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

M.DES INDUSTRIAL DESIGN PROJECT III

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INDIAN INSTITUTE OF TECHNOLOGY BOMBAY
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Approval

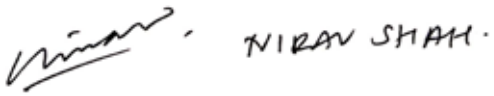
Industrial Design Project lll

The project titled " **Cooking application using steam from solar steam generator** " by **Saijith M S**, is approved for the partial fulfilment of the requirements of a postgraduate degree in Industrial Design at IDC, IIT - Bombay

Project Guide 

Chair Person 

Internal Examiner 

External Examiner 

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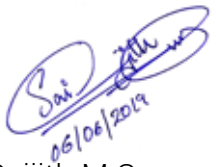

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I take this opportunity to express my gratitude to my guide
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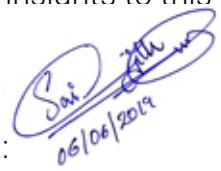
Last but not the least I am grateful to my classmates for contributing their valuable insights to this project.



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Abstract

Solar energy is considered to be the most renewable, clean and abundant source of energy. The application of solar energy has been implemented in various fields, cooking being one of them.
The Heat Pump lab at IIT Bombay has developed a solar steam generator that is simple and affordable. Existing studies in the field show that using steam for cooking can save up to 40%-60% of fuel as compared to traditional cooking.

Presently there are many manufacturers who produce cooking vessels in the market, that use steam as a source for cooking food, which has its own pros and cons. These kinds of vessels are most effectively used in the area of community cooking (hospitals, hostels, temples, etc.).

This project is an attempt to make the whole cooking activity much easier for the user, i.e. making it an user-centric design. Finding the flaws in the existing cooking vessels and to deliver a new product that gives a new cooking experience for the user are the further objectives.

The project has gradually attained its shape after studying a broad spectrum of steam generated cooking to understand the possibility and scope of this project, and finally narrowing it down to steam based rice cooker. This report outlines the detailed design process followed during the project.

1. Introduction

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, which becomes the main renewable source of energy. The solar energy available in a year exceeds the possible energy output of all fossil fuel energy reserves in India.[1]

The application of solar energy is extended to a larger scope, cooking being just one among them. Taking forward cooking as an aspect, the heat pump lab of IIT Bombay has developed a solar steam generator for community cooking.

This project was an extension of their idea. The design journey started by understanding the technology and finding the scope for the application of this technology in community cooking spaces. Extending that scope, the idea was to come up with a design intervention that is possible in the field.

2. 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.

2.1. The Technology

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. It has enhanced efficiency due to reduction in heat losses.

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.[2]

Durability is enhanced and maintainability is improved due to the enclosed reflectors. 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. [2]

The steam generated by this unit is currently being tested to cook food. The cooking vessel used is standard pressure vessel used for industrial applications.

After initial data collection, it is found that solar steam based cooking is practiced for preparing food on large quantity in places like hotels, temples etc.

