COOKING APPLICATION USING STEAM FROM SOLAR STEAM GENERATOR (RICE COOKING VESSEL)

M.Des Industrial Design Project III

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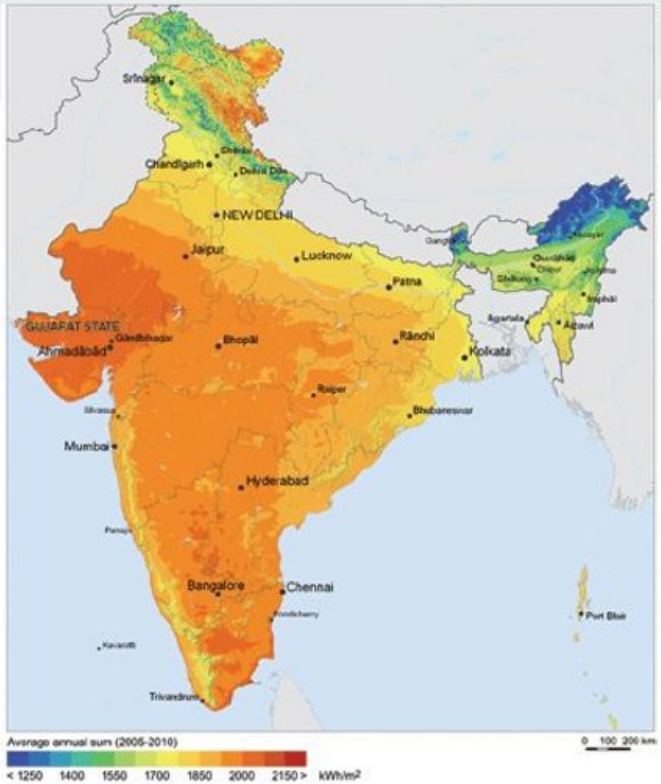


Main renewable sources of energy

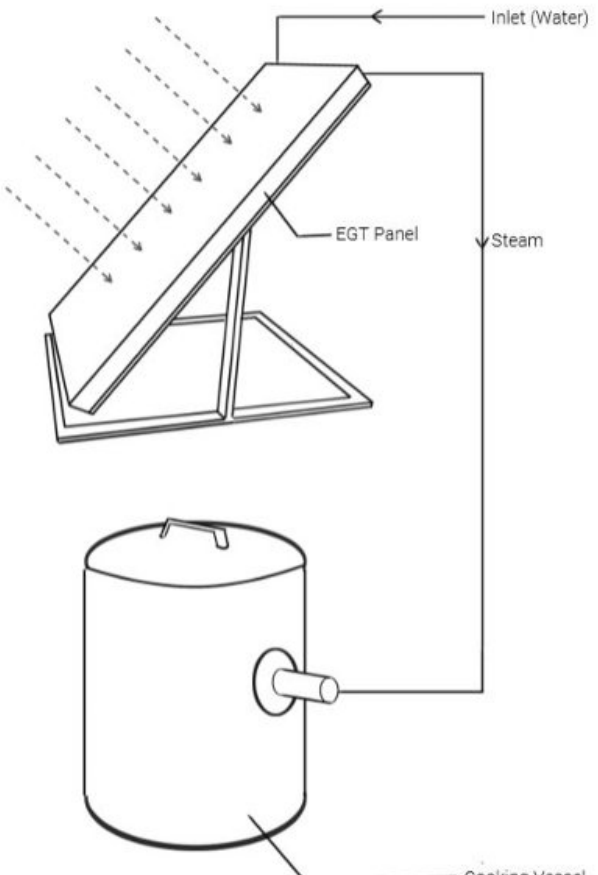
Solar energy is clean and abundant source of energy. This energy is utilized for many applications and cooking is one of them.

With about **300 clear, sunny days in a year**, India's theoretically calculated solar energy incidence on its land area alone, is about **5,000 trillion kilowatt-hours (kWh) per year.** The solar energy available in a year exceeds the possible energy output of all fossil fuel energy reserves in India.

Simple and Affordable Steam Generator developed by Heat Pump Lab (Mechanical IITB)

Heat Pump lab at IIT Bombay has developed a steam generator which uses **evacuated glass tubes deployed with multi-wall polycarbonate top cover and multi layer rigid foam back insulation**

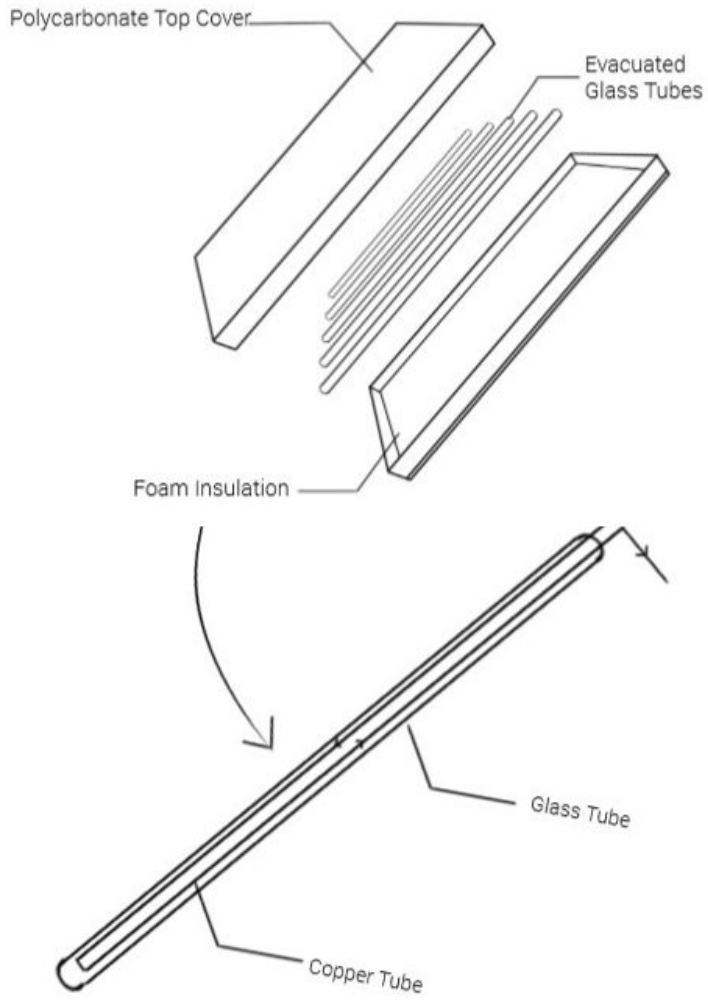
Storage medium **temperature of 200 to 300°C are achieved** with this design. Preliminary experimental data reveals that such collectors can be used to generate steam at 1 to 10 bar using the low cost seasonally tracked low profile collectors.



The inner glass tubes are filled with heat storage medium to store the collected heat

A copper tube coil with aluminium foil fin is deployed in the storage medium to enable extraction of heat as and when needed.

Heat loss from the bottom side is reduced using a multilayer rigid foam insulation under the EGT and reflectors.



Area of exploration.

Implementation of this technology in places where food is cooked in huge quantities (hotels, hostels, hospitals etc) so that a lot of other sources (fossil fuel, LPG) of energy can be saved.

Data Collection

Data collection has been done to understand about the technology involved and to gain an overall idea about the existing trend and products that is prevailing in the market.

Advantages Of Steam Cooking System.

- Steam Cooking **retains the texture & shape** of the cooked food
- The Food **won't get over cooked**.
- In conventional cooking system 4 Burners used for Cooking 4 Items, whereas in Innovative Steam Cooking System **1 Burner cooked 4 Item at a time** Saving of Time & Fuel
- This cooking system require **less time for cooking**

Advantages Of Steam Cooking System.

- **Cost effective** as compare to any another cooking system.
- **Energy cost saving approximate from 40% to 60%** as compared with traditional cooking system.
  E.g. If your annual energy cost is Rs. 3,00,000/- then after use of our cooking system your organization will save Rs. 1,20,000/- to 1,80,000/- every year.
- **Meal preparation time saving is approximate from 35% to 50%** as compared with traditional cooking system.
- Kitchen remains much cleaner because of **less smoke produced.**

Steam Boiler

- ELectric steam boiler
- LPG steam boiler
- Fire wood steam boiler
- Solar Steam boiler

LPG steam boiler

Electric steam boiler

Fire wood steam boiler

Solar steam boiler

Steam Vessels

There are various kinds of steam vessels available in the market, which are used in chemical industry, cooking industry etc.

Steam Jacketed Cooker

Approx. Rs 65,000 / Unit
Material : Stainless Steel
Material Grade : SS 304, SS 316 L
Capacity : 150 Litre and above

Non Jacketed Steam Cooking System

Approx. Rs 2.5 Lakh / Unit
Material : Stainless Steel
Material Grade : SS 304
Capacity : 150 Litre and above

Jacketed Steam Cooking System

Approx. Rs 1,00,000 / Unit
Material : Stainless Steel
Material Grade : SS 304, SS 316 L
Capacity : 150 Litre and above

Sealed Kettles

Approx. Rs 1,20,000 / Unit
Material : Stainless Steel
Material Grade : SS 304
Capacity : 100 Litre to 1500L

Steam Kettle With Stirrer

Approx. Rs 1,00,000 / Unit
Material : Stainless Steel
Material Grade : SS 316
Capacity : 100 Litre to 800L

Steam idli cooking device

Approx. Rs 10,000 / Unit
Material : Stainless Steel
Material Grade : SS 304
Capacity : 60,120,180 upto 360idlies per cycle

Tilting Steam Boiling Pans

Material : Stainless Steel
Material Grade : SS 316
Capacity : 150 litre and above
Type : Vertical

Steam jacketed vessel

Material :Stainless Steel
Material Grade : SS 316
Capacity : 150 liters & above.

Shirdi, Maharashtra, India

- The system **generates steam** for **20,000 pilgrims twice a day.**
- The system comprises of **73 solar dishes,** each with an aperture area of 16 m2
- The system is also **connected to a conventional boiler,** which runs on **Liquefied Petroleum Gas (LPG),** in case the weather turns out to be too cloudy.
- The installation is expected to **save around 100,000 kg of LPG per year,** which is equivalent to INR 2 million.

Tirumala Tirupati Devasthanam

- Tirumala Tirupati Devasthanam has the **world's largest solar steam cooking system** using the Scheffler Community Kitchen design.
- The system is comprised of **106 rooftop-mounted parabolic concentrators** that generate steam for cooking up to **30,000 meals daily.**
- It saves Tirupati **1.2 lakh litres of diesel every year.**
- The chefs say that it takes less than **20 minutes to cook an entire meal.**

Major manufacturers of steam cooking vessels

Suryansh Enterprise
http://suryanshenterprise.com/

Swaraj Industries
https://www.swarajindustries.com/steam-cooking-system.html

Scheffler Community Kitchen
http://solarcooking.wikia.com/wiki/Scheffler_Community_Kitchen

Cleveland
https://www.clevelandrange.com/Products/Steam-Jacketed-Kettles/Floor-Models

Berto's
https://www.bertos.com/en/plus/tilting-boiling-pans/19-152.html

User Study

Study has been conducted to understand about the cooking pattern in a community cooking spaces,to know more about the steam cooking, their pros and cons right from the users perspective.

Hostel 6

LPG steam boiler, rice cooking vessel, jacketed vessel, idli cooking device.

Cooking rice, Boiling water, sambar, dal etc idli were the main dishes prepared using boiler.

Hostel 12

LPG steam boiler, two rice cooking vessel, two idli cooking device

Cooking rice, Boiling water, idli are mainly cooked using the device.

Cooking Process

Steam boiler

1. Water tap to the boiler is opened and ensured there is enough water pressure. Then the boiler is started.

Water inlet to vessel

2. Water is filled in the vessel to the required level.

Non-jacketed vessel

3. Steam is passed into the vessel to get the water boiled. Lid is kept closed to attain the boiling point faster.

Rice transferring into the vessel

4. Washed rice is transferred into the vessel once the water gets completely boiled.

Stirring the food

5. Rice has been stirred and checked in between to make sure it is completely cooked.

Food getting cooked

6. Once completely cooked lid is removed and the steam inlet valve is closed.

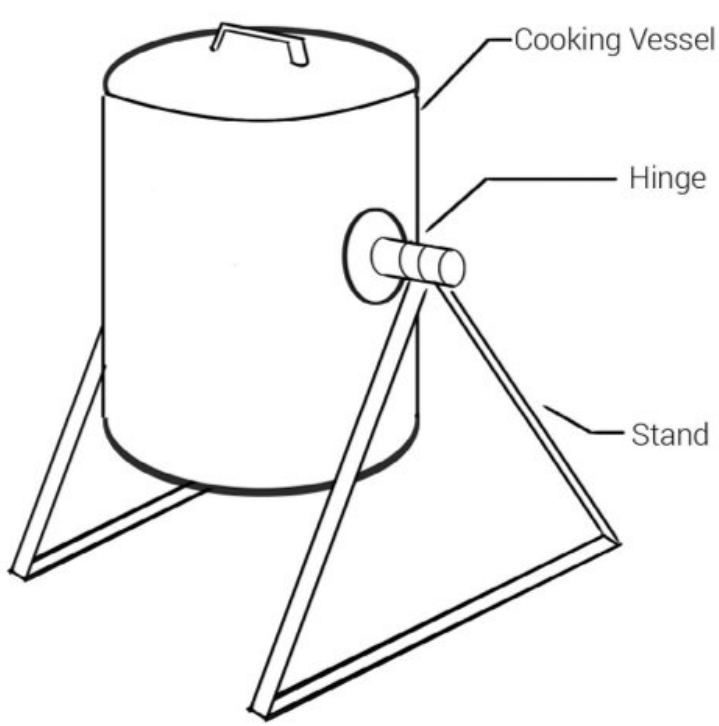
Draining of waste water.

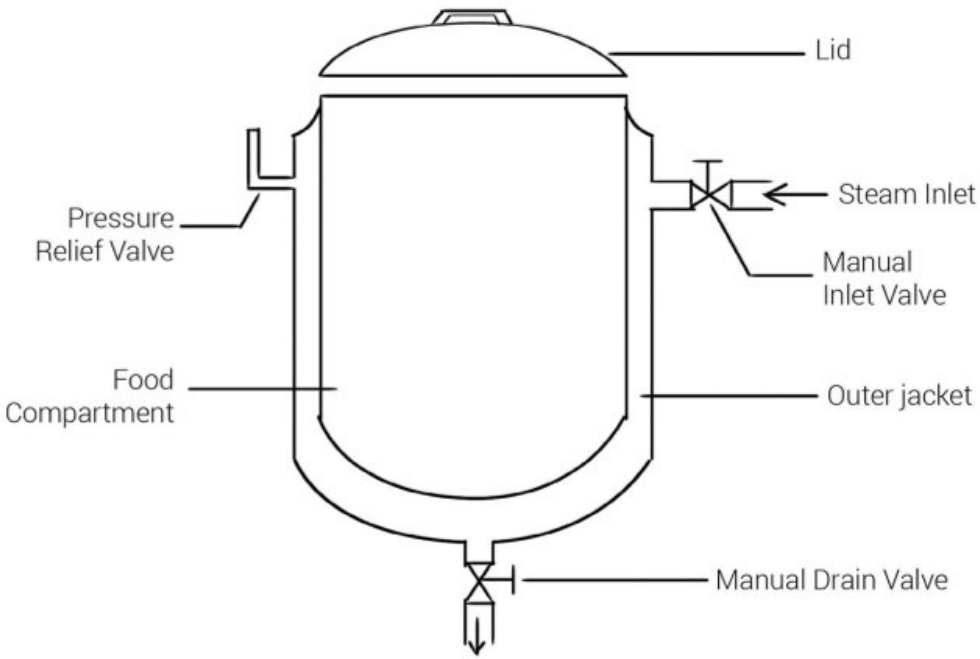
7. The drain valve at the bottom of the vessel is opened and excess water is drained out.

Transferring of food

8. The vessel is then tilted to transfer the cooked food from the cooking vessel.

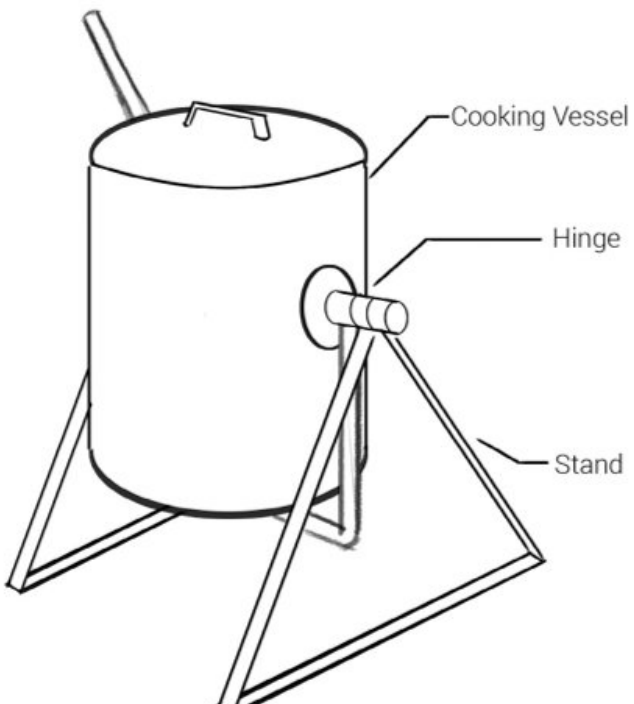
Jacketed vessel

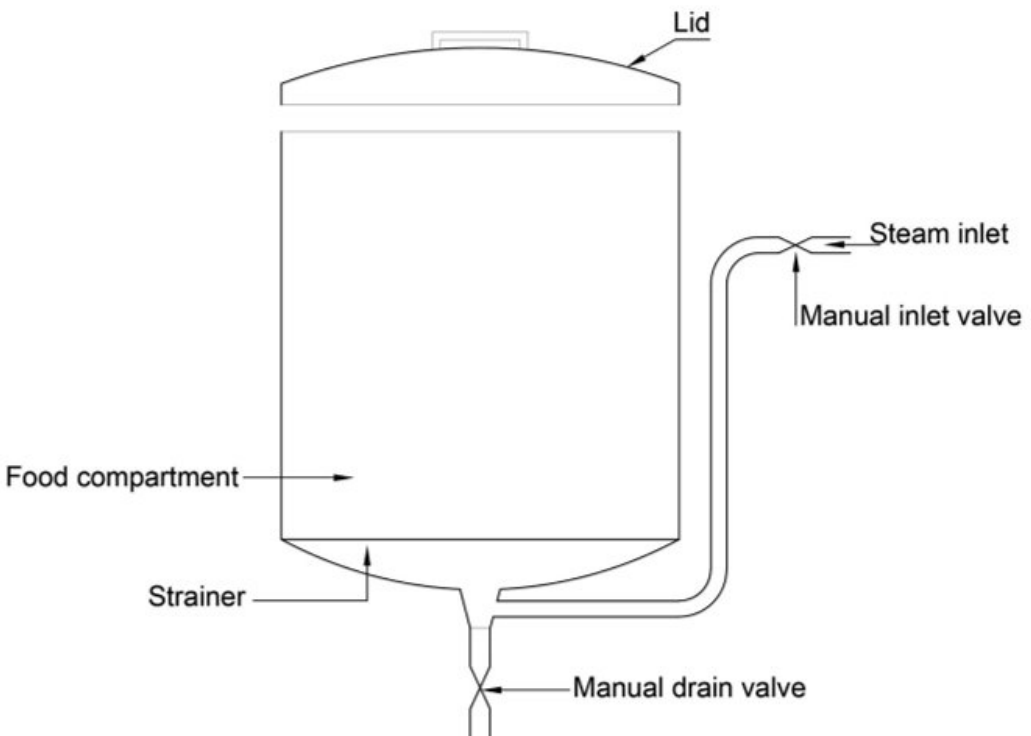




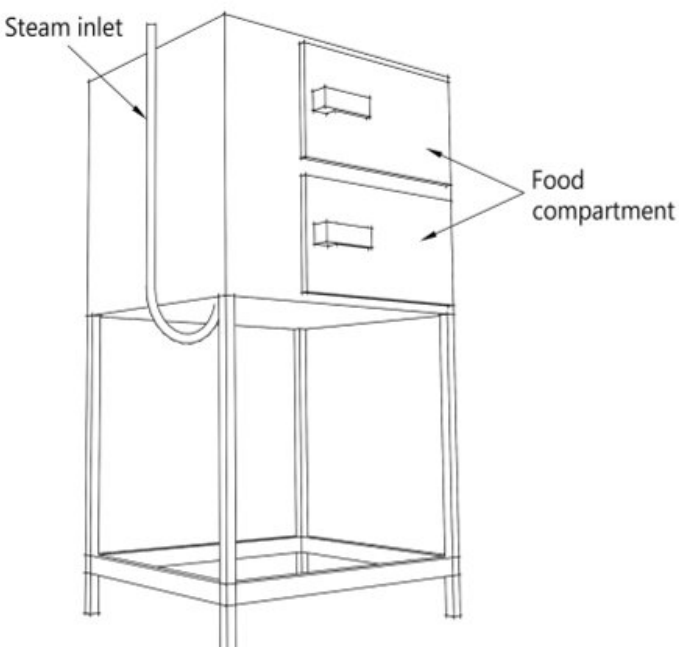
Heats most of the surface area which results in faster cooking.

