

❖ Design of an Induction Cooking Set.

- Guide : Prof. K.Munshi

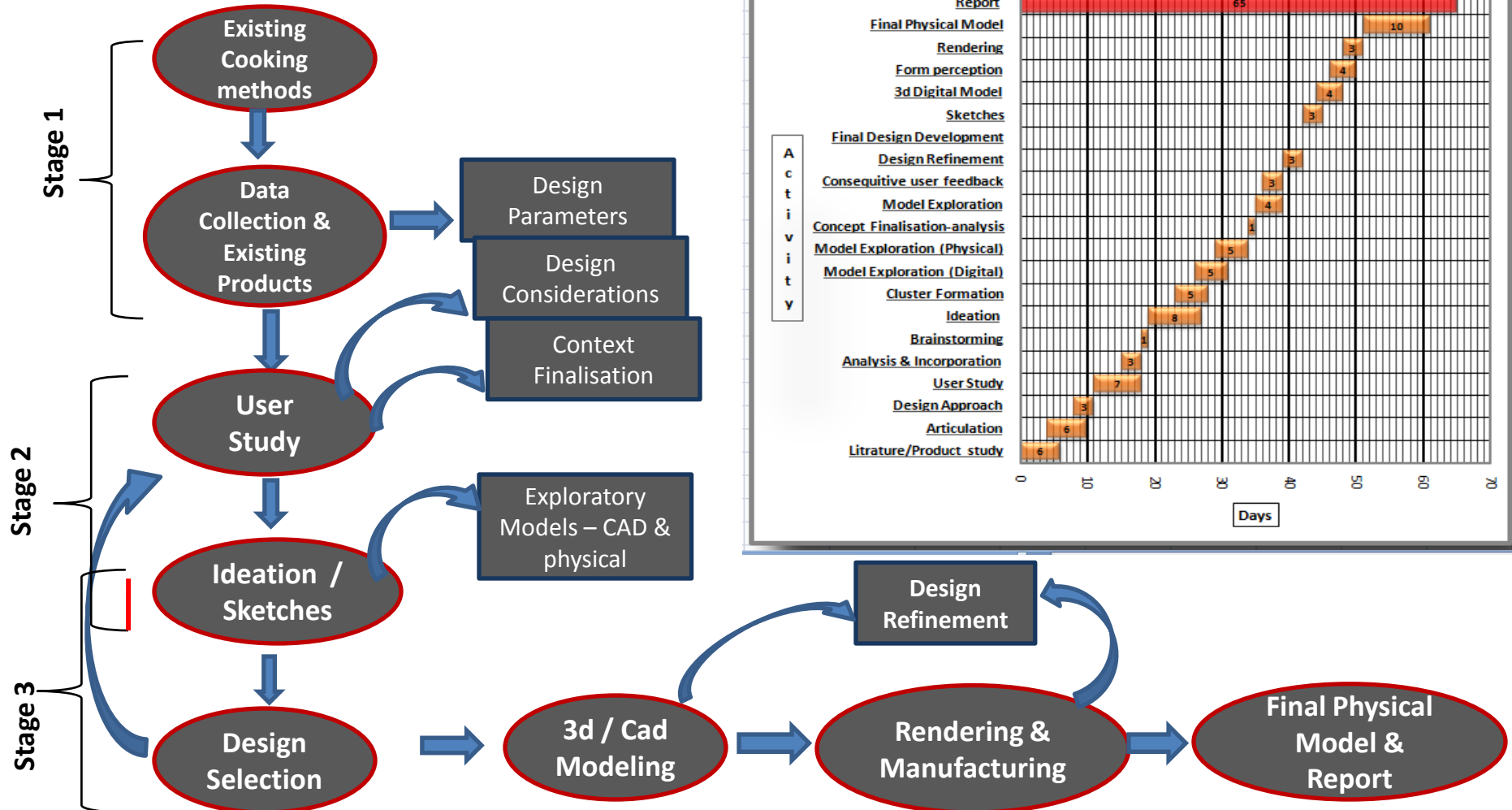
INTRODUCTION & DESIGN OBJECTIVE:

- People would always prefer to have **home cooked food**.
- Cooking food at your own will.
- In case of bachelors and hostellers, there is **no preinstalled cooking infrastructure**.
- A bachelor / hosteller would need an **easy to cook** and a **non messy system, less space occupancy**, and an **incubated basic storage** if possible.
- Hence, induction cooker proves to be the **most appropriate** cooking system within the context.

□ Design Objective:

- To design an induction cooking set (*induction cooker + cookware*) for bachelors/hostellers –
a niche in the Indian market.

• My Approach:



DATA COLLECTION :

Various Cooking Methods:

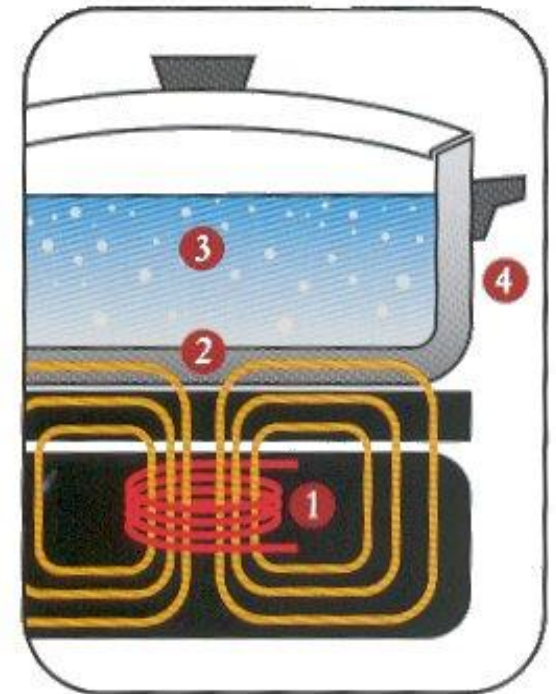
Conduction, Induction, Convection, Microwave, Radiation

What is Induction?

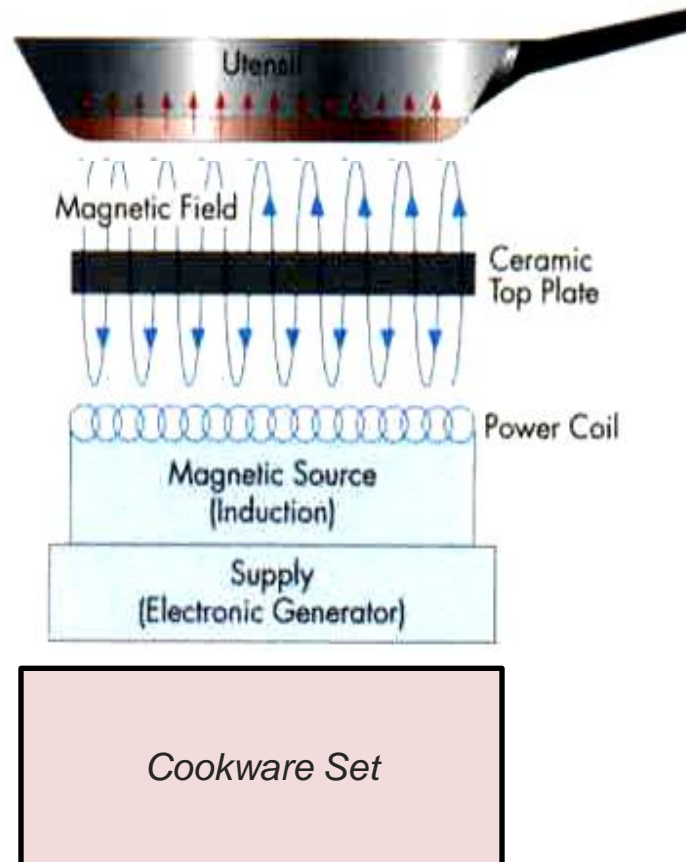
- An electromagnetic coil beneath creates a magnetic field
- Heat is induced into the cookware (2) by this electromagnetic field effect. .- (1)
- this field comes in contact with surface of cookware(4), and by its **oscillation**, induces heat within the pan and cooks the contents. –*generates eddy currents due to hysteresis effect.*

Heat transfer:

- Appliance to cookware- via magnetic induction
- cookware to food (3) – via conduction.



□ Typical Product Assembly Format:



Advantages:

- Works on electricity.
- Induction cookers are faster.
- more **energy-efficient** than other cooktops.-
90% energyefficient, (compared to 50% for gas).
- Cooking top surface remains at room temp.
- does not warm the air around it.
- Monitored voltage level - **Smart cooking**.
- Precise temperature control and instant response.
- Ease of Maintenance.

Drawbacks:

- **Price:** retail price - ranges between \$300 to \$1000.
- **Ferro-magnetic material** – copper, aluminium, & ceramics will not work as cookware.
- heat up time is almost **instantaneous** – requires full concentration.
- The temperature is **controlled by switching on and off** the magnetic field – creates temperature extremes.
- The material and wall thickness of the cookware is critical.
- Sometimes **decisive** – as it has a cool cook top.

EXISTING PRODUCTS:

Existing Products:

Induction Cooker:

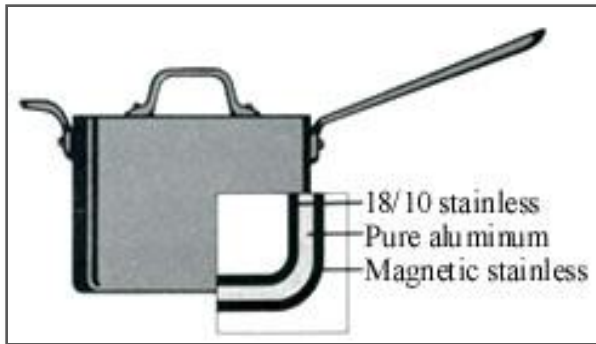
- **Dimensions:**
Approx. 360x60x400mm
- **Material:** A.B.S. , Ceramic
- **Form :** Often Circular, Large radius, seldom with sharp edges & pointed corners,
- **Color:** - Often monochromatic.
- Exhibits color contrast between body and ceramic top.
- **Weight:** 2.5 kg. to 3 kg.
- **Elements:** An assembly base, copper coil within, ceramic cooking top, digital display panel, buttons & knobs.
- **Display panel:** Power, timer, preset function options, temperature settings, & progressive indications.



Existing Products:

❑ Cookware Set:

- **Dimensions:** Varies (*approx. 3/5th of conventional sizes*)
- **Material:**
Commonly **cast iron** (*anodized*),
Tri-Ply – 3 layered copper/aluminum
and ferromagnetic steel sandwich)



- Must be **stackable**.
- Easy to **maintain and clean** –free from undercuts and grooves.



Material Thickness:

Thin bottom - conducts heat quickly but unevenly

Thick Bottom - conducts heat slower, but more evenly, reducing hot spots.

To keep heat retainment, the thickness would be in the higher ranges.

(*approx. above 1.25mm*).



Cookware Analysis:

1. Material Analysis:
2. Shape Configuration Analysis:

1. Material Analysis:

Each material has its own **Thermal conductivity & Heat capacity**. (*Specific heat*)

Thermal Conductivity: *is the materials ability to absorb energy,*

Heat Capacity: *is the amount of energy that is needed to raise or lower the temperature of the material.*

Appropriate Materials:

Cast-iron

- Retains heat for long.
- Takes time to heat.
- Highly ferro magnetic.
- Cooks evenly.

Material	Thermal conductivity	
Copper	401 W/m*K	
Aluminum	237 W/m*K	
Cast Iron	80 W/m*K	
Carbon steel	51 W/m*K	
Stainless steel	16 W/m*K	

Material	Specific Heat	Density
Aluminum	910 J/kg*K	2600 kg/m ³
Stainless Steel	500 J/kg*K	7500 - 8000 kg/m ³
Carbon Steel	500 J/kg*K	7500 - 8000 kg/m ³
Cast Iron	460 J/kg*K	7900 kg/m ³
Copper	390 J/kg*K	8900 kg/m ³

Composition:	Comments:
Copper with tin lining	tin lining - can be susceptible to melting ; copper exterior requires more care
Copper with stainless steel lining	imparts the utensil with copper's excellent thermal properties
Aluminum with stainless steel lining	Thick aluminum provides excellent thermal response to thin steel interior.
Copper fully clad by stainless steel	exterior and interior are durable and easy to maintain
Aluminum fully clad by stainless steel	Imparts excellent conduction qualities , but has hot spots.
Aluminum with stainless steel lining and copper exterior	Same performance as above.