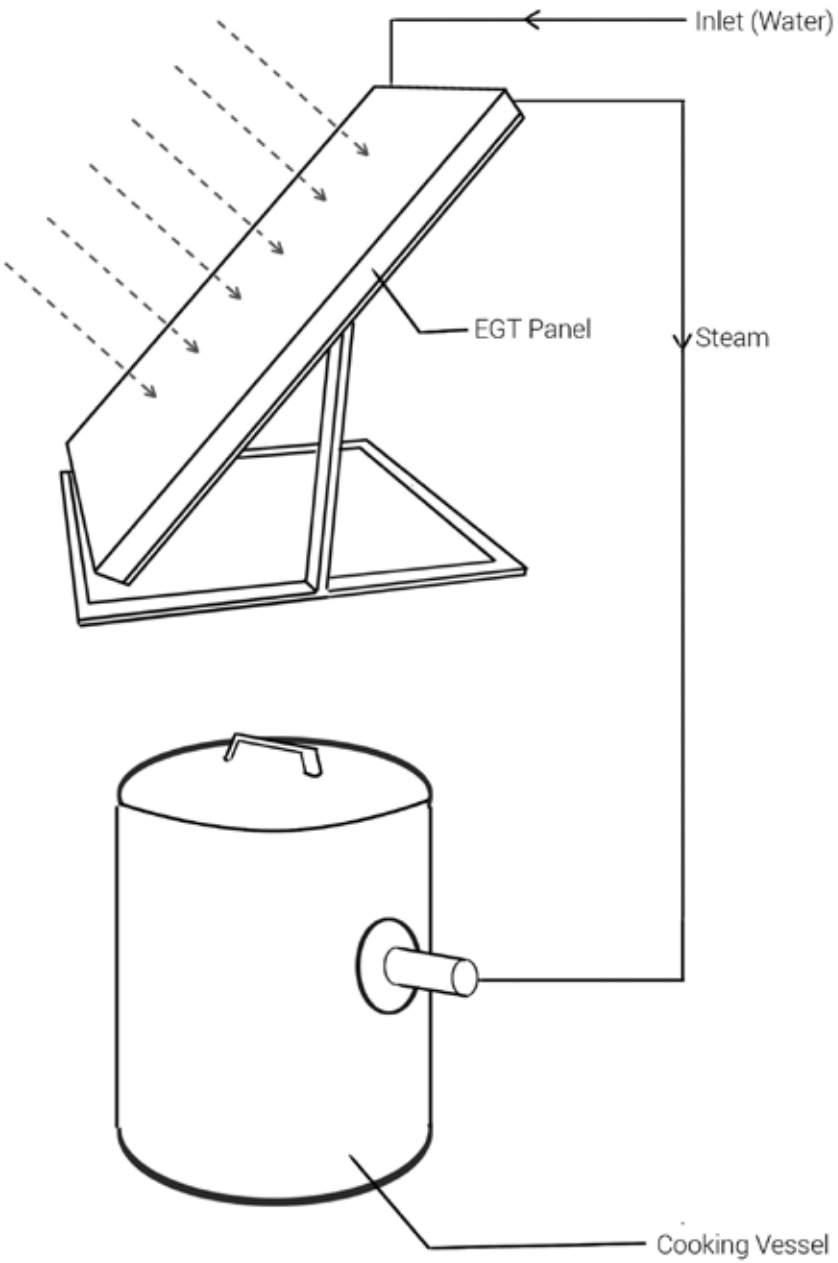


Fig1. Schematic sketch of the steam generator

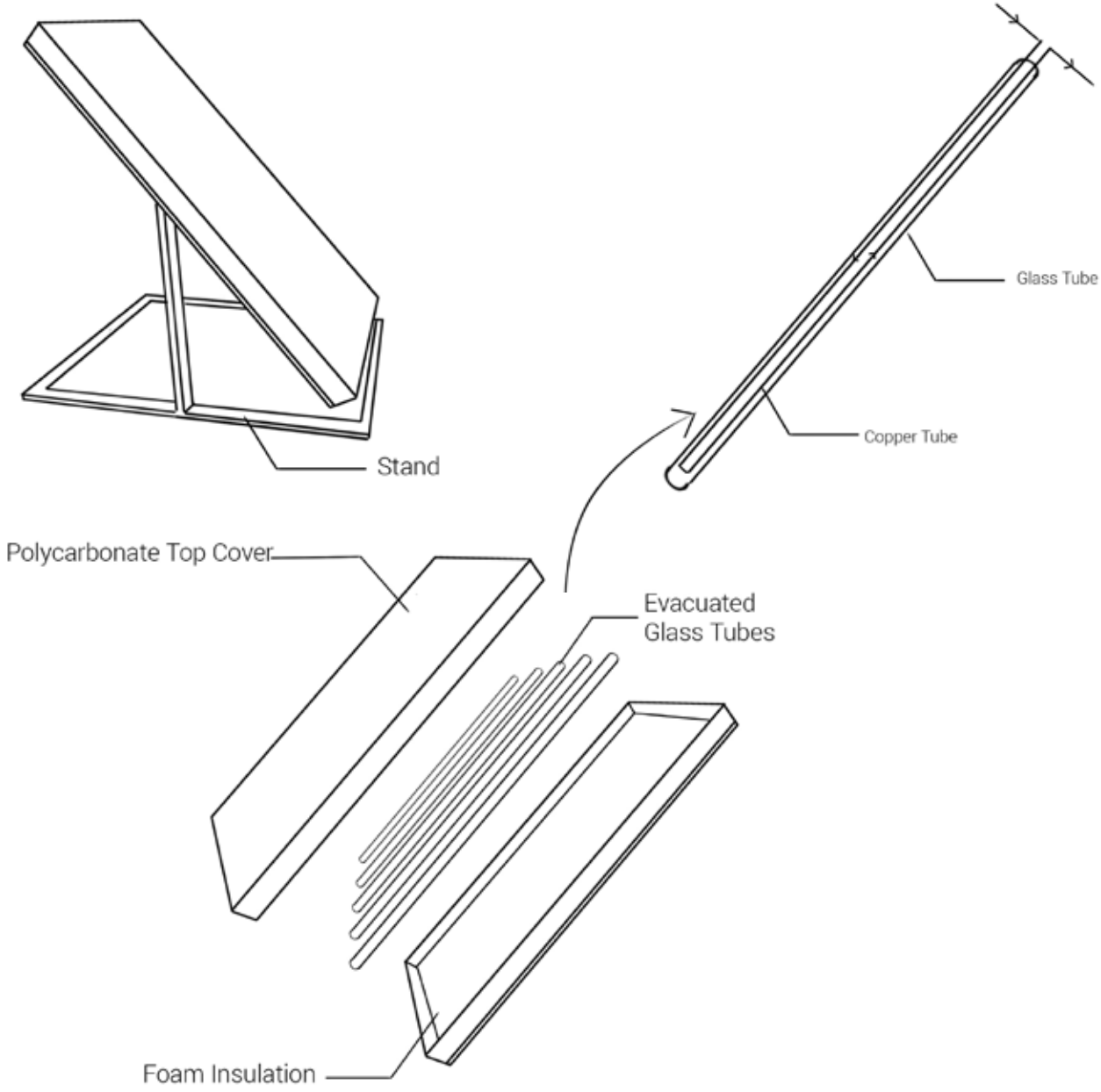


Fig2. Schematic detail sketches of the steam generator

Collector performance in the month of December 2015 in Mumbai

Time			Temp
From	Mean	To	°C
9.00	9.15	9.30	50
9.30	9.45	10.00	63
10.00	10.15	10.30	76
10.30	10.45	11.00	90
11.00	11.15	11.30	105
11.30	11.45	12.00	114
12.00	12.15	12.30	123
12.30	12.45	13.00	131
13.00	13.15	13.30	144
13.30	13.45	14.00	157
14.00	14.15	14.30	159
14.30	14.45	15.00	161
15.00	15.15	15.30	149
15.30	15.45	16.00	144
16.00	16.15	16.30	140

2.2. Why Steam Cooking ?

Fig3. Steam

- Steam Cooking retains the texture & shape of the cooked food.
- The chances of food getting over cooked is very less.
- In conventional cooking system 4 Burners are 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
- Cost effective as compared 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 time is approximate from 35% to 50% as compared with traditional cooking system.
- Kitchen remains much cleaner because of less smoke produced.

2.3. Market Study

There are four kind of steam boilers available in the market.