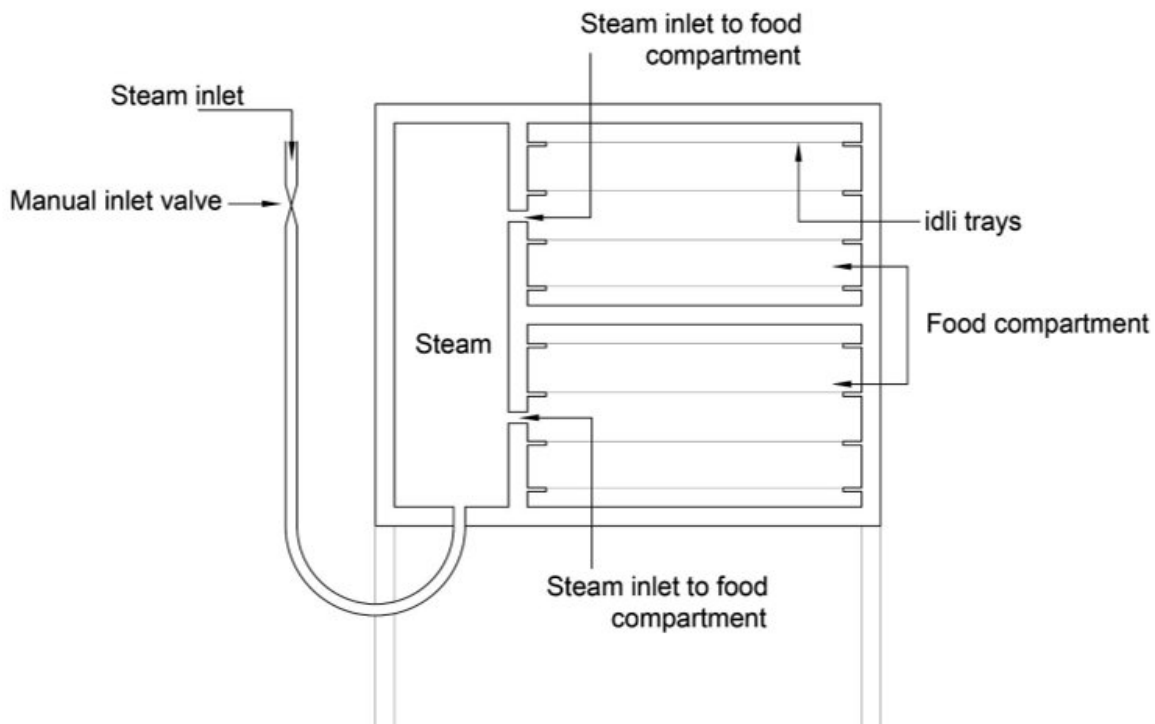
Non Jacketed vessel





Idli cooking device





Observations

Fig38. Water connection to the vessel.

No proper water connection

Fig39. Using stirrer for cooking.

Difficulty in stirring because the vessel is always free from the hinge.

Fig40. Drain valve

The main drain valve and its tap are tightly designed.

Observations

Fig41. Lid of the vessel.

Difficulty in keeping the lid of the vessel.

Fig42. Steam valve of the vessel.

Tap of the steam is not at an approachable distance.

Fig43. Jacketed vessel.

Cleaning of the vessel becomes difficult.

Observations

Fig44 Draining the waste water.

No proper drain for the waste water after cooking.

Fig45 Stirrer kept on top of the vessel.

No proper place to keep the stirrer.

Fig46 Transferring food

The handle design makes it difficult for the user in tilting the vessel.

Design Brief

To design a cooking device heated by steam which can perform rice cooking for 500 to 600 people in a community cooking environment (hostels, hospitals, canteens etc.).

Design Problem

The problem here is to come up with a user-centric design for a cooking system which is heated using steam from solar steam generator. The main intention is to make the whole cooking experience easy for the user. There are similar products in the market which are just intended to serve the purpose; but the idea here is to identify and solve the existing problems and come up with a new design.

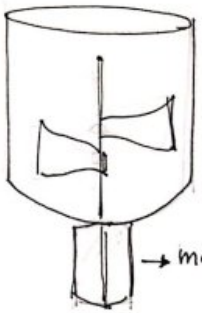
Design Considerations

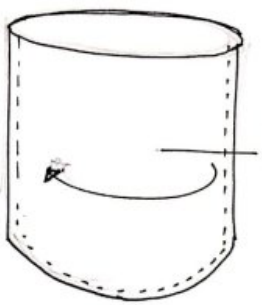
- Operation of the cooking system should **not be complicated**.
- **Food grade materials** should be chosen for main components in the system.
- Should **not have much maintenance** issues once it is installed.
- **Cleaning should be easy** since it is going to be in a mass cooking environment.
- **Functionality** is the major concern.
- **Modularity** will be an add on to the design.
- Care should be given for a **proper water inlet** for the device.
- **Locking system** for the vessel should be addressed.
- **Approachability to the drain valve** should be taken care of.
- **Drain water management** is a major concern, since the cooking environment should be always maintained clean.
- Packing, transportation and assembly should be considered in the design.

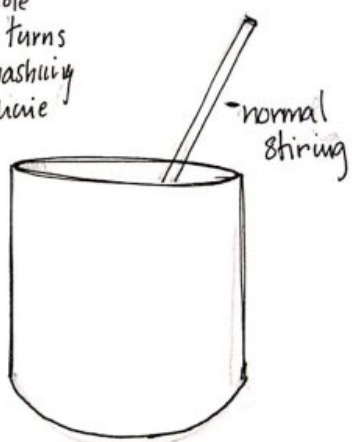
Ideation

Initially ideas were generated taking individual aspects that were found from the observations. Furthermore ideations were done combining one or more ideas that was initially done.

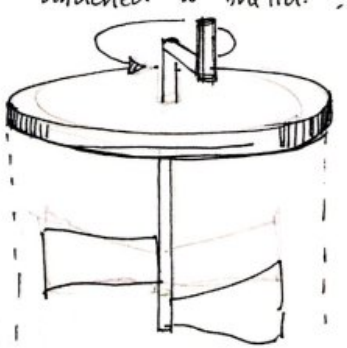
Different ways by which stirring can be done

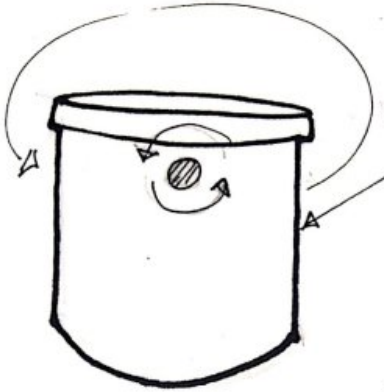


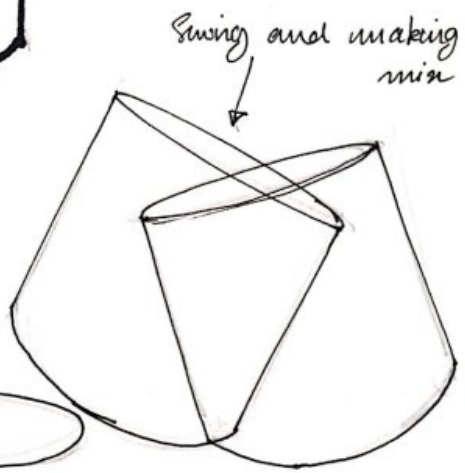


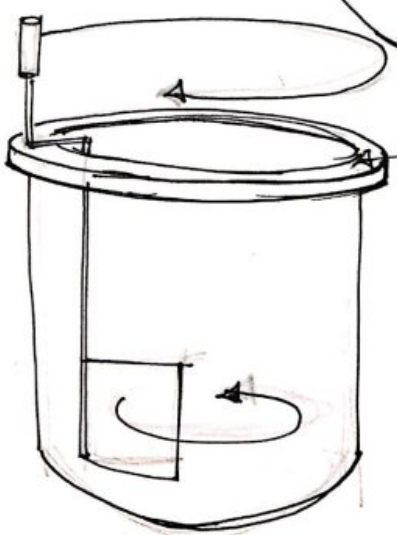


Manualy rotating stirer attached to the lid.

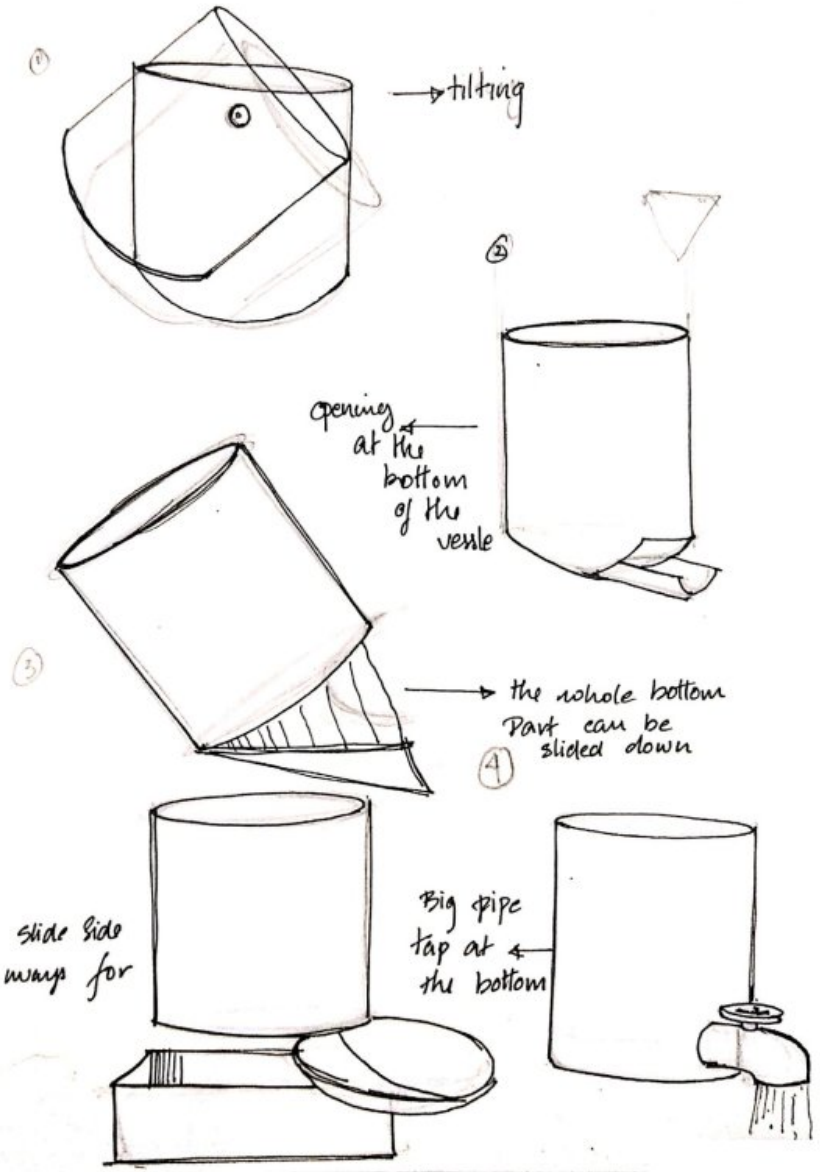




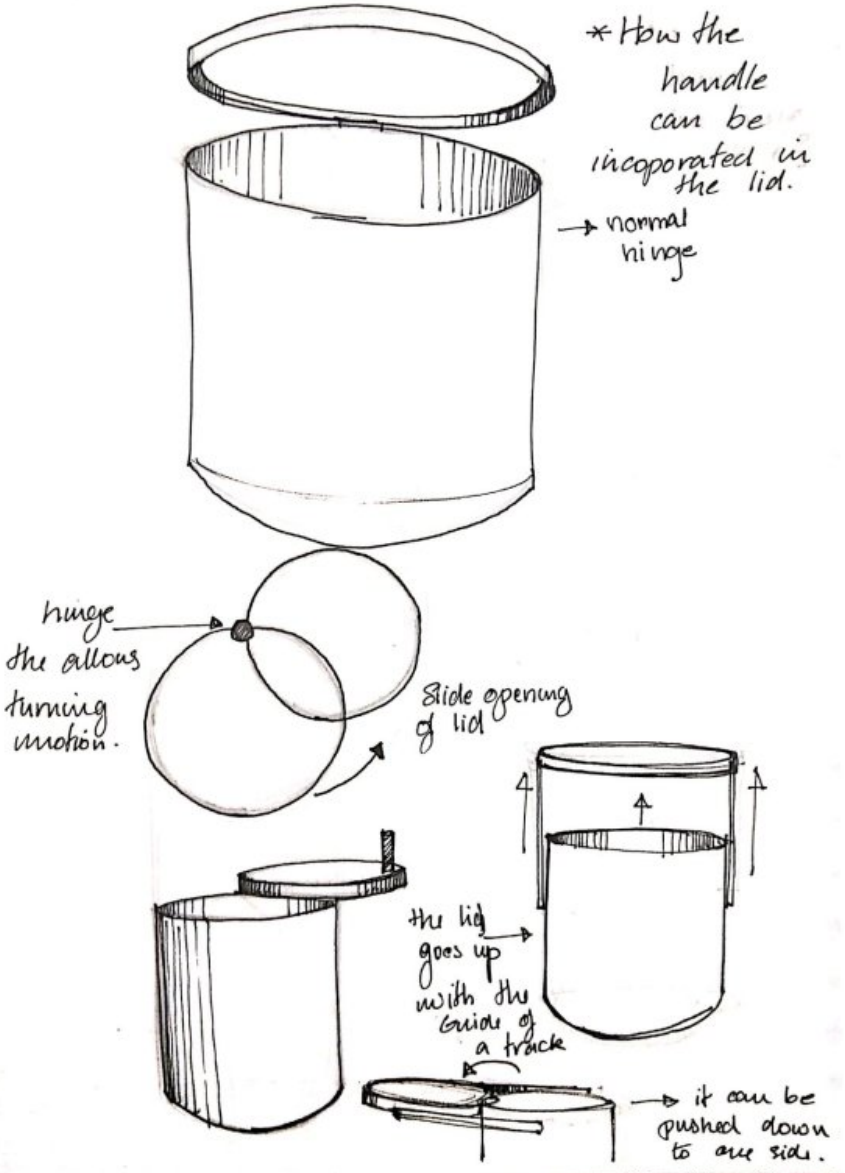




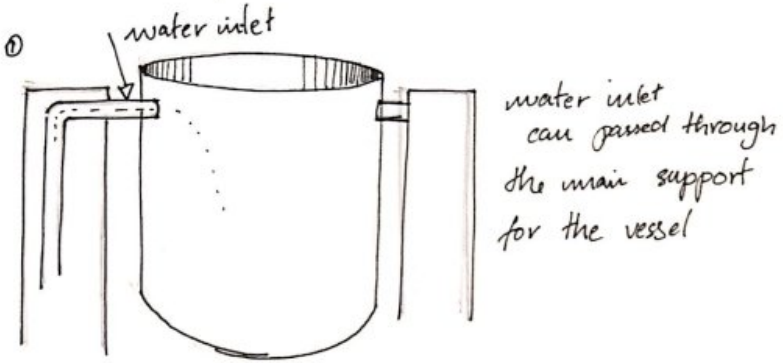
- Different ways by which food can be transfered

