



Project II

# Redesigning a Solar Powered Cookstove.

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# 1. Introduction.

## a. Introduction

The project explores the various issues people face while usage of solar cookstoves in an urban setting. The project started to find a viable solution for the usability of existing solar options and LPG availability in the rural areas but transformed into a consumer product because of the travel restrictions during the covid-19 pandemic. In Urban settings the changing and ordering the LPG cylinders every few weeks could be cumbersome; the projects aim to develop a device that could reduce the consumption of LPG source for fuel and lead the user to spend less on LPG. The users generally have to change cylinders every few weeks and order them if the cylinder is empty. The proposed design creates a solution that can limit LPG cylinders' use without imposing the user to use the said solution.

The Council on Energy, Environment, and Water (CEEW) is one of South Asia's leading not-for-profit policy research institutions. It states that till 2035, increasing the efficiency of the solar panels will be on the agenda. [1] But, Until then, we should utilize multiple fuel sources to have clean cooking. The project's technical aspect is referenced from the Master's report, where the researcher was able to use low powered Pv cells to generate enough heat to cook food.

## b. Objective

To re-design a solar powered cookstove using low PV cells for middle class to upper middle class user sector residing in urban households.

## c. Rationale behind selecting the problem

Through personal experiences I realized the design of the stove varies from type to type, even the direction in which the users must turn the knob is different in every stove. Since the inception of PMUY, the rural as well as urban areas have the LPG coverage of 96 % of total population of India. [2] Yet, because of economic reasons or the issue with the availability of the LPG cylinders due to remote location in rural areas the people for whom this scheme was created were not able to benefit it. So, creating a economically viable and renewable source of energy was required and that is why this I took this problem as a challenge, aiming to solve it.

## d. Beliefs

All stoves which are used in Indian kitchens have different knob direction. Evidence: The user statements and observation lead to the said argument.

The users belonging to the middle-class sectors would be inclined to buy a solar device.

Evidence: The user interviews and statements

Indian kitchens contain the same types of utensils which include tawa, kad-hai, pressure cooker etc. most of which have a round bottom rather than flat ones.

Evidence: Photographs of different kitchen with similar types of utensils.

## 2. Project Timeline.

In order to plan and execute the entire project, the following timeline had been planned. Various factors including occasions, tests, holidays etc. were taken into consideration with buffer time for the smooth execution of the project. Below is the table of steps on the left side which are

weekly followed. The weeks are denoted as 'W\_(no. of the week on the given month)', for example, W\_3 in August means the third week of August.

S.No.	List of Steps	August		September				October				November				December	
		W_2	W_3	W_1	W_2	W_3	W_4	W_1	W_2	W_3	W_4	W_1	W_2	W_3	W_4	W_1	W_2
1	Basic Reading																
	Research																
2	Reading Reports																
3	Synchronic Study																
4	Mechanism/Components																
5	Preliminary Ideations																
6	Preliminary Concepts																
7	Discussion with Expert																
8	Discussion with PV vendors																
9	Ideations																
10	User study																
11	Proof of concepts																
12	Concept Development																
13	Pre-Jury																
14	Report Making																
15	Final Design																
16	Presentation																

Image 2.1: Project schedule shown in weeks.

# 3. Methodology.

The following diagram shows the approach that has been implemented in this project. The methodology includes literature study which involves understanding the hand pump and its context followed by the field study involving semi structured interviews and observations. Analyzing the data

from the studies are done along with ideations in parallel. Concepts are developed and further refined as per the inspirations, studies, expert reviews, jury comments and feedbacks from the users.

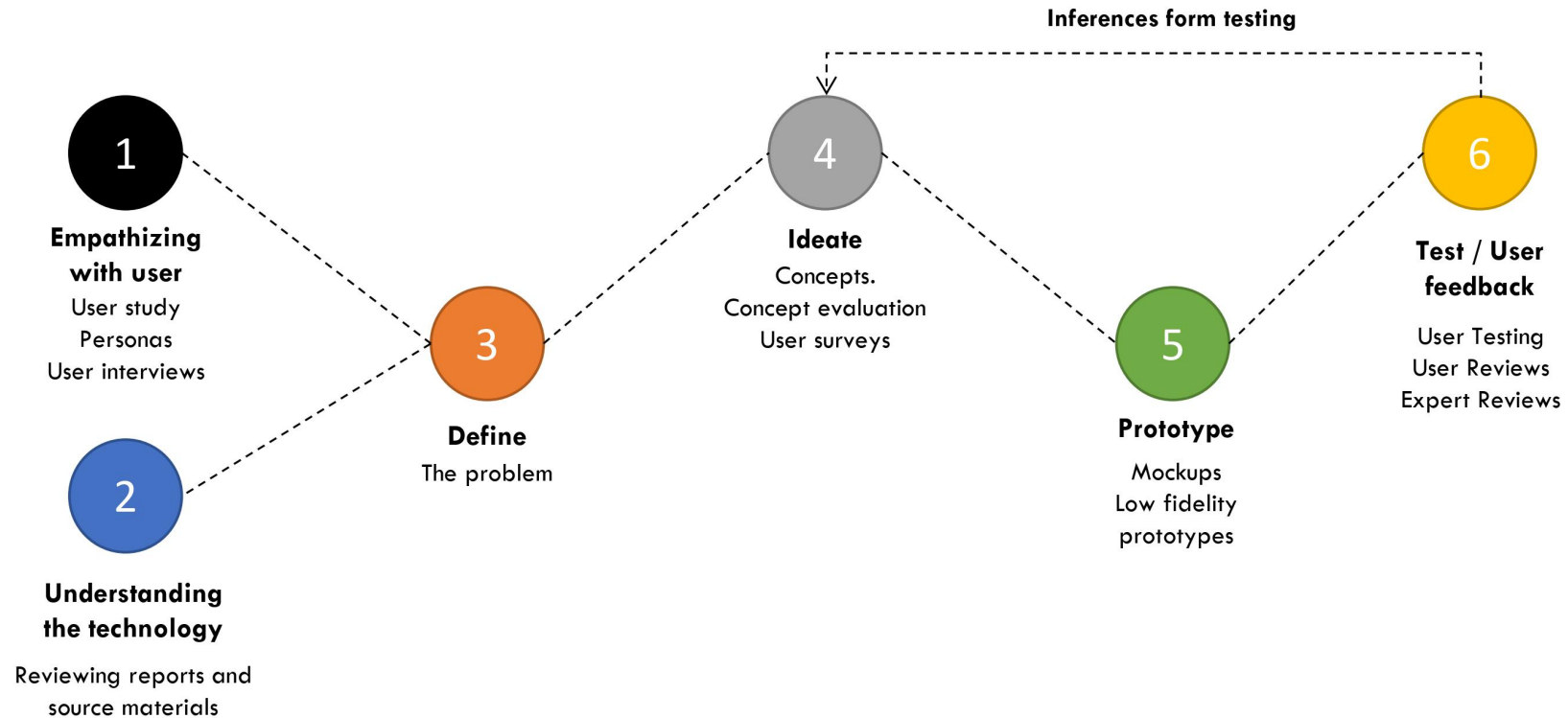


Image 3.1: Diagram shows the step wise progression and methodology of work implemented.

# 4. Literature Study

## a. Synchronic Analysis

- **Box type solar cookers**

Conventional box-type solar cooker consists of insulated box with the transparent glass cover. Sun light radiations incident on the reflector plate get reflected toward glass cover and energy in the form of radiations gets trapped inside the insulated box cooker by the phenomena of the greenhouse gas effect. Schematic of the conventional solar cooker is shown in figure 4.1. Trapped radiations inside the insulated box increases the temperature of the medium inside the box up-to 100 o C. Heat energy gets transferred to the food material in the utensils placed inside

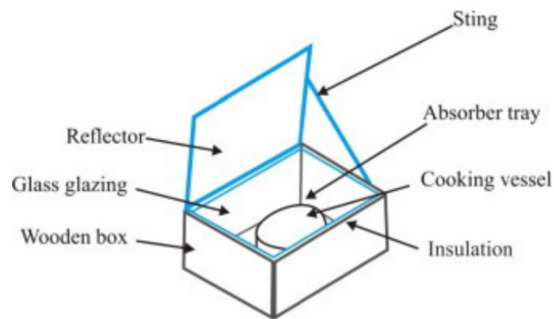


Image 4.1. Box type Solar Cooker

the insulated box. Trapped heat that transferred to the food through the cooking vessel helps in the cooking process. Although the cooking with conventional box type solar cooker is the clean cooking practice with no recurring cost, but this type of solar cooker has

got poor user acceptance due to various cooking constraints such as this solar cookstoves compels to cook outdoor in the open sunlight.

- **Induction type cookers**

Induction Type cookers is performed using direct induction heating of cooking vessels, rather than relying on indirect radiation, convection, or thermal conduction. In an induction cooktop, a coil of copper wire is placed under the cooking vessel and an alternating electric current is passed through it. The resulting oscillating magnetic field wirelessly induces an electrical current in the vessel. This large eddy current flowing through the resistance of the vessel results in resistive heating.

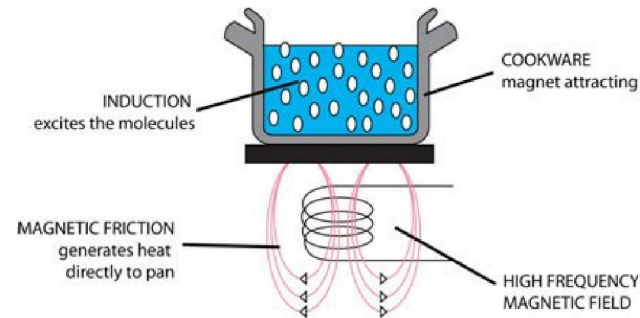


Image 4.2. Induction type Cooker

Although the induction type cookers are most efficient mode of cooking food but because induction coils require AC current, the DC current form the solar Panels would required to be changed to AC current and then stored in batteries for further use, which increases the overall cost of the system.