Fig4. LPG steam boiler

Fig5. Electric steam boiler

Fig6. Fire wood steam boiler

Fig7. Solar steam boiler

Steam Cooking Vessels

Fig8. Steam jacketed cooker

Steam Jacketed Cooker

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

Features:
- It Is Triple Layered Cooking Vessel Made From AISI Stainless Steel 304/316 L, Food Grade Quality Material For Cooking Of Rice (50 Kg In 20 Min), Dal (35 Min), Vegetables (30min), Milk (150 Ltrs In 25 Min), Pulses (30 Kg In 45-50 Min), Potatoes (140 Kg In 25 Min), Khaman (17 Kg In 15 Min), Pasta (120 Kg In 30 Min), Non Veg, Water.
- The cooker is provided with Solid Stainless Steel Shafts supported on special bearings mounted On Heavy Duty S.S. Tubular Stands.
- The complete cooker is polished & buffed to mirror finish for hygienic cooking.
- Gear / Manual Type tilting arrangement is provided to unload the vessel.
- The Vessel is designed for Jacketed Steam Pressure & Tested Hydraulically Steam Pressure.[3]

Fig9. Steam non-jacketed cooker

Steam Non-Jacketed Cooker

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

Features:
- Avoids Blemishing & Overheating Of Food. Maintains Nutritional Value, Protein, Vitamins, Quality & Taste Of Food.
- Requires Less Time @40% less than conventional cooking easy to clean & maintain.
- Optimum utilization of steam enthalpy due to a high degree of superheat.
- Completely hygienic & safe boiling than any other method as food is cooked In SS 304 vessel.
- Less Manpower .
- Vibration-less & noiseless boiling & cooking in this system.
- Effective heat transfer - less time to cook food.
- Reduction in cooking cost by 50%.
- Hybrid steam generators with Dual Fuel - Firewood/Bio Gas/LPG/ Solar/Electricity/Heat.
- Very safe & easy to use,skilled labour not required[3]

Jacketed Steam Cooking System

Fig10. 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
Type : Vertical, Tilting

Features:
- Avoids Blemishing & Overheating Of Food. Maintains Nutritional Value, Protein, Vitamins, Quality & Taste Of Food.
- Requires Less Time @40% less than conventional cooking easy to clean & maintain.
- Optimum utilization of steam enthalpy due to a high degree of superheat.
- Completely hygienic & safe boiling than any other method food is cooked In SS 304 vessel.
- Less Manpower.
- Vibration less & noiseless boiling & cooking in this system.
- Effective heat transfer less time to cook food.
- Reduction in cooking cost by 50%.
- Very safe & easy to use. [3]

Fig11. Sealed kettles

Sealed Kettles

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

Features:
- Completely SS 304 construction Triple layered Double Jacketed Insulated sealed vessel made from AISI S.S. 304 stainless steel (Jindal/ Salem) food grade quality material for processing of Food. Heavy Duty Silicon Gasket will be provided for Sealing of Vessel. [3]

Fig12. Steam kettle with stirrer

Steam Kettle With Stirrer

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

Steam Jacketed Kettle with Stirrer that is available in various sizes and capacities at market leading prices. All these products are widely demanded by several industries like food, chemical, petrochemical, and packaging.
- Corrosion resistance, Long service life, Low maintenance. [3]

Fig13. Idli steamer machine

Idli Steamer Machine

Approx. Rs 10,000 / Unit
Material : Stainless Steel
Material Grade : SS 304
Capacity : 60,120,180 upto 360idlies per cycle.
Features:
- Energy saving. The heating efficiency can be as high as 95%.
- Its 40% cheaper than LPG.
- Less maintenance [3]

Fig14. Tilting steam boiling pans

Tilting Steam Boiling Pans

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

- Indirect steam heating. Powered by means of a throttle valve.
- Hot and cold water taps on the worktop with an articulated spout for filling and washing the tank.
- Cooking temperature optimization by means of a valve for the steam flow adjustment. Motorised tilting around the front axis. The structure is in 30/10 stainless steel. [4]

Fig15. Direct steam mixer kettle

Direct steam mixer kettle

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

Stainless Steel enclosed Mixer Bridge. All Plumbing, Electrical and Hydraulics enclosed in Consoles. Gallon markings, Bayonet Mounted Scraper and Agitator. 3" Butterfly Valve. Hot and Cold Water Faucet.
Steam Control Kit. Safety Device prevents high speed starts; Mixer stops when Bridge is lifted. Kettle and all exterior surfaces are Stainless Steel.

Features
Mixing - 3 Horsepower Hydraulic powered Agitator, Scraper and Bridge Lift. Infinitely Variable Scraper Speed Control from 0 to 40 rpm. Infinitely Variable Ratio between Scraper and Agitator: Agitator rotates from 0 to 8 times the speed of the Scraper. Removable (without tools) Nylon Blades scrape the entire Jacketed Surface.
Safety Device prevents high speed Starts. Mixing stops when Bridge is lifted. Agitator and Scraper are Bayonet Mounted for easy removal.
Tilt Mechanism - Roller bearings and case hardened self-locking worm and segment gear.
Water Faucet : Hot and cold water faucet with 3/4" swing spout.[5]

2.4. Similar Products In The Market.

Fig16. Suvie Smart Oven

Suvie Smart Oven

- While the movement of hot air ensures consistent heating and browning, steam adds moisture at the right times and in the right amounts, resulting in delicious, nutritious meals.
- Adding convection cooking to steam equates to foods that are cooked with steam and can be browned by dry convection heat before serving.
- Consistent heating and browning from the convection.
- Risks of overcooking are reduced and boil-overs are eliminated.[8]

Fig17. Nilma MINI STEAM

Nilma MINI STEAM

Cooking times are reduced by 30%-40% compared to traditional cooking in water; frozen or pre-cooked food prepared with MINI STEAM, will be tender and perfectly moist. MINI STEAM also allows significant savings on labour, because it is completely automatic, and on power, thanks to its exclusive heat recovery system; MINI STEAM is the equipment with the lower energy consumption in its category. Mini steam with its new cooking system is ideal for hotels, restaurants and small communities, because it make every menu economical.[9]