2. Shape Configuration Analysis:

different types of cookware to suit the requirement are:

FRYING (*omelet pan or a skillet*).

SAUCE - reheating foods to making delicate sauces.






OVEN

STOCK - excellent for soups, pasta and large sauces which call for minimal surface evaporation.

PRESSURE COOKER

ROASTER

Dutch oven		7 quarts	french oven casserole
roaster		large	roasting pan
stock pot		large	—

Name	Looks like	Good size	aka
traditional skillet		12 inches	frypan omelet pan
non-stick skillet		12 inches	frypan omelet pan
cast-iron skillet		12 inches	frypan
sauté pan		3 quarts	—
sauce pan		3 quarts	—
saucier		3 quarts	chef's pan reduction saucepan

USER STUDY:

User Study:

- **Part 1- The target users** are the hostellers and the bachelors.
- **Part 2- Existing users-** Housewives and cooks were also interviewed.

User	Male	Female	Total
Bachelors	8	--	8
Hostellers	8	8	16

❑ Questionnaire:

- What can you cook yourself? - Rice/dal, Eggs (*boiled, fried, omelet, scrambled*) poha, upma, maggi, toast, sandwiches, soup, milk, boiling water, tea/coffee, semi cooked non-veg.
- If the product exists, what would you cook? Would you cook cahpatis? - No (17/24)
- Would you engage in **cutting**, and **grinding**? - Seldom yes (14/25)
- Do you **need** the cooking set anyways? - Yes
- How do you **visualize the product**? Its **image**....-*shape, color, closed form, open form.* - Cuboid with shutters, bright color, small and easy to carry
- The **frequency** of usage. - Atleast once a day (*midnight and late afternoon*)
- What is the **preferable space** it can occupy? - Approx 1 cu ft.
- What may be the maximum **cook top height**? 1.1m – max. (*0.8m as table top, and 0.3 m as cooktop height*)
- What is the possible amount of **time** you may put for cooking? Approx. 20 to 30 mins

- Are you a heavy eater? What is the anticipated **amount of uncooked rice** you would have?

Approximately 125-150 gms. uncooked rice.

- Would you eat **alone** or would be **accompanied** by someone?

Often accompanied by someone

Part 2- Existing users- Housewives and cooks:

- **anticipated quantity of uncooked rice** required by a single heavy eater?

Approximately 175 gms. uncooked rice.

- the approximate **volume occupied** by the same amount of rice when cooked?

Approx. 280 cu cm.

(Online volumetric conversions= reference -

http://www.onlineconversion.com/weight_volume_cooking.htm)

❏ Product Brief :

▪ Core benefits :

- Compact & an independent cooking appliance.
- Energy efficient
- An easy to cook solution.
- Non messy,
- Easily operable.
- Indian identity in form

▪ User Profile :

- Hostellers & Bachelors. (*overnight camps – as secondary users*)
- Age Segment identified - 20 to 35 years.

❏ Product Brief :

▪ Limitations :

- High selling price- approx. =>Rs.1,200 – Rs.25,000.
- Product is in a paralyzed state if no electricity.

▪ Manufacturing Paradigm :

- Injection / Injection blow molding- body casing and snap components.
- Desirable **materials** - A.B.S. as body shell,
ceramic or toughened glass as cooking top,
acetal as interior connecting elements (*nuts, screws etc.*).
ferrite / asbestos as flux concentrators.
- Product has potent to be mass produced and hence shall prove in cheaper selling price.

❏ **Product Brief :**

▪ **Product Safety :**

- No sharp edges.
- Product must signify when on.
- Visual element to convey the heat of the cookware.

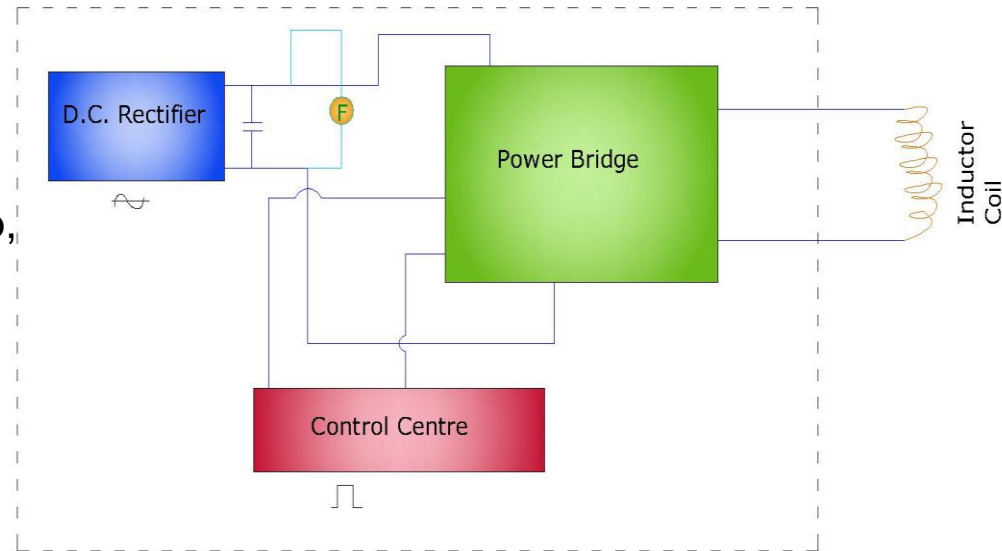
▪ **Product Positioning :**

- Can play a very important role in the daily lifestyle of the user.
- High potential to induce the venture of new products by contemporary manufacturers.

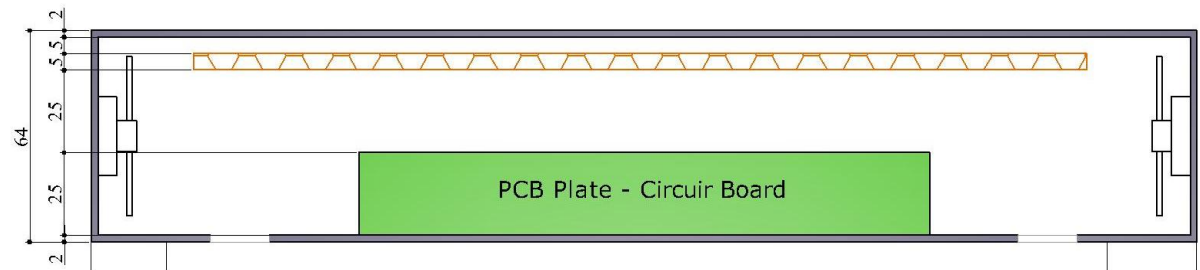
❑ Product Components :

- An assembly base,
- copper coil inductor within,
- ceramic / toughened glass cooking top,
- digital display panel, buttons & knobs.
- P.C.B. Plate -
- Convection Cooling fan(s)
- Air Inlet / outlets.
- **Display panel:**

Power, timer, preset function options,
temperature settings, & progressive
indications.



Schematic Circuit Diagram



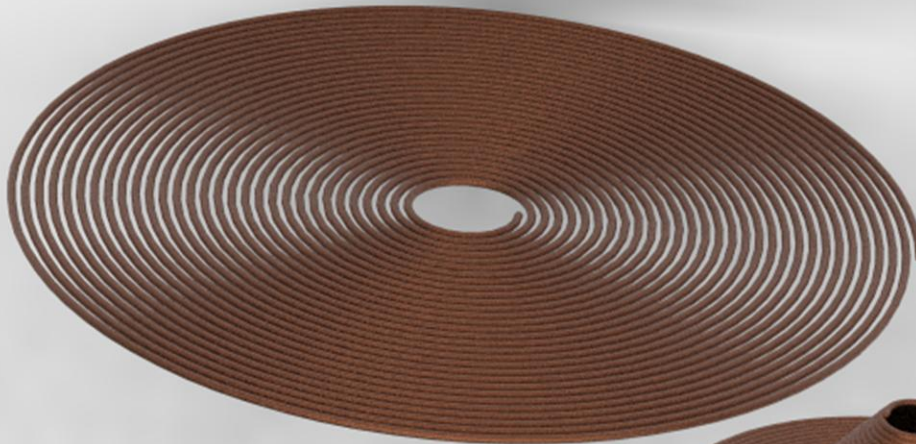
Typical Cross Section of Induction Cookers



• *Multi Stranded Coil*

■ Multi Stranded inductor Coils:

• Different Inductor Coil Formats



Archimedean horizontal



Wok shaped



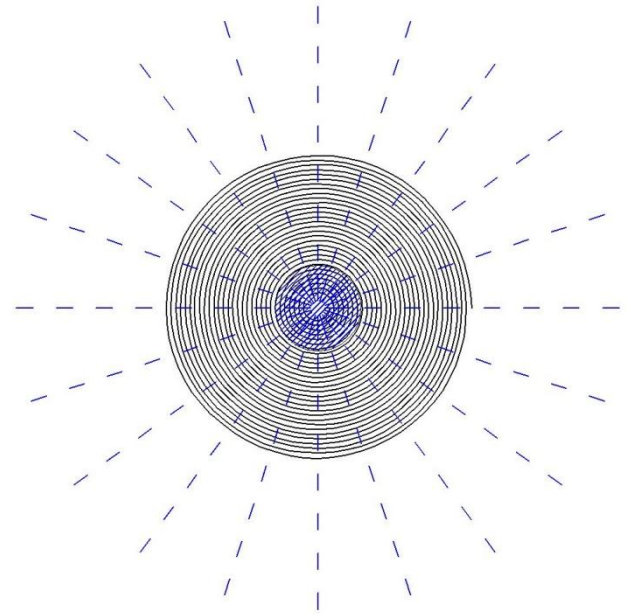
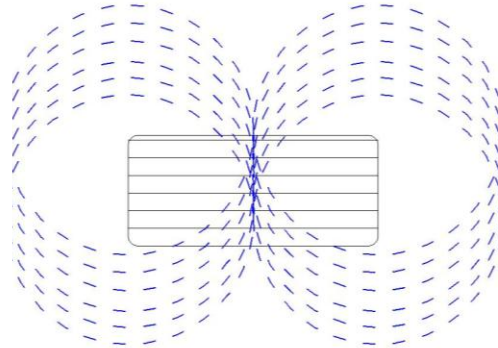
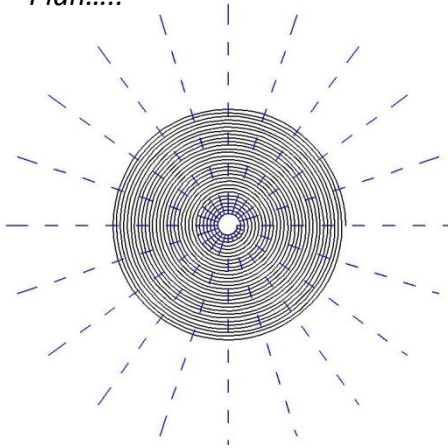
Helical- Archimedean



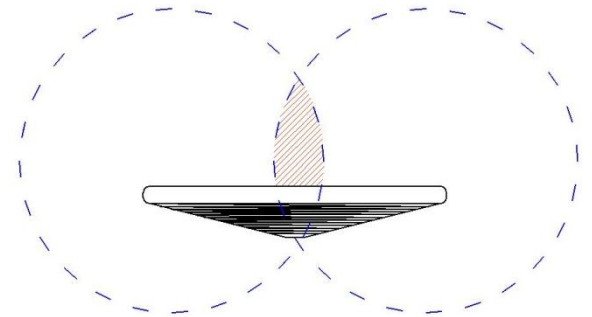
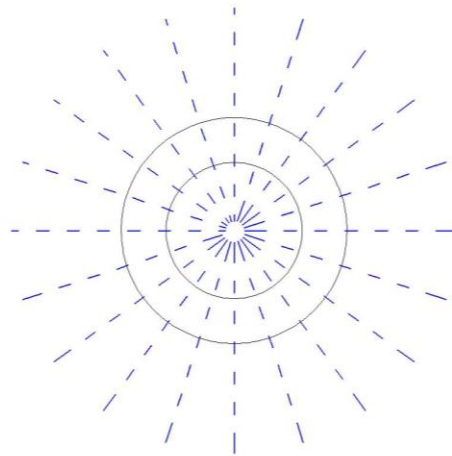
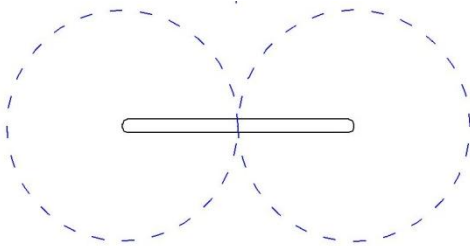
Wok- Archimedean

- **Inductor Coil Analysis :**

Plan.....