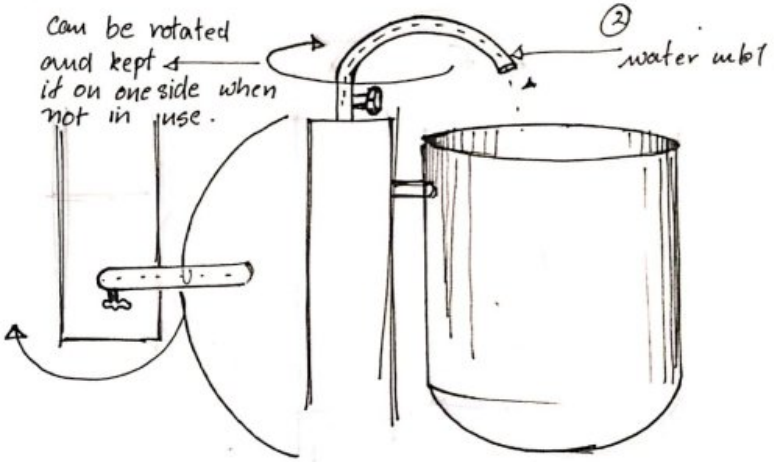


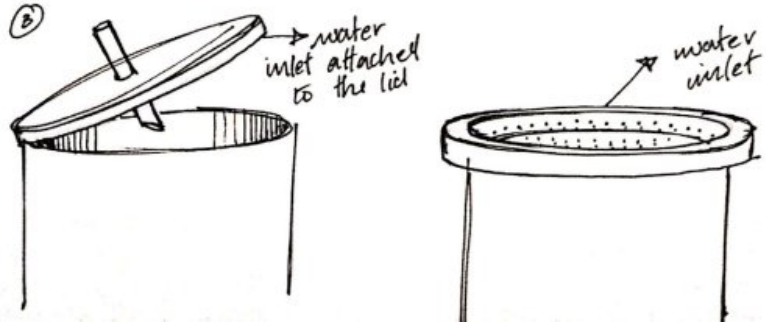
Different approch by which lid can be attached



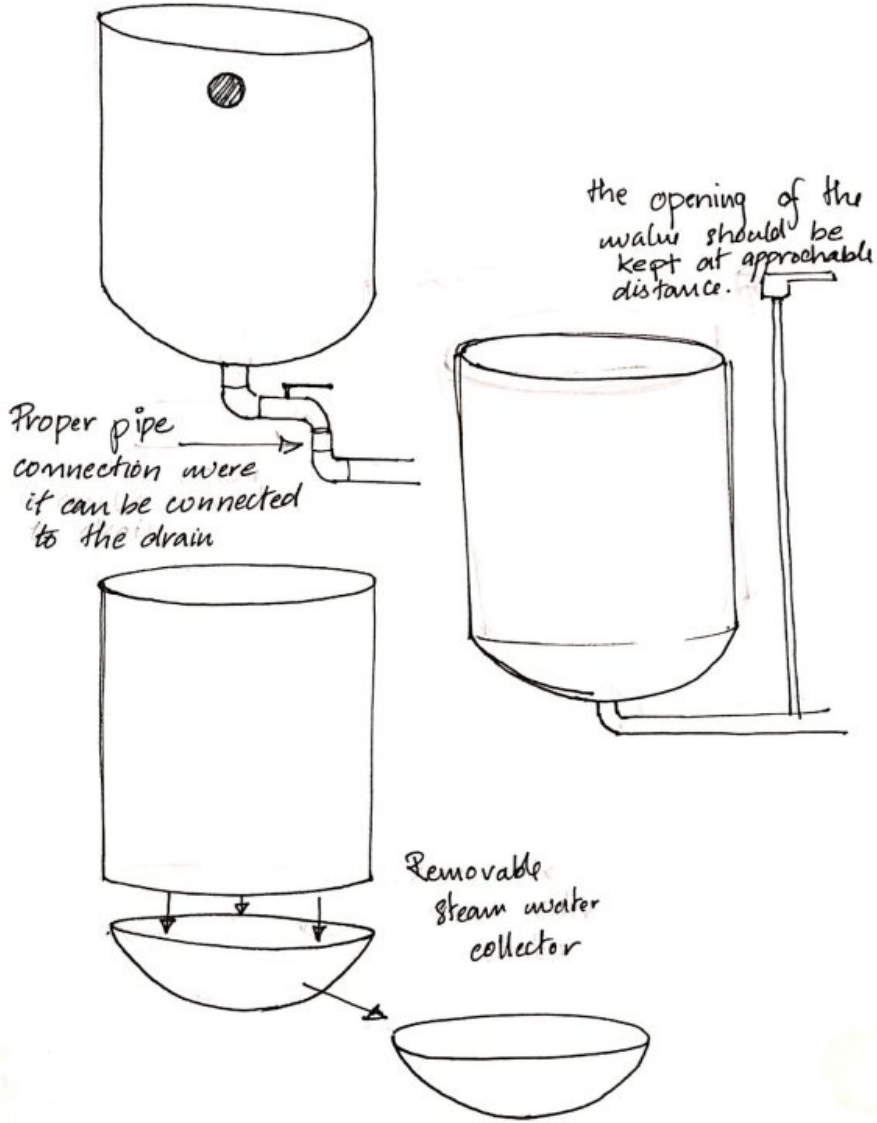
water inlet option



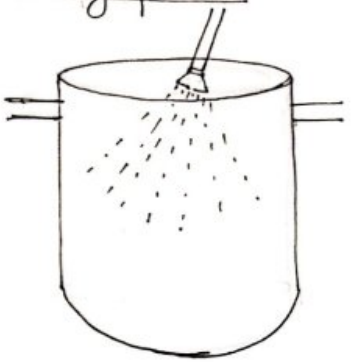




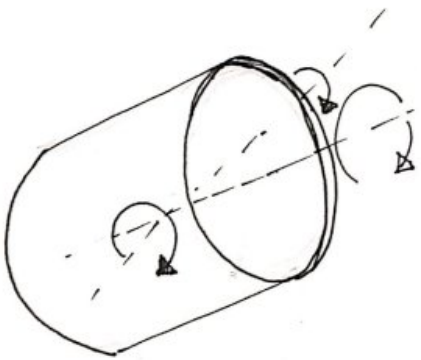
Draining of Steam water.



Cleaning possible



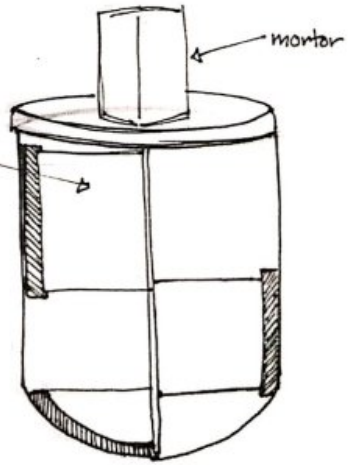
Something that can act as both inlet for water at the mean time can be used for cleaning.



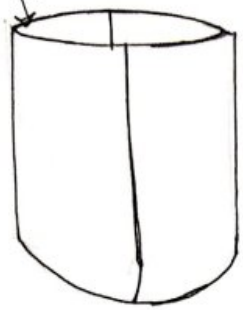
→ what if the vessle can be tilted and rotated.

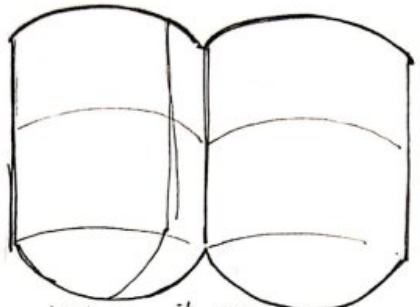
Automatic cleaning
Some addon to the stirrer.

New head can be placed when cleaning is required.

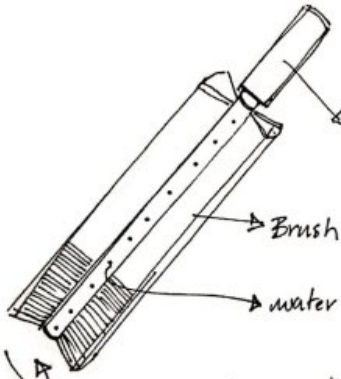


openable vessle



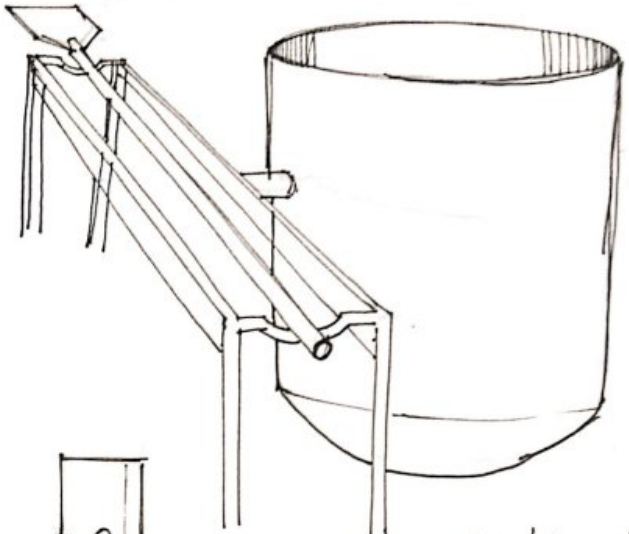


Making it easy to wash/clean

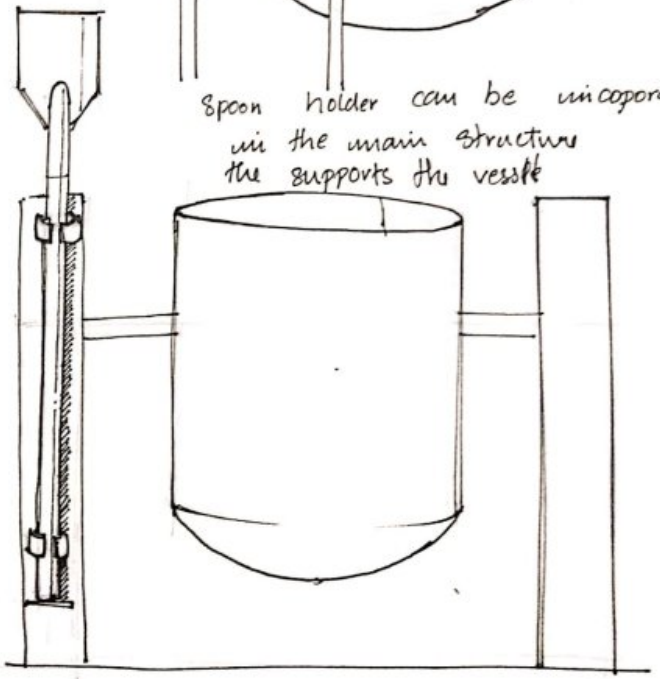


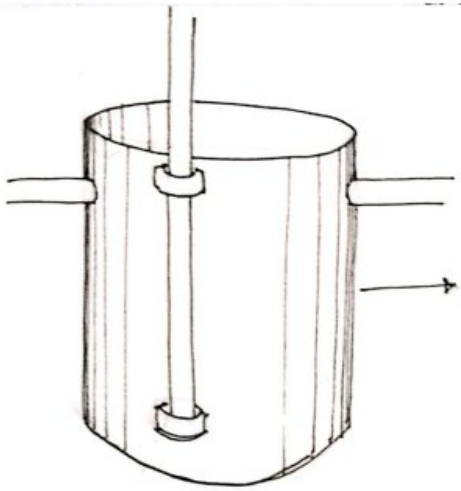
rotate so that cleaning can be done easily

Placement of Spoon

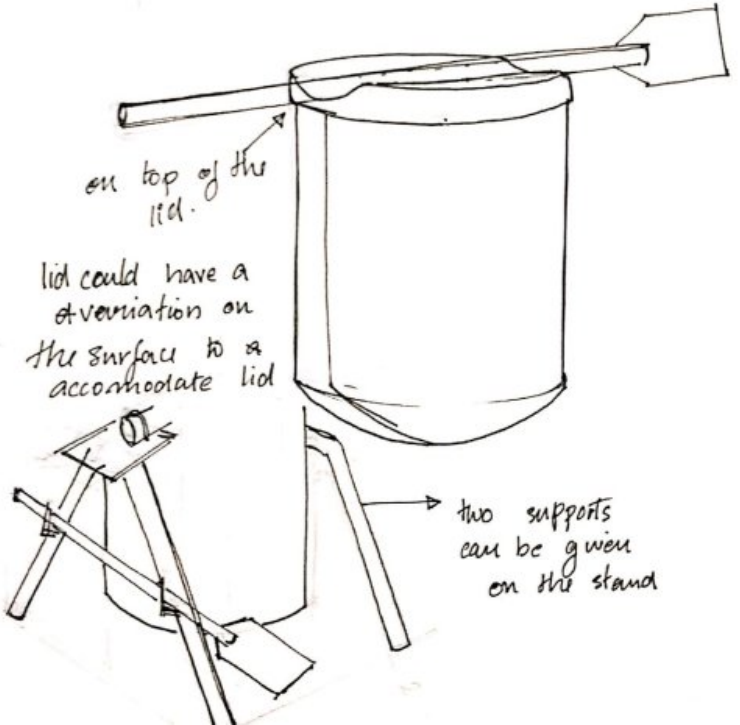


Spoon holder can be incoporated in the main structure the supports the vessle





Spon holder on the vessle

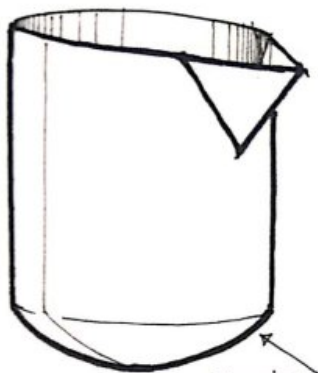


on top of the lid.

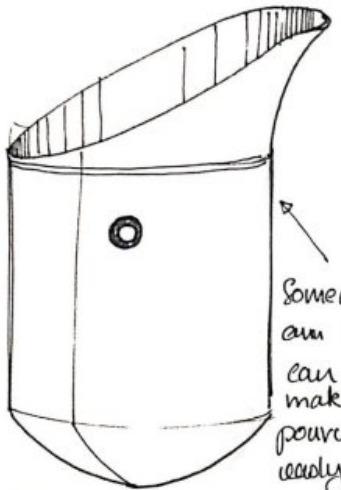
lid could have a dvevriation on the surface to a accomodate lid

two supports can be given on the stand

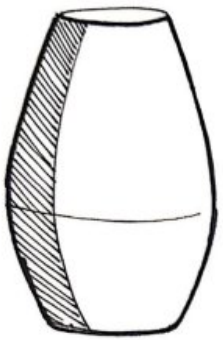
Shape exploration

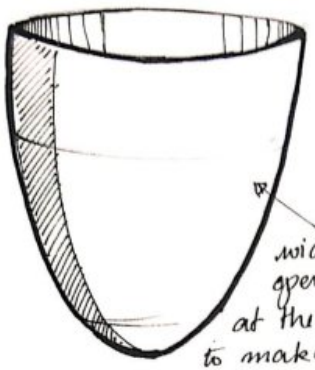


Pouring can be made easy

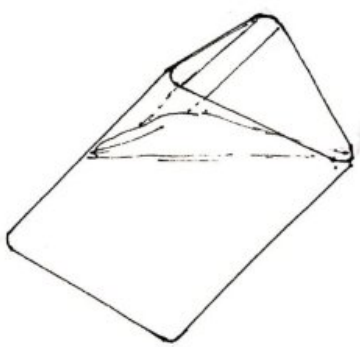


Some addition can that can make pouring easy

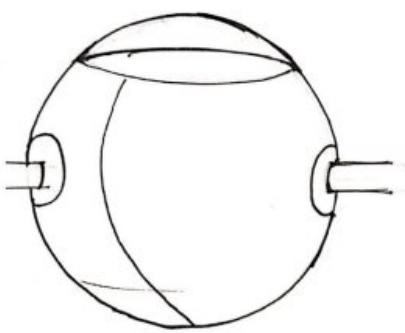




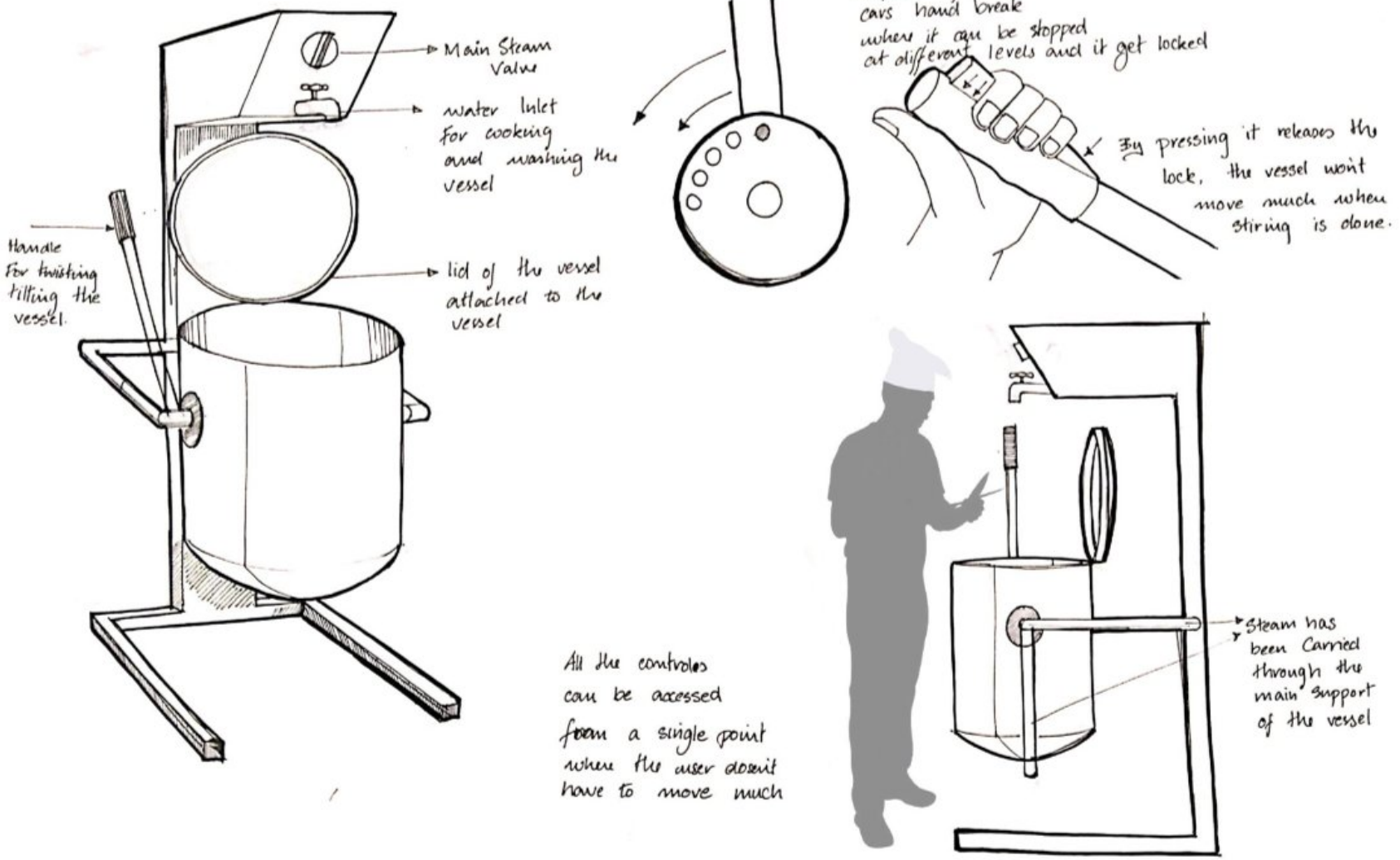
wider opening at the top to make transferring of food easy.