Fig18. Commercial food steamer

Commercial food steamer

It adopts two double solenoid valve steam admission control,and can keep temperature constant.
Adjustable doorknob with special design, handle base and adjustable hinge can ensure steaming cabinet sealing.
The door of cabinet adopts integrative silica gel sealing strips , good sealing and long service life.
Adjustable temperature controller, time controller, and alarm indicator, you could set on the basis of product's feature.[10]

Fig19. Counter top Steamer - Gas

Counter top Steamer - Gas

Connectionless Countertop Gas Steamer is NSF listed as both a steamer and holding cavity. Ideal for batch cooking applications. Combination of heater and convection fan results in higher efficiency and lower energy use. Easy to use mechanical controls. Three gallon capacity water reservoir. [11]

2.5. Similar technology already installed

Shirdi, Maharashtra, India

Fig20. Solar receivers at Shirdi, Maharashtra

The system comprises of 73 solar dishes, each with an aperture area of 16 m2, which were placed in series and parallel combination. It was designed in such a way that even if electricity is not available to run the feed water pump for circulating water in the system, it is able to generate a sufficient amount of steam to cook food for the given number of people.

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 or dusk will set in. The installation is expected to save around 100,000 kg of LPG per year, which is equivalent to INR 2 million (approx. US$ 45,000).

The temple's Trust has already had satisfactory experiences with a smaller system installed in 2001. This system consists of 40 dishes with 10 m2 each and provides energy for cooking 6,000 meals for 3,000 people daily. The now improved technology with 16 m2 solar dishes has reduced the area installers have to cover, as well as operational and maintenance requirements.[6]

Tirumala Tirupati Devasthanam, Andhra Pradesh

Fig21. Solar receivers at 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.

The system designed to produce over 4000 kgs of steam/day at 180 degree centigrade and 10 kg/sq cm is adequate to cook two meals for approximately 15,000 persons. Nearly 50,000 kilos of rice along with sambhar and rasam are cooked in the kitchens of Tirumala every day of the year without using conventional gas.[7]

3. 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 corns right from the users perspective.

Hostel messes in IIT Bombay campuses were visited to understand the current cooking vessels they use and to know more about the steam cooking that happens in the kitchen.

Hostel 6, IIT Bombay, Maharashtra

Fig22. Cooking vessel and steam boiler at hostel-6, IITB

The steam cooking system in hostel 6 mess consist of a LPG steam boiler which produces steam for mainly cooking rice, idli and boiling of water.

They have mainly two vessels jacketed and a non jacketed vessel. The jacketed vessel is mainly used for making curries dal, sambar etc. The non jacketed one is mainly used for cooking rice and boiling of water.

The same boiler has been connected to the idli steamer machine which is able to produce 120 idlies at a time.

The chefs and workers claims that the idli and rice cooking vessel is really effective because it consumes very less cooking time.

Hostel 12, IIT Bombay, Maharashtra

Fig23. Steam boiler and cooking vessel at hostel-12, IITB

The steam cooking system in hostel 12 mess consist of a LPG steam boiler, two non jacketed vessel and two idli steamer machine. The boiler has been connected to the two vessels and one idli steamer machine.

The non jacketed vessels is mainly used for boiling water for cooking purposes and rice cooking. 30 to 40kg of rice can be cooked at a time. The capacity of the cooking vessel is 150 litres. It takes 15 to 20 minutes to cook 30-40kg of rice once the water is boiled. For a single meal which feeds more than 600 students 60kg of rice is cooked, which is cooked in two batches in the vessel. It takes 1 hour in the morning and an hour in the evening to cook rice, the rest of the time the vessel is used for boiling water for cooking other dishes.

Two idli steamer machine, one which is directly connected with the boiler and the other one has an inbuilt boiler.

Cooking Process

Fig24. Steam boiler

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

Fig25. Water inlet to vessel

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

Fig26. 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.

Fig27. Rice transferring into the vessel

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

Fig28. Stirring the food

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

Fig29. Food getting cooked

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

Fig30. Draining of waste water.

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

Fig31. Transferring of food

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

Non-Jacketed cooking vessel

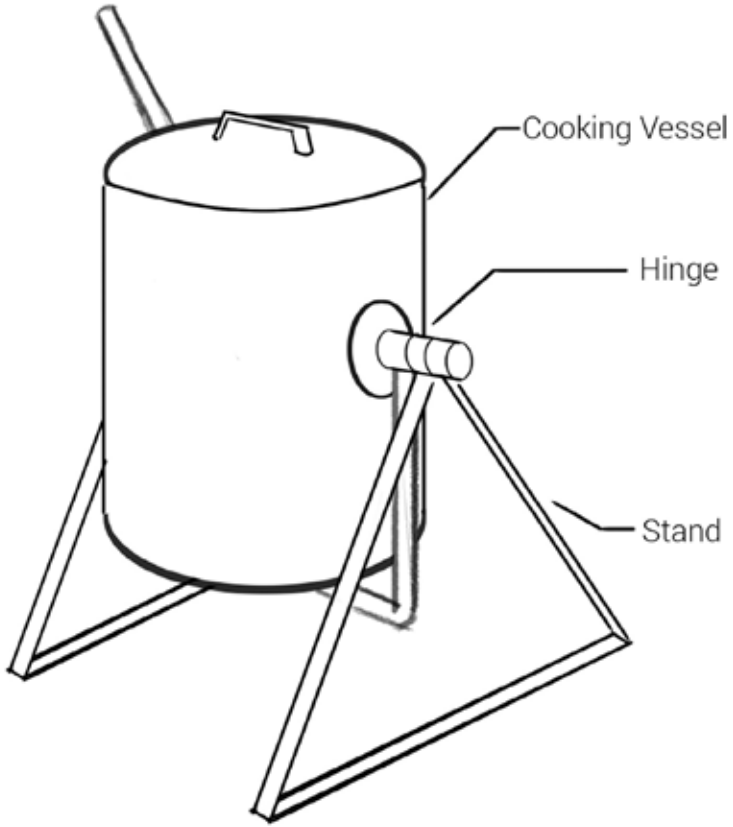


Fig32. Schematic sketch of non- jacketed cooking vessel

Schematic sketch showing the details of a non-jacketed steam vessel.