## 4. Literature Study

- **Resistive element type cookers**

Resistive element type cookers work using a heating element which is also called a resistor. Resistors work by converting electrical energy to heat energy; in other words, they get hot when electricity flows through them.

A typical heating element is usually a coil, ribbon (straight or corrugated), or strip of wire that gives off heat much like a lamp filament. When an electric current flows through it, it glows red hot and converts the electrical energy passing through it into heat, which it radiates out in all directions.

There are lots of different kinds of heating elements. Sometimes the nichrome is used bare, as it is; other times it's embedded in a ceramic material to make it more robust and durable.

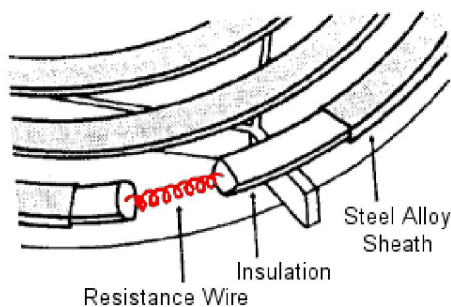


Image 4.3. Induction type Cooker

These kinds of cookers can be configured to operate with the DC Voltage produced by the solar panels. There is no conversion required from DC

to AC as that was the case in induction type cookers. The heating element can be configured in various layouts, i.e., the coils can be put in parallel to achieve a greater amount of heat production with the same amount of power. The coils itself can be arranged in various shapes and sizes to achieve the desired result.

### b. Report Analysis.

The technological aspect of this project is inspired by the works done in a MTech project report 'Design and Development of Solar Photovoltaic equivalent of the box type solar cooker & resistive cookstove' - By Prasad Kulkarni, IIT Bombay (Year 2020)

This project was able to conclude that a relatively low power (100W) solar panel can be used directly (without battery and Inverter) to cook food (Boiling type) using **Insulation** (to reduce the heat loss and increase efficiency). [3]

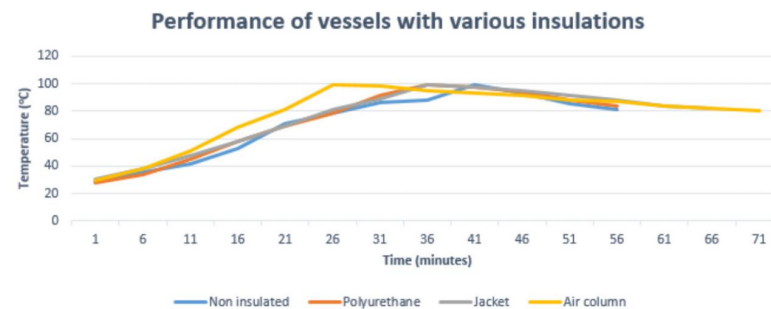


Image 4.3. Results of insulated vessel with air column as insulation.



# 4. Literature Study

## c. Design Considerations.

- **Internal resistance of Solar Panel**

Solar panel works at its best when internal resistance of panel matches with external resistance i.e. resistance of the coil. But the resistance of the panel increases with reduced solar irradiance and the Coil resistance increases with increase in its temperature. Conclusion being that the resistance of the coil should be the same as the internal resistance at  $V_m$  &  $I_m$  for maximum efficiency.[3]

$$R = \frac{V}{I}$$

Image 4.4. Internal Resistance formula

- **Insulation of the heated vessel**

As per the experiment conducted by Prasad Kulkarni, he suggested to use an air column as the insulation if possible as it is most effective. The size of the air column should follow a thumb rule of 10% of the radius of the vessel if larger than convection comes into play which reduces the efficiency of the insulation. [3]

## d. Time Analysis

A time study was conducted to analyze the variations in cooking process that is how much time was assigned to boiling the food (100 - 120c) and frying the food (200 - 220c) in an Indian household kitchen.

Time	Item	Frying 220c	Boiling 100-120c	Total time
6:47 P.M	Tea	00:00 min	05:00 min	05:00min
8:02 P.M	Okra	03:36 min	14:39 min	19:54 min
7:30 A.M	Tea	00:00 min	04:47 min	04:47 min
9:15 A.M	Dhokla	02:40 min	22:04 min	25:52 min

Image 4.5. Initial Observations

Initial observations showed that the amount of time boiling the food was greater than the amount of time dedicated to frying the food. But the number of observations made were not enough to create a claim that Indian style of cooking dedicated more amount to boiling the food.

A detailed study with larger number of observations were required to proof the said claim.

After a detailed study was done, as you can see in the image 4.6, the amount of boiling food items is significantly more than frying food items in the Indian style cooking.

So we can conclude a device which can boil food items in the kitchen would significantly reduce the amount of LPG consumed.

## 4. Literature Study

Time	Item	Frying 220c	Boiling 100-120c	Total time
9:15 A.M	Tea	00:00 min	07:00 min	07:00 min
10:05 A.M	Parathe	20:00 min	00:00 min	20:00 min
1:22 P.M	Dal	04:00 min	28:00 min	32:00 min
1:34 P.M	Rice	00:00 min	20:00 min	20:00 min
2:10 P.M	Tea	00:00 min	09:00 min	09:00 min
4:49 P.M	Bread Pakode	34:00 min	00:00 min	34:00 min
5:29 P.M	Tea	00:00 min	06:00 min	06:00 min
8:23 P.M	Besan sabzi	07:00 min	34:00 min	41:00 min
9:15 P.M	Roti	26:00 min	00:00 min	26:00 min
10:45 P.M	Milk	00:00 min	15:00 min	15:00 min

Image 4.6. Detailed Observations

### e. Solar Panel Configuration

Discussion with SIRIUS (solar panel vendor) was made to create a custom solar panel according to our needs.



Image 4.7. Sirius solar energy systems

As we are not using any intermediate source of power but the solar panel, there is a need to design special solar panels for the purpose of cooking.

The solar panels which are available in market as said by the panel manufacturers were not optimized for the purpose of cooking, so special panels need to make which can be developed for the sole purpose of cooking.

After a series of discussions with the vendors, we were able to finalize the configuration for solar panels which are in Image 4.8.

System Voltage : 98V  
Resistance : > 30 Ohms  
Sl.No Solar Panel Sizing

Date : 15.10.2020

Sl.No	Panel Voltage (Vmp)	Panel Current (Imp)	Panel Wattage	No of Panels in Series	Total Panel Wattage	Panel Resistance Each	Total Resistance
1	49	4	196	2	392	12.25	24.50
2	49	4.5	220.5	2	441	10.89	21.78
3	49	5	245	2	490	9.80	19.60
4	49	5.5	269.5	2	539	8.91	17.82

Image 4.8. The finalised configuration of solar panels

The final configuration was selected to be the power output of 196 wattage

### f. Hotplate

Hot plate is a portable self-contained tabletop small appliance cooktop that features one or more electric heating elements or gas burners. A hot plate can be used as a stand-alone appliance but is often used as a substitute for one of the burners from an oven range or a kitchen stove. Hot plates are often used for food preparation, generally in locations where a full kitchen stove would not be convenient or practical.

## 4. Literature Study

Hot plate would be the ideal solution for creating this kind of low powered heating solution. The hotplate does not only eliminate the possibility of oxidization of the heating element, the breaking of the heating element but also help to distribute the heat uniformly because of the insulation compound used in hotplates that is a mixture of talc, magnesite and water.[4]



Image 4.9. A typical portable hot plate

Some of the key components which helps in functioning of a hot plate is the Heating element, cast iron top, insulation, and thermostat. [4]

The cast iron top is used because of its property of heat retention. The Thermostat is used to control the temperature of the device i.e., when it is



Image 4.10. Insulation used in hotplates

used in a household 220 v supply, where it can reach up to 250 c. But the purpose for which the hotplate we will be using will not reach to that level and hence is not required.



Image 4.11. Thermostat used in hotplates.

# 5. User Research

## a. Preliminary User survey

A preliminary user survey was conducted to understand the acceptance rate of PV cooking. A selective sampling was done where a total of five people with different occupation were taken and asked whether they prefer PV over other modes of cooking.

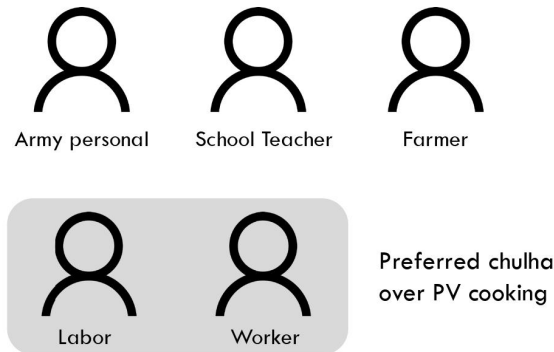


Image 5.1. User survey with selective sampling.

**Out of 5 people, 3 people were in favor of solar PV cooking. The users who were of low-income group preferred a traditional Chula over PV cooking.**

**This analysis showed that the choice of the end-user about cooking methodology depends upon awareness, economic condition, the traditional habit of cooking, and the ease of cooking.**

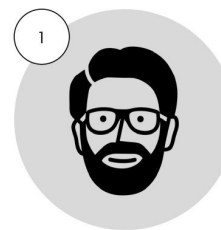
The users who would benefit it the most were the people from rural areas

as since, the inception of PMUY, 94.3 % Indian population had access to LPG gas but only a fraction of PMUY users could avail for the refill because of economic factors. A low-cost solar PV cooker would help the users in rural areas but because of limitations on travelling and resources the study was restricted to urban areas.

The primary users were in between middle class and upper middle class residing in urban households. Based on the primary research and secondary research. User personas were created to understand the users better.

## b. User personas

Based on the interviews and observations following user personas were developed.



