryer was capable of around 350 RPM.

$$\text{G - Factor} = \frac{\text{rpm}^2 \times d}{1790}$$

Drum Rotation AVINASH PRABHUNE – INDIVIDUAL CONTIRBUTION

An interesting behavior was discovered during the tumble cycle. It was expected that if the drum speed was lowered that the clothes within the drum would travel upwards with the drum rotation and then fall from the top and then travel up again, similar to what a roller coaster would do if it did not have enough speed in an upside down loop. This behavior did happen, however the clothes did not separate from each other, and instead fell in clumps.

To counter this behavior and increase drying surface area exposed to hot air, the tumble mode was interspersed with short spins of 5-10 seconds. This allowed the clothes to once again hug the edges of the drum before falling during the tumble cycle, this time in a new arrangement. This method tossed the clothes within the small drum chamber, allowing the drum volume to be minimized while maximizing the contact of clothes with hot air.

We also realized the need for baffles within the drum to 'trip' the clothes as they spun around and prevent them from sticking together in clumps.

Design Recommendations

The primary design constraints that we faced were due to the manufacturing options available. Early in the design process it was made clear that the most cost effective, quick, and quality method of manufacturing available to us was laser-cutting. Water-jet cutting was also available although it was more expensive. CNC machining, or general machining was not an option due to the poor quality of finished products and lack of skilled machinists in the area around Pondicherry. Hence, sheet stock was the preferred medium and defined much of how we thought and approached our design solutions.

The following design recommendations are the summary of individual contributions to the design problems found during the testing phase. The names of the individuals are mentioned below in order to highlight their equal contributions to the project.

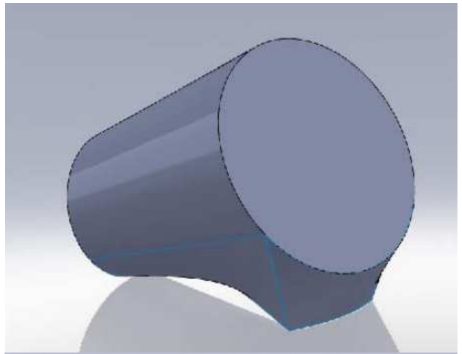
Design Recommendations
1. Form Factor

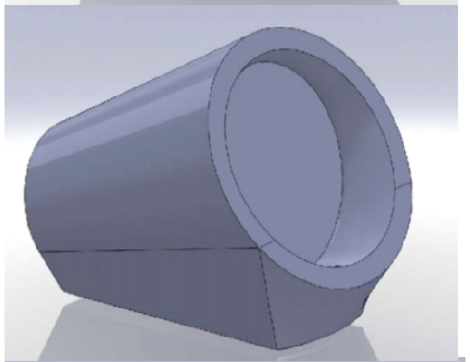
Form Factor Development

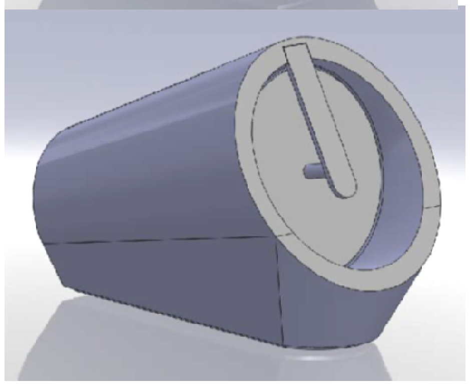
AVINASH JAYAKUMAR– INDIVIDUAL CONTIRBUTION

Functionally, it was deemed necessary to establish a good clear airflow path in the drum using forced air on the intake into the drum, and push air out during the exhaust of wet process air. The overall cylindrical form factor would need to be modified to a conical shape, so as to force the air into a "nozzle-like" shape, creating a pressure differential.

The conical form was also chosen as it appeared to make the product more inviting to the user, providing a clear indication of where the user must interact with the product. A symmetrical product such as a cylinder might confuse the user about which end does what, but with such a form the confusion would be minimized. The form also appears more interesting visually, and allows for the product to be confidently displayed at home.







Design Recommendations

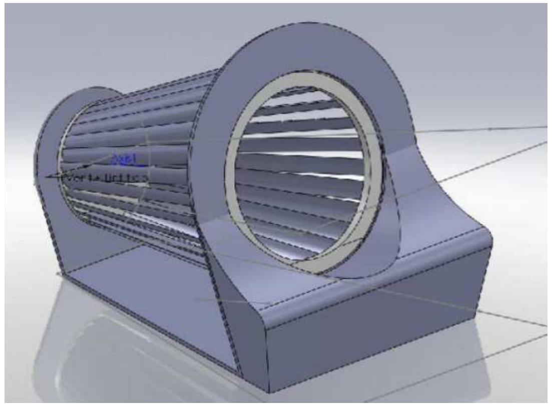
2. Chassis Structure

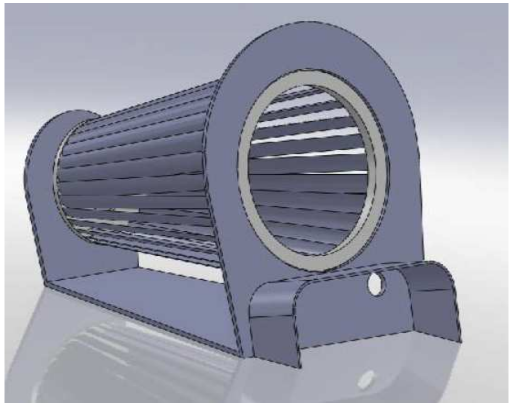
Chassis Structure

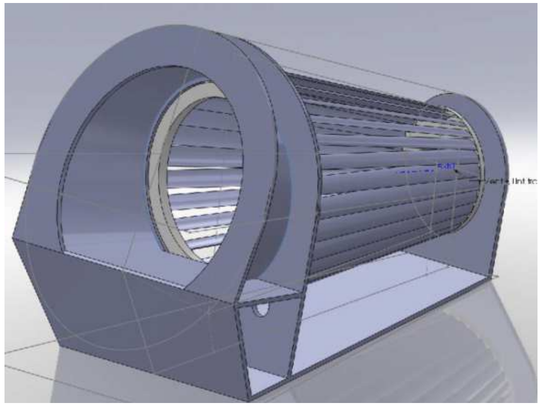
AVINASH PRABHUNE– INDIVIDUAL CONTIRBUTION

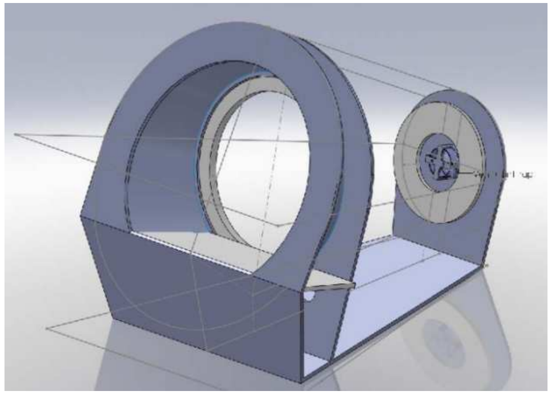
The outer chassis is a support structure of the product . We have to think about packaging and supporting all of the components without affecting the basic form. As mentioned earlier, sheet metal is the quickest way to make prototype, as we have accesses to laser cutting machine and water jet cutting machine. To make it more stable and rigid, the chassis should be a one piece uni-body. It means the body should have minimum number of joints. A uni-body will also allow the inherent spring effect of the sheet metal to add rigidity to the structure when the chassis is loaded. Some chassis options are shown below.