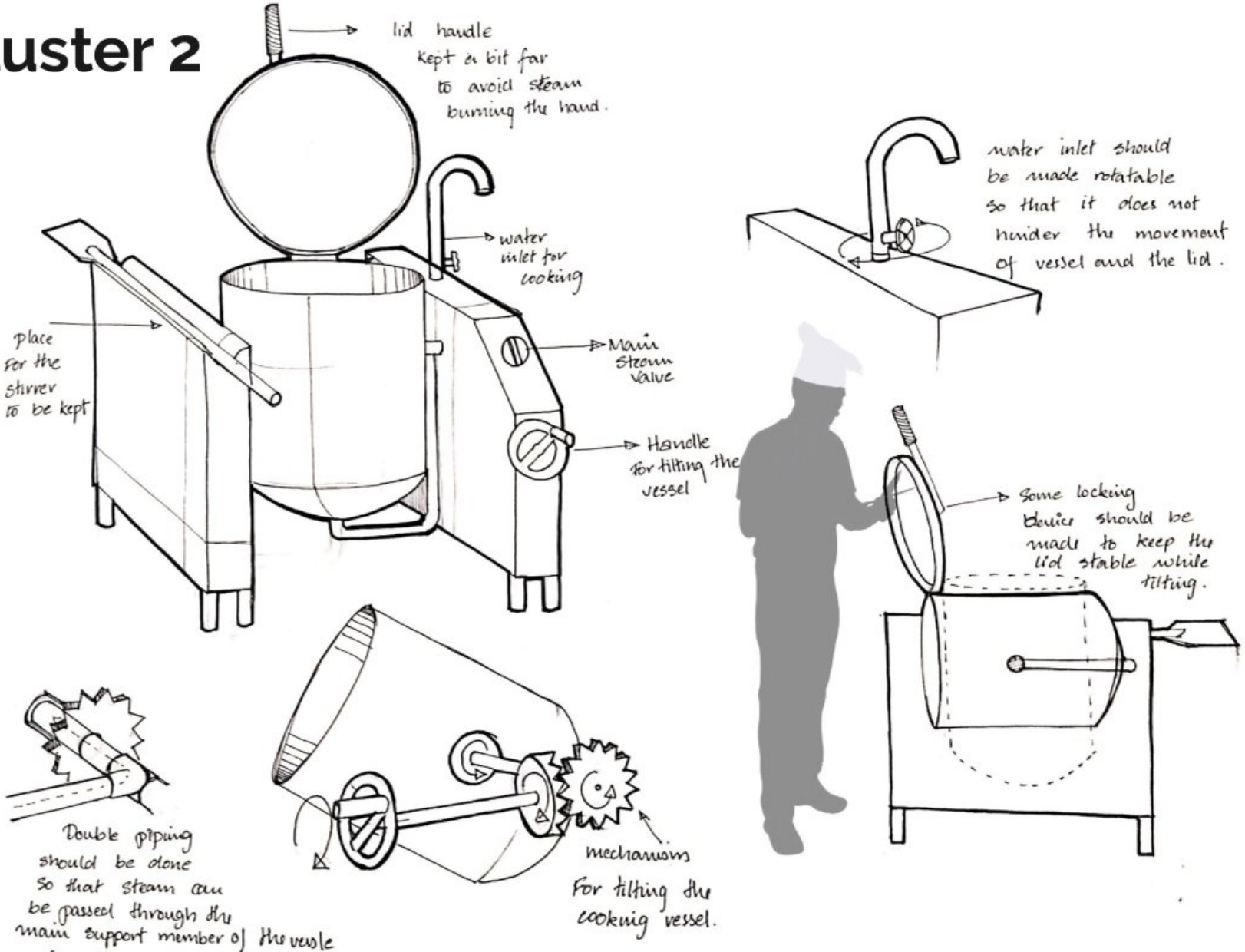
Triangle shape with rounded corners pouring and cleaning will be easy



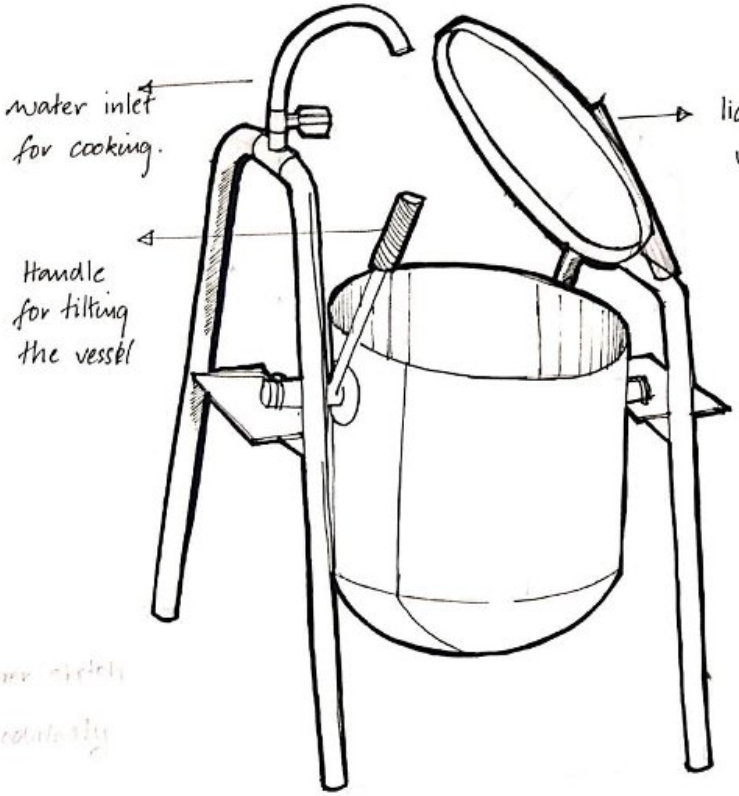
Cluster 1

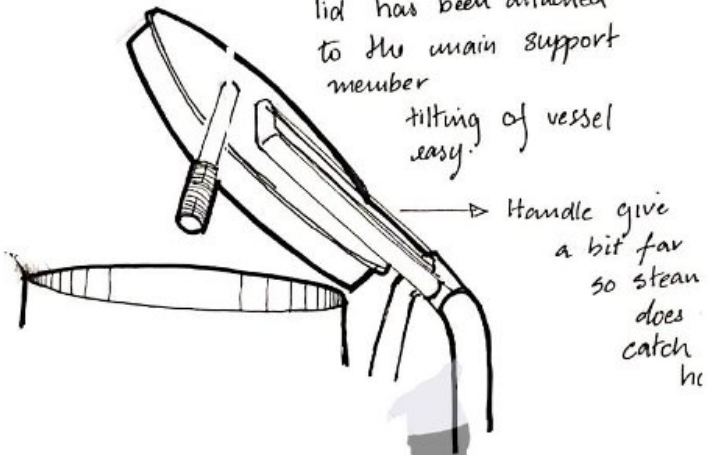

Main Steam Valve
water Inlet For cooking and washing the vessel
Handle For twisting tilting the vessel.
lid of the vessel attached to the vessel
Inspired from cars hand break where it can be stopped at different levels and it get locked
By pressing it releases the lock, the vessel won't move much when stirring is done.
All the controles can be accessed from a single point where the user doesn't have to move much
Steam has been Carried through the main support of the vessel

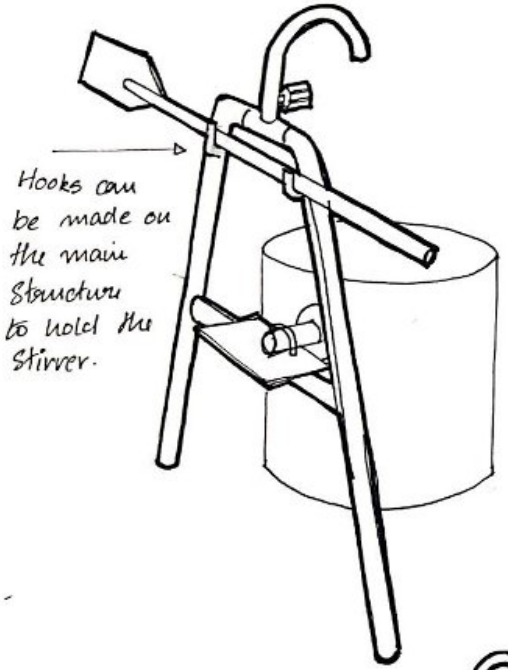
Cluster 2

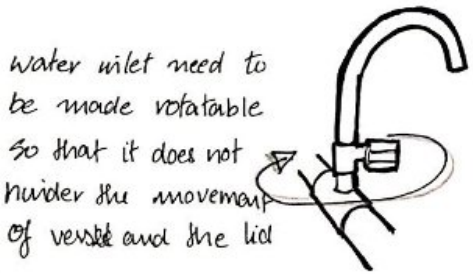

lid handle kept a bit far to avoid steam burning the hand.
water inlet for cooking
Main Steam valve
Handle for tilting the vessel
place for the stirrer to be kept
water inlet should be made rotatable so that it does not hinder the movement of vessel and the lid.
some locking device should be made to keep the lid stable while tilting.
Double piping should be done so that steam can be passed through the main support member of the vessle
mechanism For tilting the cooking vessel.

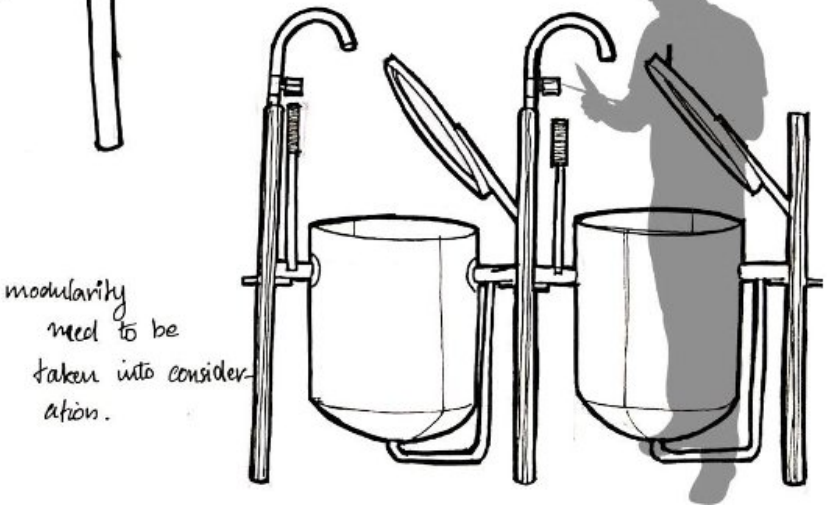
Cluster 3

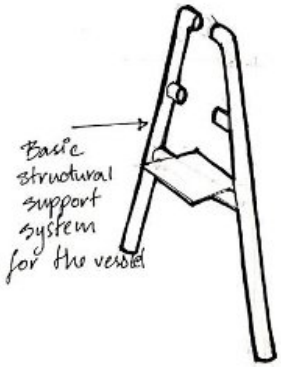

water inlet for cooking.
lid for the vessel
Handle for tilting the vessel

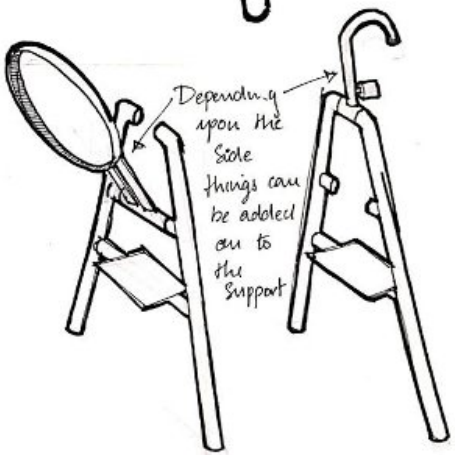

lid has been attached to the main support member
tilting of vessel easy.
Handle give a bit far so steam does catch h


Hooks can be made on the main Structure to hold the Stirrer.

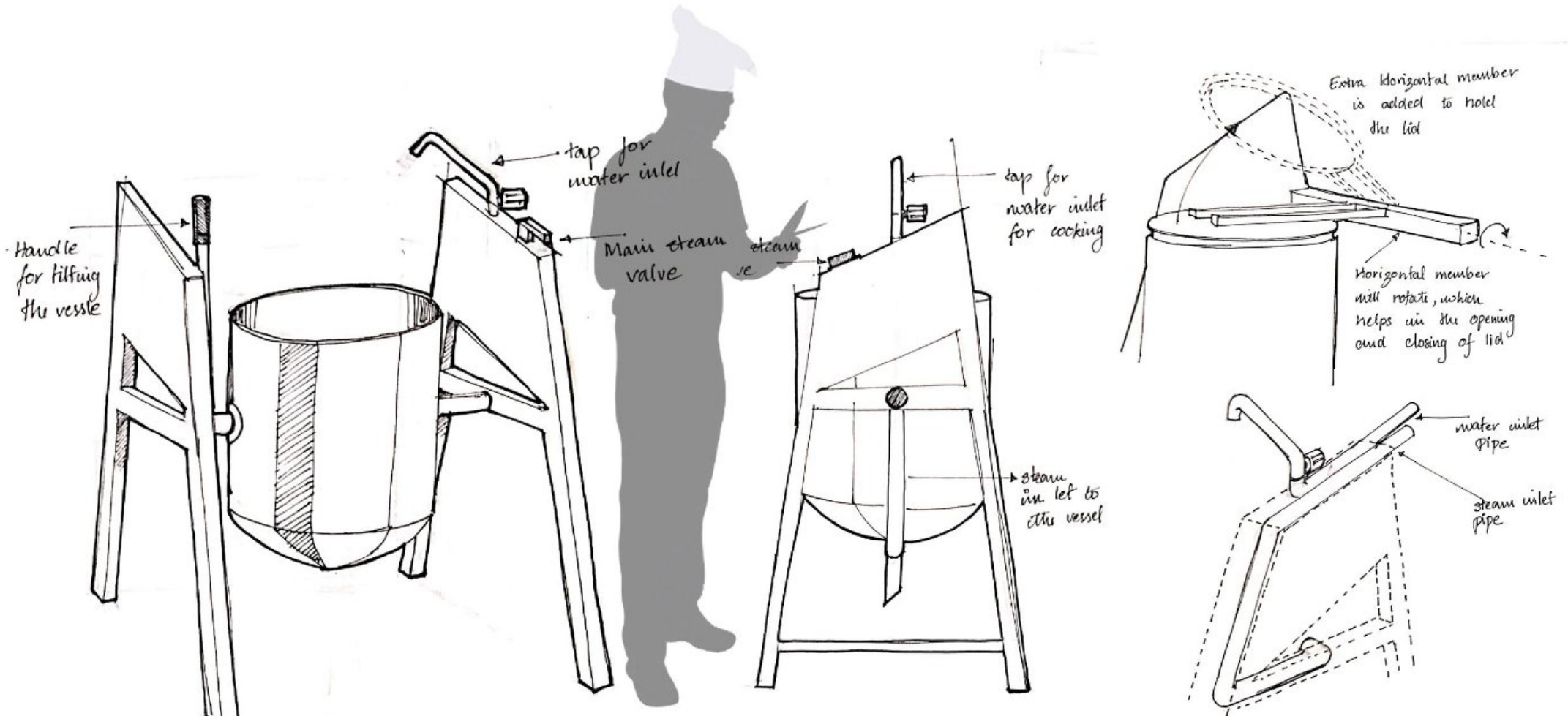

water inlet need to be made rotatable so that it does not hinder the movement of vessel and the lid


modularity need to be taken into consideration.

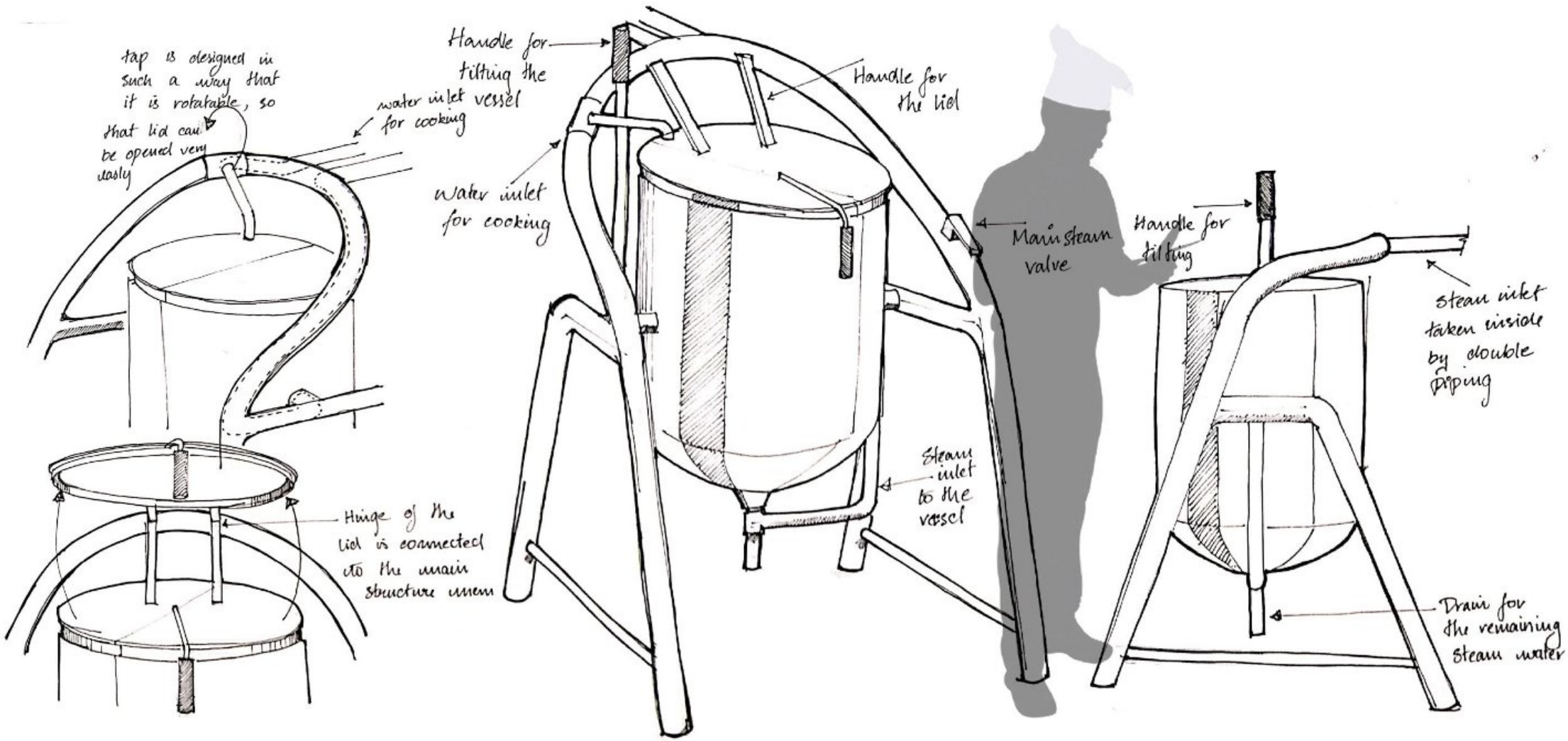

Basic structural support system for the vessel


Depending upon the Scale things can be added on to the support

Cluster 4


tap for water inlet
Handle for tilting the vessle
Main steam valve
tap for water inlet for cooking
steam in let to the vessel
Extra Horizontal member is added to hold the lid
Horizontal member will rotate, which helps in the opening and closing of lid
water inlet Pipe
steam inlet pipe