Busy Bhupinder, 45yrs old

“ I am always busy some work and I hate it when the cylinder runs out while I am cooking, I always forget to order the cylinder on time ! ”

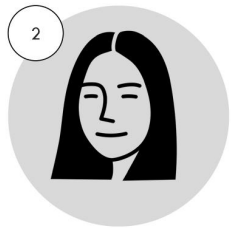
### Frustrations

- I hate when my distraction causes me to have failed dinner attempt.
- Environment should be preserved , I already have some solar cookers in my house, but they takes too much effort.
- I seriously don't have time to order a new cylinder every month.

## 5. User Research

### Needs

- Something which can reduce the number of times I have to order a cylinder.
- Something which is little forgiving when I have to cook and do the work.
- Something which doesn't need me to buy a special utensil, I have a lot of utensils already.



2

Lathargic Lata, 35 yrs old

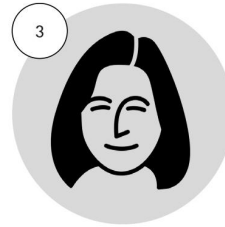
“ As much as I love cooking, I hate it when I have to change cylinders every few weeks. I want to save some money, I wish there was a cheaper alternative. I could really use some extra cash. ”

### Frustrations

- Lives in a residential flat on the fourth floor, usually required assistance with the cylinder more so than often.
- Doesn't like to change the cylinders every two weeks.
- Doesn't have a gas pipeline installed in locality.

### Needs

- It cost around 10,000 every year that I can put to some other use.
- I would like to save some cash.
- An alternative source of cooking.
- Something which is economically viable.
- something which doesn't need me to buy a special utensil



3

Woke Wadhavi, 27 yrs old

“ I belong to a middle class family but I am very woke about the environment. Climate change is a big issue and transitioning to using free energy might help to solve this issue tremendously. ”

### Frustrations

- Most of solar cookers forces me to be out in the sun.
- If any renewable energy is used there's some technology which must be used with a special utensil.
- Most of the induction i.e. Solar powered stoves, requires a lot of initial capital to invest in.

### Needs

- Something good for the environment.
- Something which lets me the part of change.
- A stove which is also functional.
- A stove that isn't like a solar stove that forces to me to be in the sun.
- Something which is economically viable.

### Next Step :

Based on personas created , Three different concept paths were devised .

# 6 . Preliminary Ideations

## a. Concept Ideation one.

Since 94.3% Indian population have LPG stoves in their houses, we can use the existing eco system to reduce the cost of further developments. A modified burner cap that can be fitted on the existing LPG stove, which can provide LPG + Solar energy at the same time.

The resistive heating element will be embedded in the pan and powered

by a female connector at the base. The modified burner cap will have a male connector which will be connected to the pan to provide heat produced by the solar panels.

Double vaulted air-column for maximum thermal efficiency. A lid would be required to further contain the heat inside the pot. Different variation of the pot can be produced that include saucepans, sauté pans and further down the line.

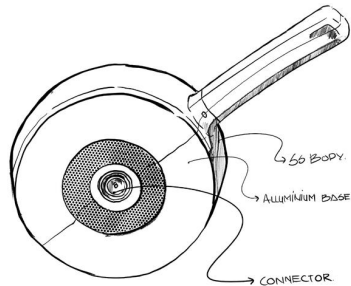


Image 6.1. Connection as Electric kettles

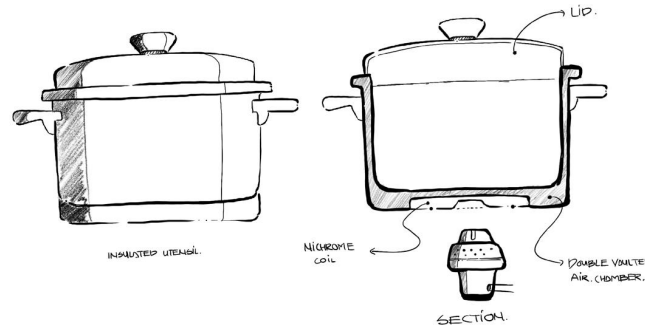


Image 6.2. Special Utensils needed

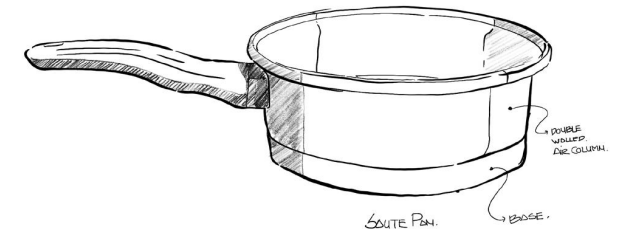


Image 6.3. Different types of pan

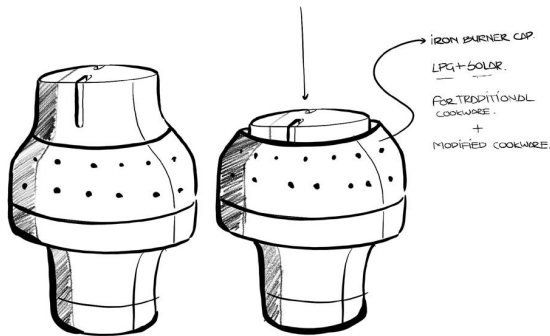


Image 6.4 . Ideations for a retractable option



Image 6.5. 3d printed concept

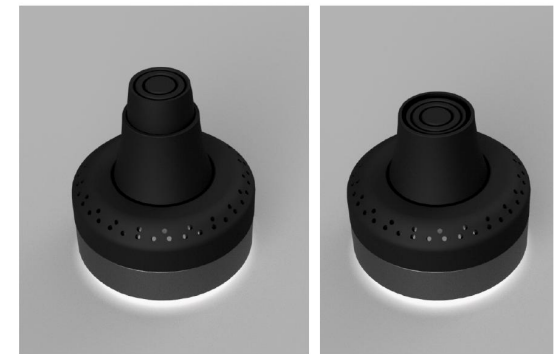


Image 6.6. Rendered concept

# 6 . Preliminary Ideations

## b. Concept Ideation two.

Using the same idea as before i.e. To modify the burner cap but this time using resistive elements like nichrome to create a hot plate for all the conventional utensils.

Hotplate because this kind of device can be used as an addon without changing the stove itself and can be used according to the users demands and will. i.e., The device can be placed aside when all the burners are to be used but can be kept on the burner when all the LPG burners aren't being used.

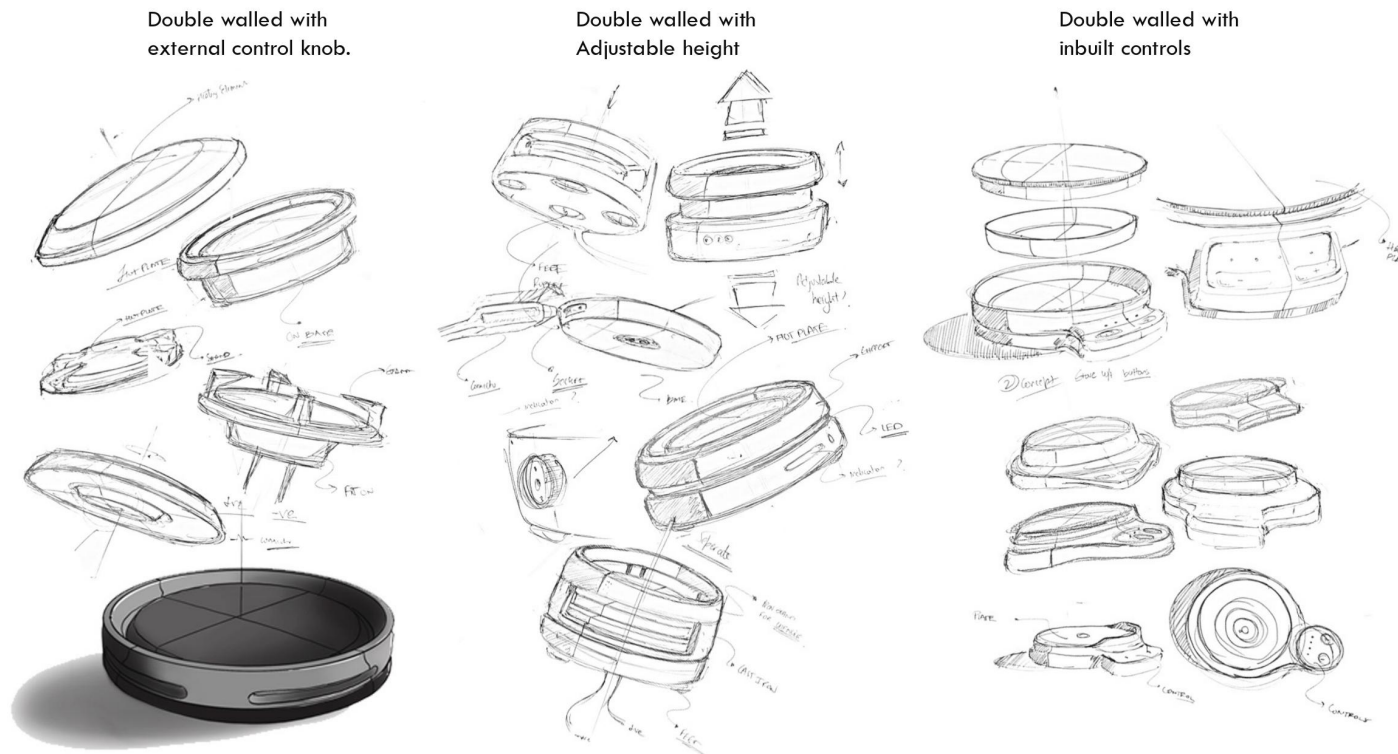


Image 6.7. Ideations for a hot plate.