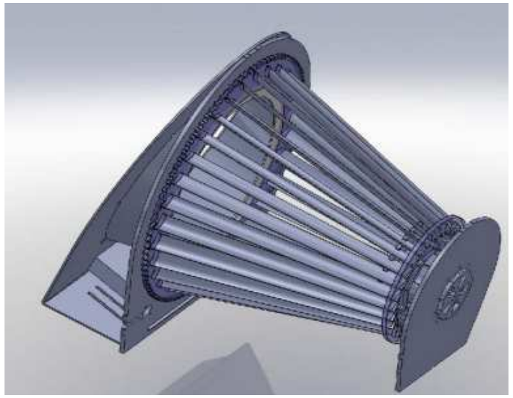
Chassis Structure Design

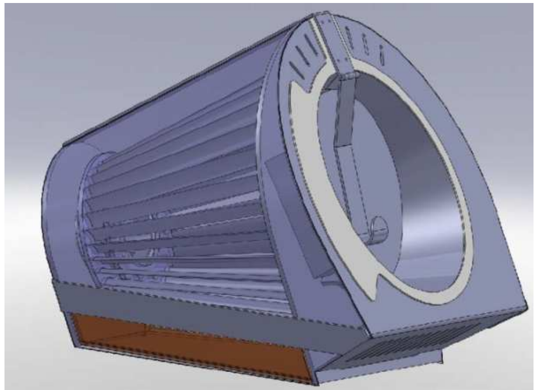




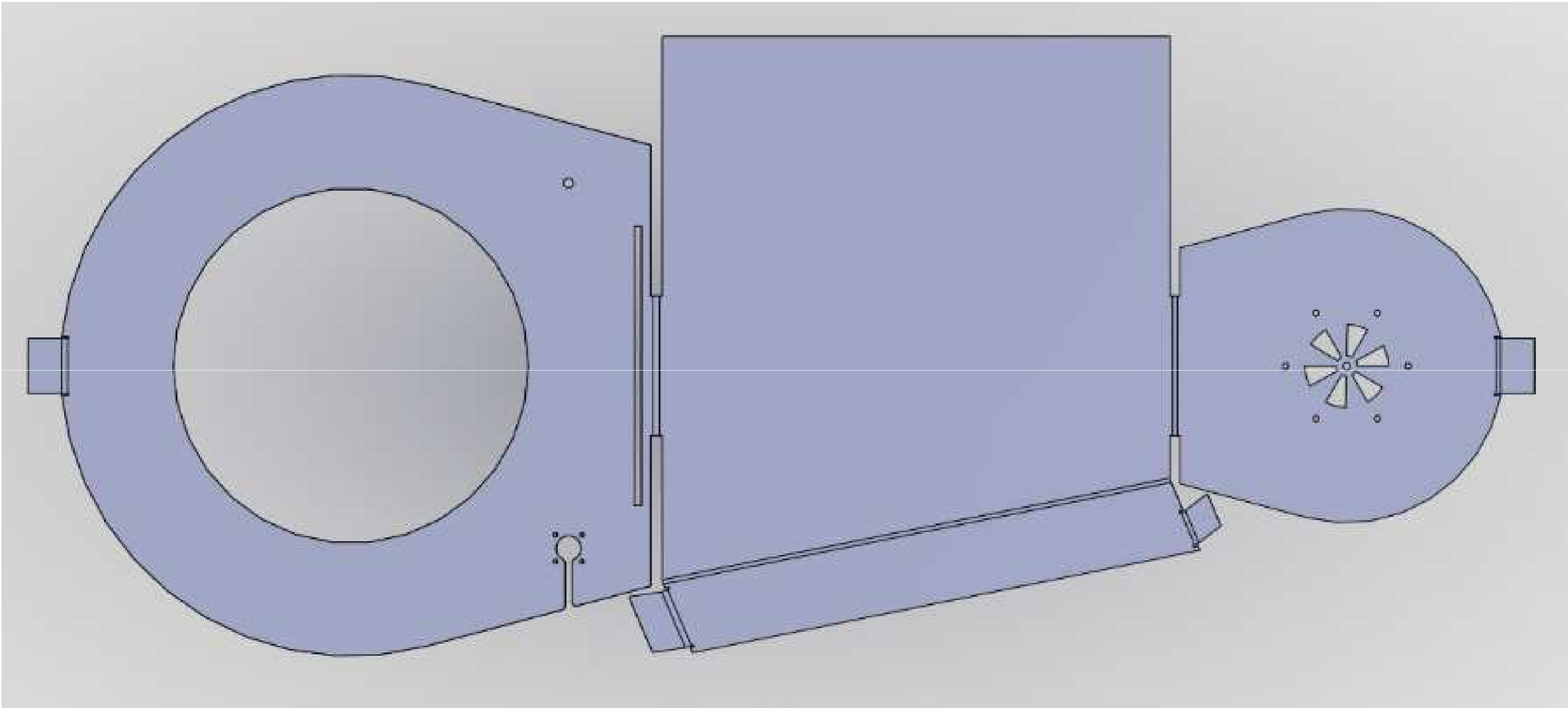








Chassis Structure Design unfolded view



Design Recommendations

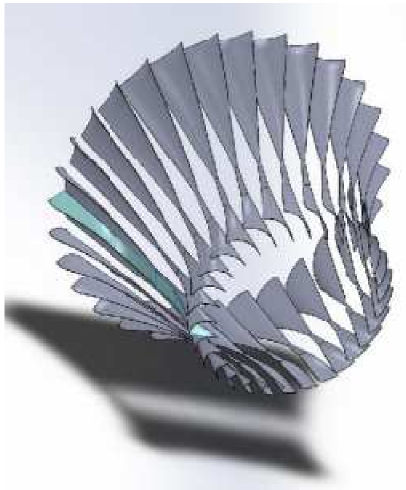
3. Blade Profile

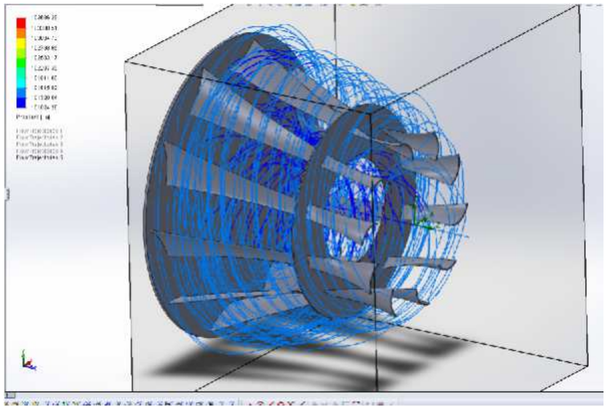
Blade Profile Optimization

AVINASH PRABHUNE – INDIVIDUAL CONTIRBUTION

The blades need to perform two functions. They act as a support structure for the drum and create airflow circulation within the drum chamber. Currently, the blades only create turbulence outside the drum, and do not effectively draw air in to the drum. They perform effectively as a 'blower' type fan throwing air tangentially like hair-dryers. They create adequate airflow during the higher speed spin cycle but are not good enough during the tumble cycle. To combat this, the profile of the blade and the angle of the blade mount was changed along with the conical drum axis. To increase air suction in the intake, and increase air circulation at the exhaust, two-thirds of the blades are shaped to push out air, and the back one-third is curved to draw in air.

Twisted Blade





AirFlow Simulation on SolidWorks

Overall thermal efficiency of the dryer improved as we reuse some hot air that is exhausted from the drum. A simplified flow simulation was done to predict the impact of the new blades.

Design Recommendations

4.Component Layout

Component layout for compact packaging

AVINASH PRABHUNE / AVINASH JAYAKUMAR

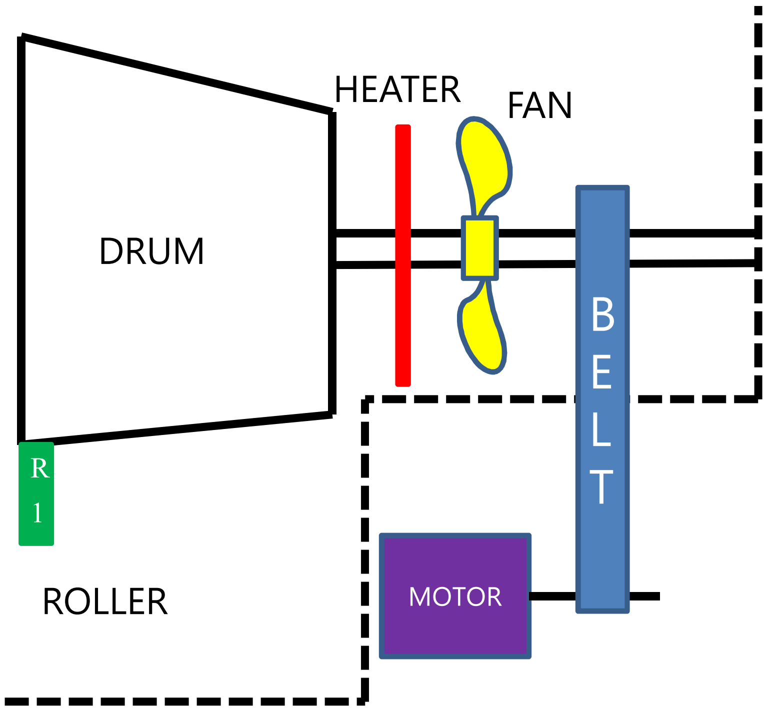
To maintain the compactness of the product, while maintaining the functionality, various component packaging layouts were considered. These were driven principally by the choice of having an additional motor driving the fan blades used to increase airflow during tumble cycle. These are presented below. Brief Pros and cons of each configuration is listed along with the layout.

The overall prototype incorporating our design recommendations is shown in the images below.