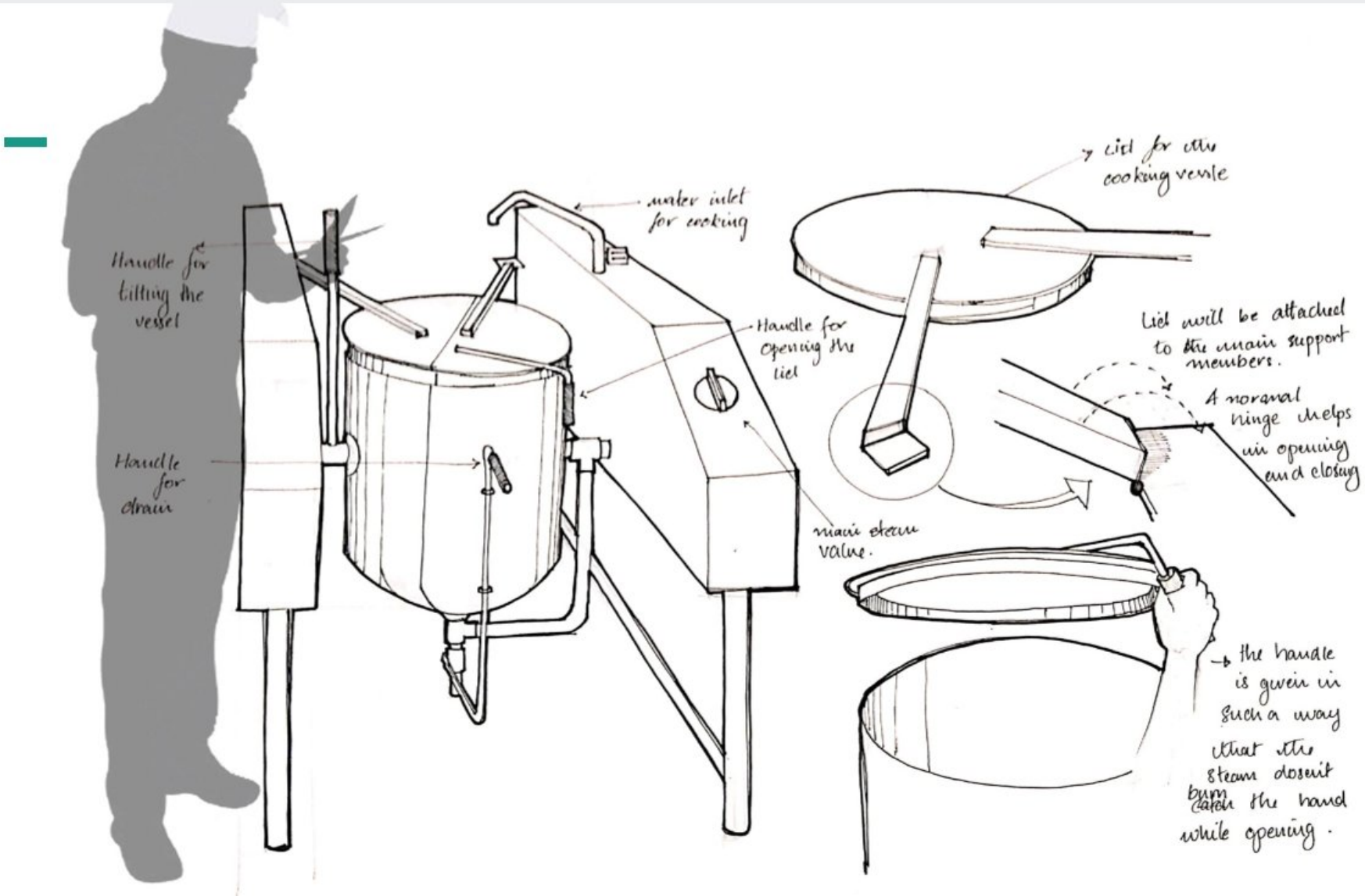
Cluster 5


tap is designed in such a way that it is rotatable, so that lid can be opened very easily
water inlet for cooking
Handle for tilting the vessel
Handle for the lid
water inlet for cooking
Main steam valve
Handle for tilting
steam inlet taken inside by double piping
Steam inlet to the vessel
Hinge of the lid is connected to the main structure where
Drain for the remaining steam water

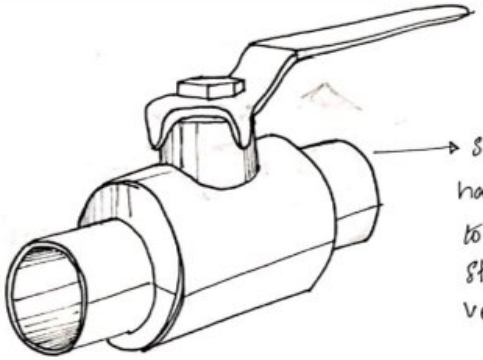
Final amalgamation of ideation - Concept

From the initial ideations and the inference made from those, the final concept has been arrived. The idea was to keep all the main controls and valves in a single side rather than scattering them all over which makes it easy to handle the device and to keep the design as simple as possible.

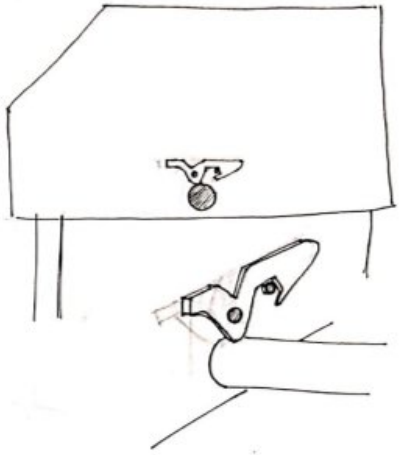
Concept


Handle for tilting the vessel
Handle for drain
water inlet for cooking
Handle for opening the lid
main steam value.
Lid for the cooking vessle
Lid will be attached to the main support members.
A noranal hinge helps in opening and closing
the handle is given in such a way that the steam doesnt burn the hand while opening.

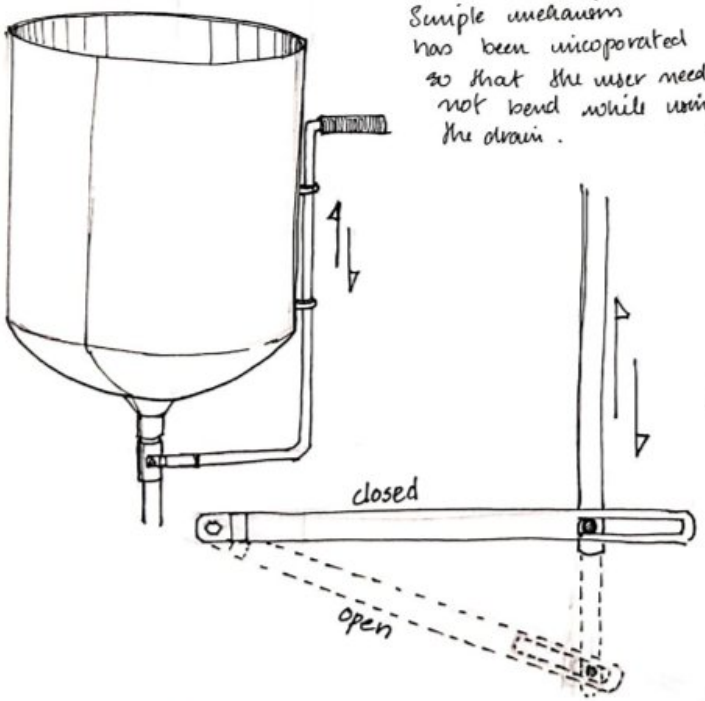
Concept



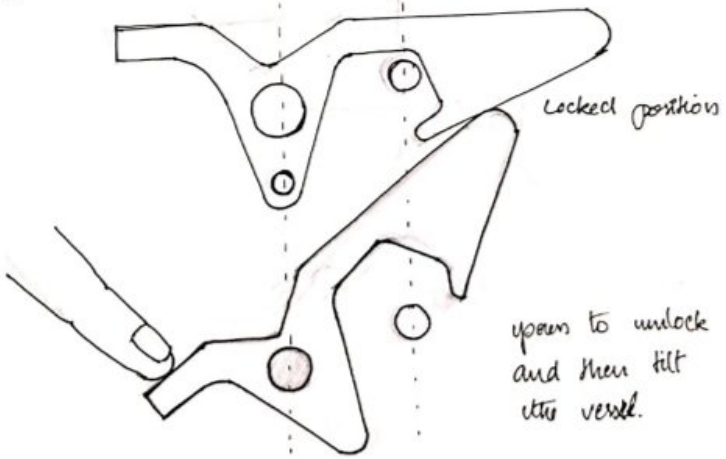
Standarid Valve has been used to to drain the excess Steam/water in the vessel



massive locking system has been used to lock the vessle in place.



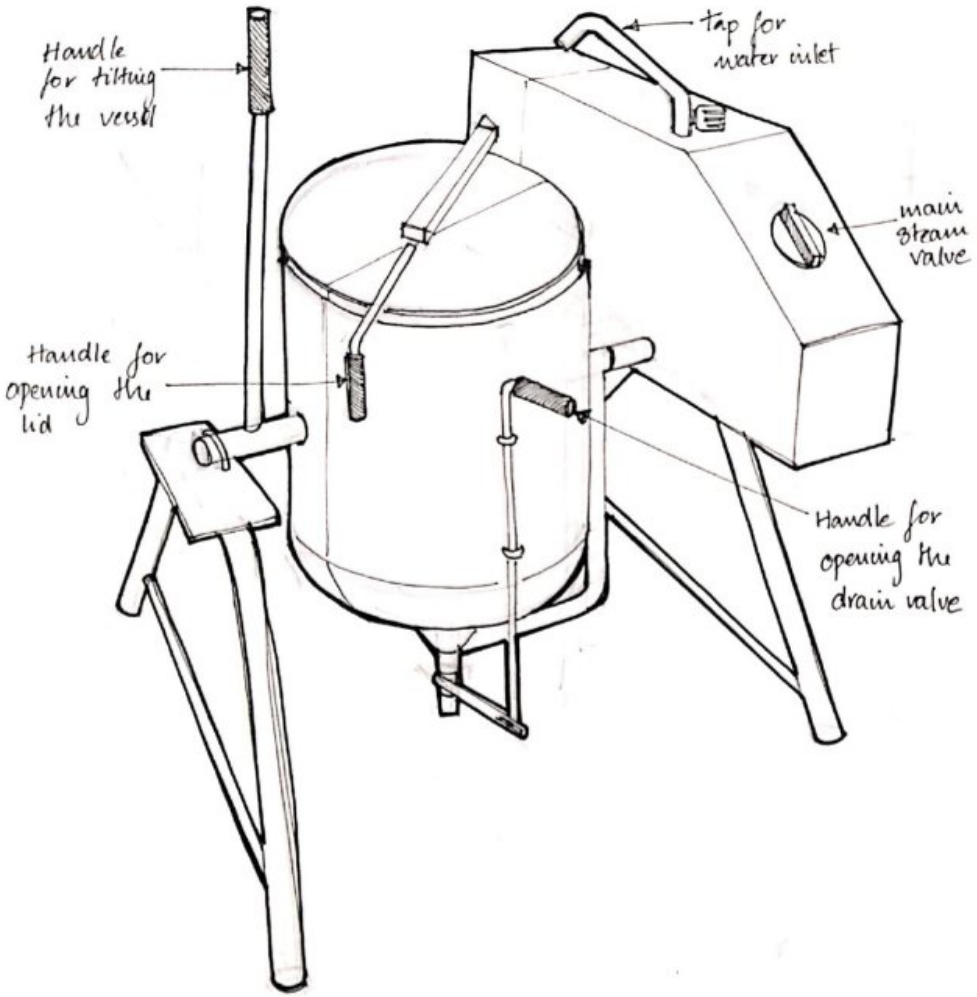
Simple mechanism has been incoporated so that the user need not bend while using the drain.

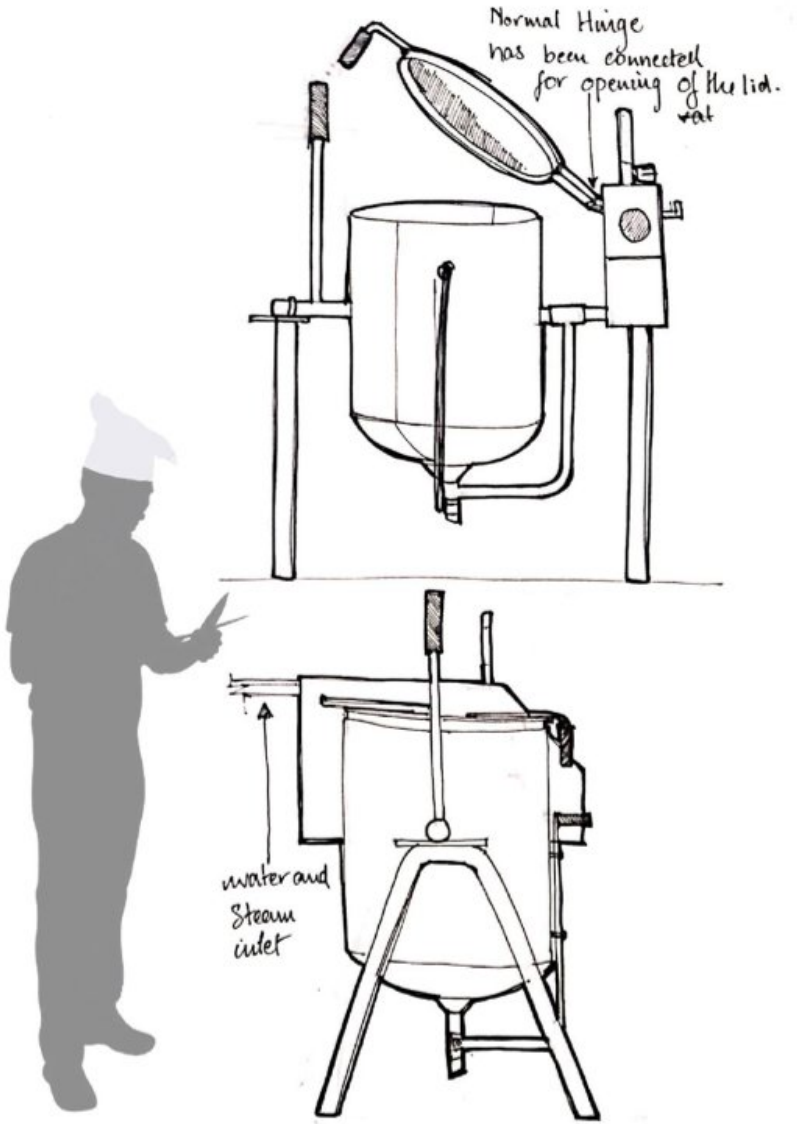


Locked position

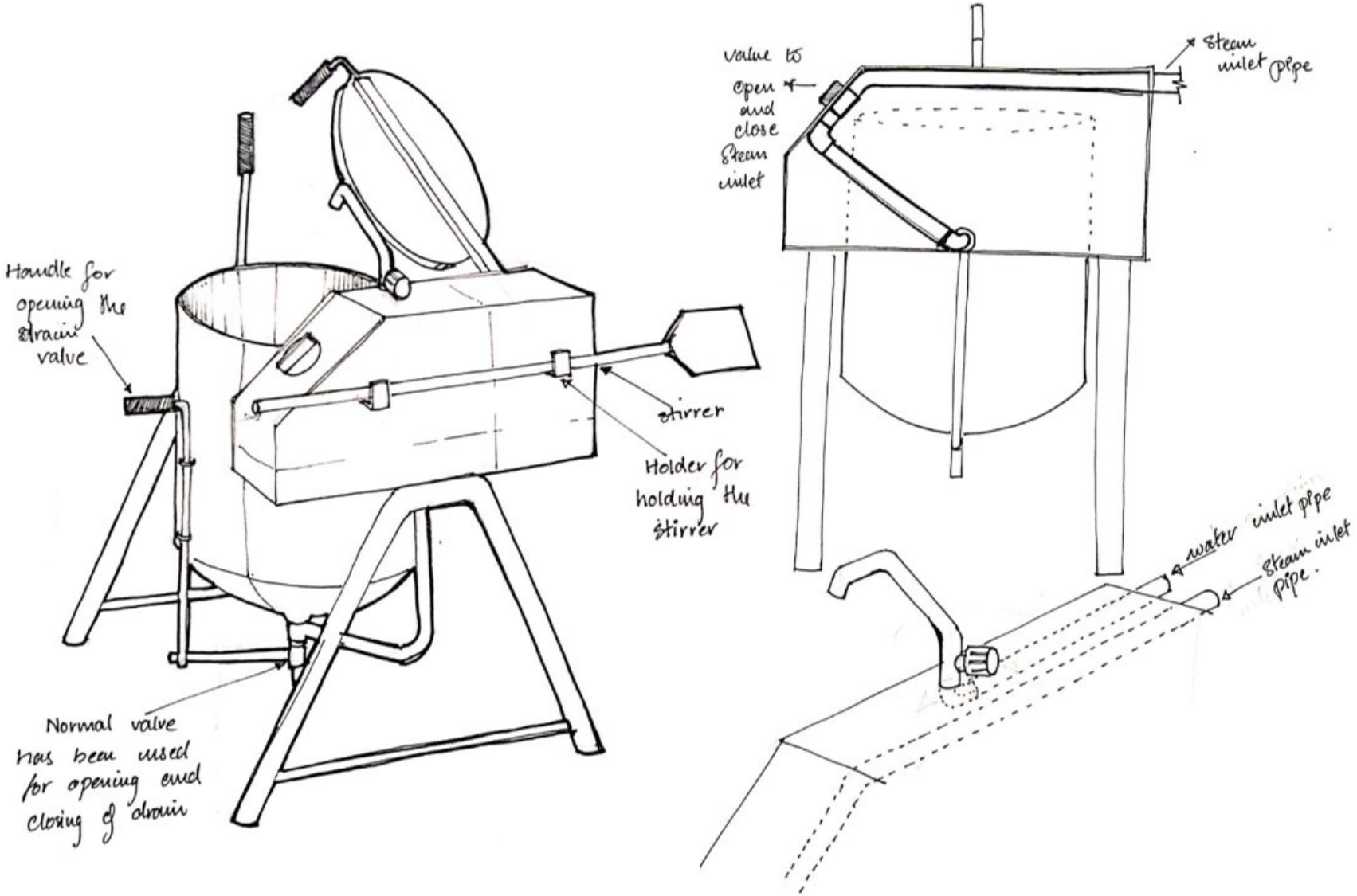
open to unlock and then tilt the vessel.