Image 6.8. 3D concept render with pot on top

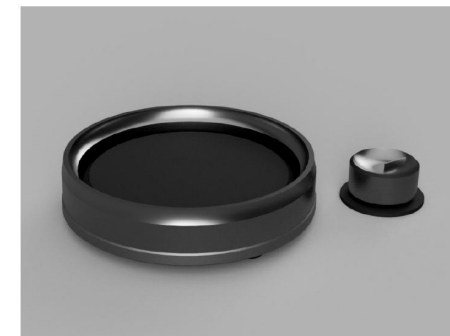


Image 6.9. 3D concept render for hot plate.

# 6 . Preliminary Ideations

## c. Concept Ideation three.

If the solar panel with 1KV are used the above design would not be required as 1kv of power is sufficient for all cooking purposes- frying, chapati making, boiling etc.

This concept was developed as entirely a separate product. Which will not be a part of the existing eco system. It would function like a separate stove on the side of existing stove. The pot would be submerged inside the cavity to gather heat from all the sides of the utensil.

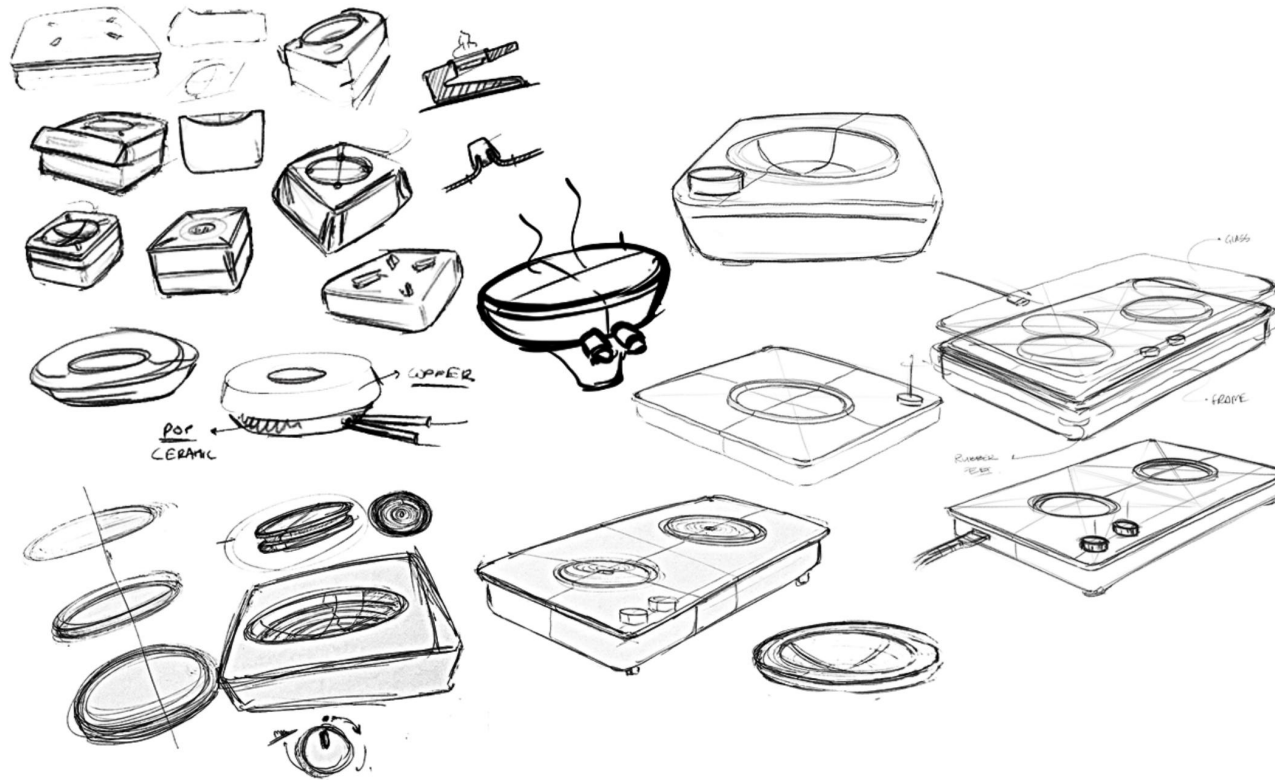


Image 6.10. Ideations



Image 6.11. 3D Concept render with pot on top

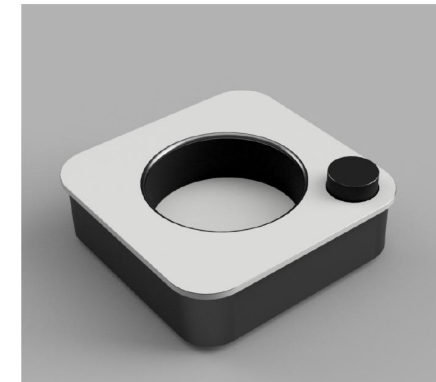


Image 6.12. 3D Concept render for hot plate.



# 7 . Concept Evaluation

For Evaluation, I created a pros and cons list. The benefit of creating the pros and cons list was to make the users understand the difference between the concepts which would help them to ultimately rate the best concept out of all.

So, a user survey was conducted where I expressed their points to the user and asked them to choose the best one out of the three ideations.



- Only one type of utensil can be used. ✗
- Works with the existing eco-system. ✓
- Extra counter space not required. ✓
- Extra storage space not required. ✓



- All utensils can be used. ✓
- Works with the existing eco-system. ✓
- Extra counter space not required when a burner needs to be used. ✗
- Extra storage space not required. ✓



- Limited utensils can be used. ✗
- Doesn't work with the existing eco-system. ✗
- Extra counter space required. ✗
- Extra storage space required. ✗

Image 7.1. The comparison between three concepts.

## 7 . Concept Evaluation

So a user survey was conducted where i expressed there points to the user and asked them to choose the best one out of the the three ide-  
ations.

The data was gathered form a total of 48 users caliming to be of middle

class households residing in urban areas. As you can see, the majority of the  
users preferred the second concept because of ots usability and possibly  
familiarity to the existing idea of hot plates.

The first concept was chosen the least because of it novalty and usability  
contrainits.

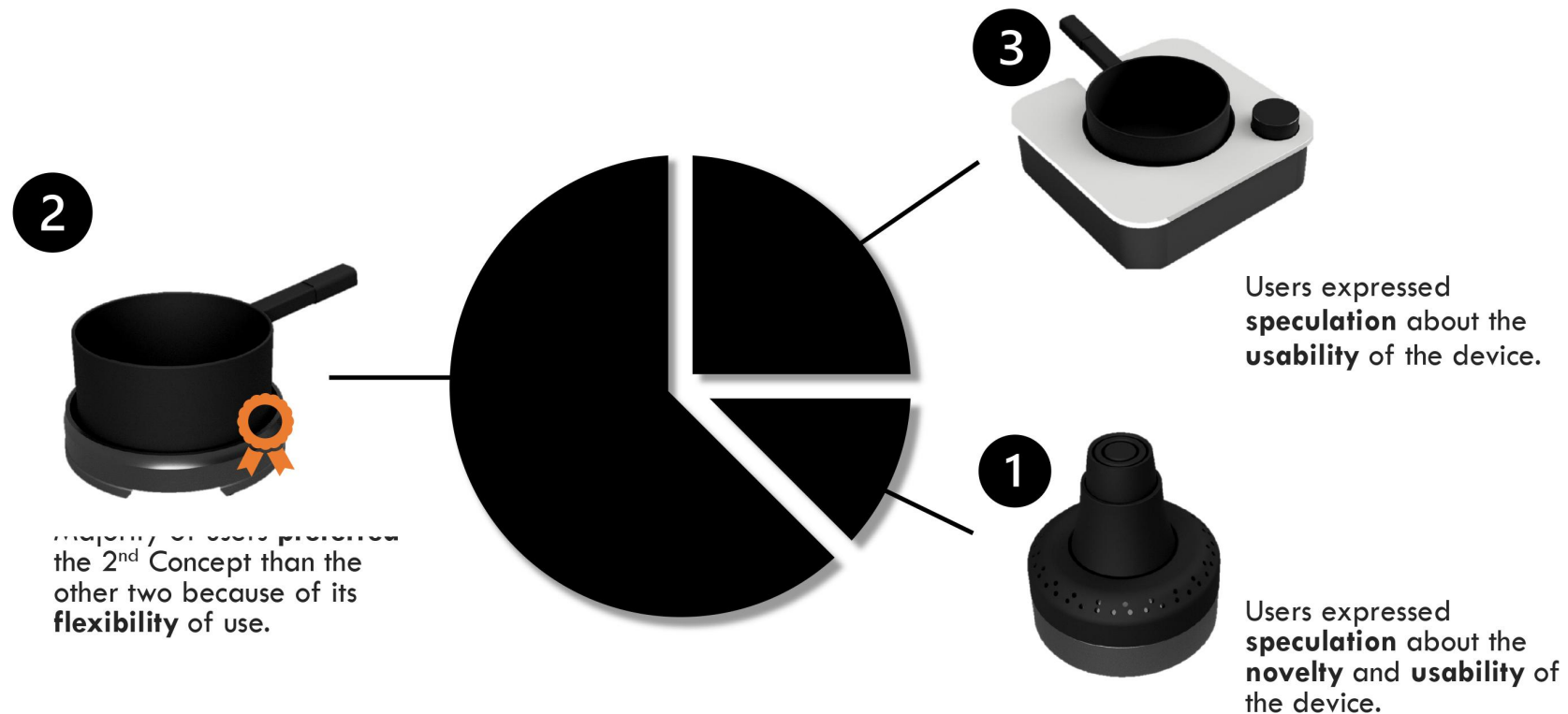


Image 7.2. User survey analysis.

# 8 . Proof of Concept

A Working prototype was constructed to understand the usability aspects and functioning. Once the technical aspect was taken care off, the next step in the process was to do a kitchen study.