Configuration 1

Fan **without** additional motor

Layout 1 : Single belt with ratchet mechanism



PROS

- Most Compact package
- Allows high drum speed rotation (1000+ rpm)
- Direct airflow through the drum
- Lower number of components

CONS

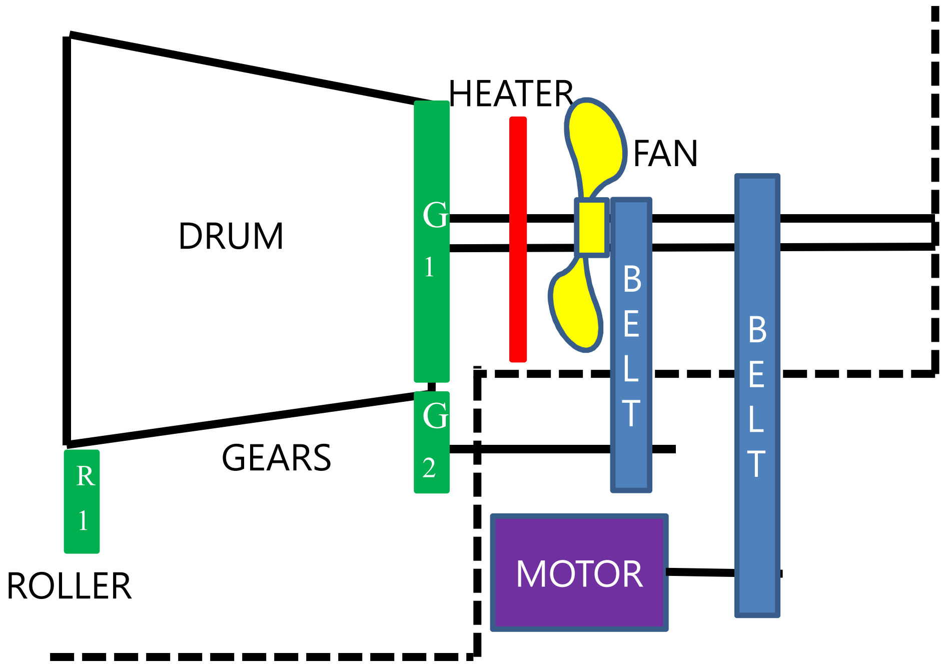
- Uncontrolled fan speed
- Overall weight increase

- Custom pulleys, custom shaft required

Configuration 1

Fan **without** additional motor

Layout 2 : Dual belt



PROS

- Allows high fan speed rotation
- Allows high drum speed rotation (1000+ rpm)
- Direct airflow through the drum

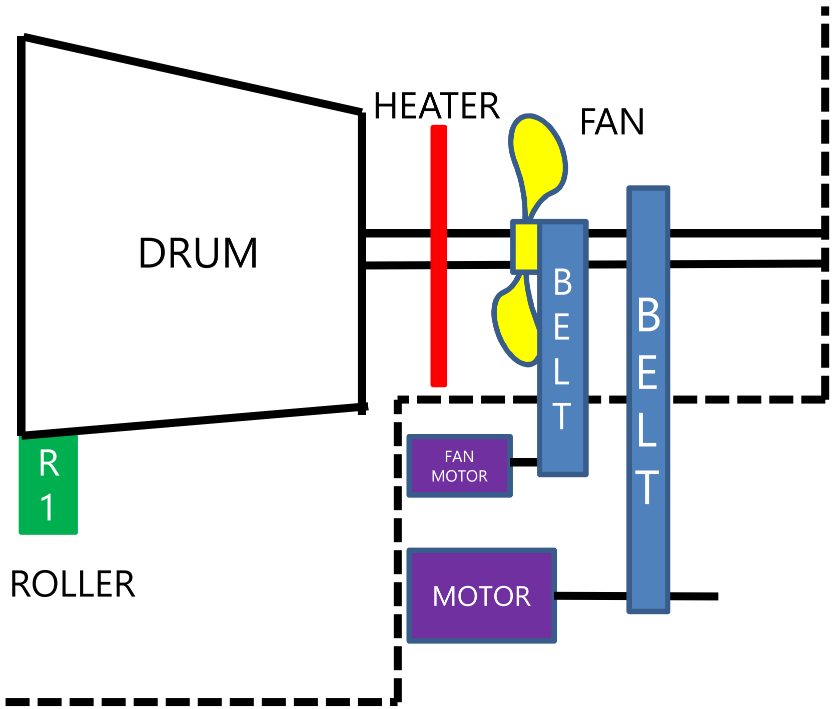
CONS

- Fan speed very fast during spin cycle
- Packaging is difficult in given space
- Extra components
- Custom pulley, Custom shaft required

Configuration 2

Fan **with** additional motor:

Layout 1 : Dual belt, separate fan motor



PROS

- Separate control for fan
- Airflow through full drum

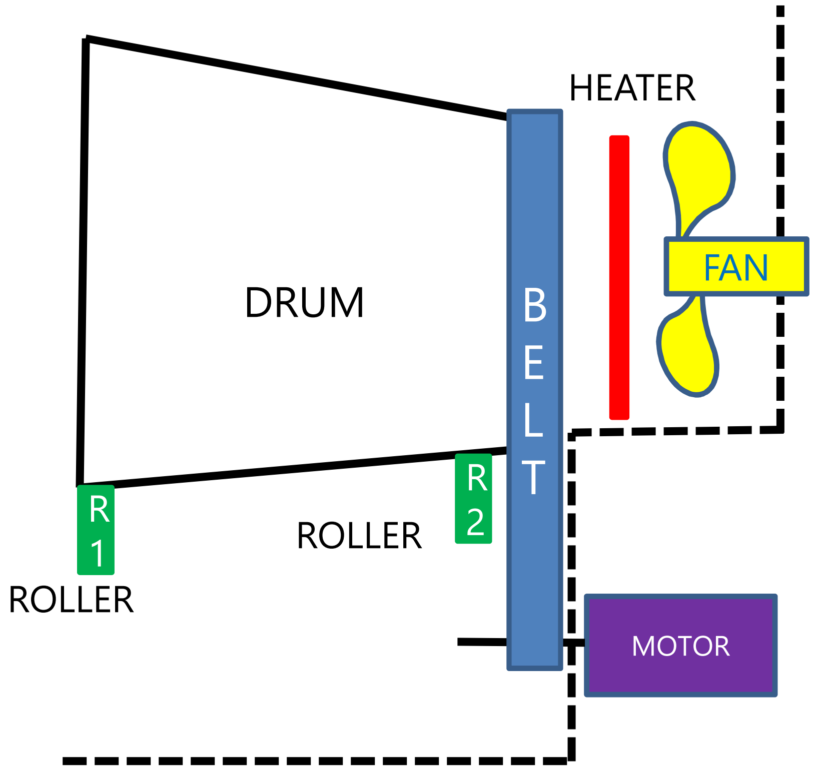
CONS

- More complex packaging
- Higher power consumption
- Expensive
- Difficult to service
- Custom pulleys, custom shaft required

Configuration 2

Fan **with** additional motor:

Layout 2 : Single belt, integrated fan motor



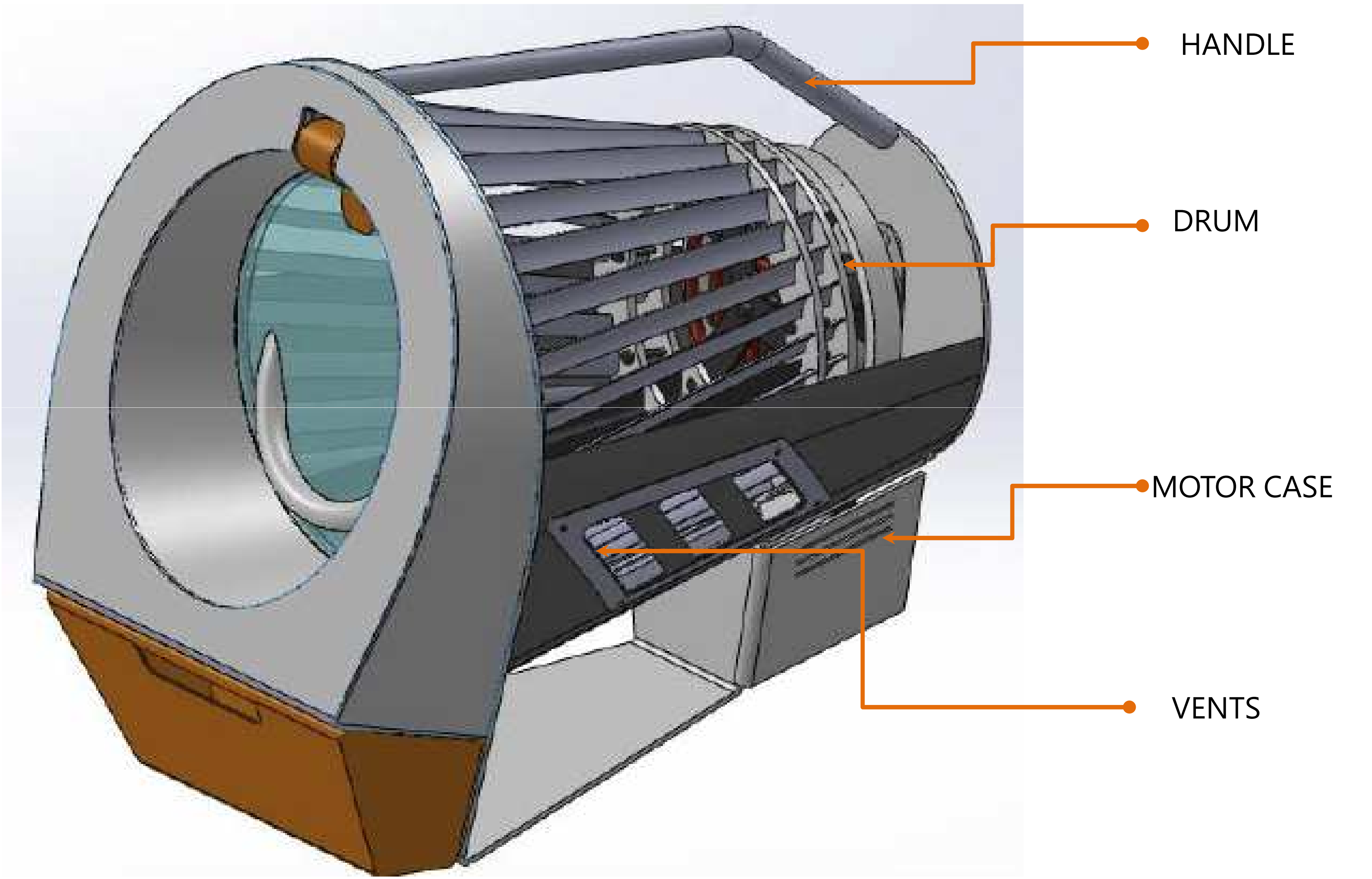
PROS

- Compact
- Less components
- Airflow through full drum

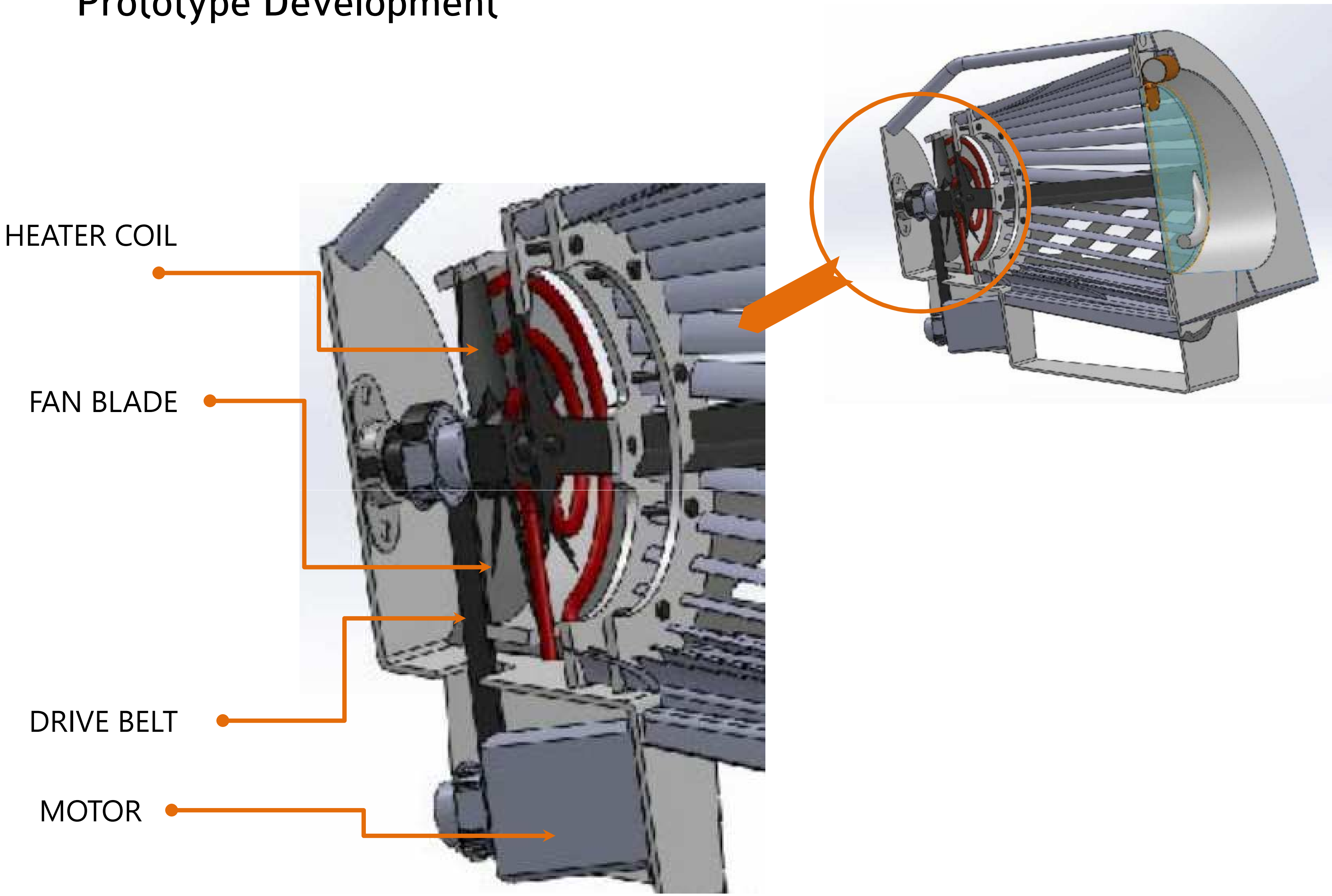
CONS

- Noisy
- Low drum speed
- Rollers add noise / packaging complexity

Prototype Development



Prototype Development



Design Recommendations

5.External Design

Overview

DEEPANWITA GHOSH – INDIVIDUAL CONTIRBUTION

The opportunity for external design for this project consisted mainly of the following components **- Handle, Door Hinge, Door Handle, Water Tray and Fascia**. These components mount on the chassis and it was important to design the most suitable way to mount these. It was important to consider the mounting method to minimize assembly complexity, and keep the entire system easily serviceable.

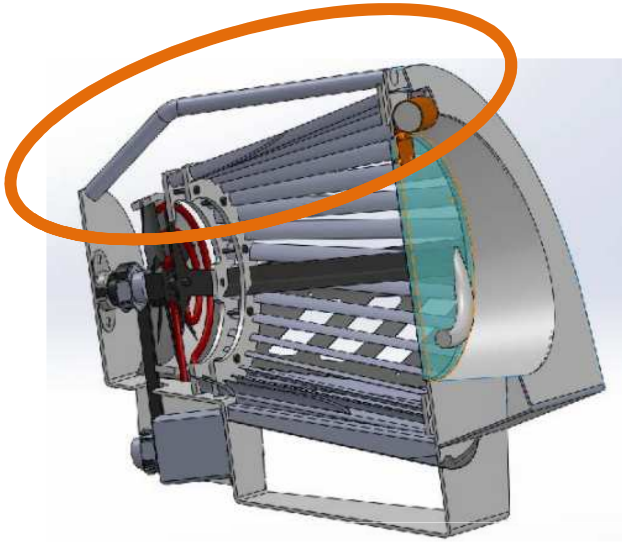
As this design process was carried for an in-house prototype, the designs were bound by constraints of easy manufacturability (less curves, complex surfaces), minimum components. It was very important to ensure that any notches or holes were kept to a minimum to prevent the accumulation of stresses due to the cyclic thermal load placed in the product.