Concept

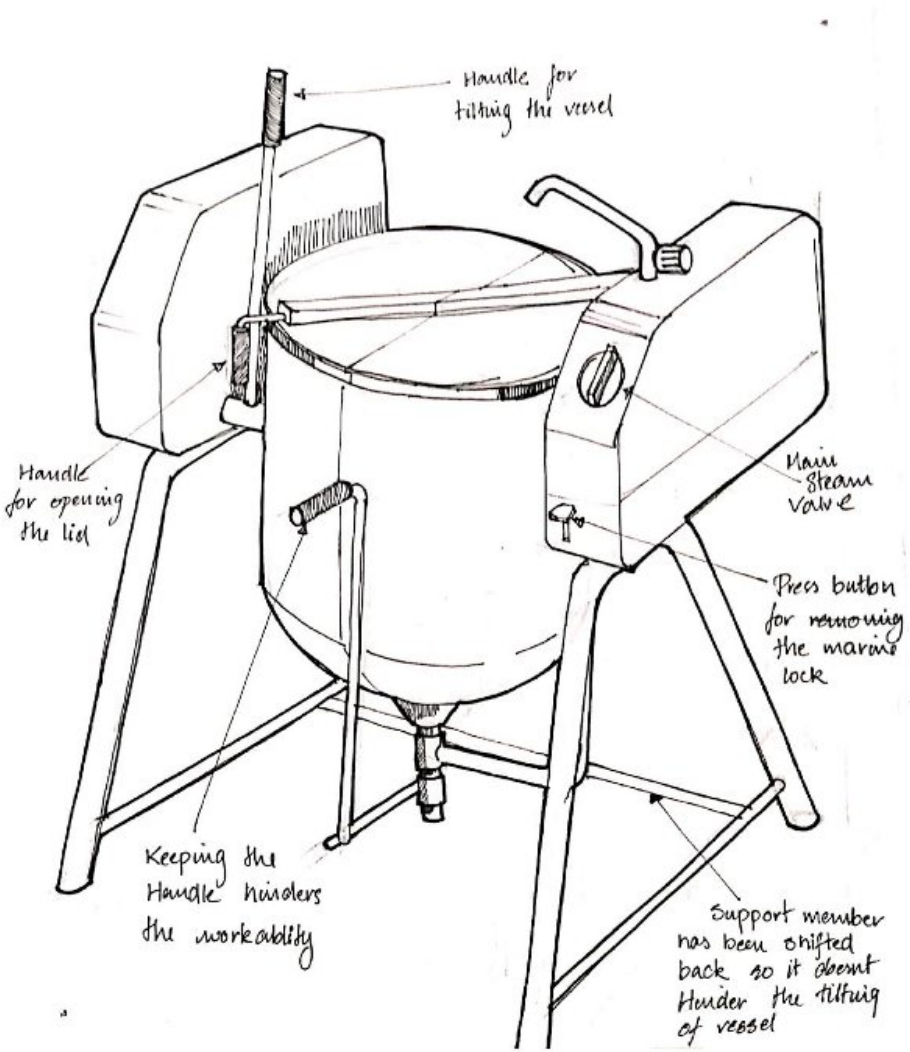

Handle for tilting the vessel
tap for water inlet
main steam valve
Handle for opening the lid
Handle for opening the drain valve

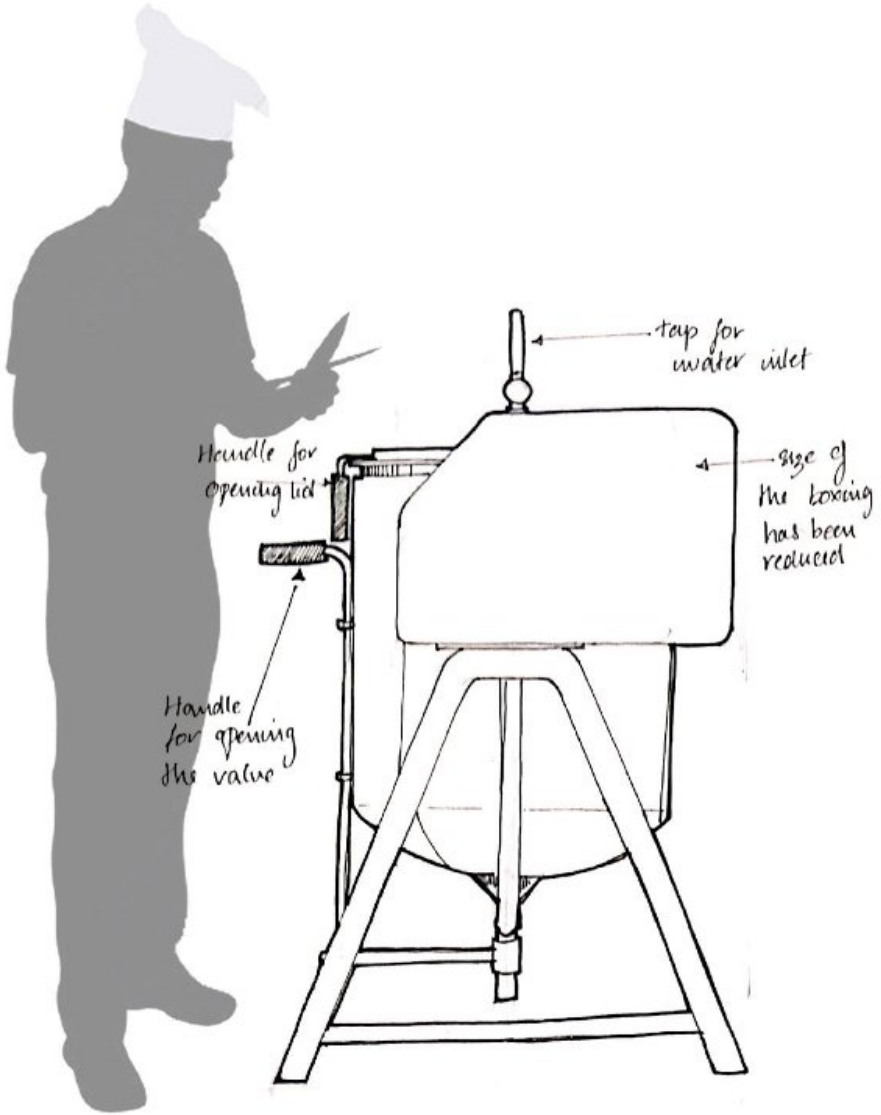

Normal Hinge has been connected for opening of the lid.
water and Steam inlet

Concept

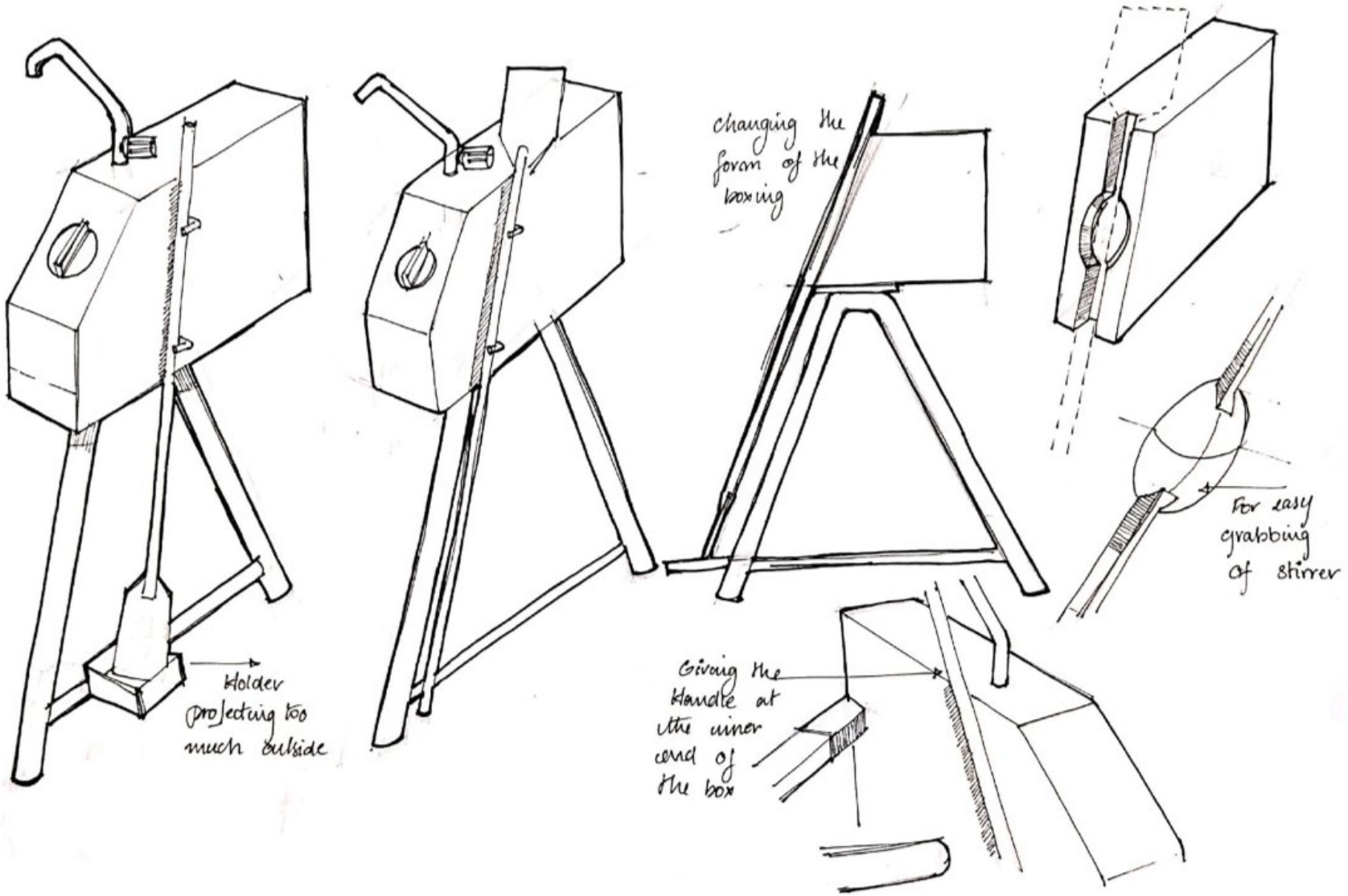

Handle for opening the steam valve
Normal valve has been used for opening and closing of steam
stirrer
Holder for holding the stirrer
Valve to open and close Steam inlet
Steam inlet pipe
water inlet pipe
Steam inlet pipe.

Concept

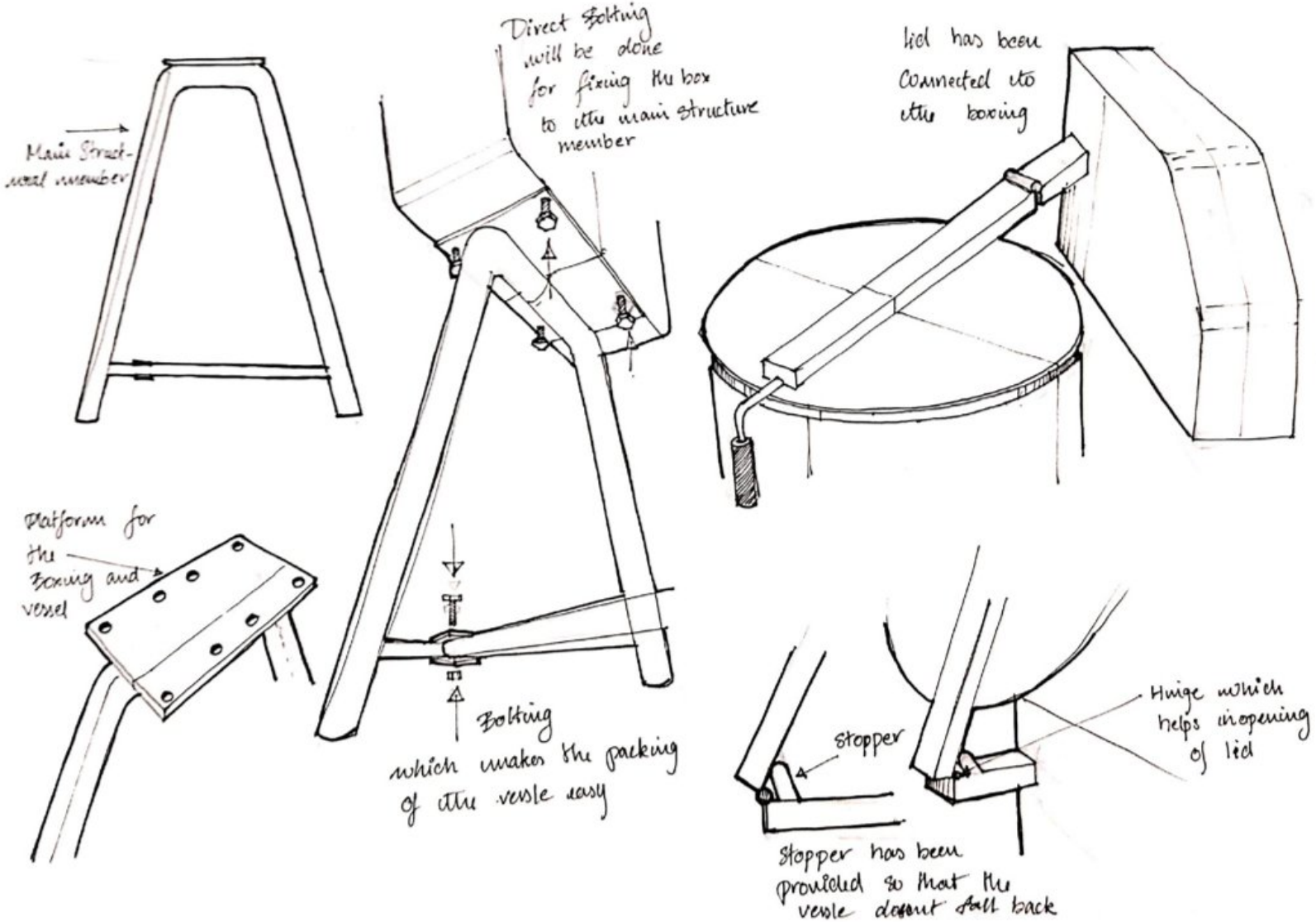

Handle for tilting the vessel
Handle for opening the lid
Main Steam Valve
Press button for removing the marine lock
Keeping the Handle hinders the workability
Support member has been shifted back so it doesn't Hinder the tilting of vessel


tap for water inlet
Handle for opening lid
size of the boxing has been reduced
Handle for opening the valve

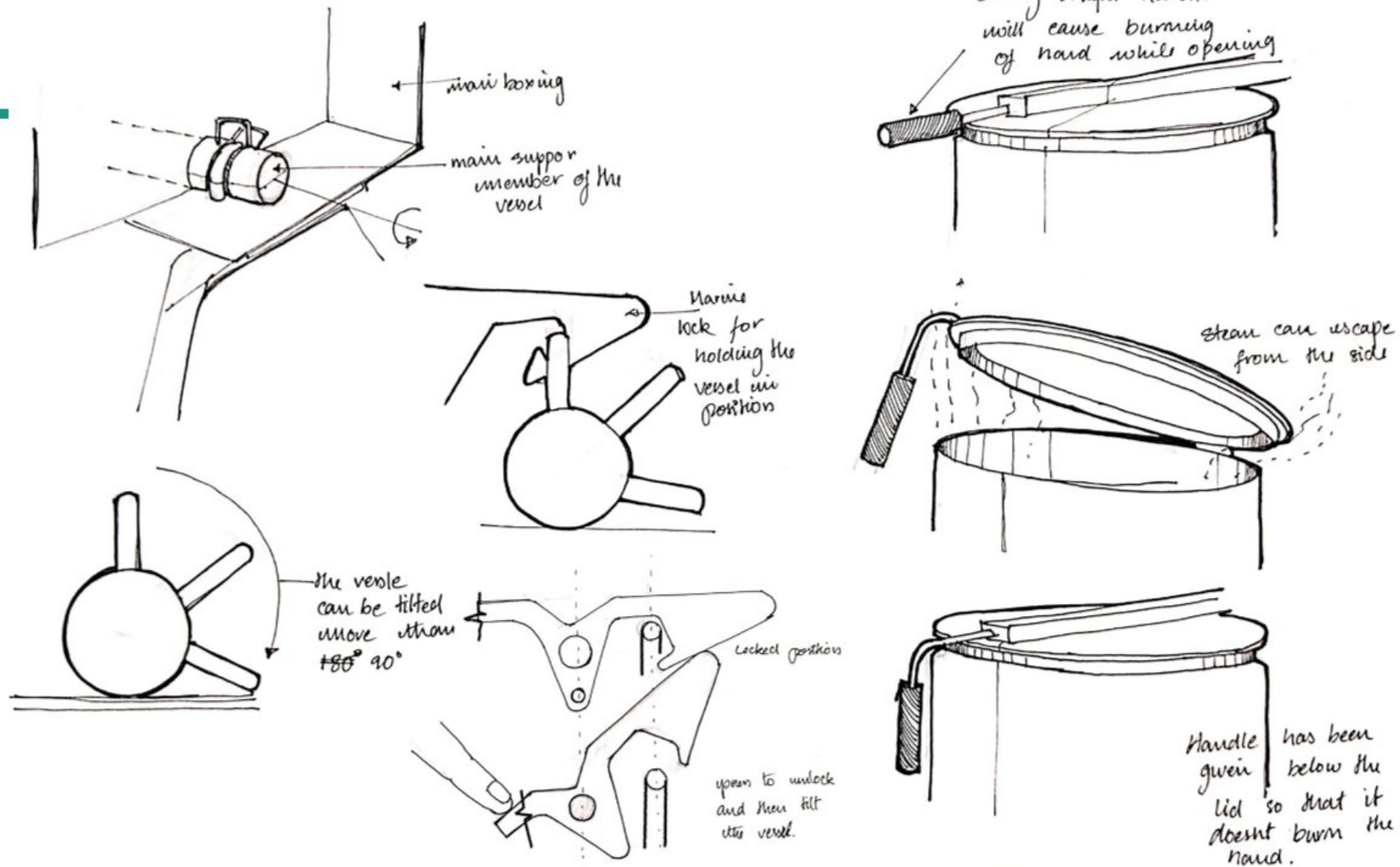
Concept


Holder projecting too much outside
changing the form of the boxing
For easy grabbing of stirrer
Giving the Handle at the inner end of the box