The idea behind why the walls on the side might be needed is that without the walls the heat escapes from the sides. But when the walls are there,

it traps the heat and, allows the utensils with round bottoms to be placed on the top.

A rig was created using coils in parallel and by using a voltage regulator that turns the voltage down from 220v to 47v, to mimic the effect that the solar panels would have caused.



Image 8.1. Working rig.

It worked on the same idea that making the walls around the heat source would trap the heat and allow better thermal performance.

it was based on the works done in the master's report.



Image 8.2. Preferred Concept

# 9 . Product Development

## a. Check.

After the working rig was completed, I started working on the final product. I created a check based on secondary research where the problems that were associated with designing an electric cookstove might be , like

- Spillage
- Grip
- Controls
- Handle
- Double wall
- Connections
- Storage
- Potsize
- Cleaning

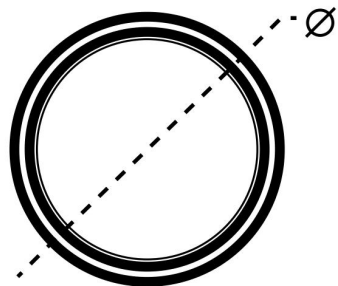


Image 9.1. Diameter chosen 18 cm

## b. Pot size

Starting with the pot size, some models were created to figure out the diameter for the hotplate and the burner stand.

The diameter of 18 cm was found to be optimal for all the utensils that are used daily in an Indian kitchen. Utensils checked with includes Frying-pans, woks, tawa, saucepan.



Frying-Pan



Wok



Tawa



Sauce-Pan



Side view



Installation

Image 9.2. Various utensils on top.



# 9 . Product Development

## d. Controls

The next step was to understand where the controls must be to achieve the best factor of safety. Whether it should be on top, or sides or front. for that a user survey was conducted, asking the users claiming to be of middle-class families to determine what kind of stoves they had in their homes. A total of 123 users participated in the survey.

So from analyzing the responses from the survey, it can be seen that majority of the users had a four stove burner in their houses. which implied that the controls must be kept on the side and not in the front of the device.

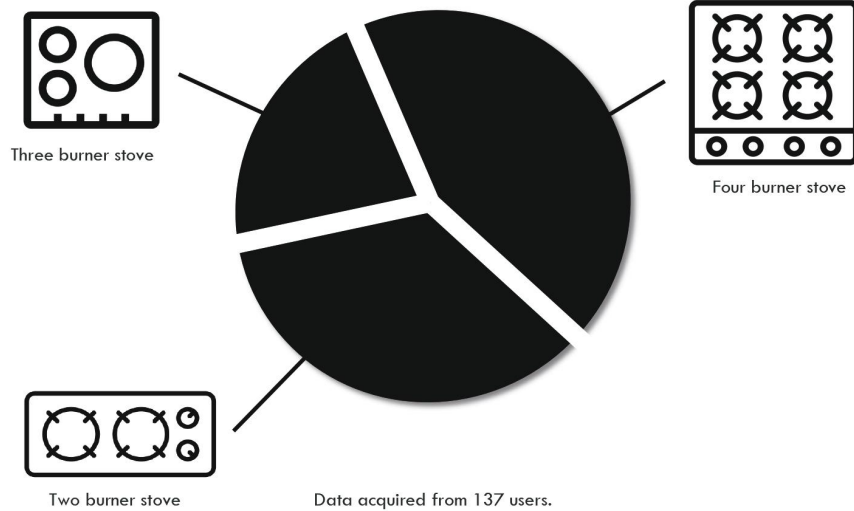


Image 9.5. User survey for stove config.

Based on the data controls were decided to be put on the sides as it allowed

**Easy access to the controls when put on a four-stove burner.**

**Putting the controls on the front will not be ideal as it would not be reachable if placed on the back burners.**

Handle placement was decided to be at the conventional space as the controls were decided to be put according to the burner configuration.

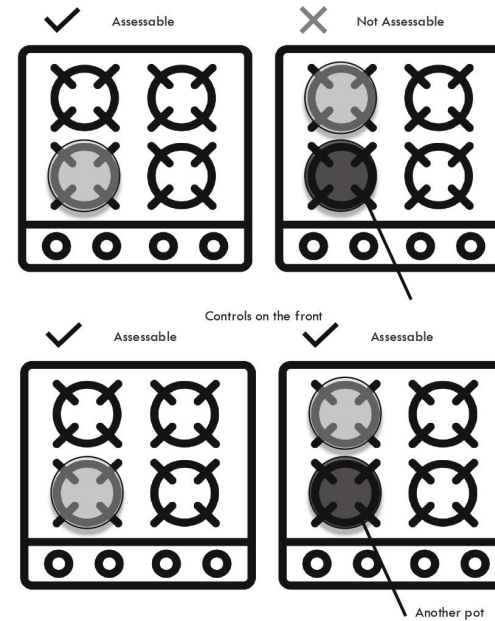


Image 9.6. Layout for four config stove.



# 9 . Product Development

## g. Preliminary Concept

So, a CAD model was made with all the ideas and solutions combined. Like the overflow channel, Visual feedback LEDs, the controls on the side I also 3D printed a low-fidelity prototype, to see where i lack in terms of

usability, dimensions, etc.

But more importantly to help user understand the product better. So, with the help of CAD and printed model, I got some interesting feedback form the users.

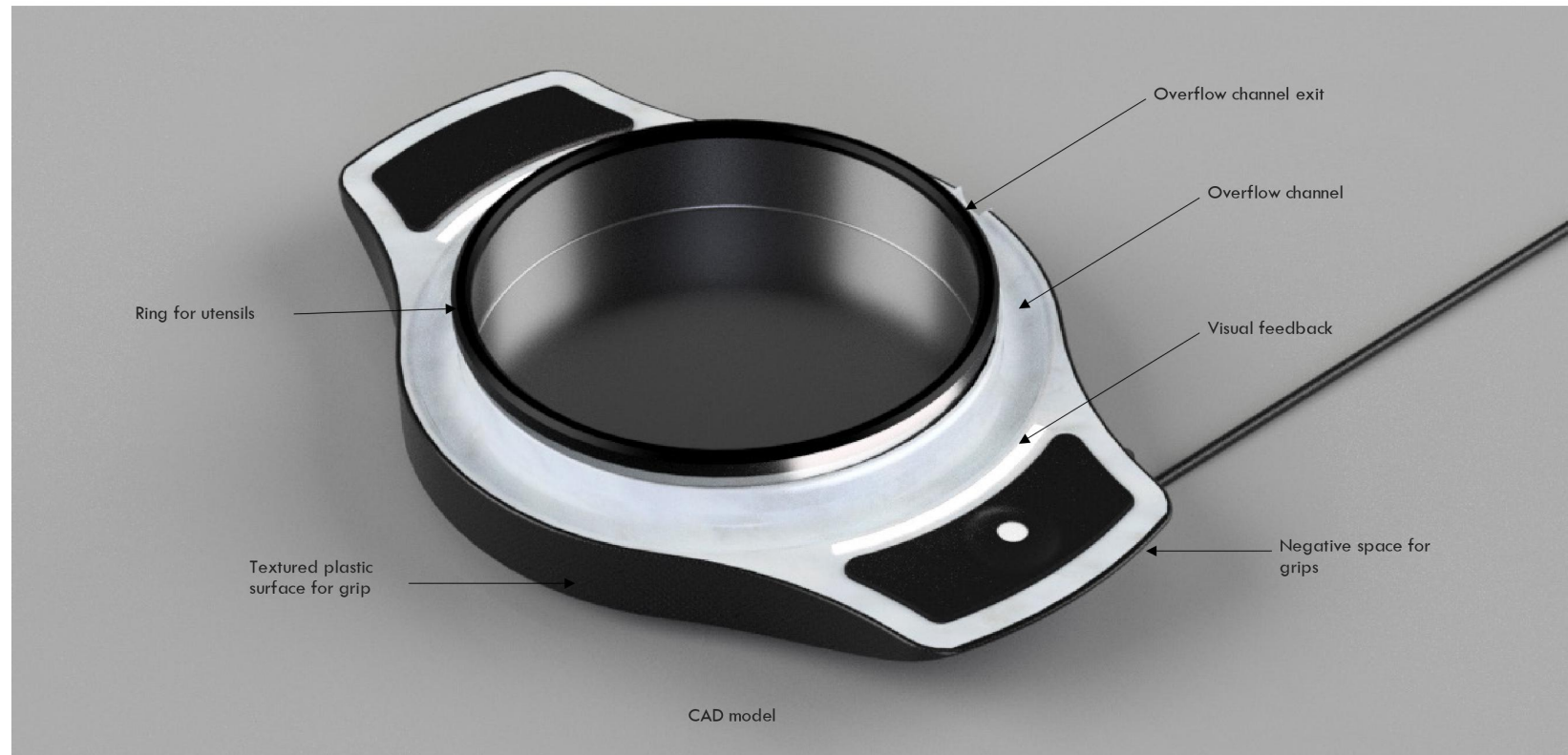


Image 9.9. CAD Model for wholistic concept



## 9 . Product Development

With the help of CAD and printed model, I got feedback after conduct user study and getting user feedback.

- One being that to many users it was giving an affordance of cooking inside it rather than with a utensils.
- It was not omni-dexterous, there wasn't enough space to put the fingers below the handle.

- How it can be stored when it's not in use or when it is not supposed to be kept on the LPG stove.
- What would happen if the gas got turned on while it's on top of the LPG stove.

There were also some problems with the current form of the stove, users pointed out a lot of things about the form including that the form looks delicate.

Low fidelity prototype



Top View



Top view with Pot



Top view with Pot

Image 9.10. 3D printed Mockup Model

## 9 . Product Development

While testing the mockup, the users used their index fingers instead of their thumbs to power on the device. which lead the device to topple over because of the shape of the bottom.