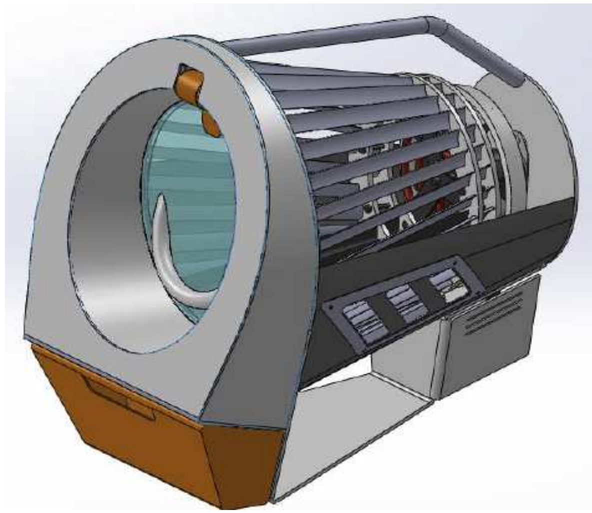
Handle Design

Requirements and Constraints:

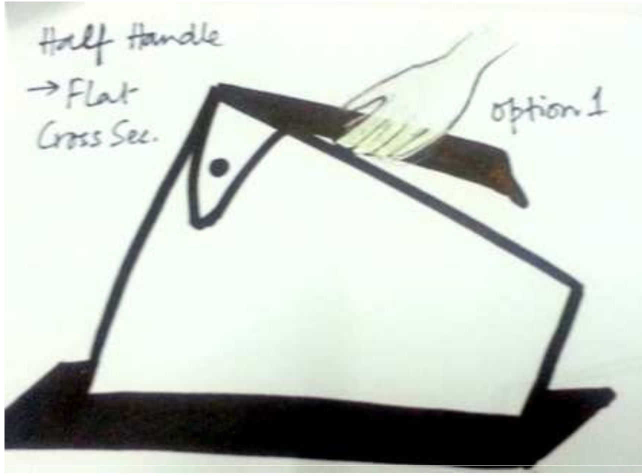
The primary design consideration for the handle is comfort during use. The design of the handle is key to ensure that the user feels secure and comfortable during any interaction with the product. The handle (encircled) is bolted on from the top, and plays another vital role – chassis support.

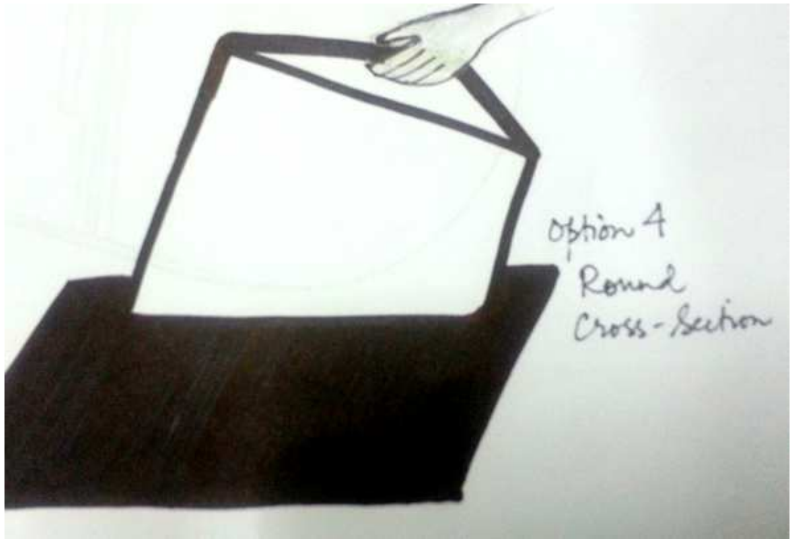
The handle acts as a connecting link between the front and back walls of the uni-body structure, which would flex backwards ever so slightly in order to secure them. Thus, as mentioned earlier the chassis would be stiff ed and supported by the handle. The handle must allow the user to balance the product while holding it, while minimizing the visual (As well as actual) increase in height of the product, to preserve it's compactness.





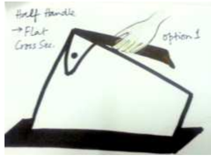
Options Explored





Options Explored

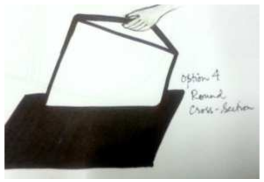
Options considered included round, flat cross sections, with the handle going the full length of the product, or only present for half the length (as indicated).



Option 1 is mounted in front, is aesthetically interesting. This option was rejected as it does not allow for a strong support. The handle uses only two bolts to secure it, with both in shear. The handle also could allow the grip to slip.

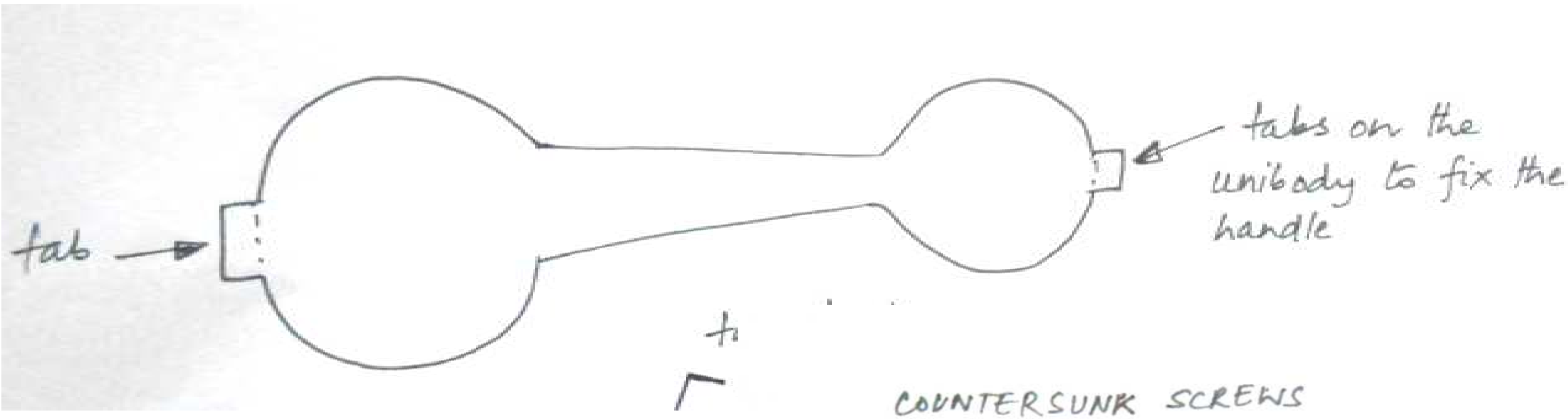
Option 2 also provides an interesting arrangement. The half handle is welcoming to the user to grip it, and provides a visual complement to the overall profile of the drum line. Again, the potential to slip and the lack of support were reasons for not selecting this handle.

Option 3 is a horizontal cross handle, centered over the drum. The supports were too intrusive to the rest of the drum design, and thus this was rejected.

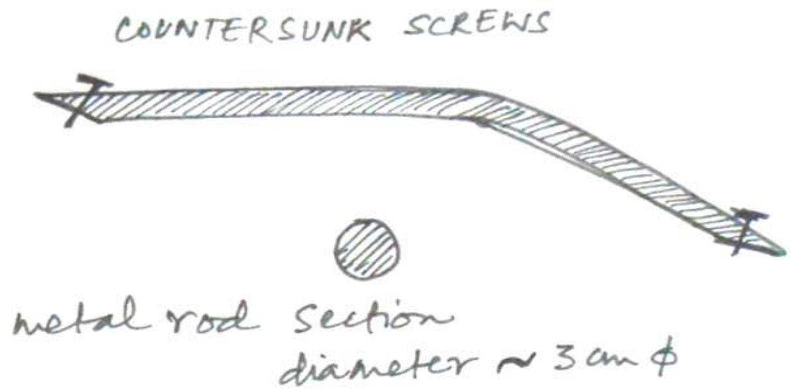


Option 4 is a simple longitudinal member linking the front and back walls. It supports the chassis, and distributes the weight of the product properly for the user. This was the chosen option.