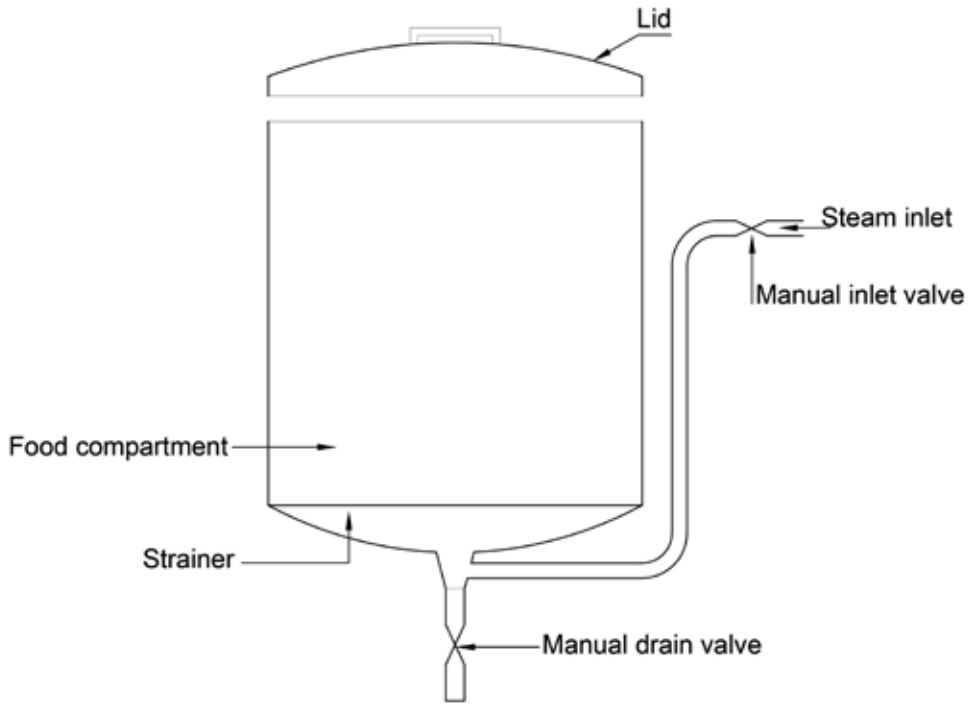


Fig33. Schematic section of non- jacketed cooking vessel

The basic components in the non jacketed steam vessel consist of a steam inlet valve which controls the steam flow, a drain valve which drains the waste water or the remaining steam water in the vessel and a strainer inside the vessel which stop from rice passing trough the drain valve.

Jacketed cooking vessel

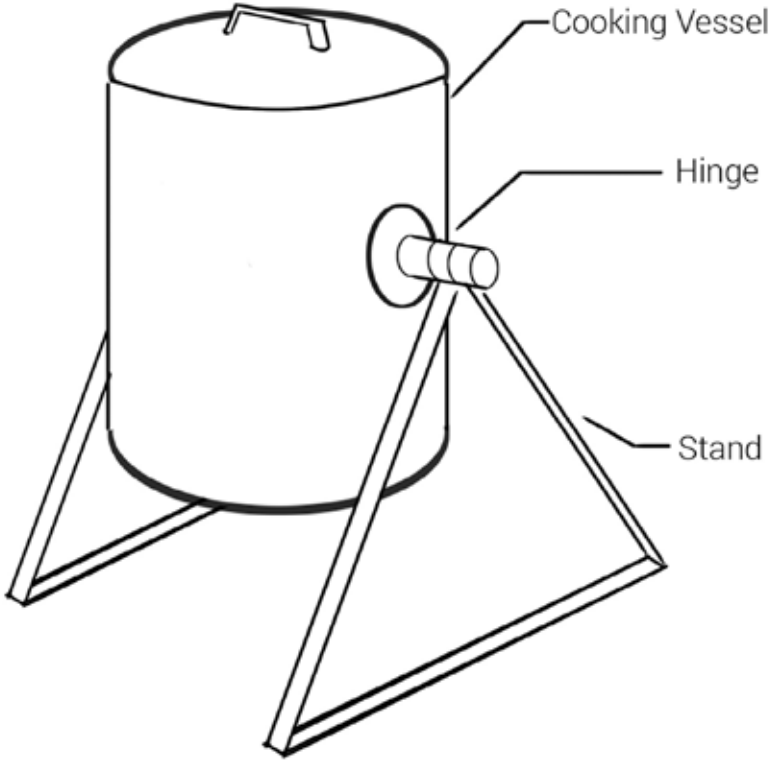


Fig34. Schematic sketch of jacketed cooking vessel

Schematic sketch showing the details of a jacketed steam vessel.