To tackle the issue of affordance, I made some changes to the hot plate. I created a rib like pattern on the top to mimic the existing hotplates top. So, again I took user feedback.

Some users claimed that now the affordance of putting food inside is not present, but some users expressed that creating rings at the bottom, it would be much harder to clean if something got burnt on the surface of it.

Next, I started ideating again.



Image 9.11. CAD model after changes



### Expectation

The user would use their thumbs to power on the device.



### Reality

The user used their index fingers to power on the device, hence toppling it.

Image 9.12. 3D Pined model toppling over.

# 9 . Product Development

## h. Form Ideations

Keeping in mind the feedback, I started ideating again, to help myself at this stage, I created a mood board that people used in the kitchen & realized a pattern.

Most of the items in the kitchen looked robust, Utilitarian, had a stable form and were monochrome.

Mood board



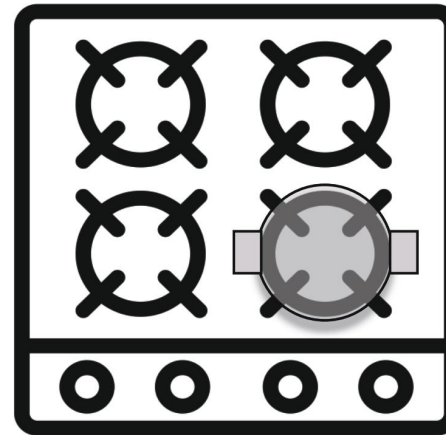
Image 9.13. Moodboard

## 9 . Product Development

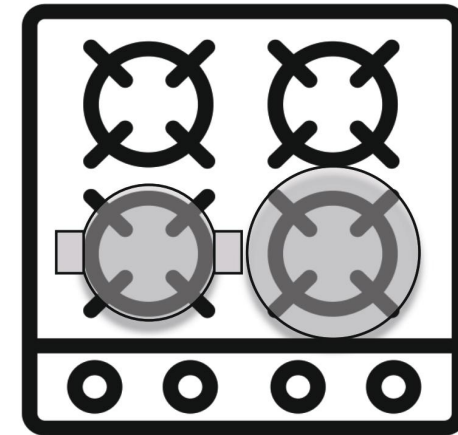
- The top of the device would be made from punched stainless steel and the bottom an injection molded part.
- It's easy to clean because of the concave surface and doesn't make you think the food should be cooked on the surface.
- Soft touch material will be used as they are hydrophobic in nature they would not allow any spill overs to stay on top.
- The bottom would be again be of stainless steel to avoid any accidental burning and melting.
- The legs are required as if there's any fire burning it would be visible.



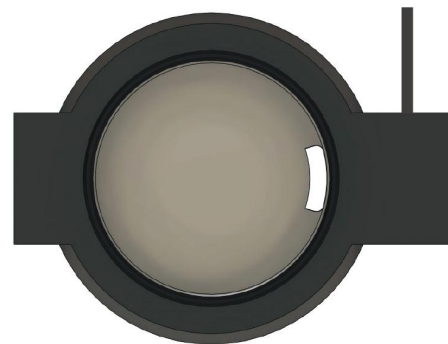
Image 9.14. Form Devedlopment with one handle shortened.



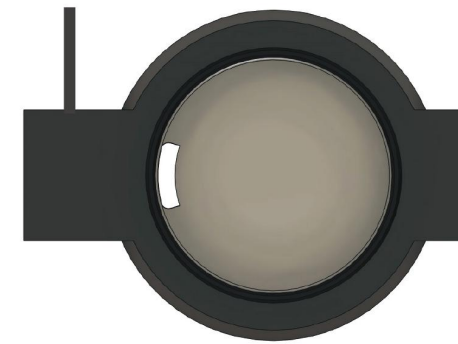
No utensil



Large utensil



Right-handed person



Left-handed person

Image 9.15 . Form Devedlopment with one handle shortened.

# 10 . Final Proposal

Form



Spills



Omni-dexterous



Textures



# 10 . Final Proposal

Store



Clean



Easy to clean concave surface

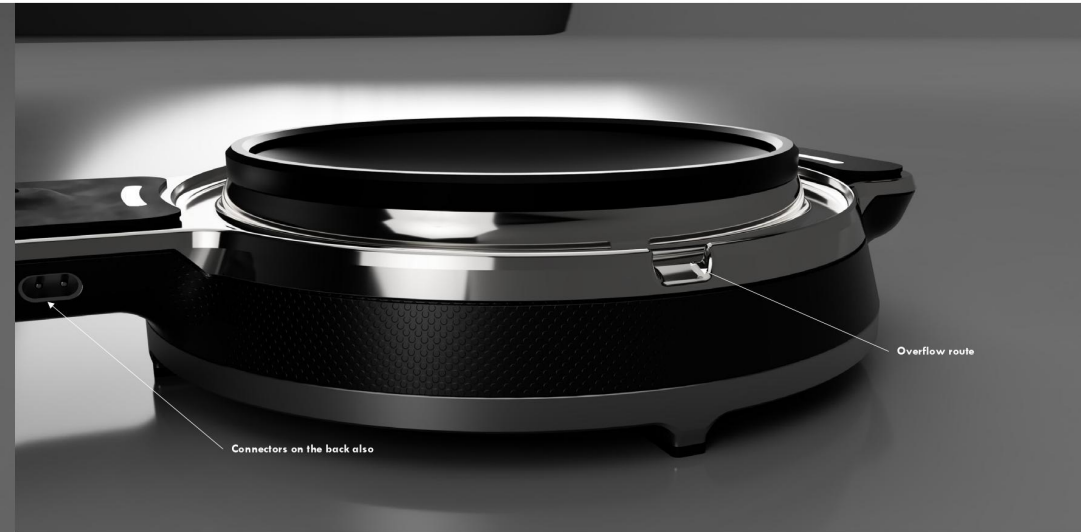
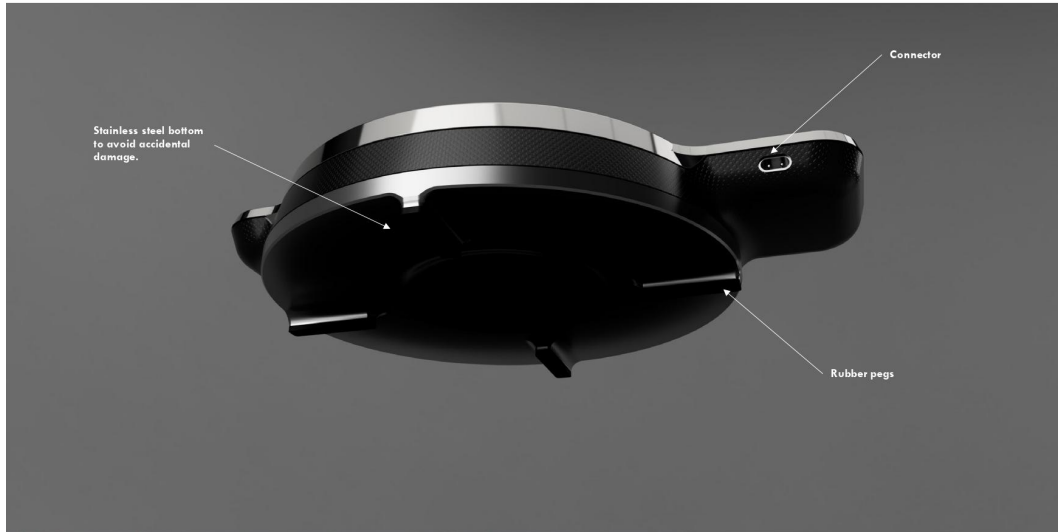
Soft touch

Connectors on both sides



- The top of the device would be made from punched stainless steel and the bottom an injection molded part.
- It is easy to clean because of the concave surface and doesn't make you think the food should be cooked on the surface.
- Soft touch material will be used as they are hydrophobic in nature they would not allow any spill overs to stay on top.
- The bottom would be again be of stainless steel to avoid any accidental burning and melting.
- The legs are required as if there is any fire burning it would be visible.

# 10 . Final Proposal



- A channel is provided to compensate the overflow situation in case there are accidental spills.
- The connectors are provided at both sides to allow the user to use the device at their own accord.
- Appropriate space was created below the handle and the stable form would not allow the device to topple over in case there's extra push at the control buttons.
- Since MCBs were required, it was better to place them on the stand itself.
- It can be placed on the top of a cookstove as well as on countertop.

# 11 . User Feedback



A medium fidelity 3D printed prototype was made to understand the usability flaws in the final design.