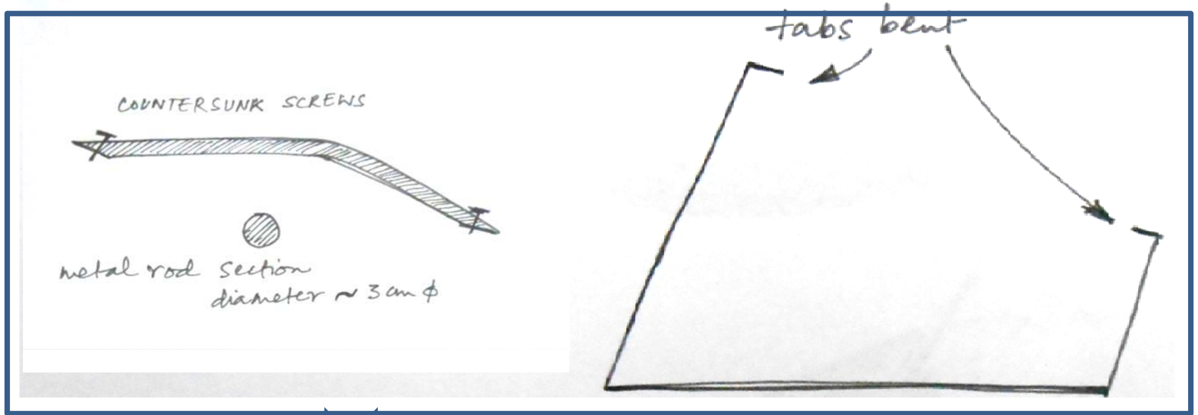
Feasible Designs

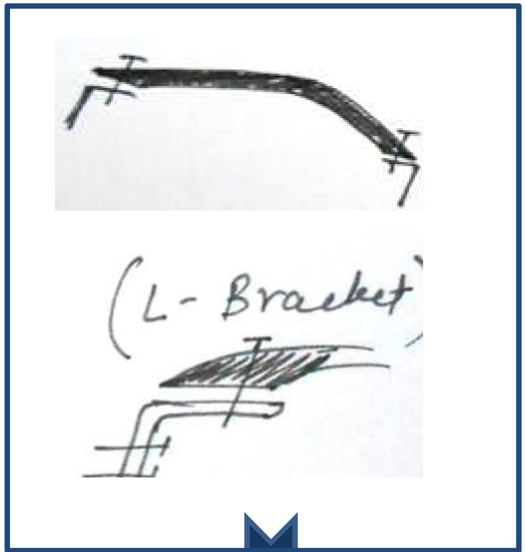


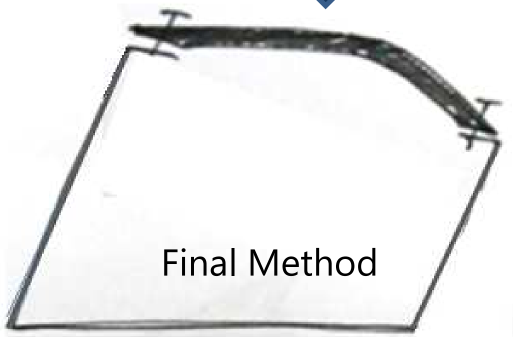
The mounting of this handle was through the use of simple tabs on the one piece chassis that are bent. The tabs provide mounting locations to attach the edges of the handle using screws. A 3cm aluminum rod was recommended for the handle.



Handle Design Options Considered

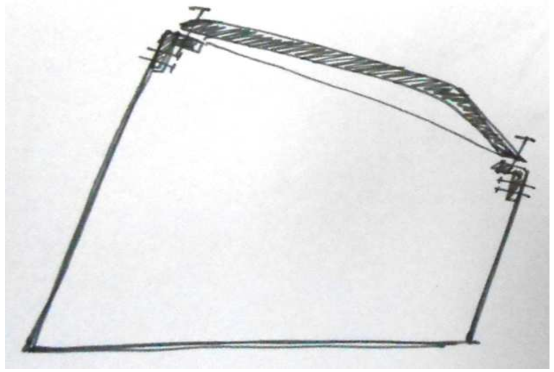




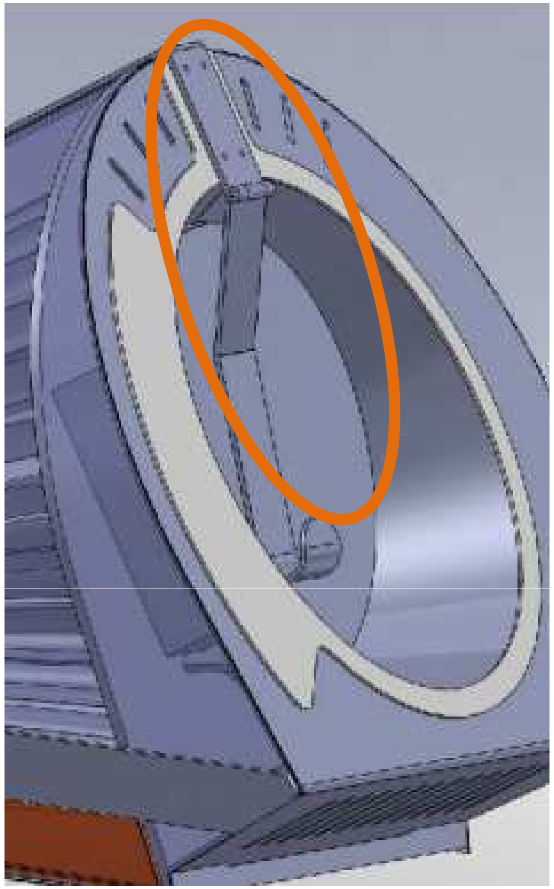


Final Method

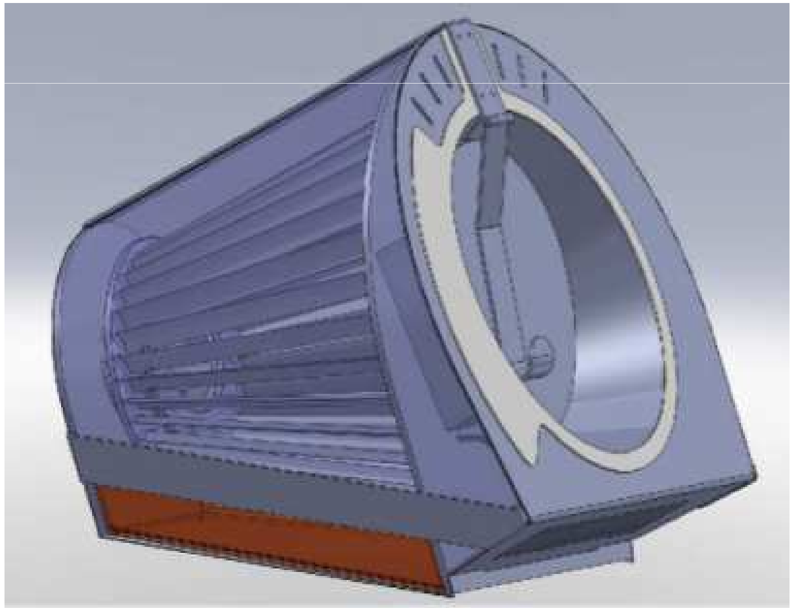
The other option that was considered is through the use of L-brackets that mount on the inner chassis walls, allowing the handle to be mounted on them. This was rejected as it involves complexity during assembly and additional components.



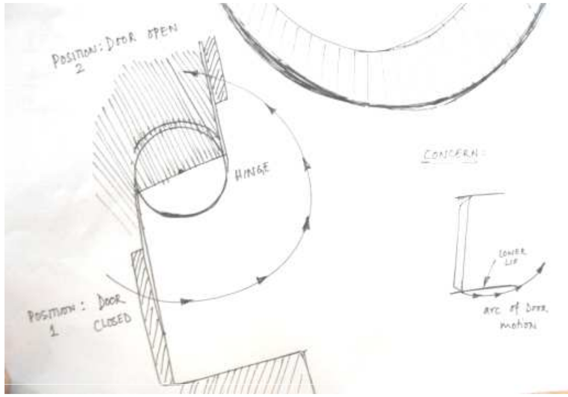
Door Hinge Design

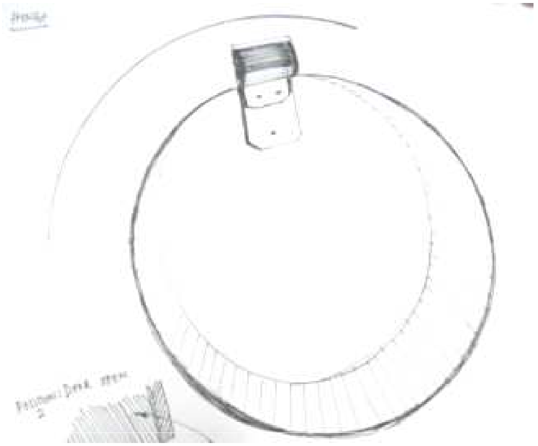


The door hinge was designed to be mounted on the front wall of the chassis. A requirement was that the door allow for 180 degrees of movement. The door should not have any excess overhang, and it should support itself in the open position (a rest back feature) to facilitate easy access to the drum interior.