Elevation.....



Archimedean horizontal

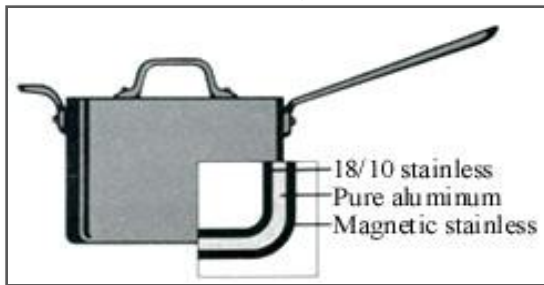
Torroidal

Wok Shaped

❑ Cookware Set:

- **Cookware** : A sauce pan & concaved pan.
- **Volume** : $320 \text{ cm}^3 > 200\text{gm uncooked rice}$
- **Dimensions**:
Sauce pan => 16cm dia., 5 cm deep
pan => 17 cm dia. (5mm concave depth)
- **Material**:
Commonly **cast iron** (anodized),
(varied wall thickness).

Tri-Ply – (3 layered copper/aluminum
and ferromagnetic steel sandwich)



- Must be **stackable**.
- Easy to **maintain and clean** –free from undercuts and grooves.

Effect of Material Thickness:

On Conduction:

Thin bottom - conducts heat quickly but unevenly

Thick Bottom - conducts heat slower, but more evenly, reducing hot spots.

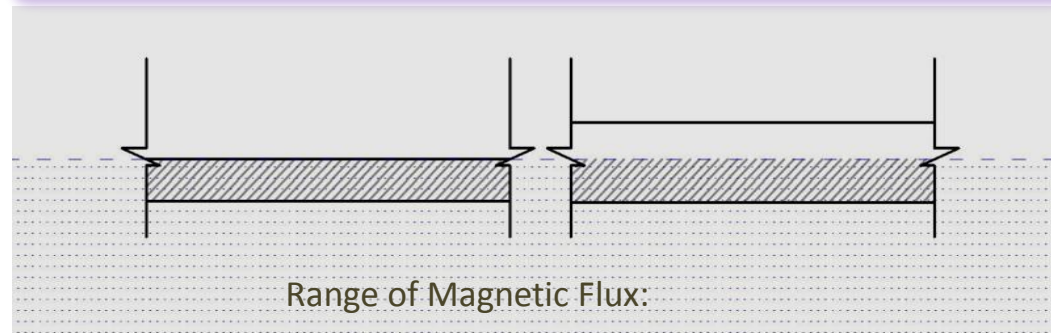
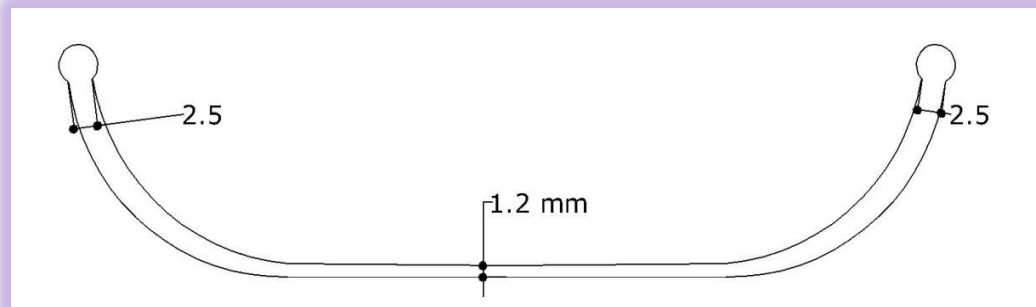
To keep heat retainment, the thickness would be in the higher ranges.

(approx. above 1.25mm).

On Induction:

More the thickness, faster the heating effect & vice versa.

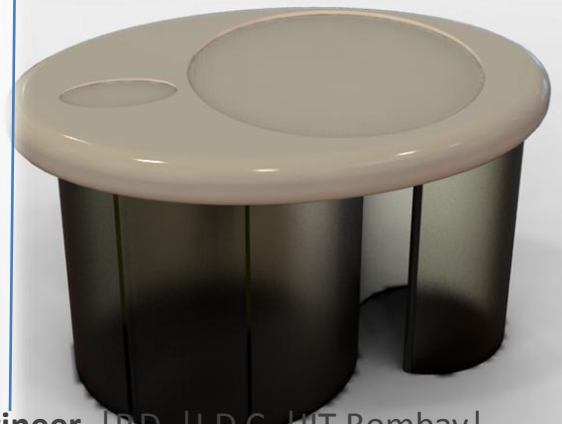
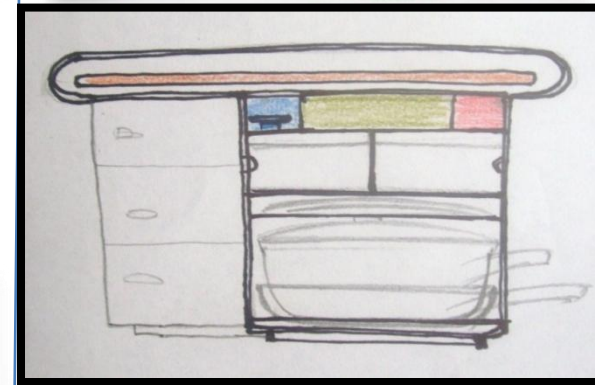
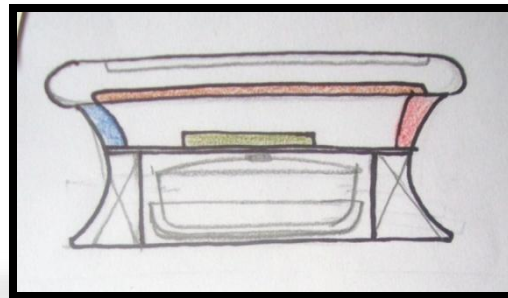
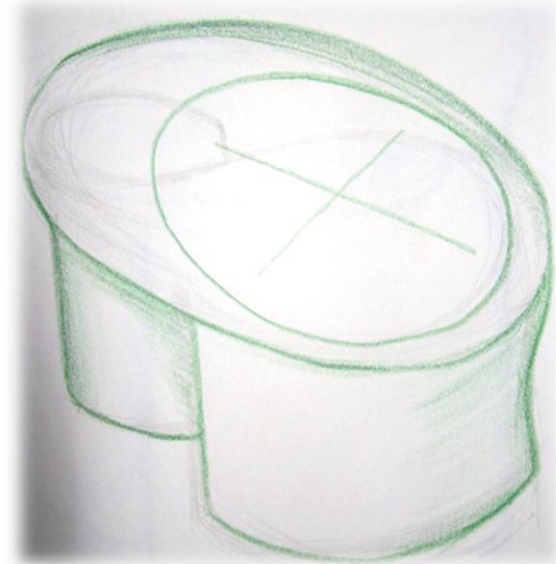
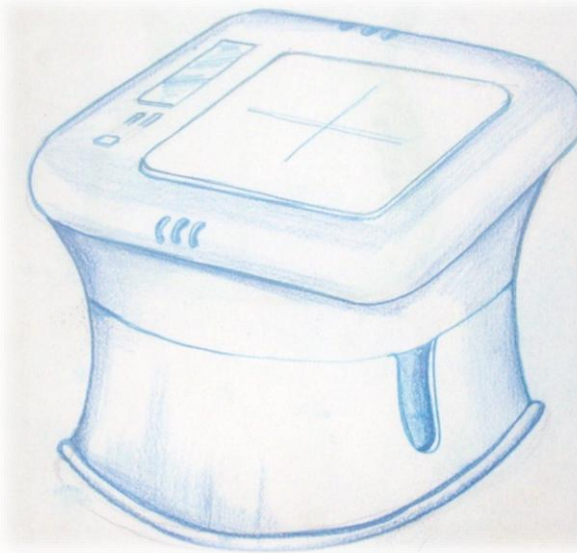
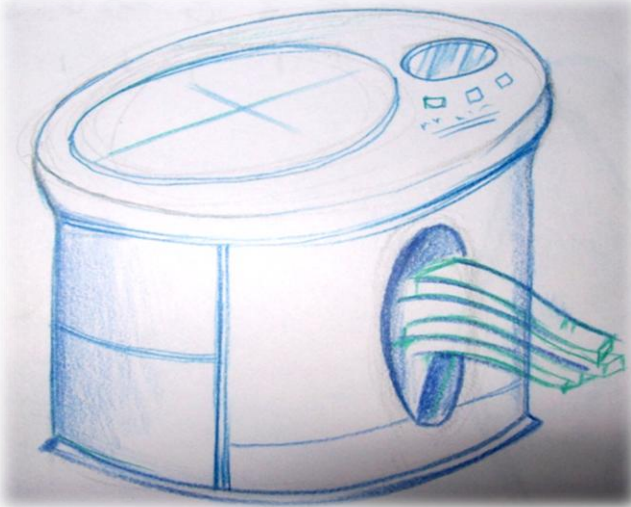
Induction Range: Varying Cookware wall thickness:



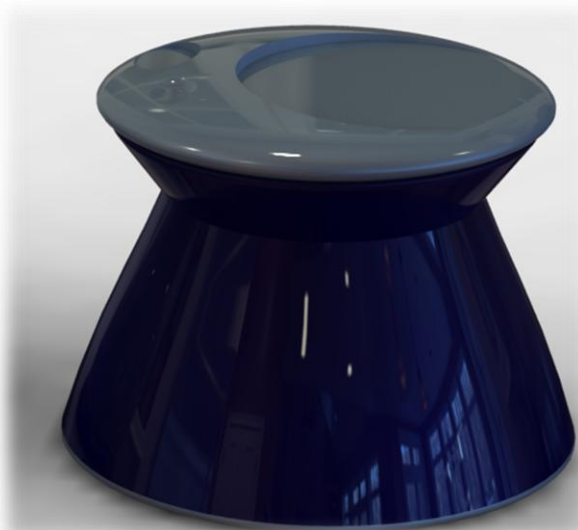
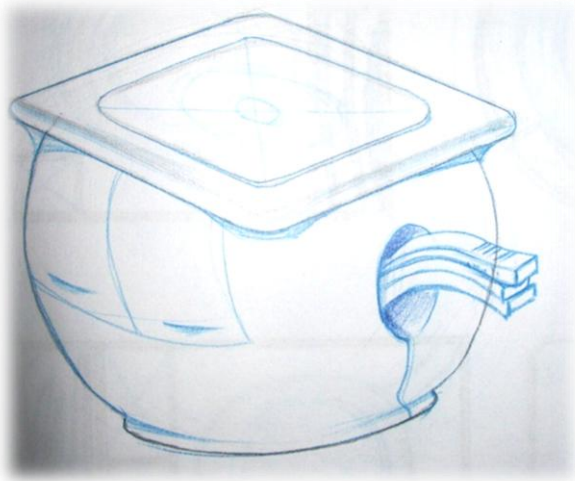
IDEATION & CONCEPTS:

Cluster 1:

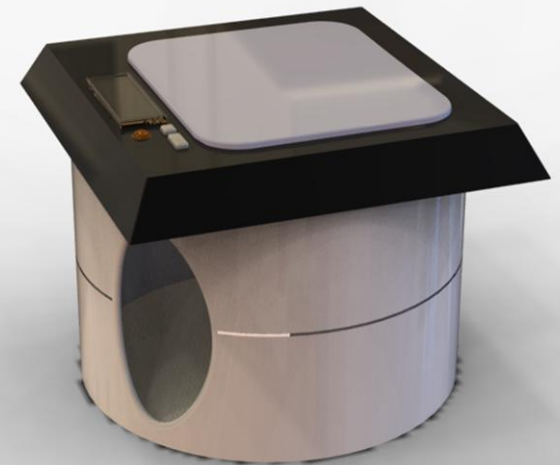
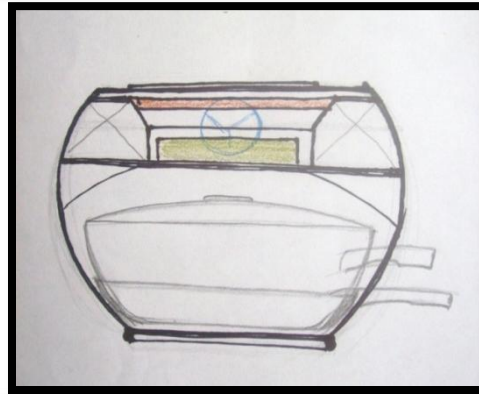
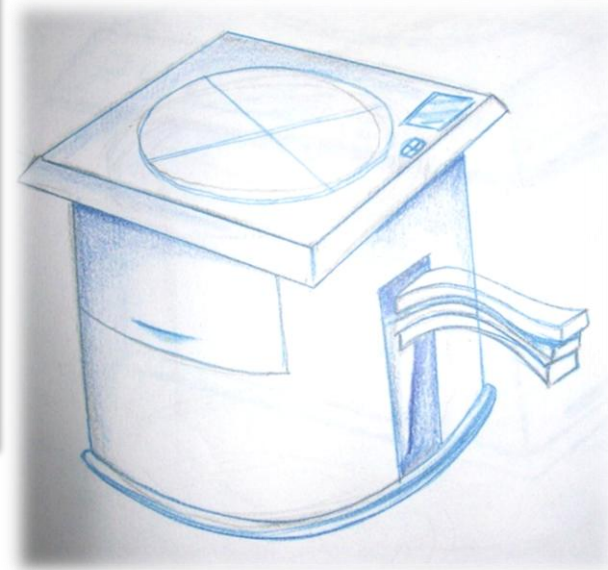
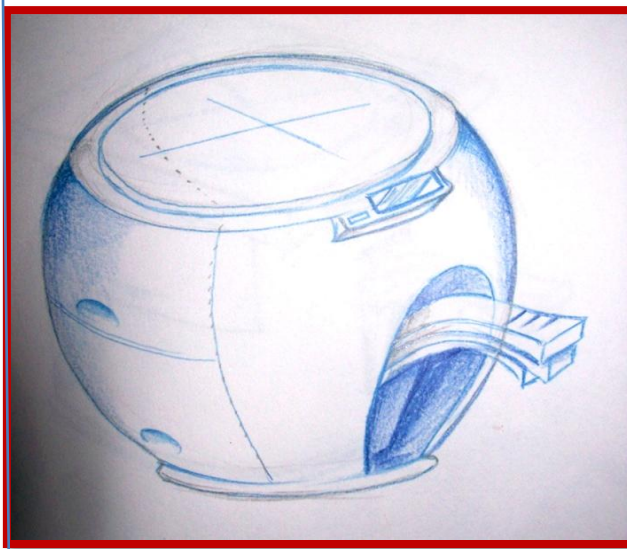
- Flat Bottom Heating
- Storage Centric



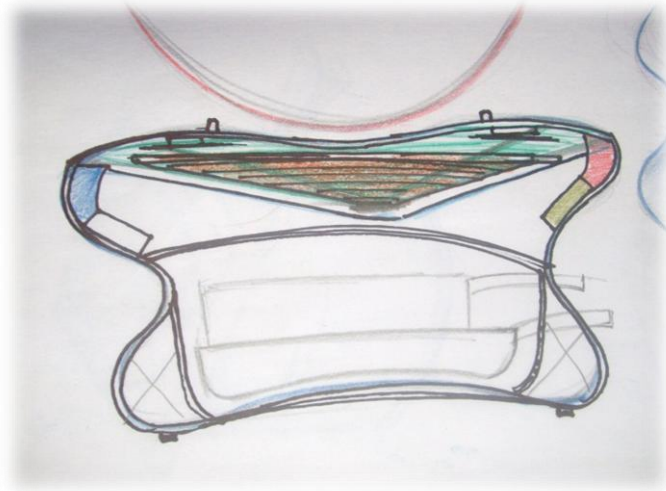
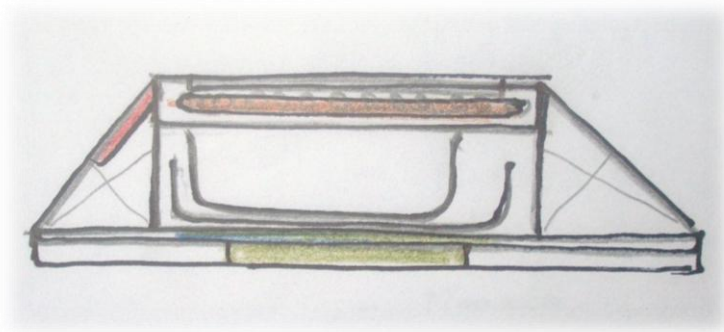
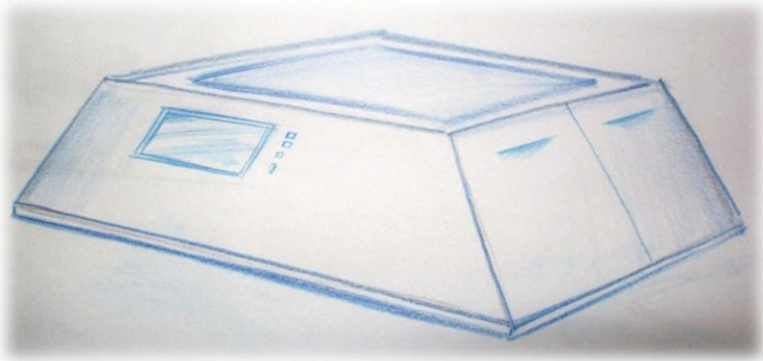
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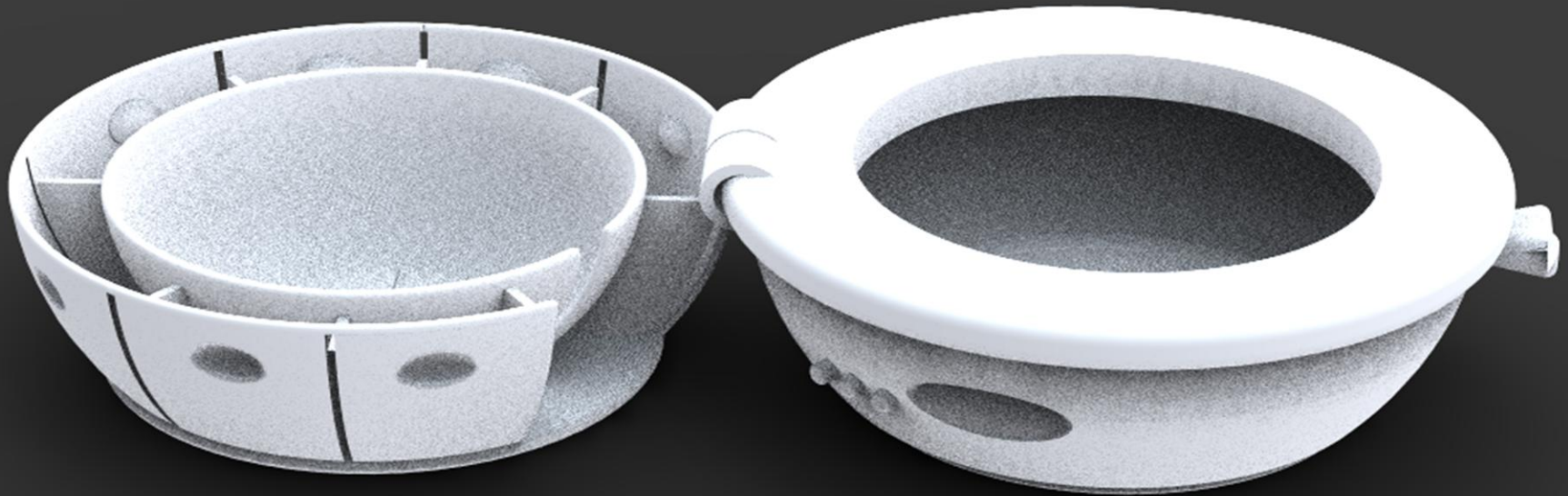
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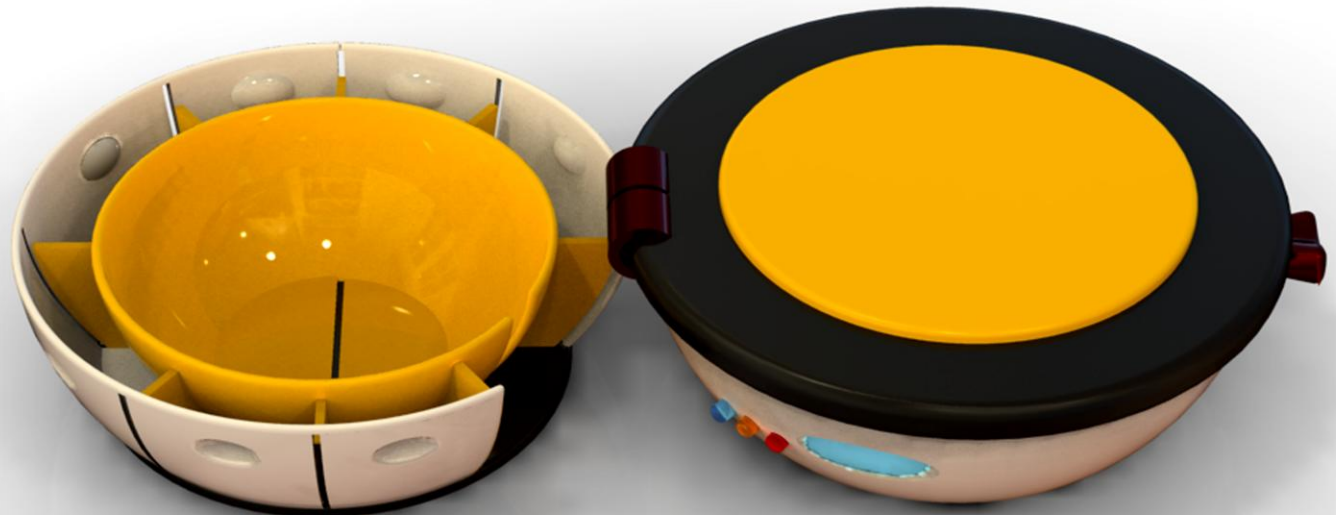
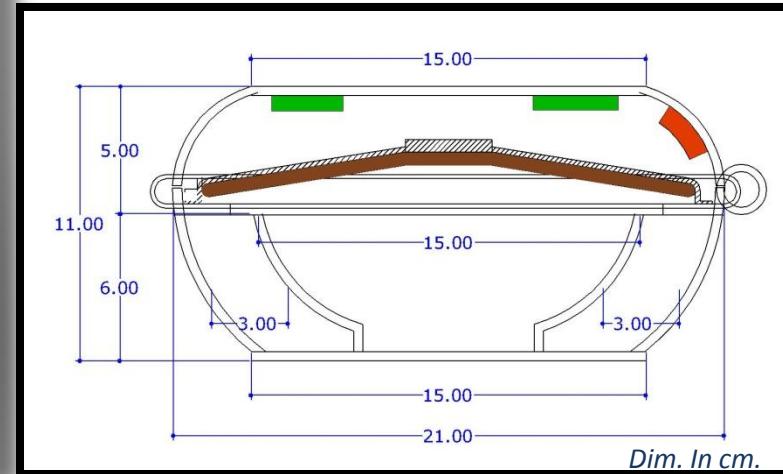
Cluster 1:



Concept 1:

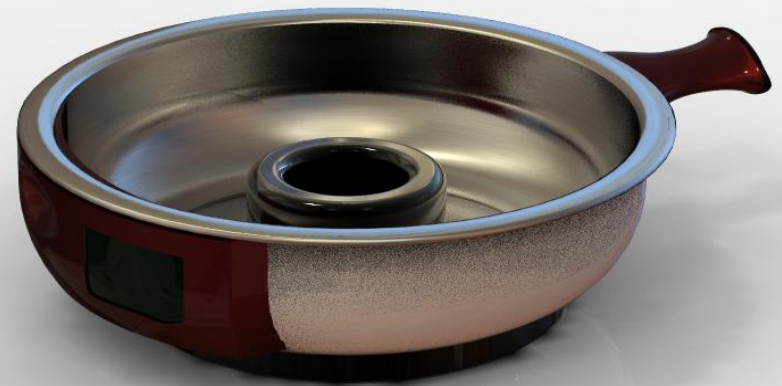
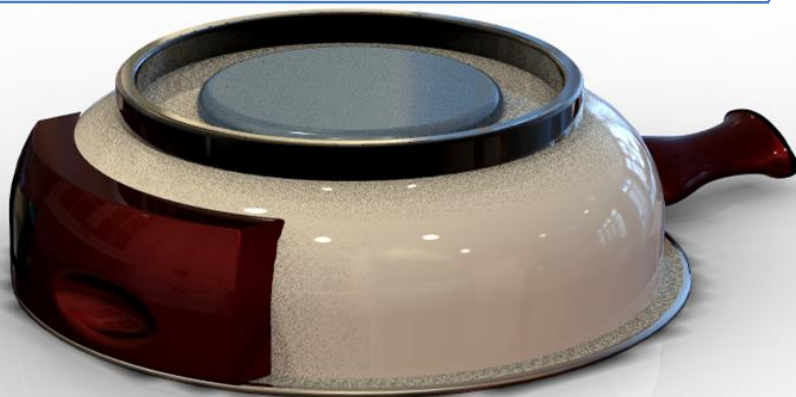
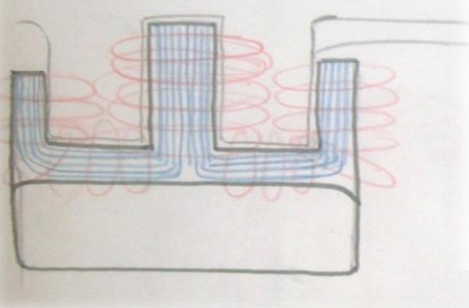
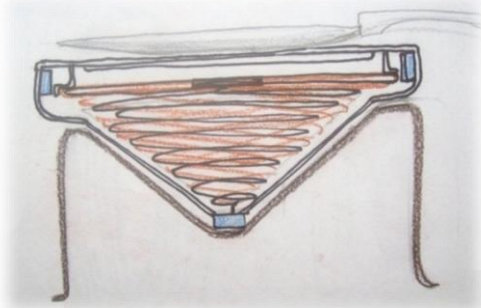


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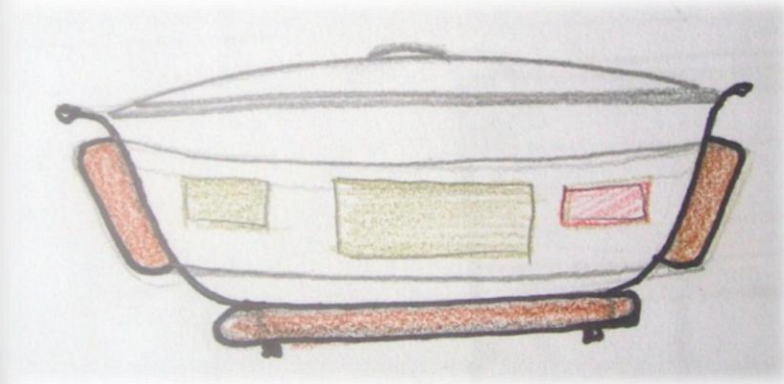
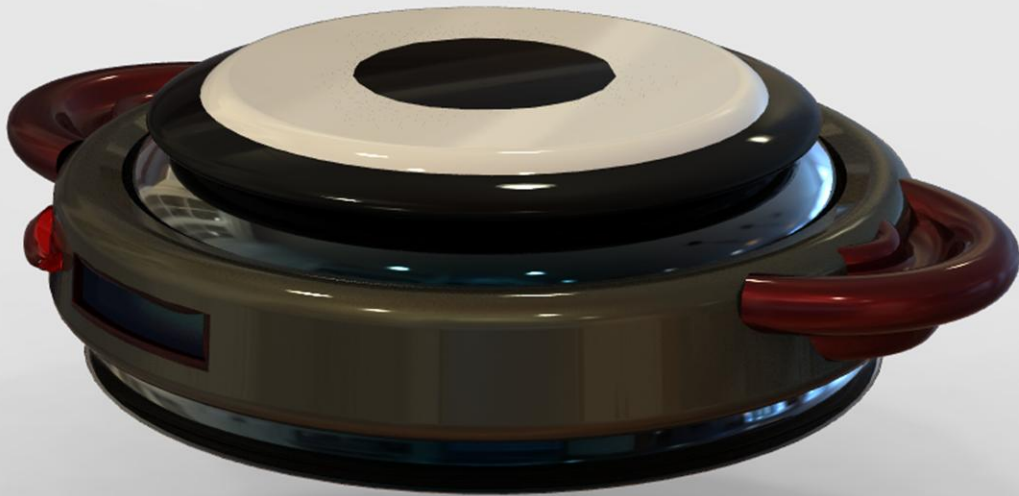
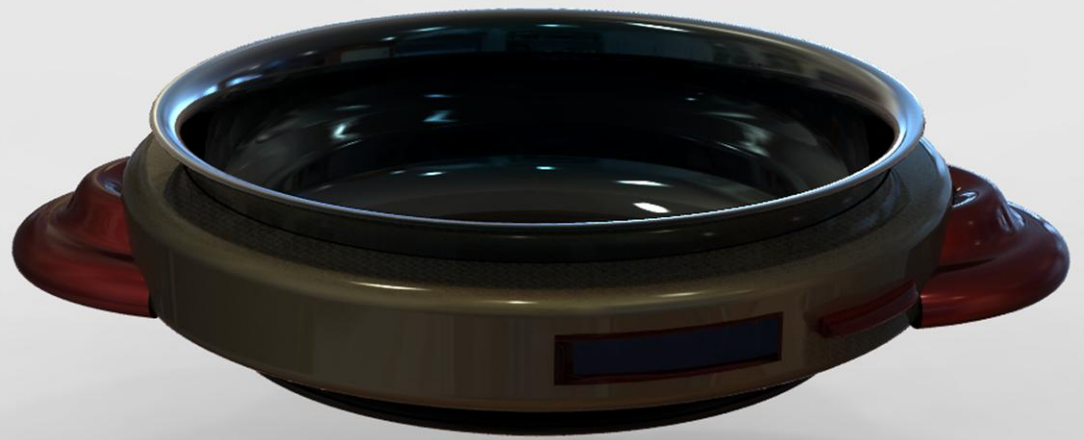


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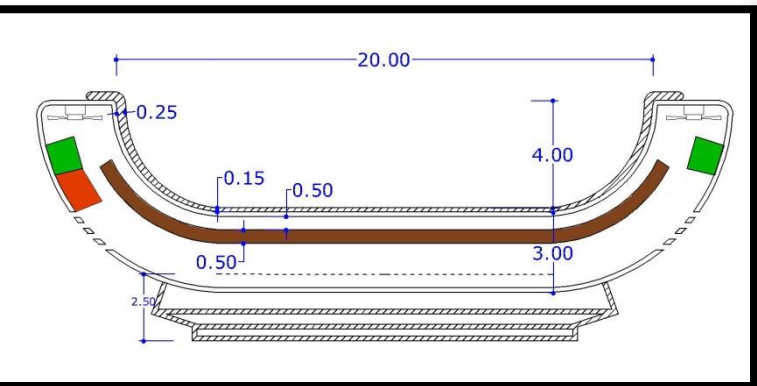
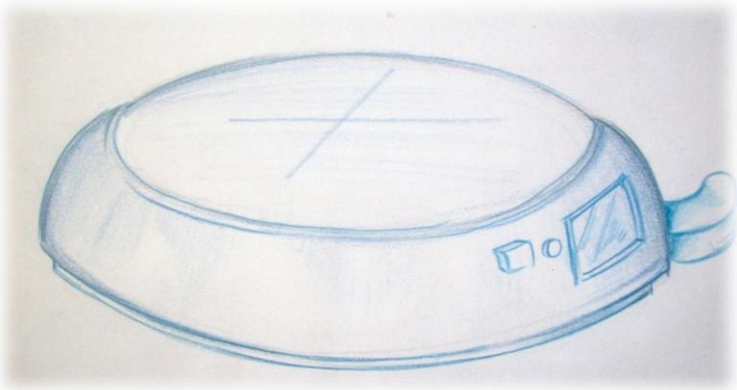
- Invertible,
- Attached cookware,
- Bottom & side heating.



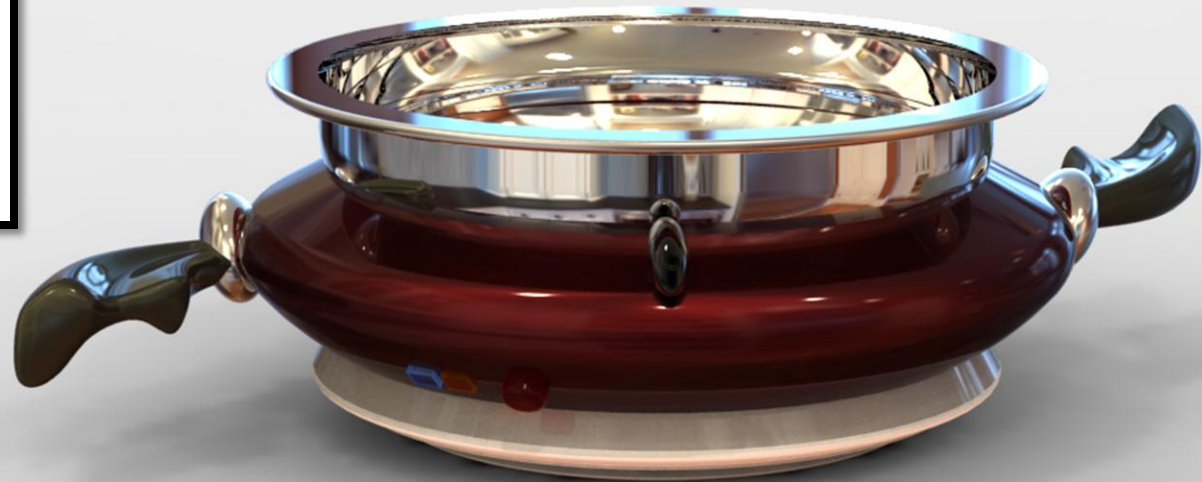
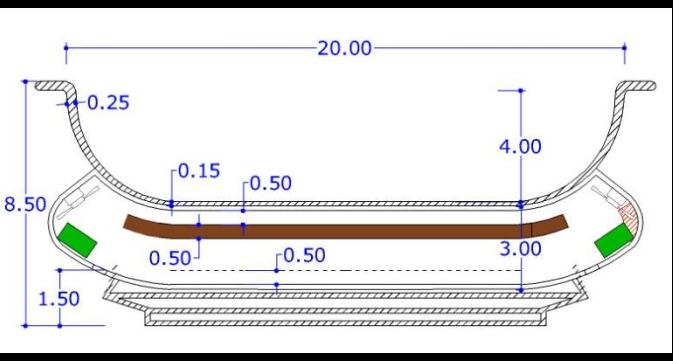
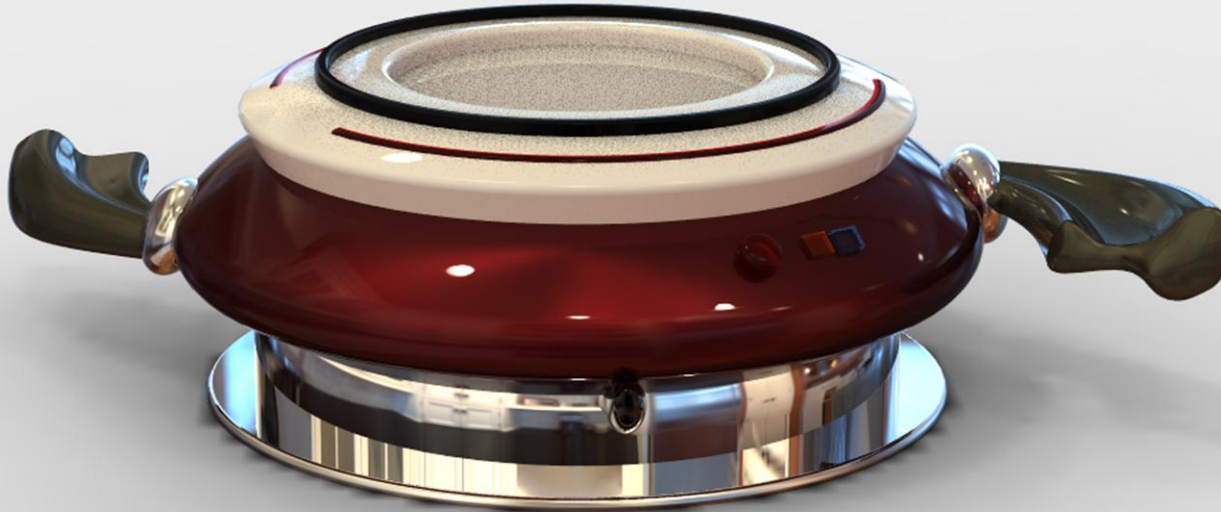
Cluster 2:



Cluster 2:

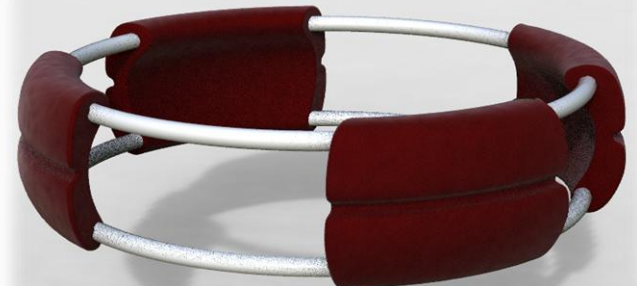
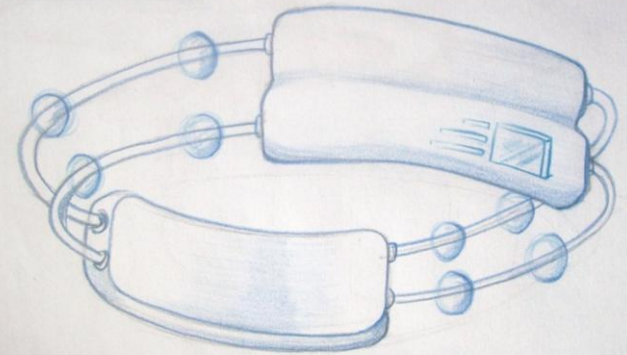
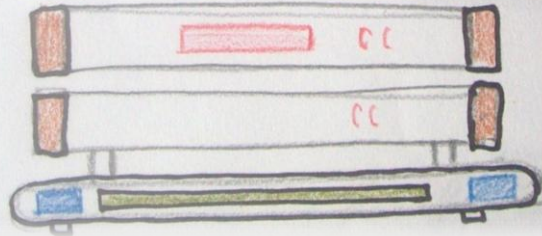
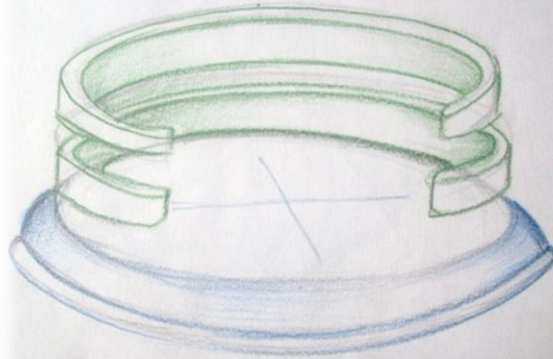


Concept 2:

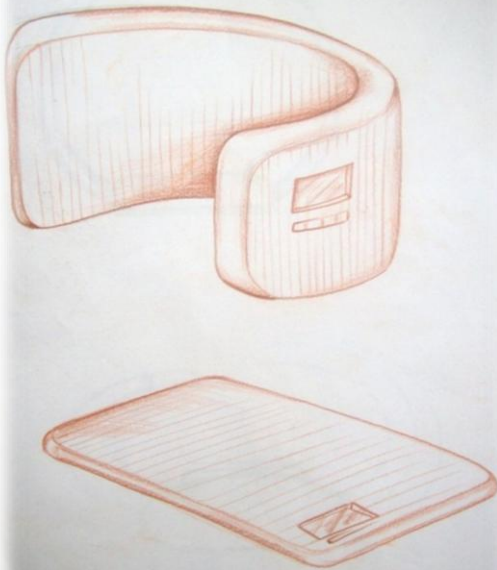
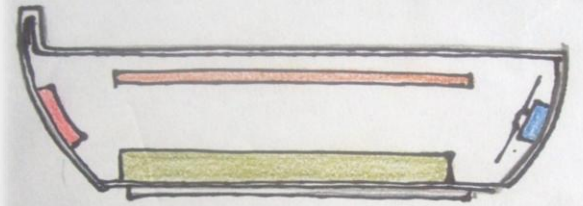
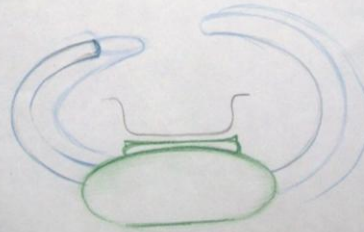
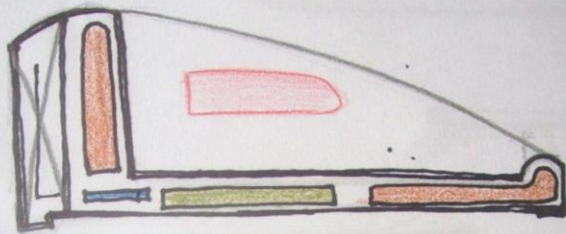
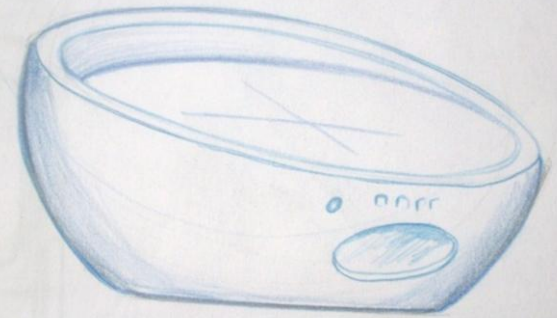
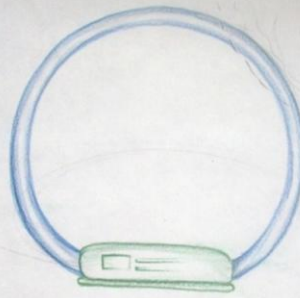
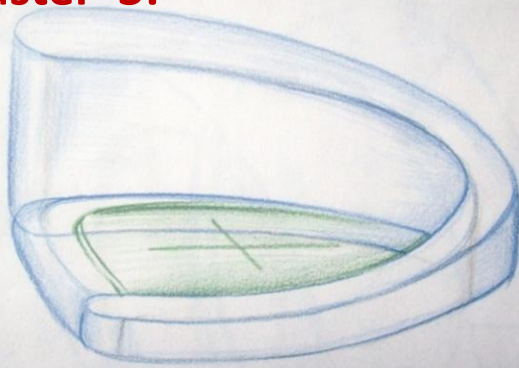


Cluster 3:

- Bottom & side heating
- Attachable gadgets.



Cluster 3:



Concept 3:



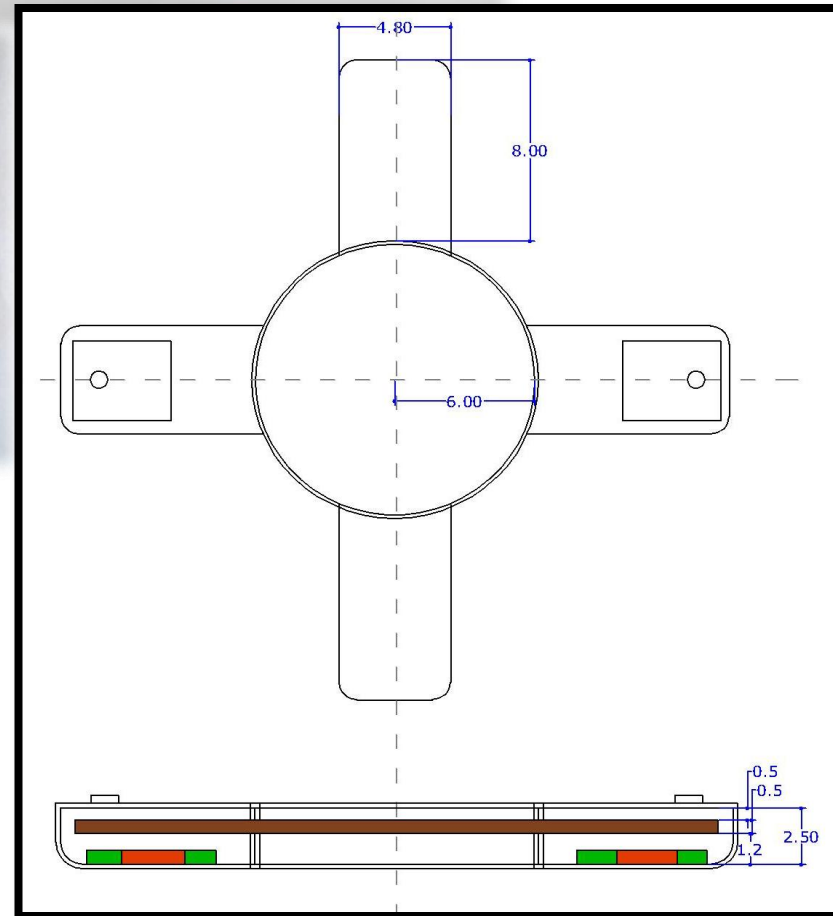
Material:

High temperature
sealants and fire sleeves

- Pyroshield™

- Pyreflect™ Firesleeve

- Industrial
Pyroshield®



Exploratory Models:

Form Exploration:

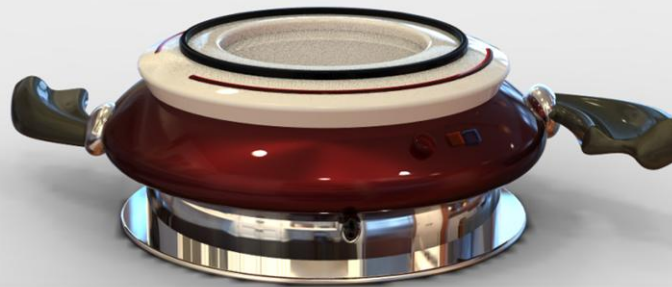


CONCEPT EVALUATION:

1



2



3



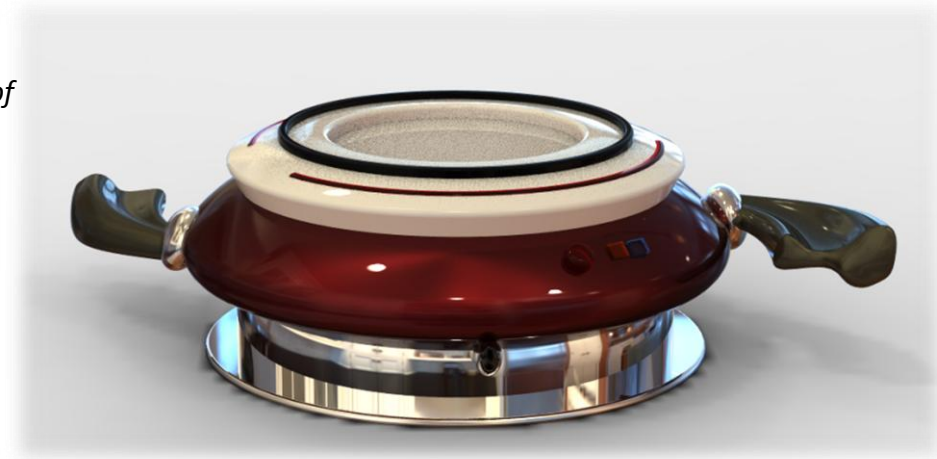
Concept No	Efficiency	Cost & Manufacturing	Safety	Compact	Durability	Tech. Simplicity	Storage Capability	Human Factor sensitive	Aesthetics	Interesting factor of Influence	Maintenance	Total Value Un – weighed	Total Value Weighed
Value Weightage	100%	90%	80%	75%	65%	50%	45%	40%	40%	30%	20%	---	
1	65	70	80	50	70	80	90	60	70	60	60	805	436
2	75	60	60	80	80	70	40	80	80	70	70	815	443
3	80	50	70	90	65	40	10	40	50	80	80	760	396

Post Design User Feedback:

The concept 2 was further exposed to the users, where the feedback of the users became the refinement criteria of the particular design.

The users were further questioned about various aspects like –

- The **overall form** of the product,
- the **ease** of usage,
- **amount of storage** within this particular design.
- **Overall product composition:**
 - display panel, positioning of
 - handles, shape, form and angle,
- product – user interaction.
- cookware must be attached or not?
- color?



Design Constraints:

- The design was brought down to a **single sided usage**, and not the inverted one.
- the cookware was **no more permanently** attached.
- Also, aspects of reverse heating of the ceramic top, was to be avoided to whatever the possible extent.

Feedback:

- **Form:** The overall **form** of the product was liked by all.

It looked **trendy**, and also had an **Indian identity**.

But a little **decrease in depth** of the body would be appreciated

- **Storage** -Contradictory to the earlier user study, they **preferred the product to house basic spices compartments as storage, and a cutting board.**

- **Cookware:**

Unlike this design, they preferred the cookware to be **detached**, but would appreciate a **snap property to the body**, when not in use.

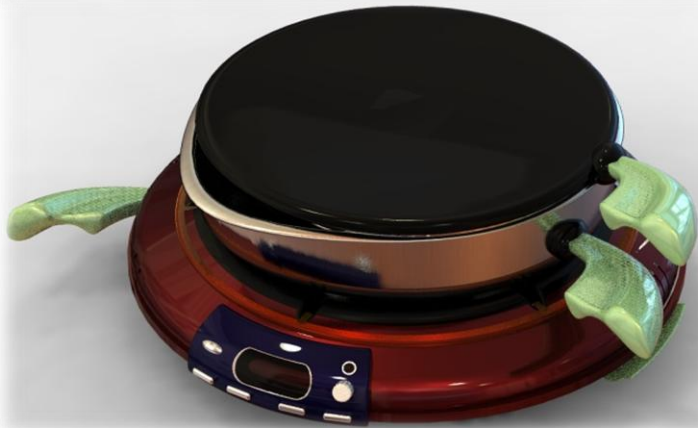
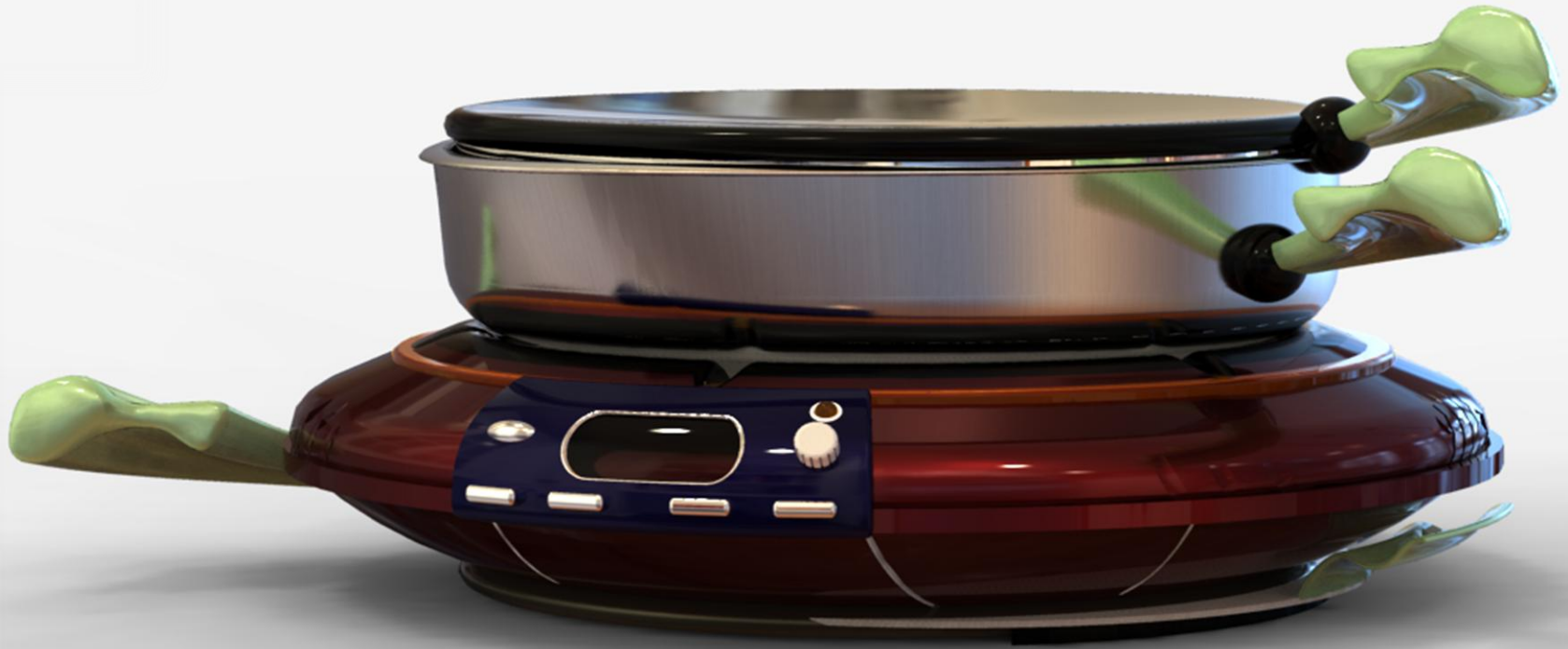
-The **handles** were simulated, and then liked by all. They found it more comfortable in comparison to the conventional handles - there could be an **extra tilt** in the handle angle w.r.t. the body. - *This was necessary for the natural angle of the fore arm during grasping.*

- Also, since the product was no longer a two sided cooking appliance, there was no **need to have handles at both sides** unlike the previous design

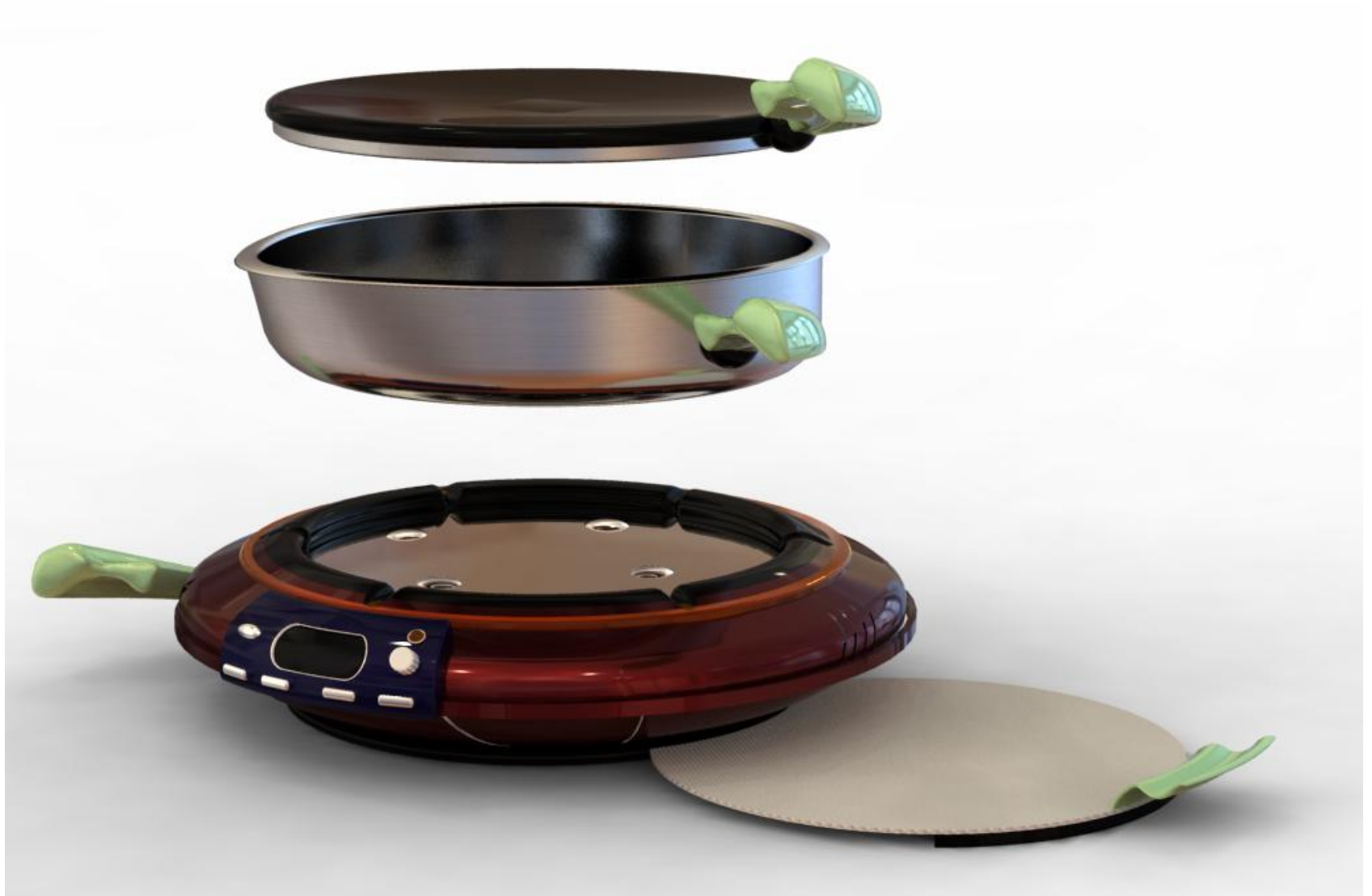
Intermediate Design:



Final Design:



Final Design:



The Model:



Product Specification:

Material : - A.B.S. Body casing, (*hardness, gloss, toughness, and electrical insulation properties*).

- ceramic as cooking top,
- acetal as interior connecting elements (*nuts, screws etc.*).
- ferrite / asbestos as flux concentrators.
- rubber pads as base.

- **Cookware** - cast iron pan, and tri ply sauce pan.

- colored Bakelite handles.

Dimensions: - **Induction cooker** -220mm external dia. x 60mm overall depth.

- **Cookware:** Pan – 180mm dia.