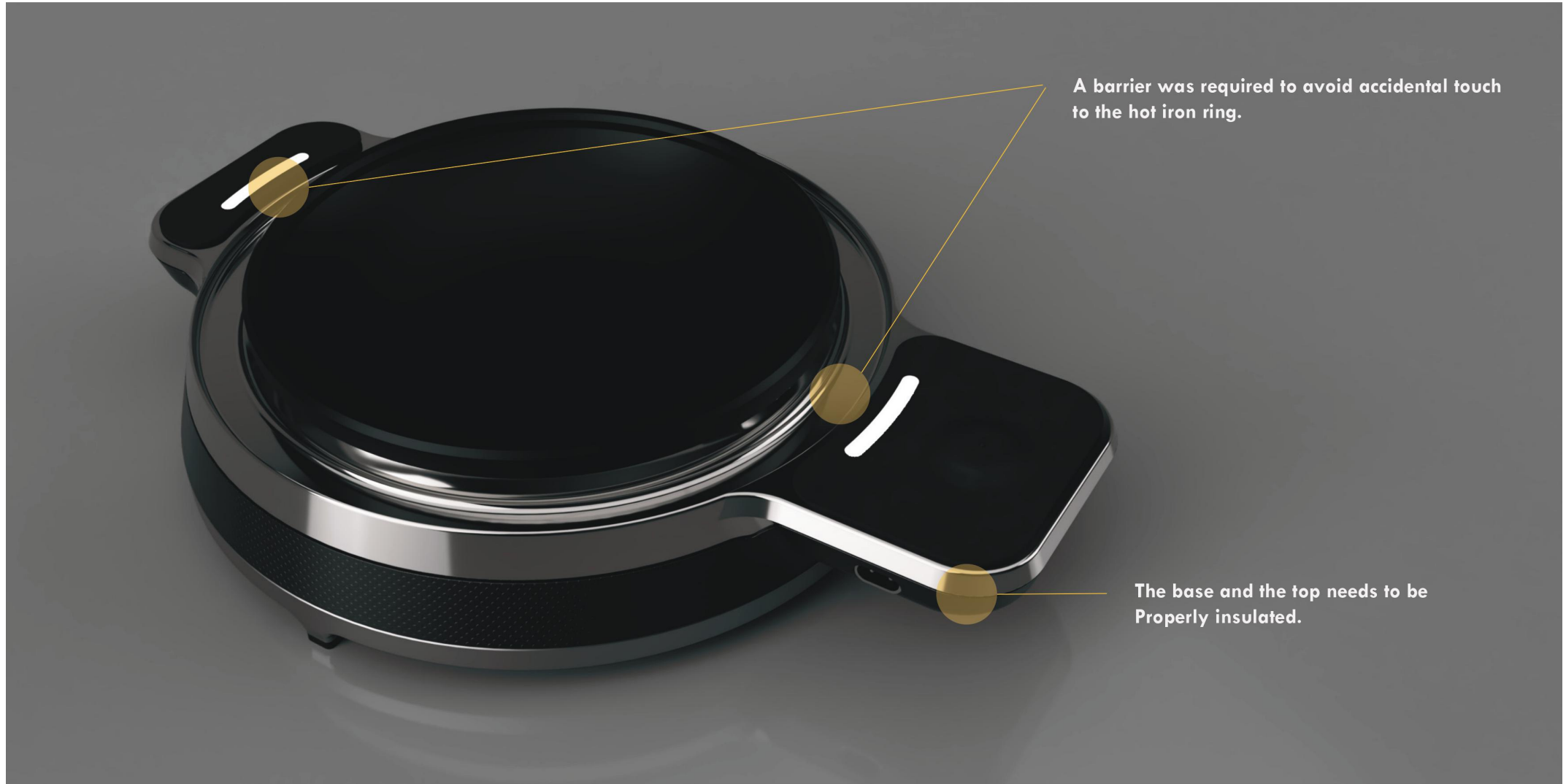
To avoid accidental burning of the stove,

The existing gas burner caps and the iron stand are needed to be removed before operating the electric stove. ( when using it on the LPG stove.)

The images shows the process of how the stove will be kept on the LPG stove. When using it on the LPG stove. The existing gas burner caps and the iron stand are needed to be removed before operating the electric stove.



## 11 . User Feedback



# 11 . User Feedback



User feedback was taken and a few drawbacks were pointed out

- There was a requirement for a barrier between the controls and the iron ring to avoid accidental touches.
- The base of the handles cannot be of metal as the heat transfer might warm up the handle
- During bodystorming, it was pointed out that the shorter handle need to be extended as it was too short.
- The iron stand and the burner cap needs to be stored when not in use.



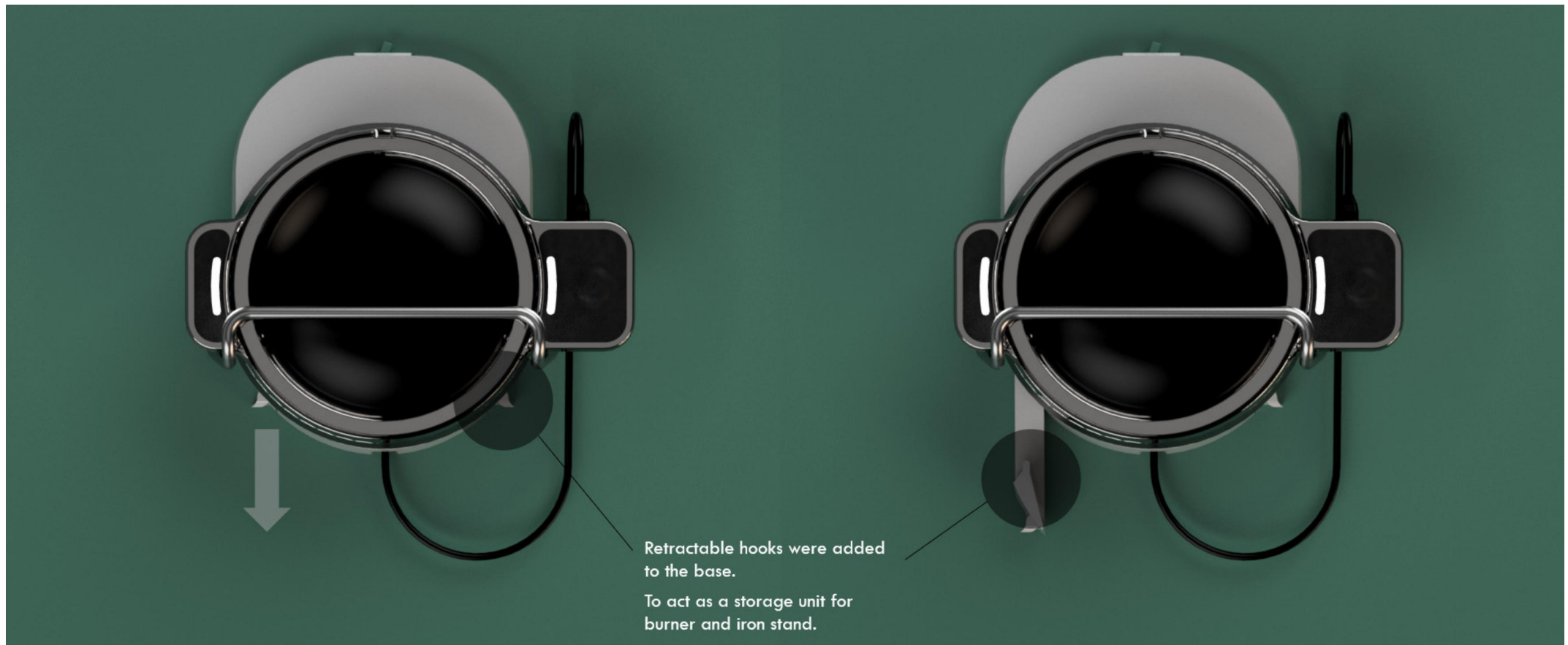
## 12 . Changes

Since, there's an activity of removing the burner stand and the burner cap, there was a requirement of a space to store the two objects.

The users expressed that there must be a place required to put the burn-

ers once there are not in use.

So, a retractable hook was added to the base where the burner and stand can be hanged.



## 12 . Changes

During the product development phase, I realised that the existing geometry was very complex in terms of manufacturing and required to be made much simpler.

So a simple geometry was developed for the same stove.

Protector fins or the barrier were added to avoid accidental touches to the iron ring.

Handles were separated from the main body and will be injection moulded, the body would be stainless steel punched and will be joined via nut.



Protector fins added to avoid accidental contact.

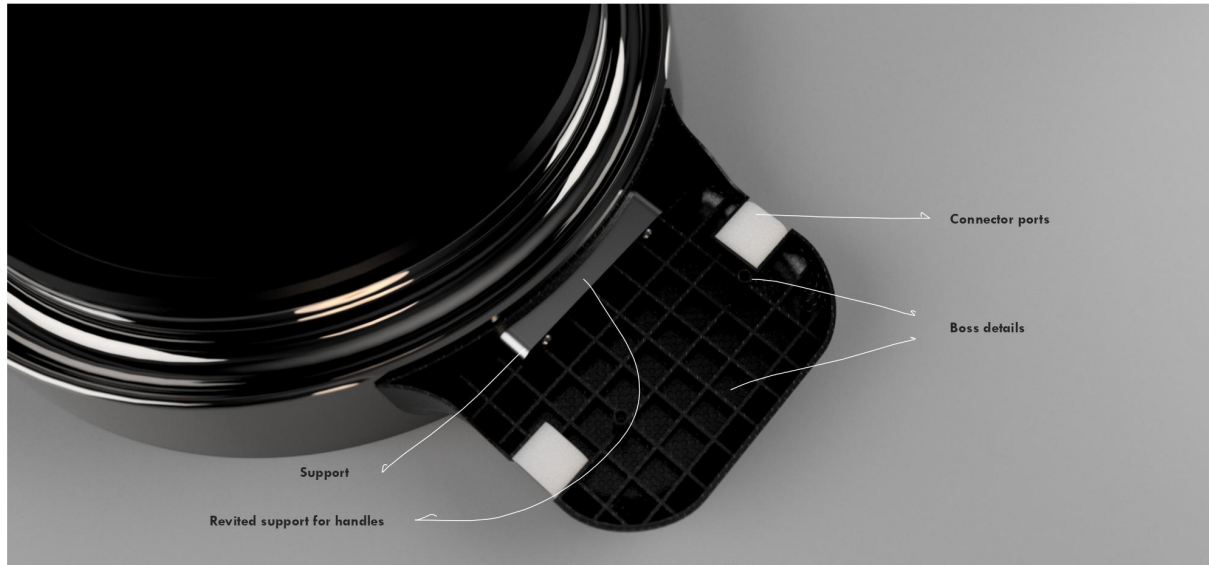
The handles are separated from the main body.

# 12 . Changes

Exploded view :



# 12 . Changes



Details :

Rib details were added according to the guidelines.