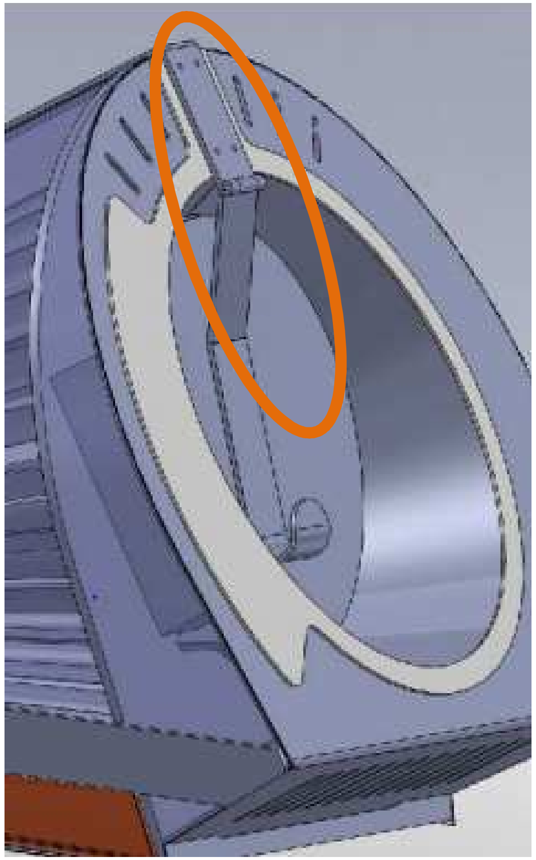
Door Hinge Design

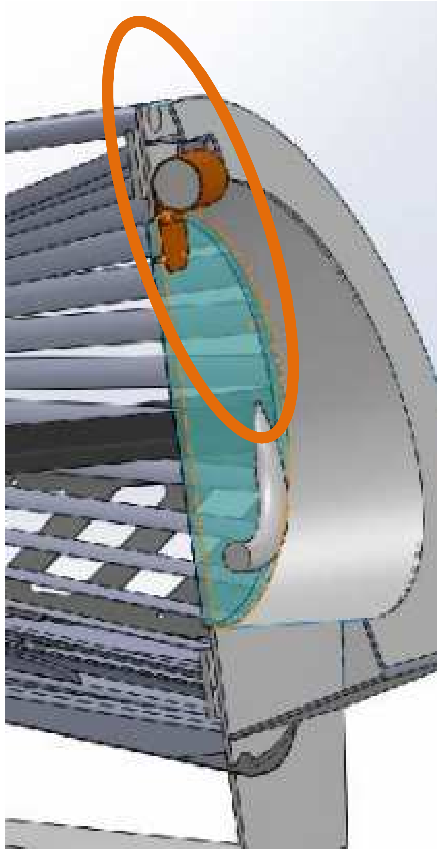


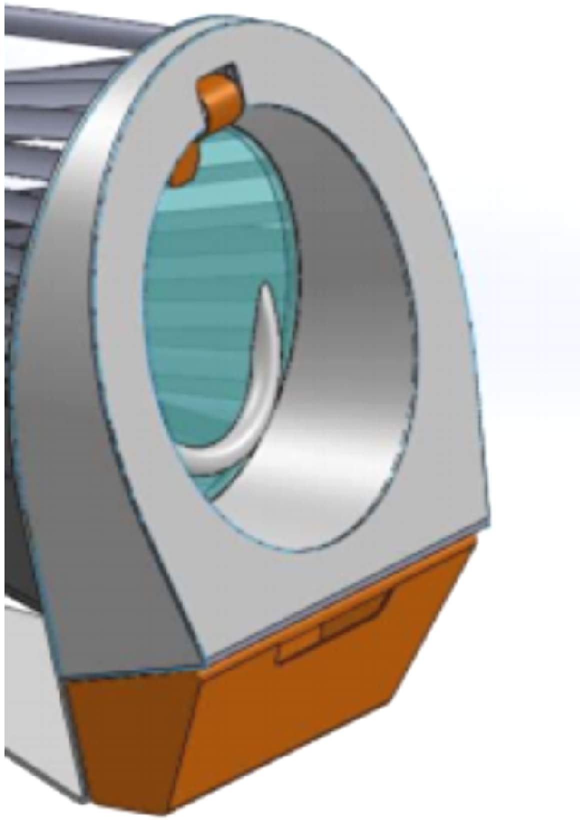


From an aesthetic stand point a door hinge was designed to be as clean as possible to look at from the front. The hinge should quietly do its function without exposing its inner workings like the common hinges seen on doors. This was achieved by enlarging the hinge, so as to highlight to the user the presence of the hinge, but still not be too loud a statement. The hinge was designed using sheet metal wrapped around **a nylon dowel centre**, that allowed for the pin to be joined through. Please refer to next page for pictures.

Door Hinge Design

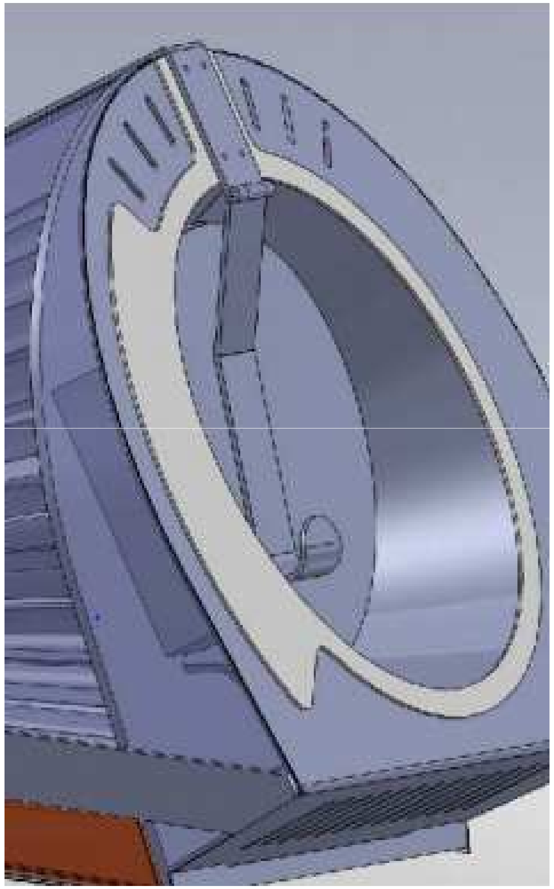






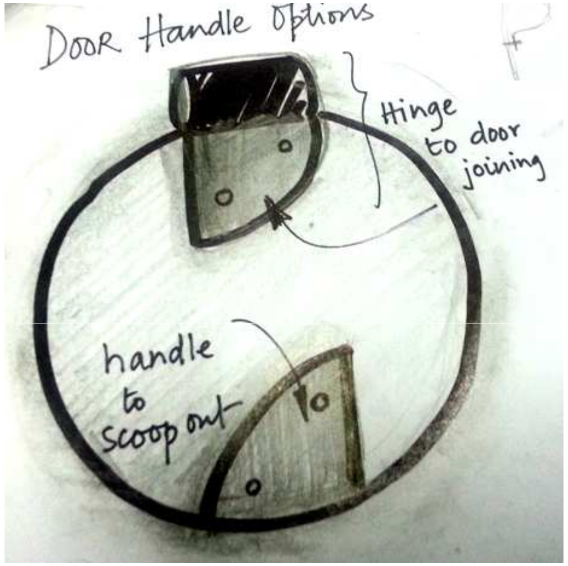
Door Handle Design

For the Door Handle design, primary concern was the comfortable grip of the user. A scoop feature was required to provide an affordance for the fingers of the user to easily grasp the door handle. The door was also to be made transparent for the purposes of the prototype and thus installation of the handle must be clean.