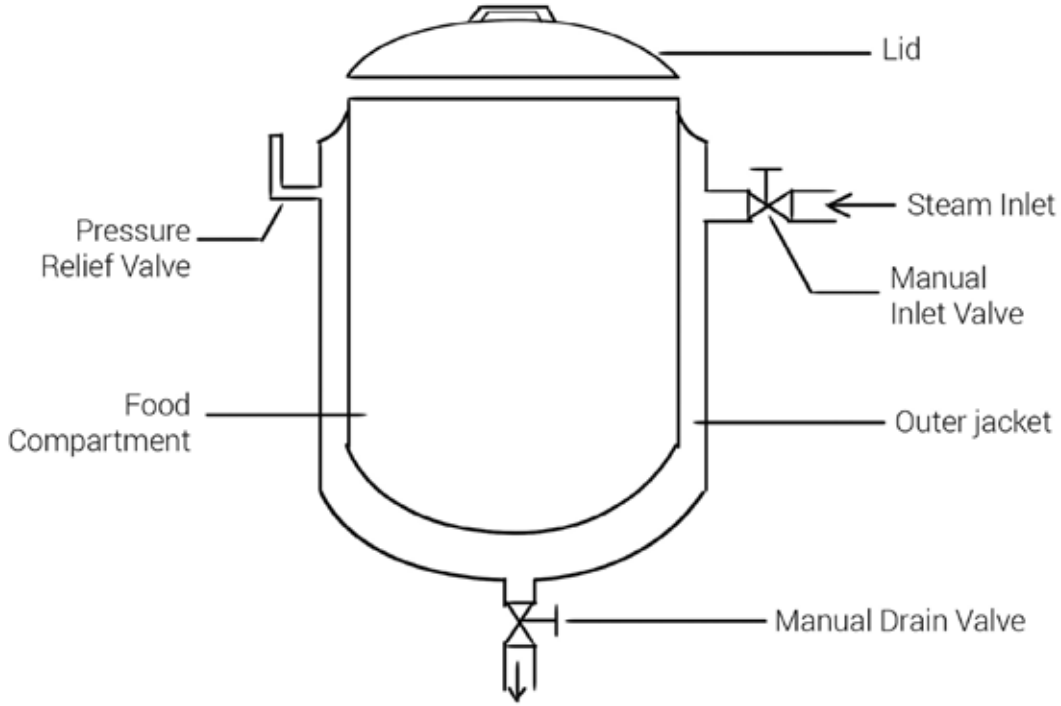


Fig35. Schematic section of jacketed cooking vessel

The basic components in the jacketed steam vessel consist of a steam inlet valve which controls the steam flow, a drain valve which drains the steam water from the two layers, a pressure relief valve for the pressure to be released when it is too high. .

Idli Steamer Machine

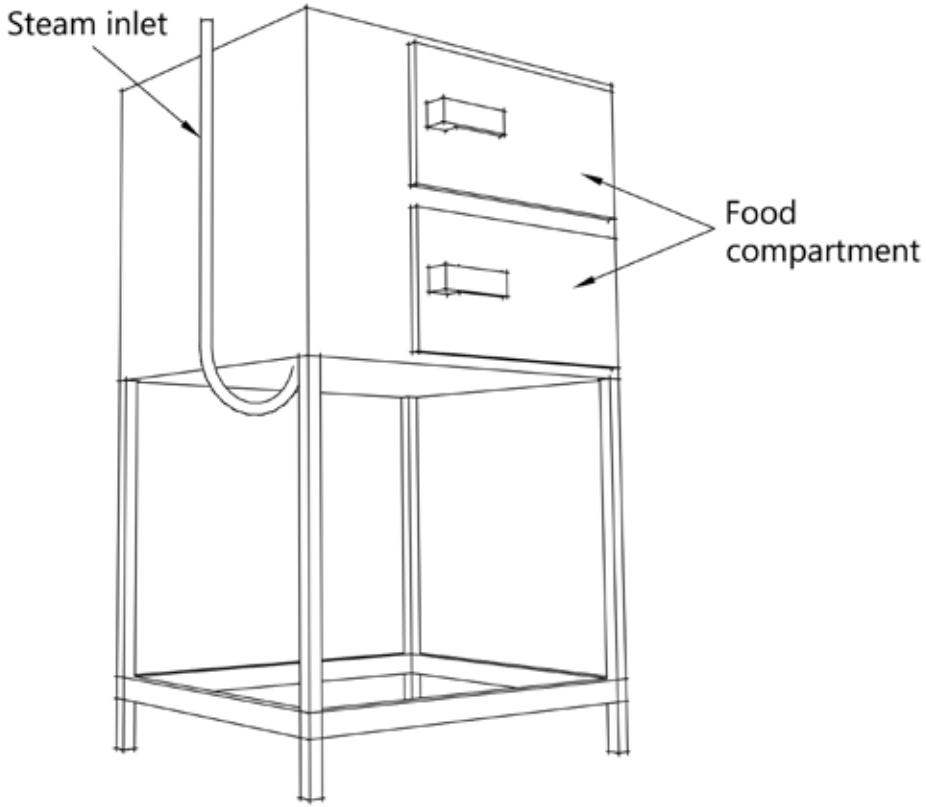


Fig36. Schematic sketch Idli steamer machine

Schematic sketch showing the details of a Idli steamer machine.

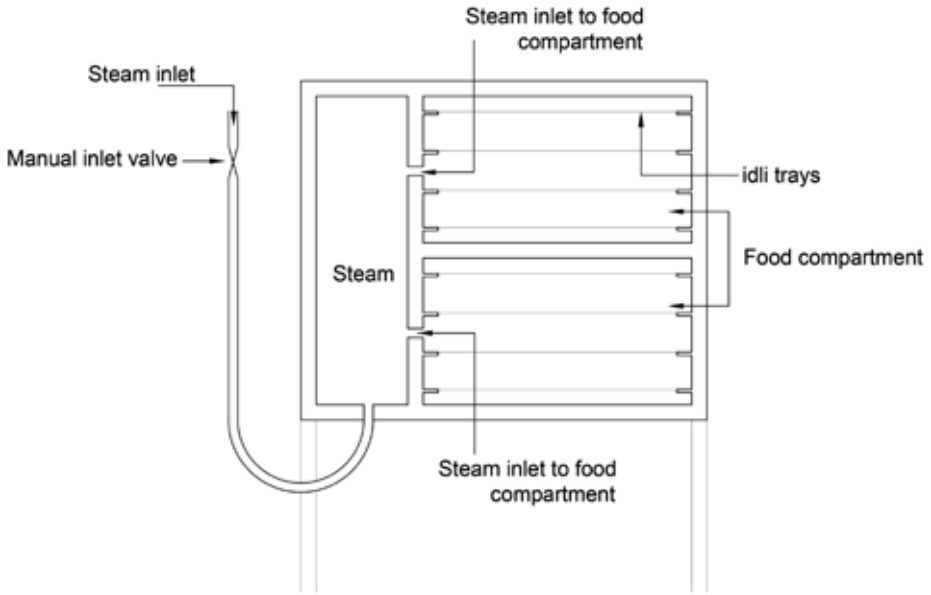


Fig37. Schematic section of Idli steamer machine

The basic components in the Idli steamer machine consist of a steam inlet valve which controls the steam flow, then it is sent to a steam compartment from there through small holes in the partition of the steam compartment it is transferred to the food compartment.