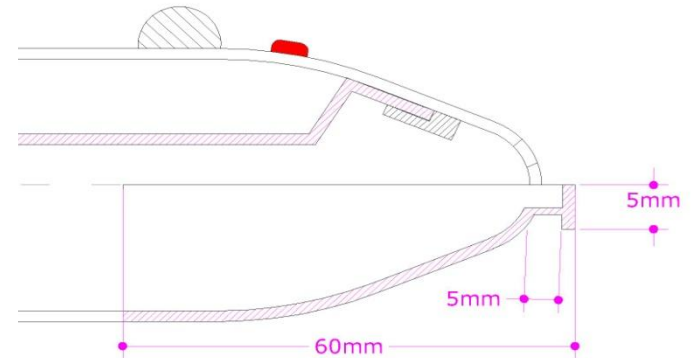
Sauce pan – 160mm dia. x 45mm

Functions : - Auto cook, cook, auto defrost, appointment.

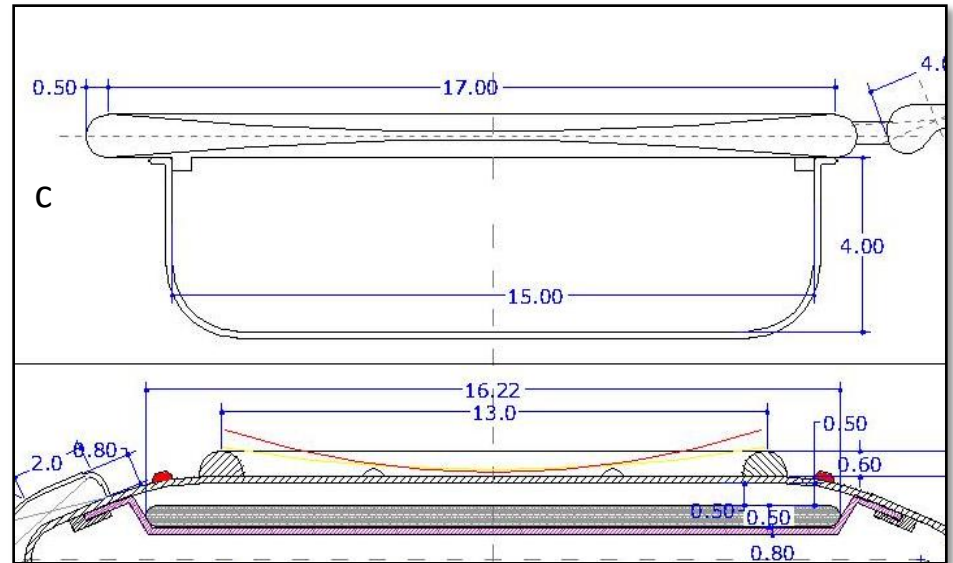
Net weight : 2 kg

Aprox. Retail Price: Rs. 2,000 to Rs. 2,500

Working Drawing:

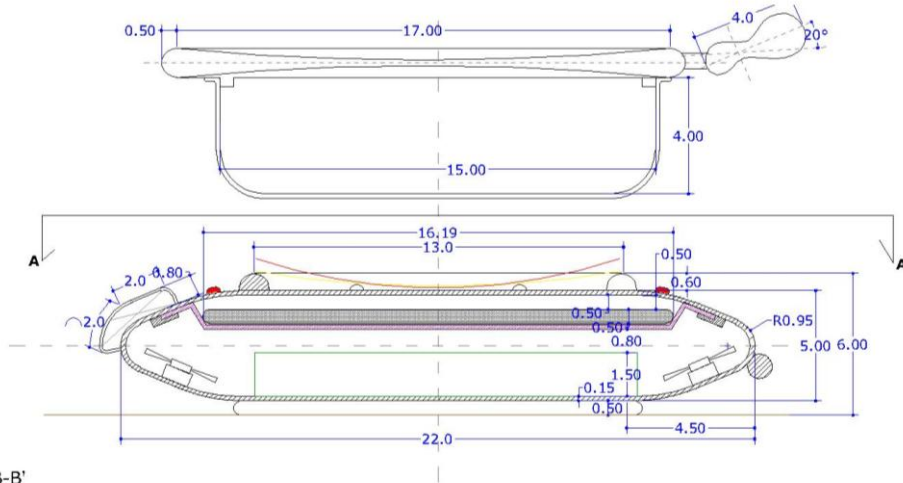


Detail of drawer:



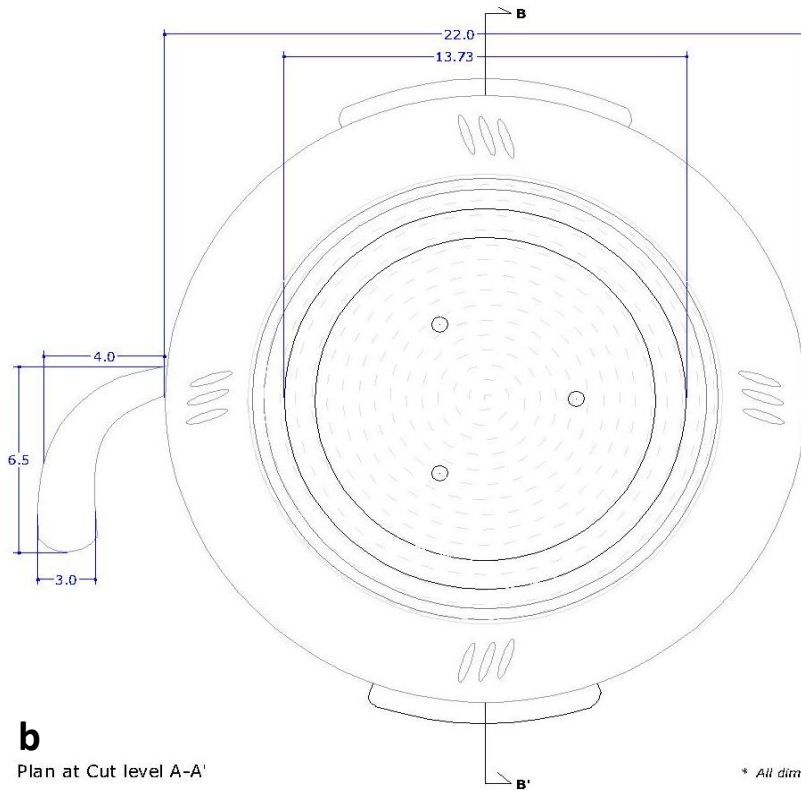
d

* All dimensions are in cm.



a

Section B-B'

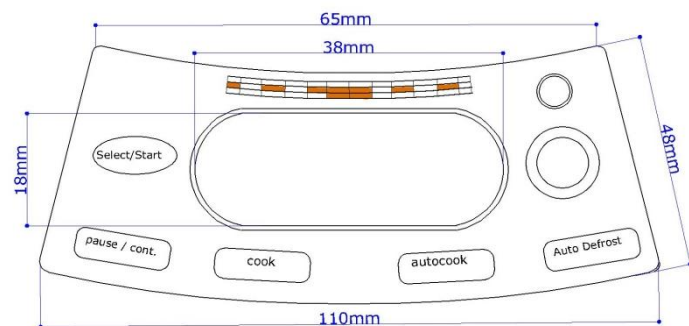
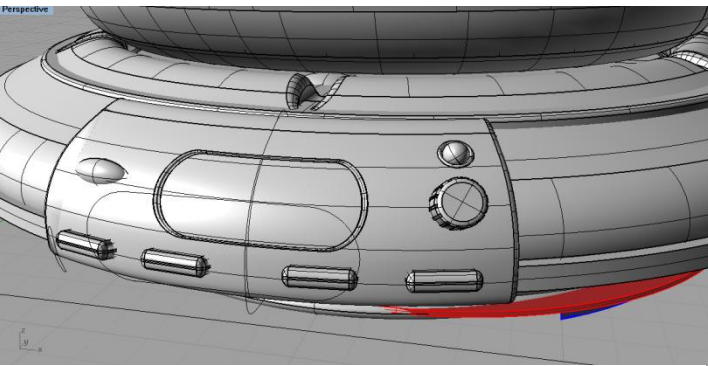


b

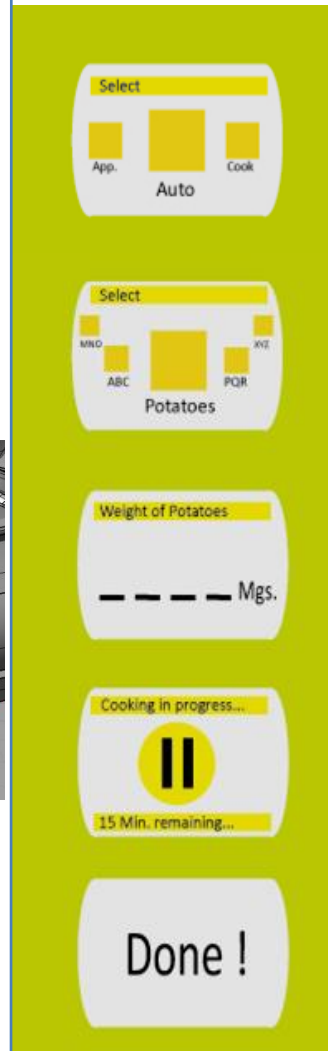
Plan at Cut level A-A'

Interaction/ Interface Design:

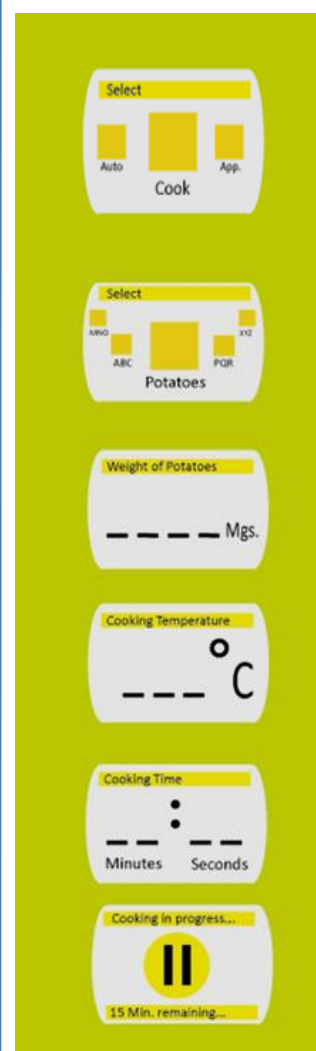
Functions: Power,
Cook
Auto Cook,
Appointment
Auto defrost
Pause / continue
Temperature setting
power/temp. setting



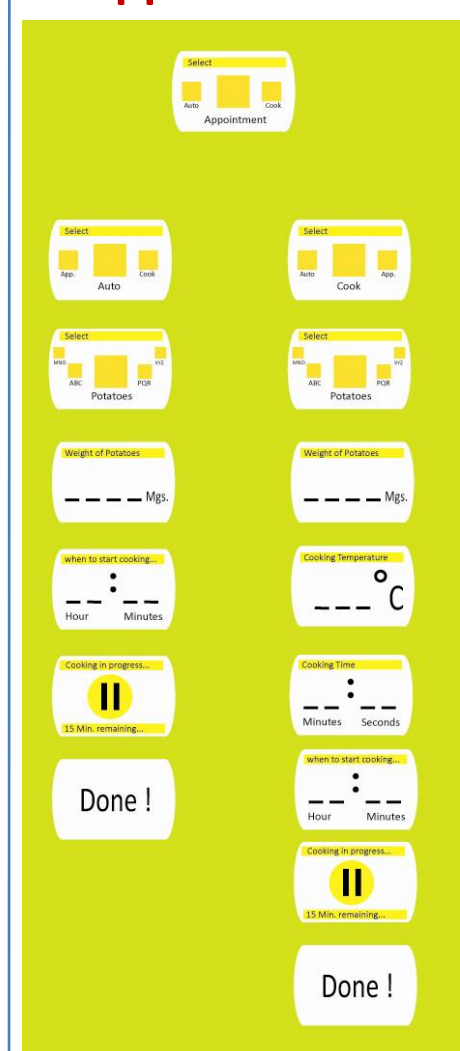
Auto Cook



Cook



Appointment



Thank You.