The thickness of the walls is taken as 2mm, height of the ribs is 6mm, width between the ribs is 6mm and the thickness is taken as 0.5mm

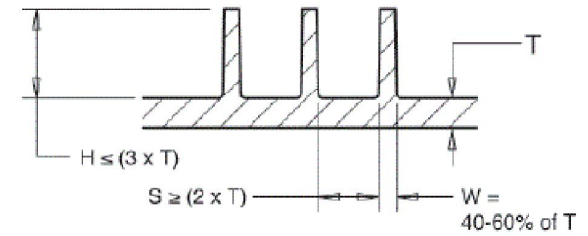
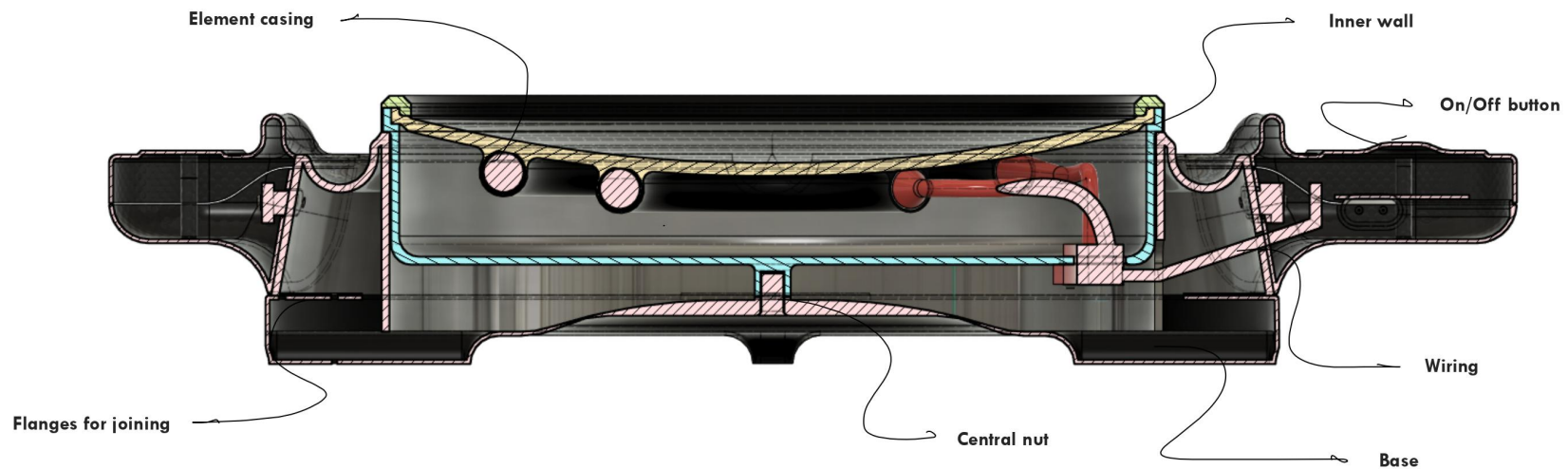


Figure 11: Design guidelines for ribs



## 12 . Changes



As a precaution against accidental burning and leaking of LPG gas, there needs to be a way to stop the leakage manually.

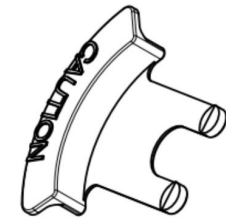
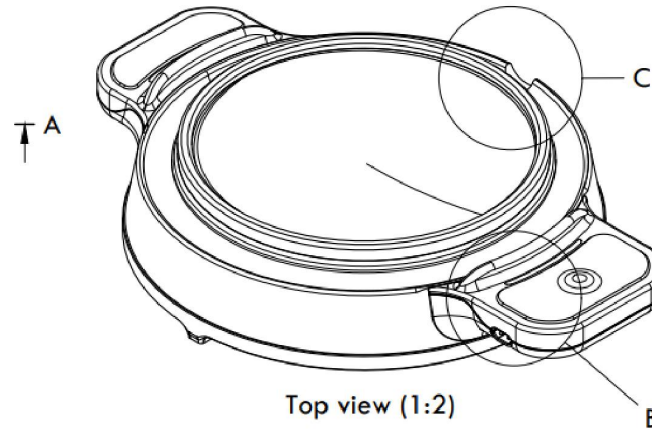
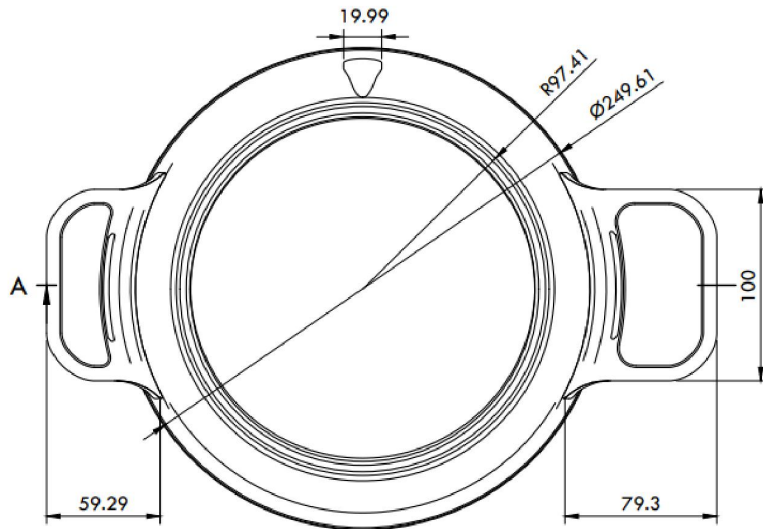
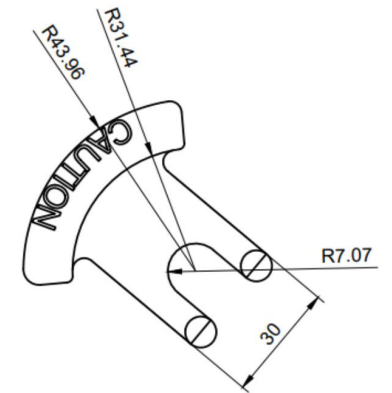
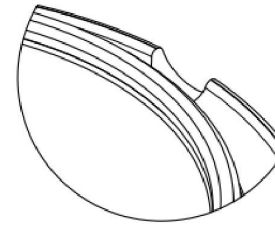
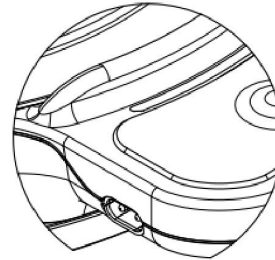
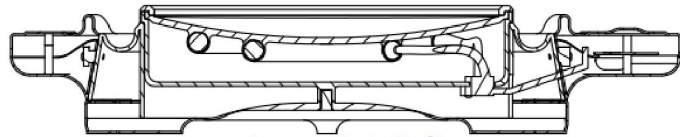
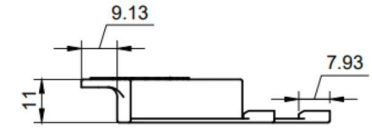
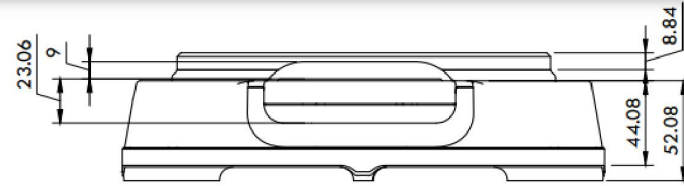
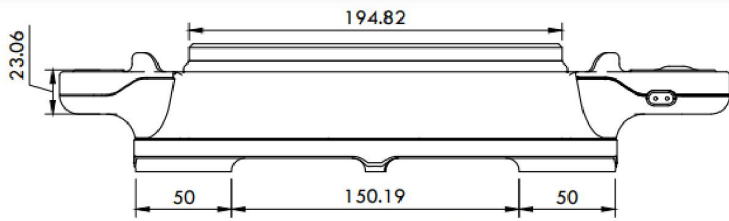
In this case, it was possible to avoid accidental burning by removing the burner cap. But it wasn't possible to manually stop the flow of LPG from the gas.

So, a visual reminder was added as an injection moulded part which can be slipped on or off to the knob on the stove.

The color of the reminder part will be of light color to create contrast and act as a reminder to check the knob is on or off.



# 13 . Detail Drawings





# 14 . Conclusion

The proposed solar PV based cooker can provide a consumer-friendly indoor cooking alternative over box type of solar cooker. Direct solar photovoltaic cookstoves have the potential to provide low-cost alternatives to LPG based cookstoves and also to the induction-based solar photovoltaic cookstove.

The major limitation in the case of box-type solar cookers was the compulsion of outdoor cooking was successfully eliminated with solar PV cookers. In the case of LPG, the limitation is of the recurring cost required to refill the LPG cylinder. This limitation can be eliminated using a direct solar PV based cookstove.

Using the proposed solar cookstove as an add-on device with the existing LPG stoves, the overall LPG consumption can be also minimized. So, it is more likely that proposed solar PV based cooking solutions will get more end-user penetration than that of the box type of solar cooker.

## **a. Future Scope**

Following activities can help in further improving the solar PV cookstove

- Develop a fully functional cookstove with the necessary PV panel arrangements.
- Conducting the on-field trials and further improving the cookstove.
- Researching more efficient materials for manufacturing and heating elements.

## **b. Addition to the report**

Further changes to the final stove design based on the user feedback and testing are yet to be added in the report.

The final design can have an integrated system in which user is able to plug the same device in the electrical outlets present in their homes. The system would be used when there's not enough sunlight .

# 15 . References

[1] [<https://www.energyinfrapost.com/indias-ujjwala-scheme-provided-lpg-access-but-failed-to-promote-its-use-study>]

[2] <https://www.energyinfrapost.com/lpg-as-clean-cooking-fuel-in-rural-india-vision-2020/>

[3] Masters's Project report by Prasad Kulkarni

[4] <https://www.youtube.com/watch?v=s9CXk-ZFrYI>

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