3.1. Observation

Interviews have been conducted with the chefs and workers in the mess to know about their problems and difficulties in using the cooking device.

In the interviews conducted, major inputs were not received from the users. This led the study to further conduct an Ethnographic study. Videos and photographs were taken of the whole activity to understand the cooking procedure closely. Further these videos and photographs were analysed and inferences was derived from it.

Fig38. Water connection to the vessel.

No proper water connection.

The present water connection is using a normal pipe which is dipped in the vessel and tightened by the vessel lid as shown in the figure. it also makes it unhygienic since the pipe that transfers water to the vessel lies in the ground when it is not used. Present arrangement makes it difficult to check the water level.

Fig39. Using stirrer for cooking.

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

There is a lack of locking mechanism in the whole system which make one hand always occupied on the handle during stirring and even during tilting and maintaining the position of the vessel.

Fig40. Drain valve

The main drain valve and its tap are tightly designed.

This makes it difficult to access the drain valve, there is high chance that the hand can get burned because of the hot water that comes out of the pipe. The location of the drain valve also makes it difficult to access, the user has to bend and reach for it.

Fig41. Lid of the vessel.

Difficulty in keeping the lid of the vessel.

There is no platform for keeping the lid in the system, every time once the lid is removed it becomes difficult to do the other operations keeping the lid in one hand or moving around with the lid to place it some were.

Fig42. Steam valve of the vessel.

Tap of the steam is not at an approachable distance.

Presently in the system the tap is provided at the rare end of the vessel, near to the wall. this makes it difficult to reach the valve especially when the vessel is hot and the steam is coming out of it.

Fig43. Jacketed vessel.

Cleaning of the vessel becomes difficult.

There is no proper locking for the vessel at different positions as one cannot reach the inside of the vessel, thereby making cleaning difficult. The water connection to the vessel is also not proper which adds on to the problem.

Fig44. Draining the waste water.

No proper drain for the waste water after cooking.

The waste water is directly drained onto the floor which makes it difficult for the user later in cleaning the floor. The vessel should perform the tilting, which makes it difficult to give a rigid pipe connection for the drain

Fig45. Stirrer kept on top of the vessel.

Place to keep the stirrer.

Stirrer is one of the main component needed for cooking. There is no provision given for the stirrer to be kept making it difficult for the user to always move around. Size of the stirrer is going to be a major challenge in providing a space for the it.

Fig46. Transferring food

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

The present detail of the handle makes the user bends to tilt the vessel, putting himself in a bad posture while operating the cooking vessel.

4. Design Brief

Design statement

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

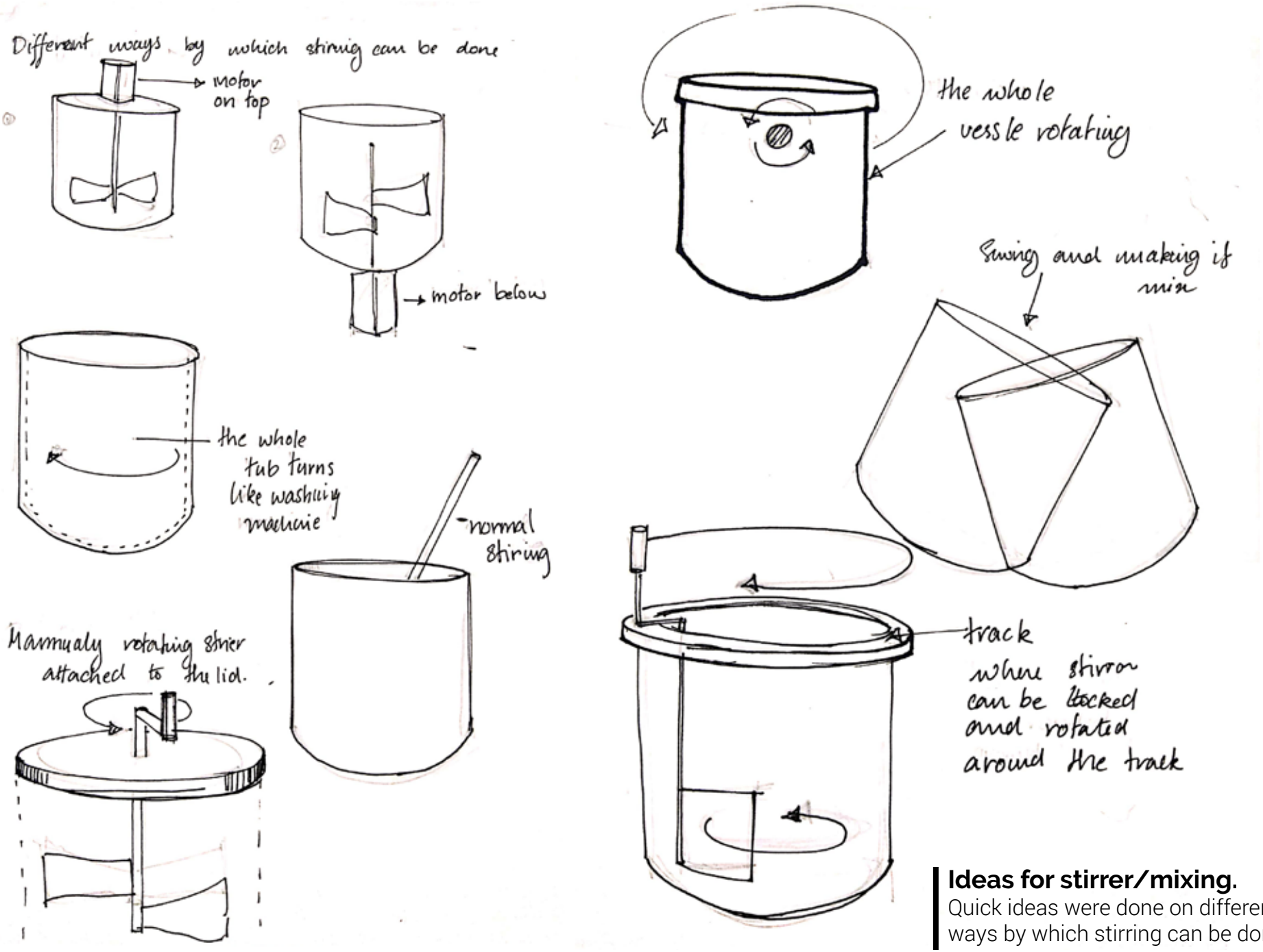
The problem here is to come up with a user-centric design for a cooking system which is heated using steam from solar steam generator. The main intention is to make the whole cooking experience easy for the user. There are similar products in the market which are just intended to serve the purpose; but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