Concept


Main Structural member
Direct Bolting will be done for fixing the box to the main structure member
lid has been Connected to the boxing
Platform for the Boxing and vessel
Bolting which makes the packing of the vessle easy
Stopper
Hinge which helps in opening of lid
Stopper has been provided so that the vessle doesnt fall back

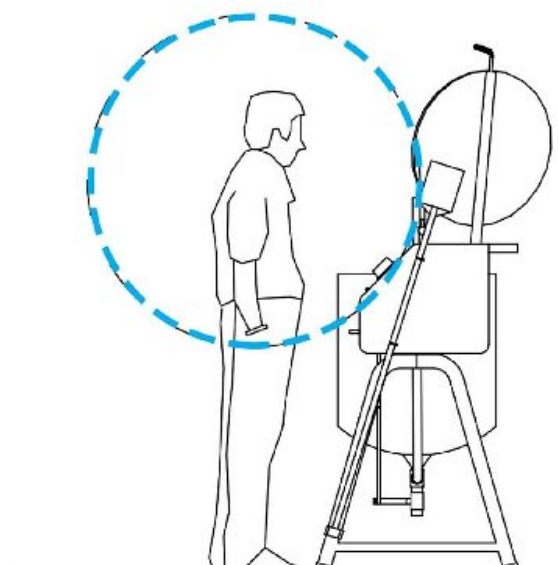
Concept

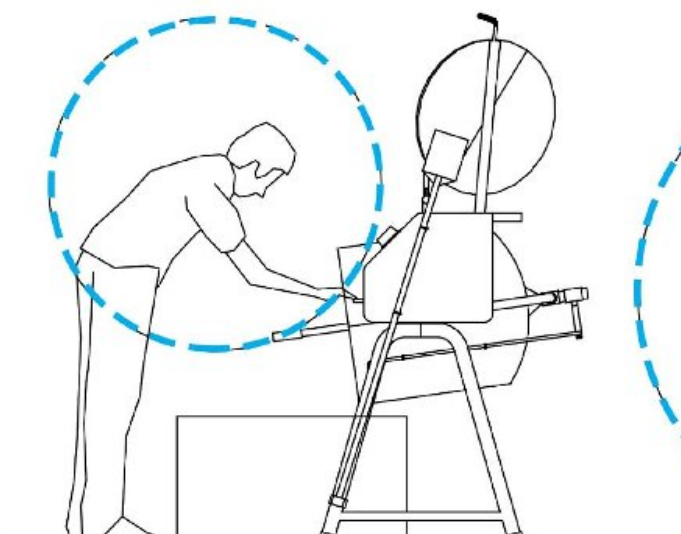

main boxing
main suppor
member of the
vessel
Handle
lock for
holding the
vessel in
position
the vessle
can be tilted
move upto
~~180°~~ 90°
Locked position
open to unlock
and then tilt
the vessel.
Giving straight handle
will cause burning
of hand while opening
Steam can escape
from the side
Handle
given
has been
below the
lid so that it
doesnt burn the
hand.

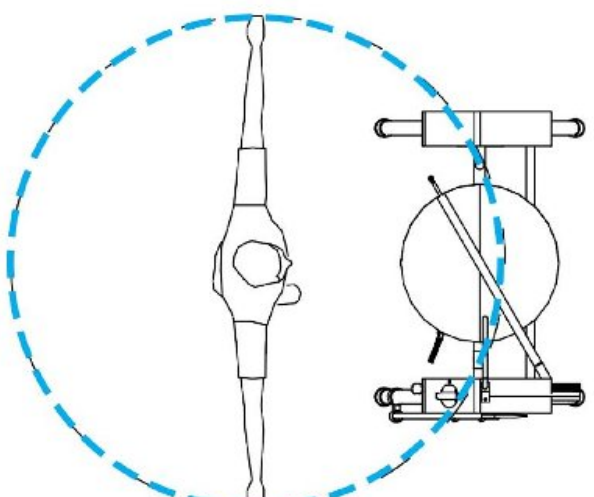
Ergonomics in the design.

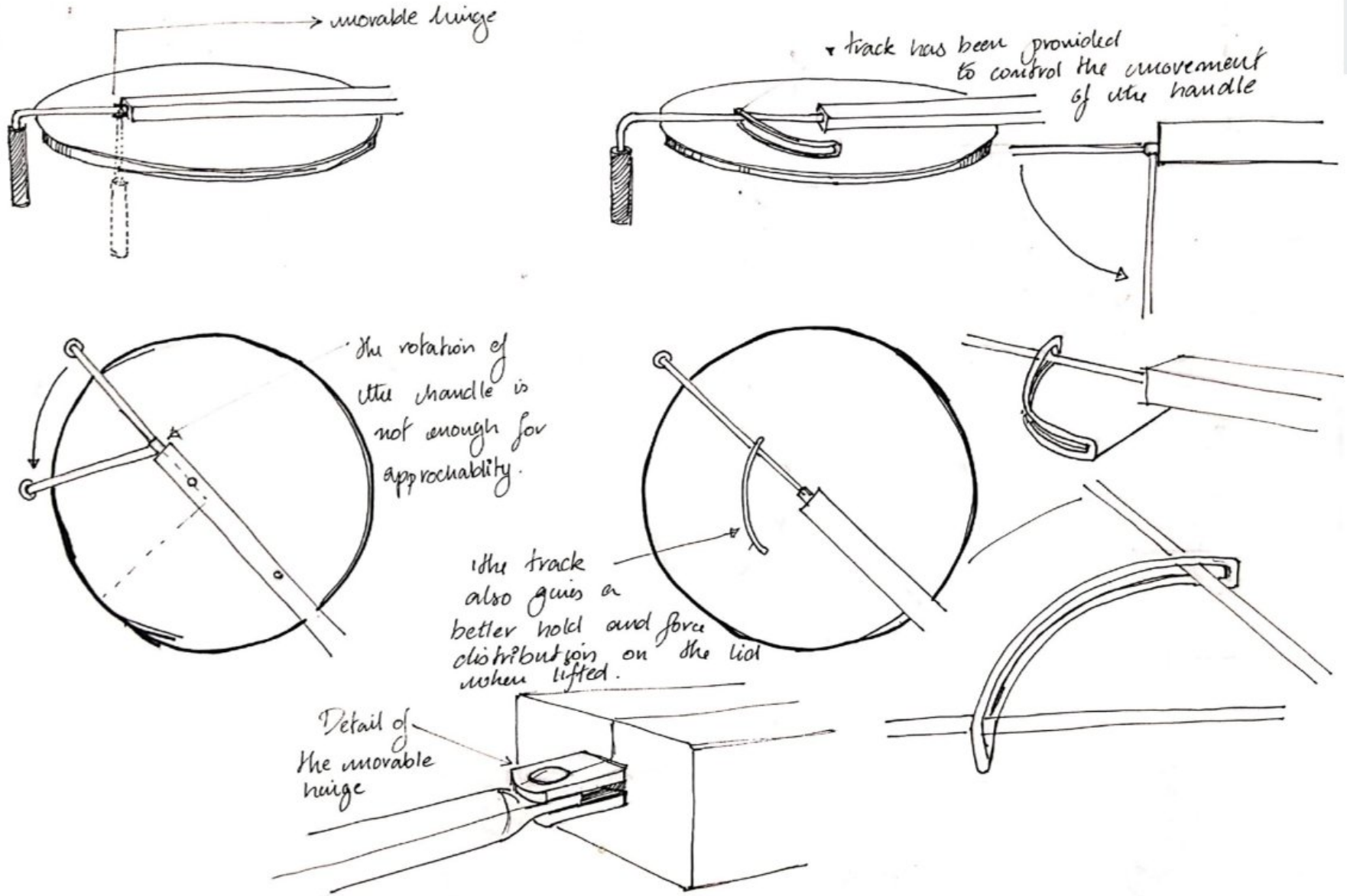
The combined height of 50th percentile 1619mm has been taken has the height to check the ergonomics of the vessel considering the average height of men is 1649mm and women is 1526mm of Indians. When analysed with ergonomic data it has been found that reachability of the lid handle is an issue.

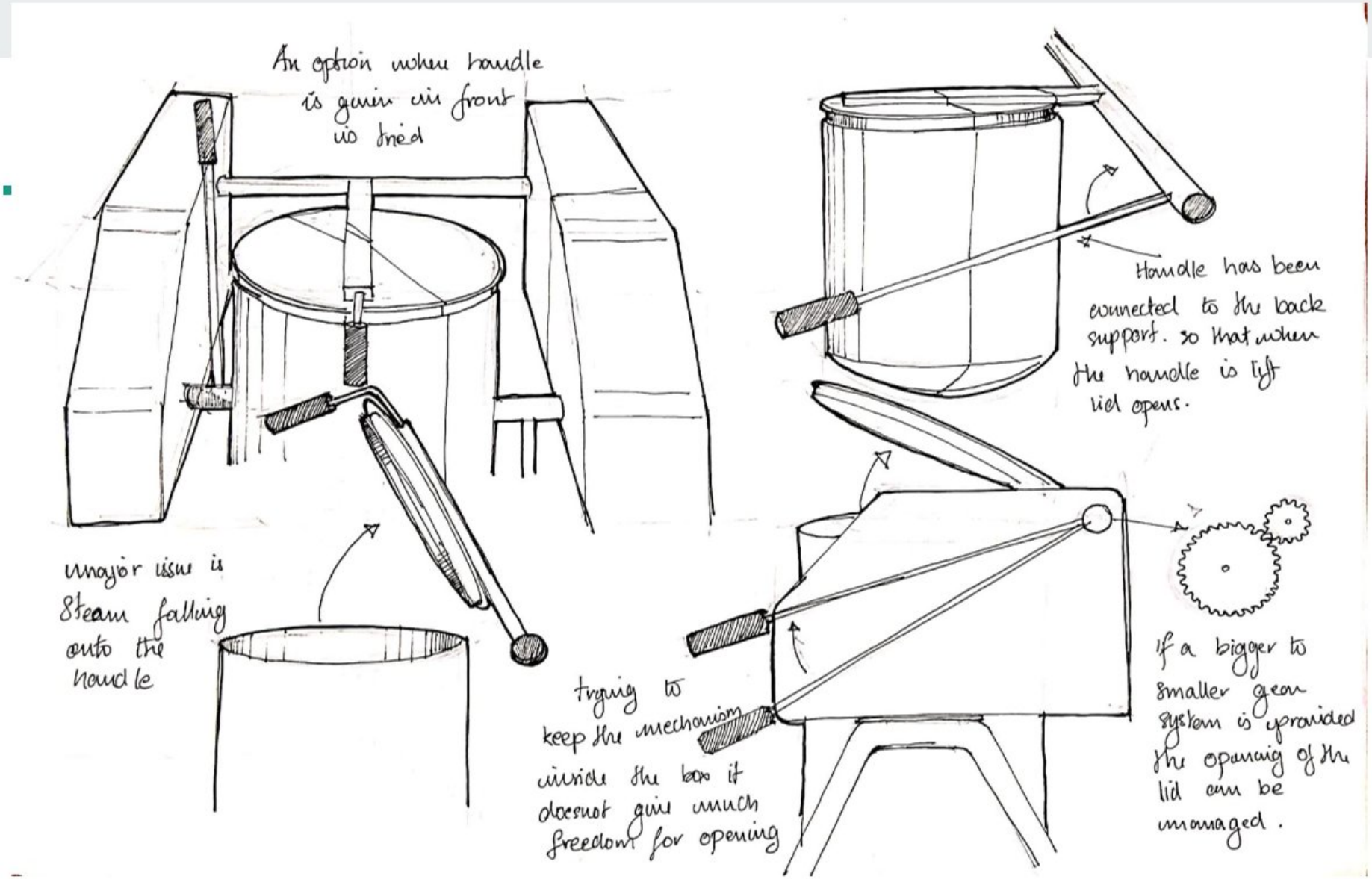
Parameters		Percentiles		
		50th	75th	90th
Stature (Height)	Male	1648	1691	1781
	Female	1517	1567	1632
	Combined	1619	1673	1771
Span	Male	1684	1739	1829
	Female	1549	1599	1679
	Combined	1659	1724	1809
Acromion to stylion length (hand length)	Male	555	583	645
	Female	516	557	606
	Combined	548	579	635
Hand length	Male	180	187	198
	Female	166	170	181
	Combined	176	184	197



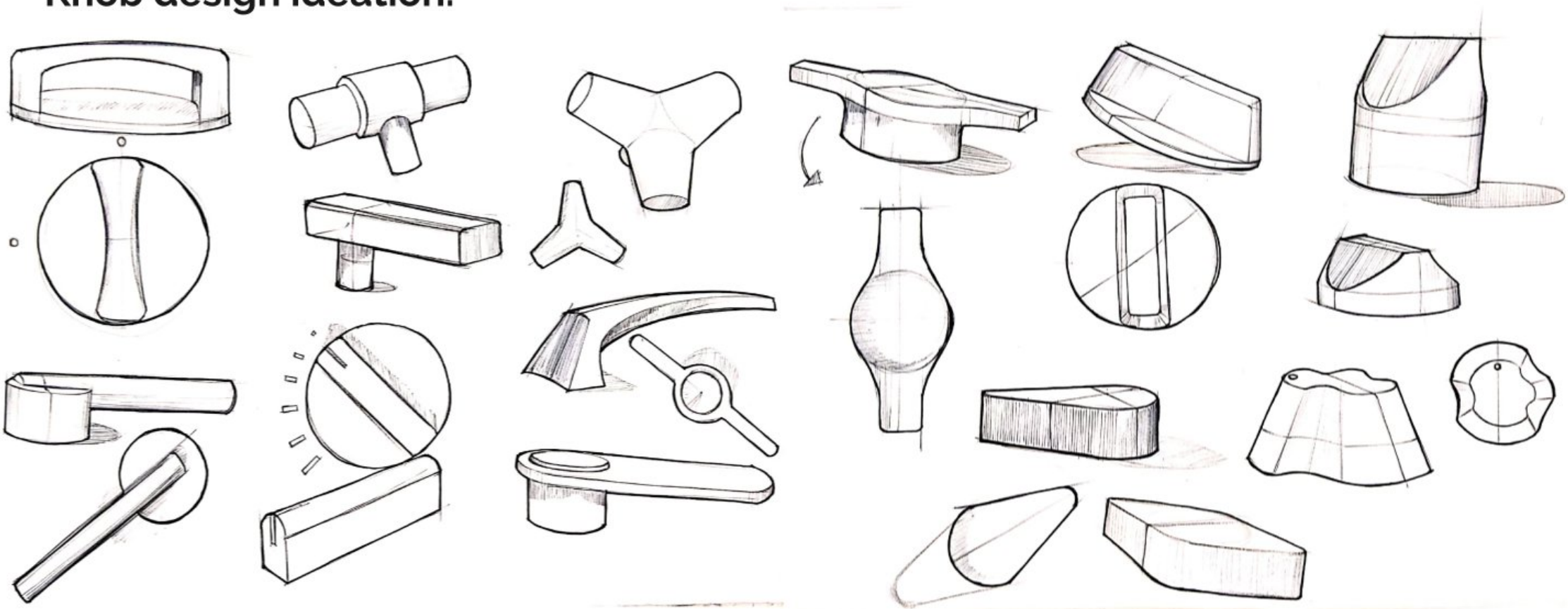




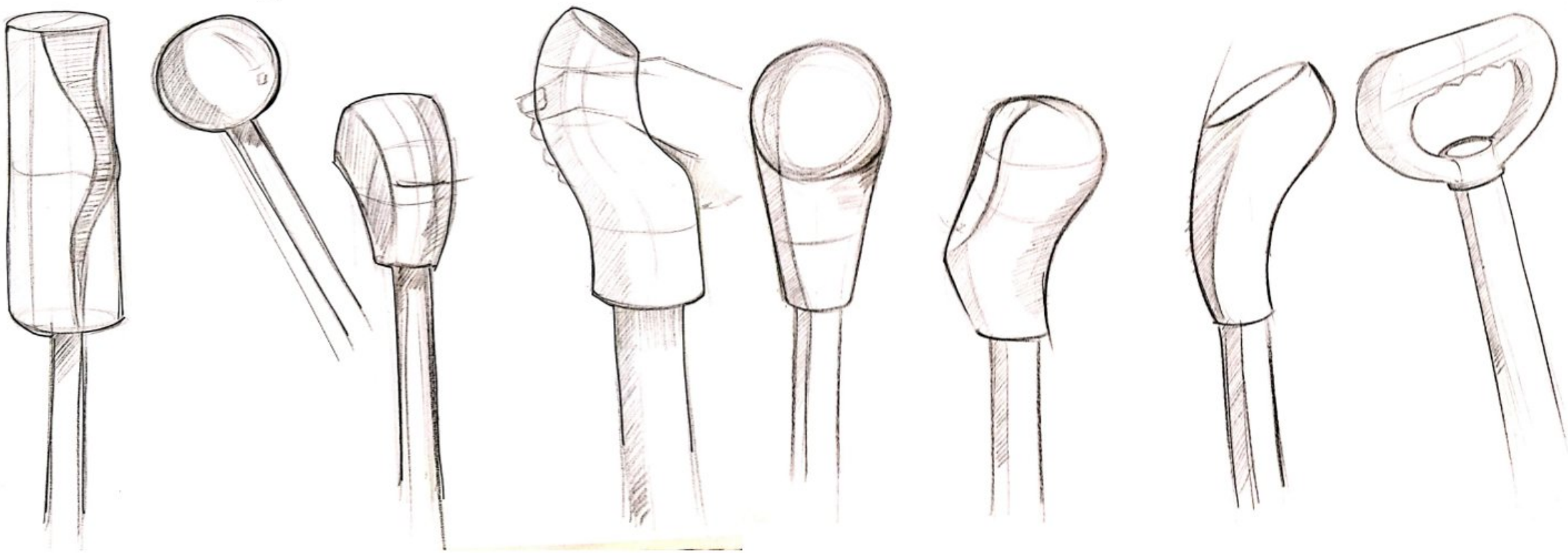

movable hinge
track has been provided to control the movement of the handle
the rotation of the handle is not enough for approachability.
the track also gives a better hold and force distribution on the lid when lifted.
Detail of the movable hinge


An option where handle is given in front is tried
major issue is steam falling onto the handle
Handle has been connected to the back support. so that when the handle is lift lid opens.
trying to keep the mechanism inside the box it doesnot give much freedom for opening
if a bigger to smaller gear system is provided the opening of the lid can be managed.