Options Explored

Option 1



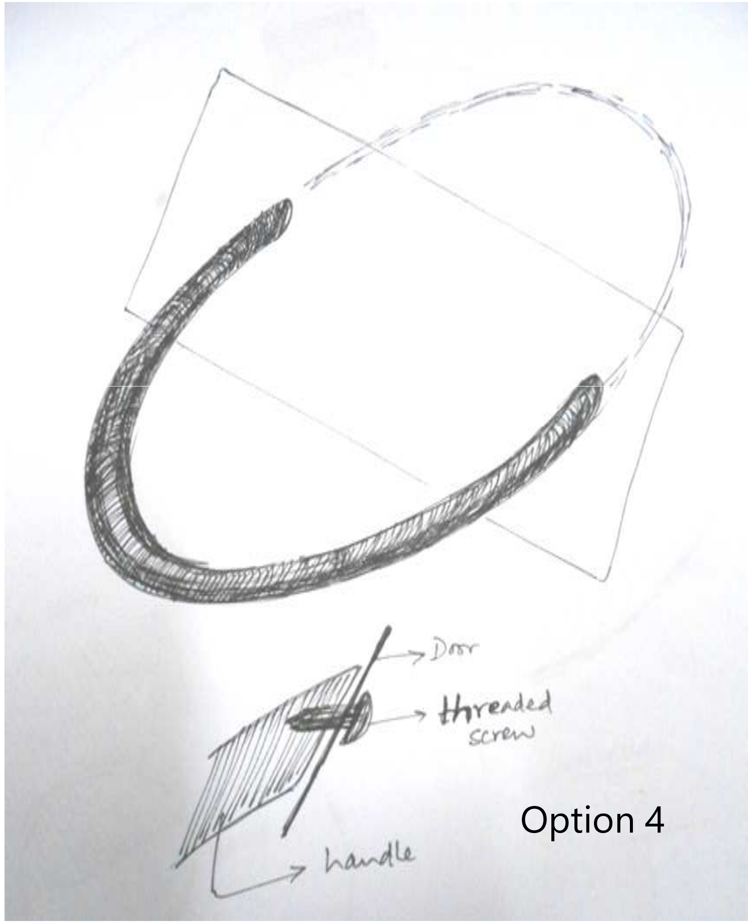
Option 2

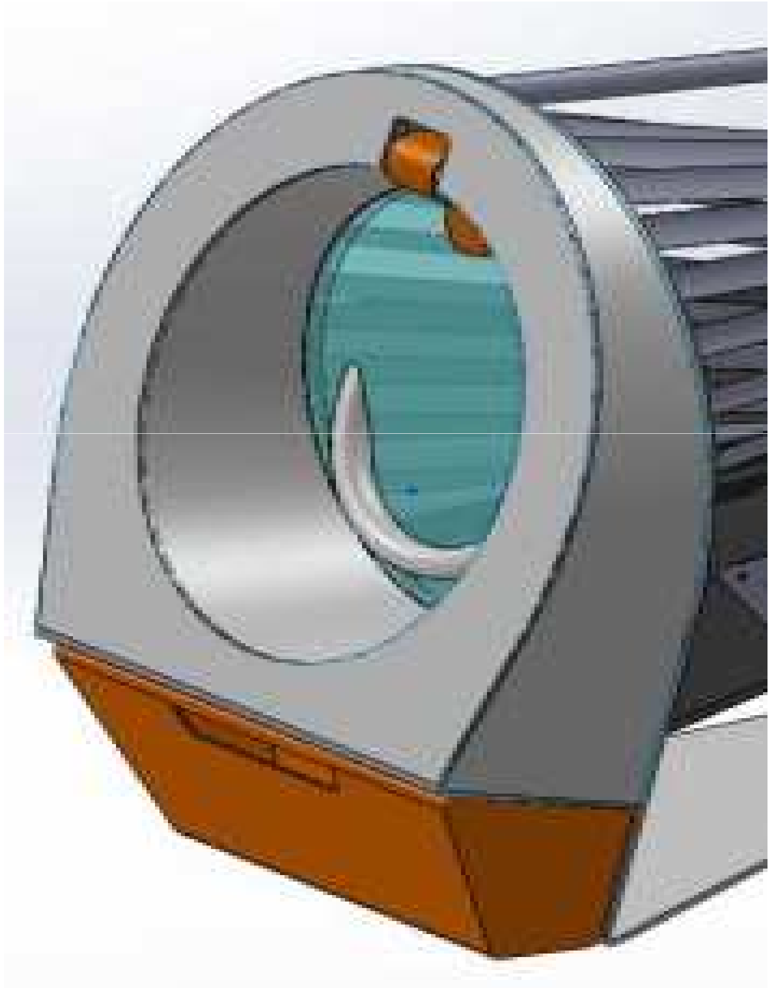
Option 3

Several options were presented for the door handle design, but in the end option 4 was chosen by the lead designer for the simple reason that the handle looked like a happy face (with a smile), and this was apparently aesthetically pleasing.

Final Door Handle Design

Semi-Circular handle preferred



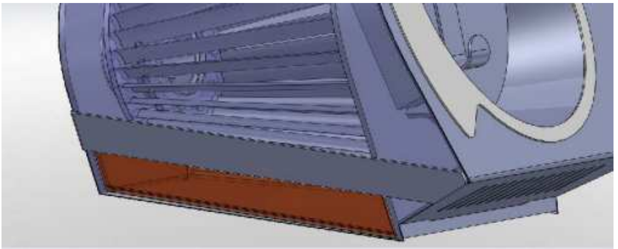


Water Tray

To collect the water droplets from the spin cycle, as well as to collect any condensate from the tumble cycle, a water cup was required for the system. Due to the shape of dryer the best position for this system would be in the front, and thus the design process for the water cup started.

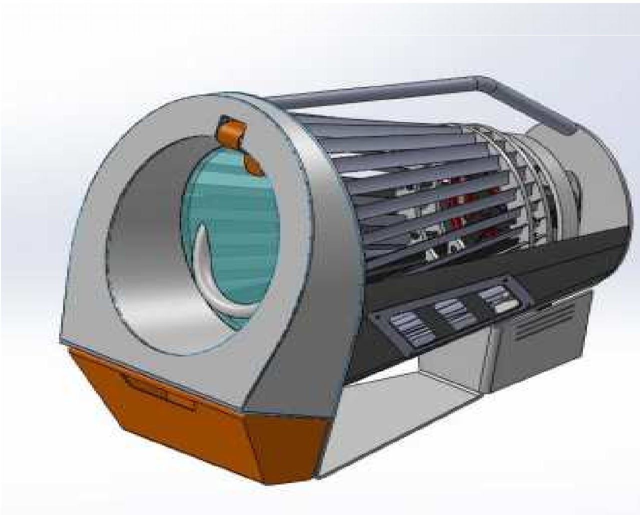
The water cup should be secure when the dryer is lifted and the tray is filled water. It is preferred that the tray be transparent for water level indication. Another constraint was that the tray should not have any holes, grooves, drawer mechanisms and small parts like rollers, etc. due to the manufacturing difficulty for the prototype.

Options Explored



A side access tray was explored as an alternative to the front access tray, but was quickly dismissed due to the large size of the tray, and the unwieldy tray load when full. This would be akin to the old condensation trays used in refrigerators from older days.

Side – Access Tray

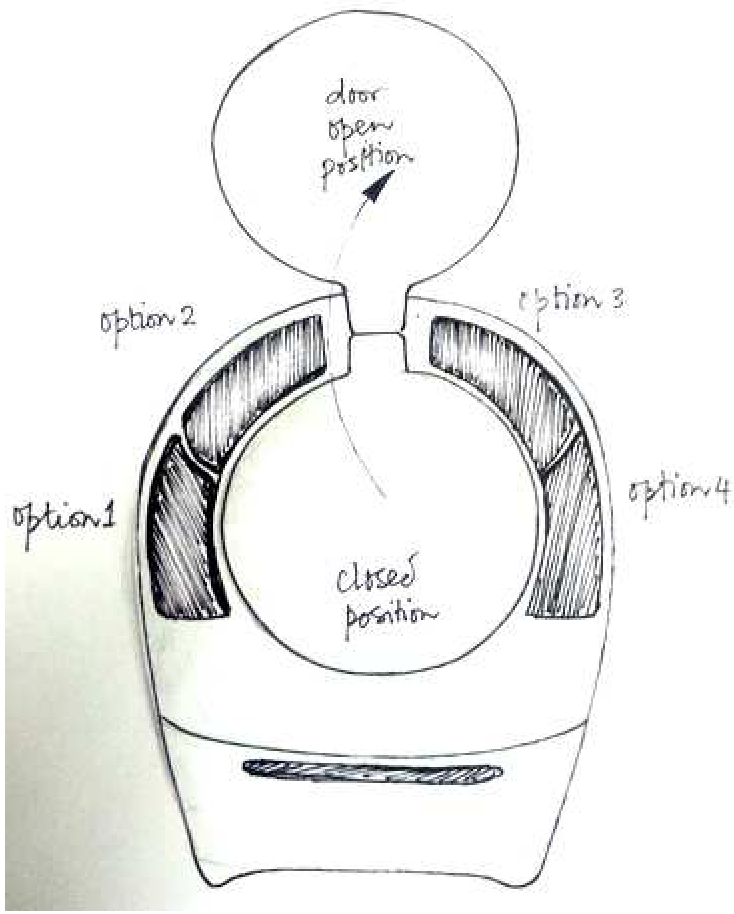


The front access water cup / tray finally designed is shown .

Front - Access Tray

Fascia

The fascia of the dryer is the location for the future control buttons of the dryer. The primary concerns while designing it were that the buttons should be accessible when the door is in the open position. The housing should be away from water. This was achieved by placing the fascia on the outer part of the front wall, using the wall to act separator between the humid chamber and the dry side. A few options for the button locations are shown.



Conclusion

The Project about the Wee Dryer was very interesting and challenging to work on. Having a mechanical engineering background helped to understand and freeze the key functionalities for the working of the Dryer. Hands-on experimenting with the prior versions of the dryer prototype helped us to articulate the best solution to the problem along with other team members.

The design was optimized to use off -the-shelf components and options that provided a structurally sound and mechanically feasible design that would be easy to build later on in the lab. Our Team ventured into a lot of in-depth analysis and problem exploration and thus the time left for prototyping, as planned originally was curtailed. The experience was very enriching.

During the course of this internship, we met a lot of new people, experienced lot of new things, ate a lot of good food and had a very memorable time in Auroville.

This experience was an important one and will be always cherished.