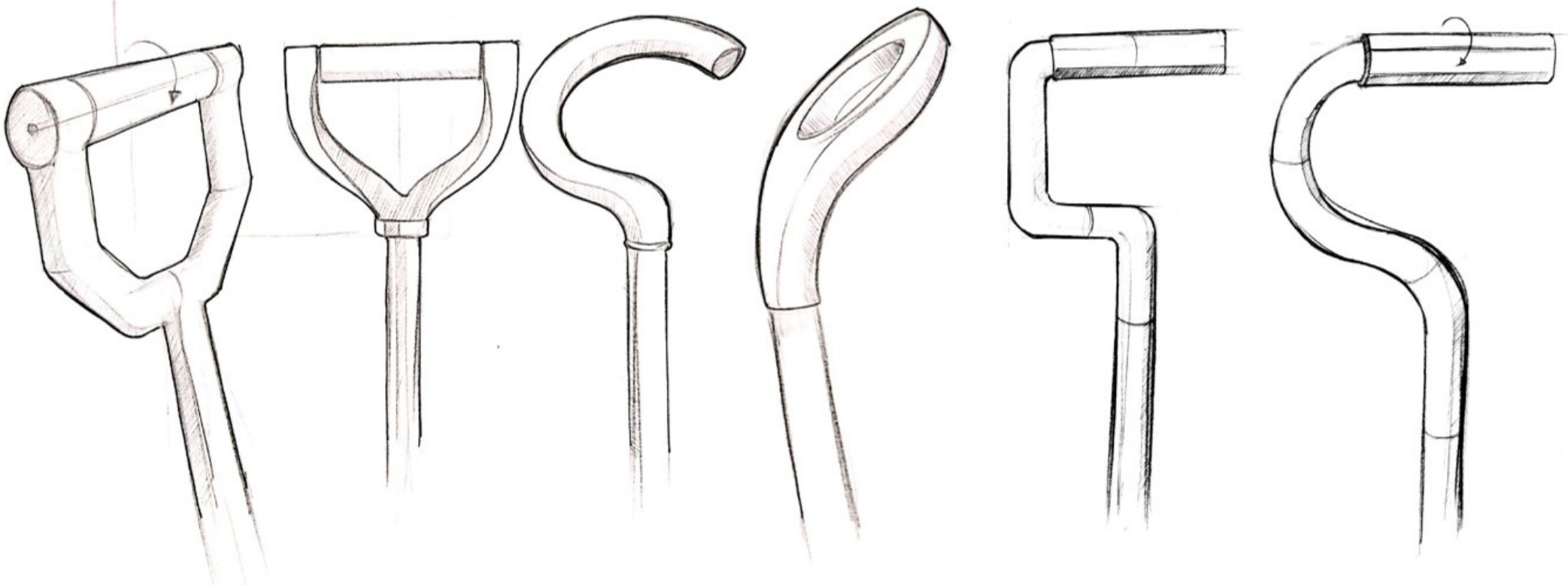
Knob design ideation.



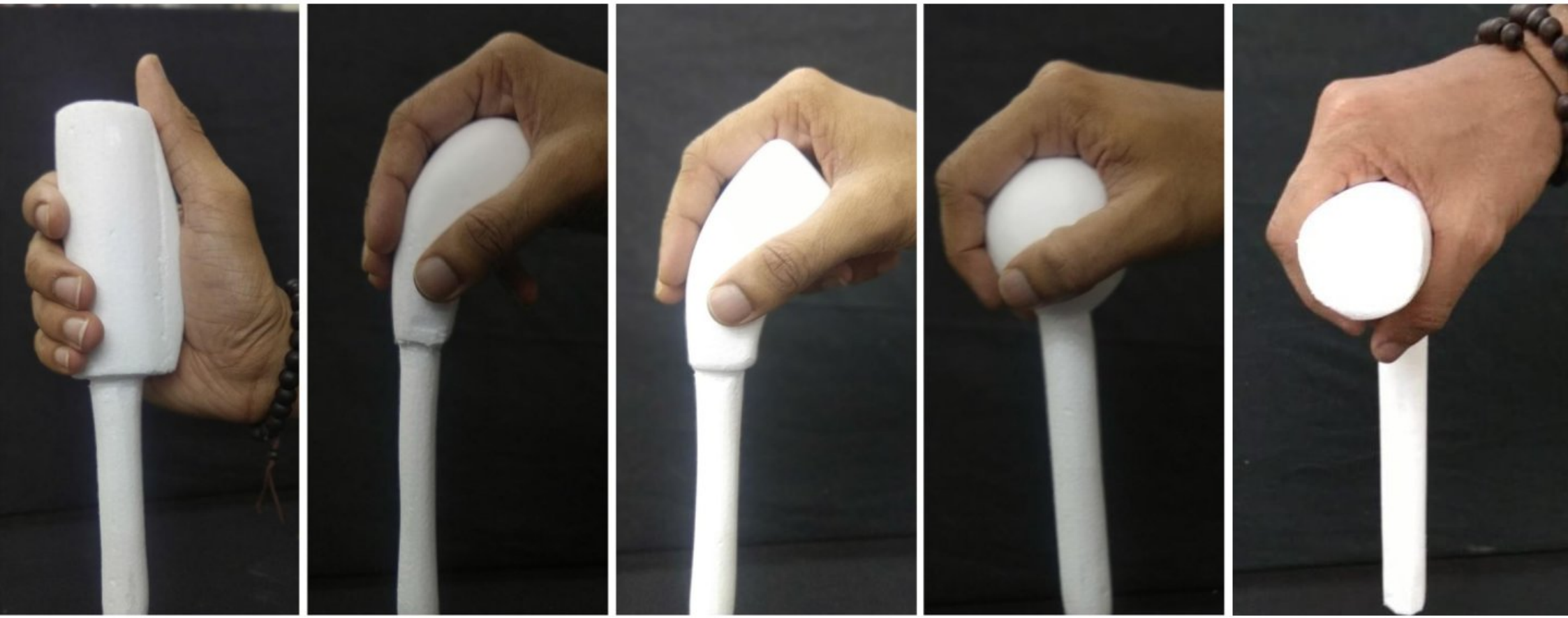
Handle design ideation.



Handle design ideation.



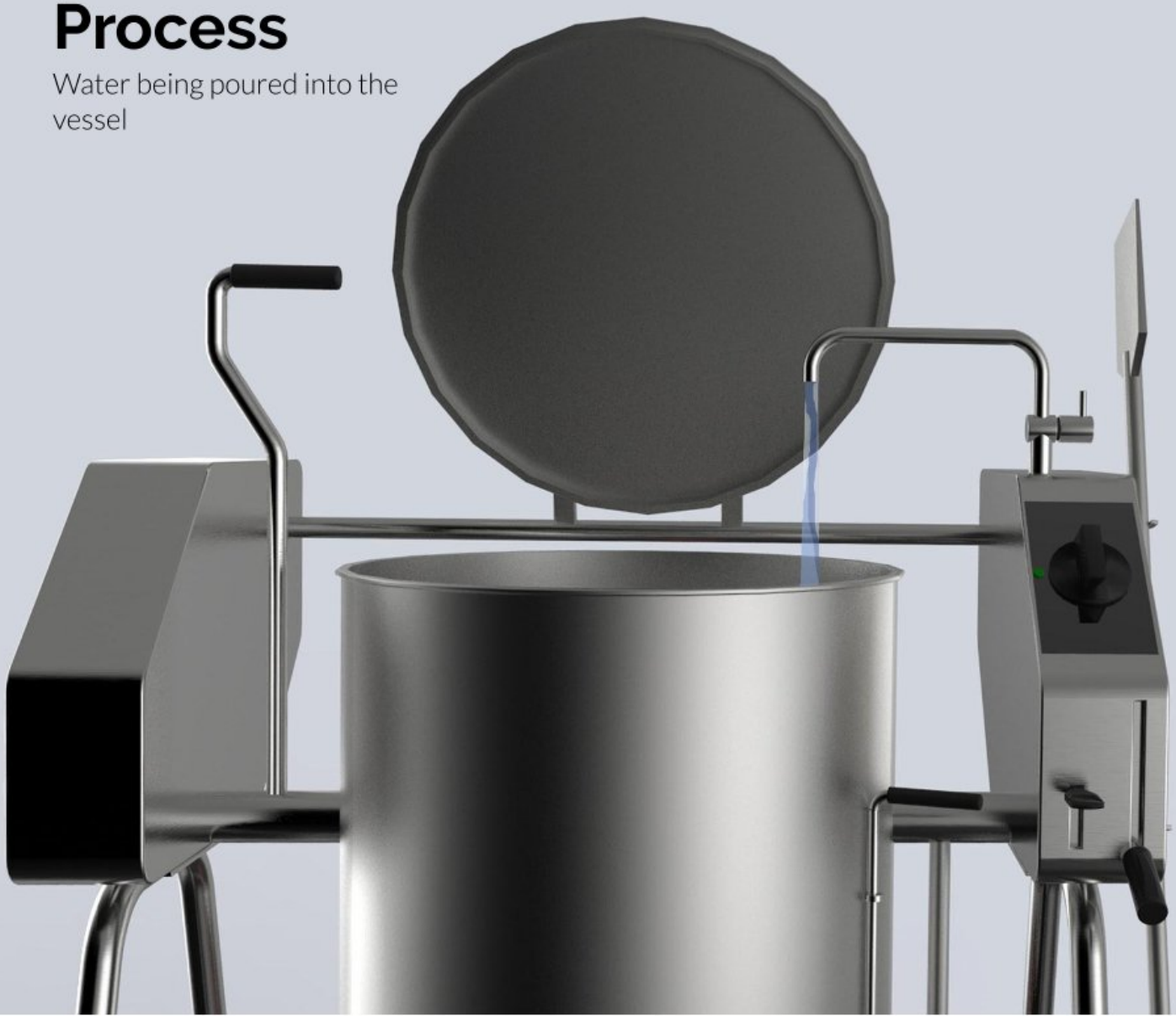
Handle design mockups.



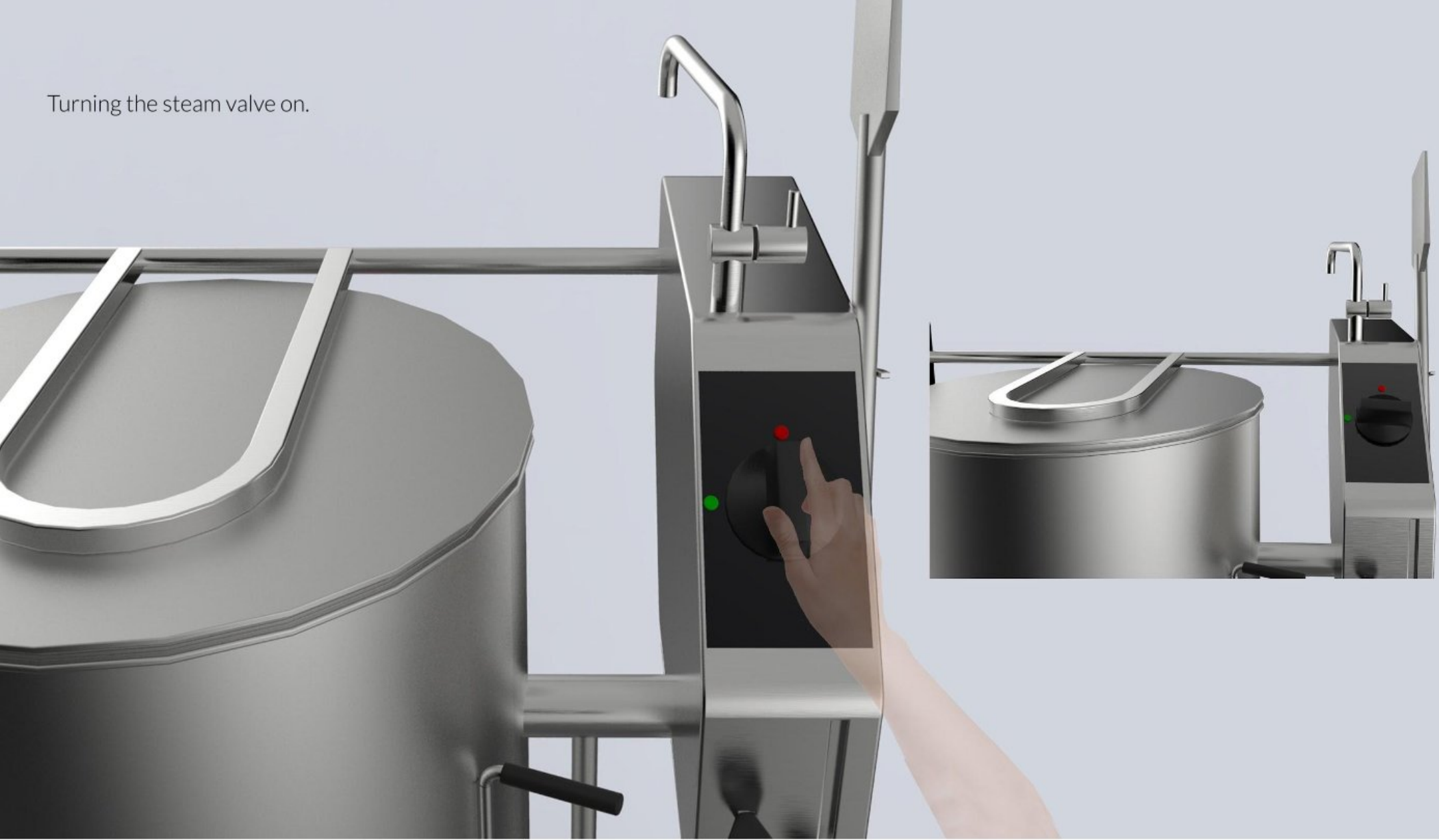
Final Design

Process

Water being poured into the vessel

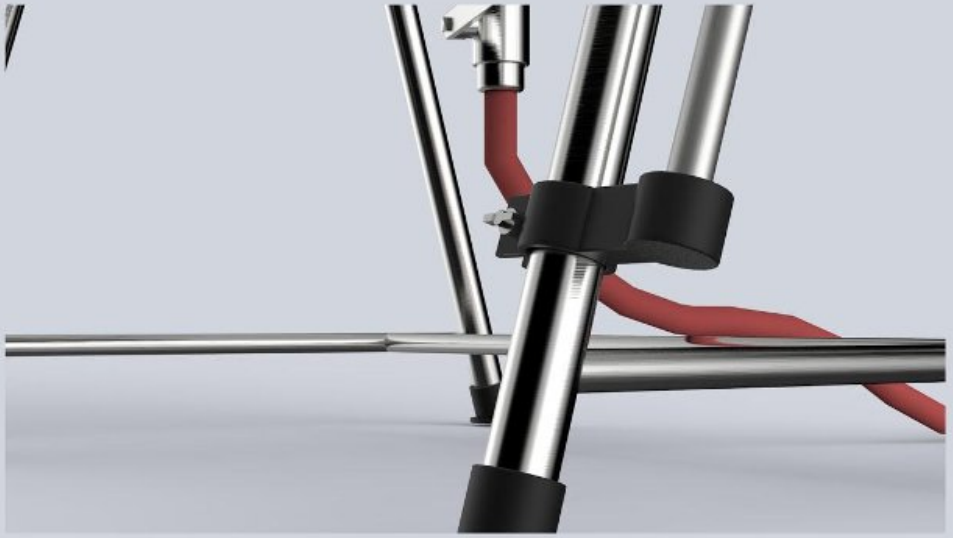


Turning the steam valve on.



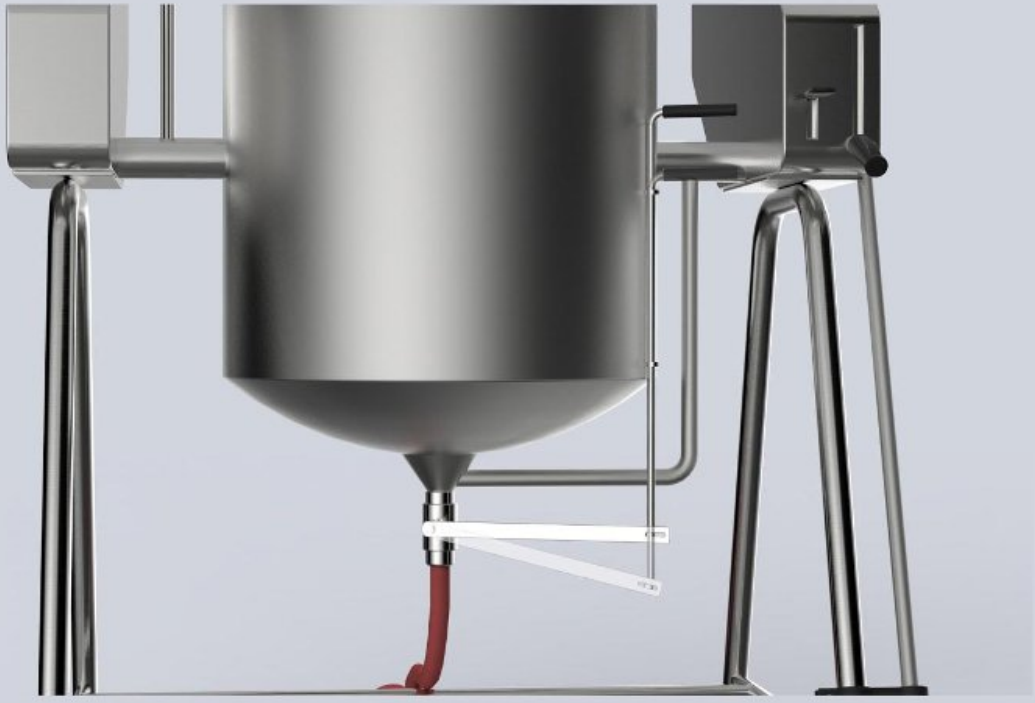
Putting the rice into the vessel

Using the stirrer for stirring



Detail showing the detail of the holder for the stirrer.

Turning the drain valve on for removing the waste water



Pressing the knob of the marine lock and tilting the vessel for transfering the food

Working of the lid mechanism

Mechanism for tilting the vessel.

Achieving modularity in design.

Thank you