Design Considerations

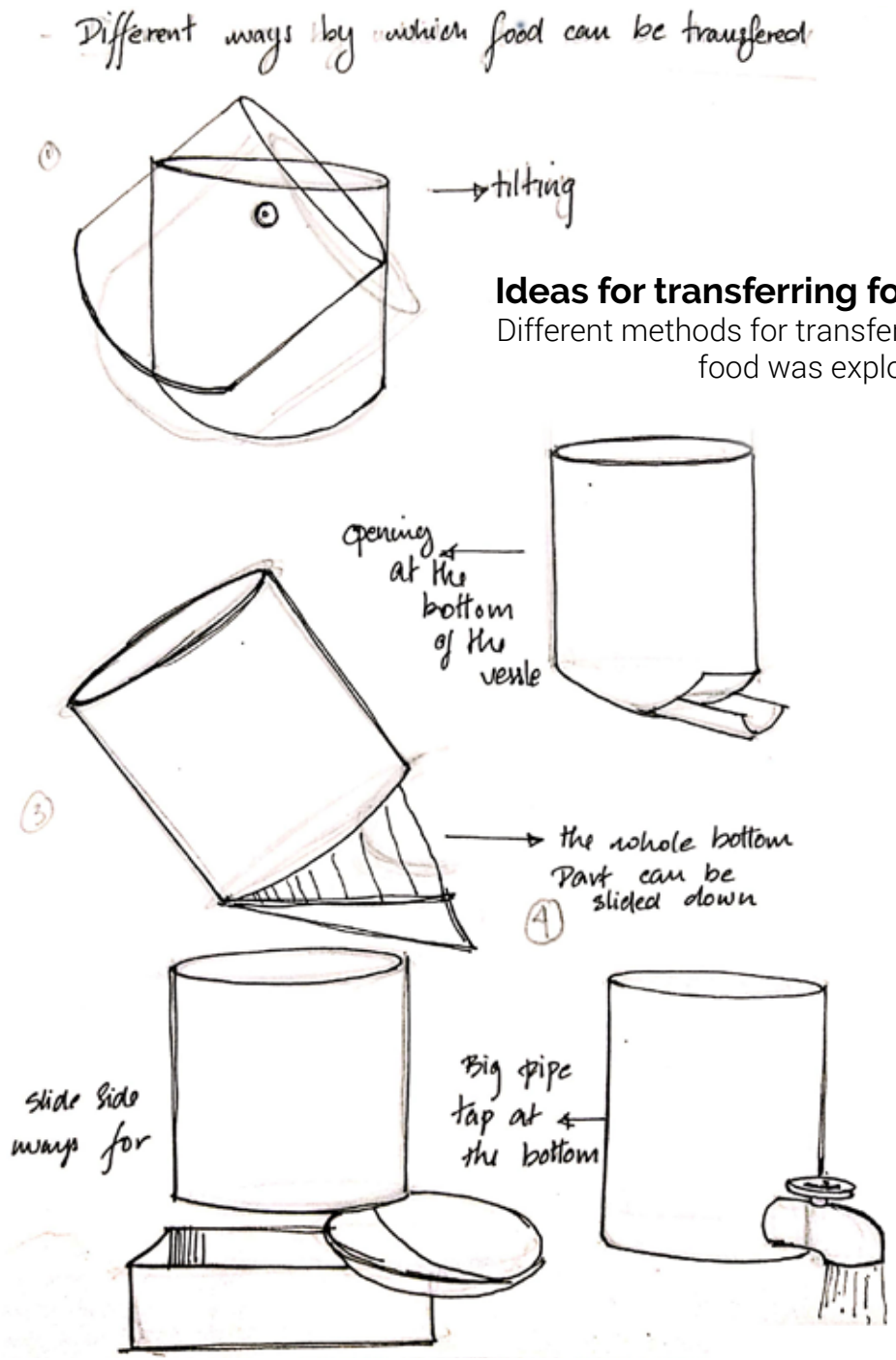
- Operation of the cooking system should not be complicated.
- Food grade materials should be chosen for main components in the system.
- Should not have much maintenance issues once it is installed.
- Cleaning should be easy since it is going to be in a mass cooking environment.
- Functionality is the 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.

5. Ideations

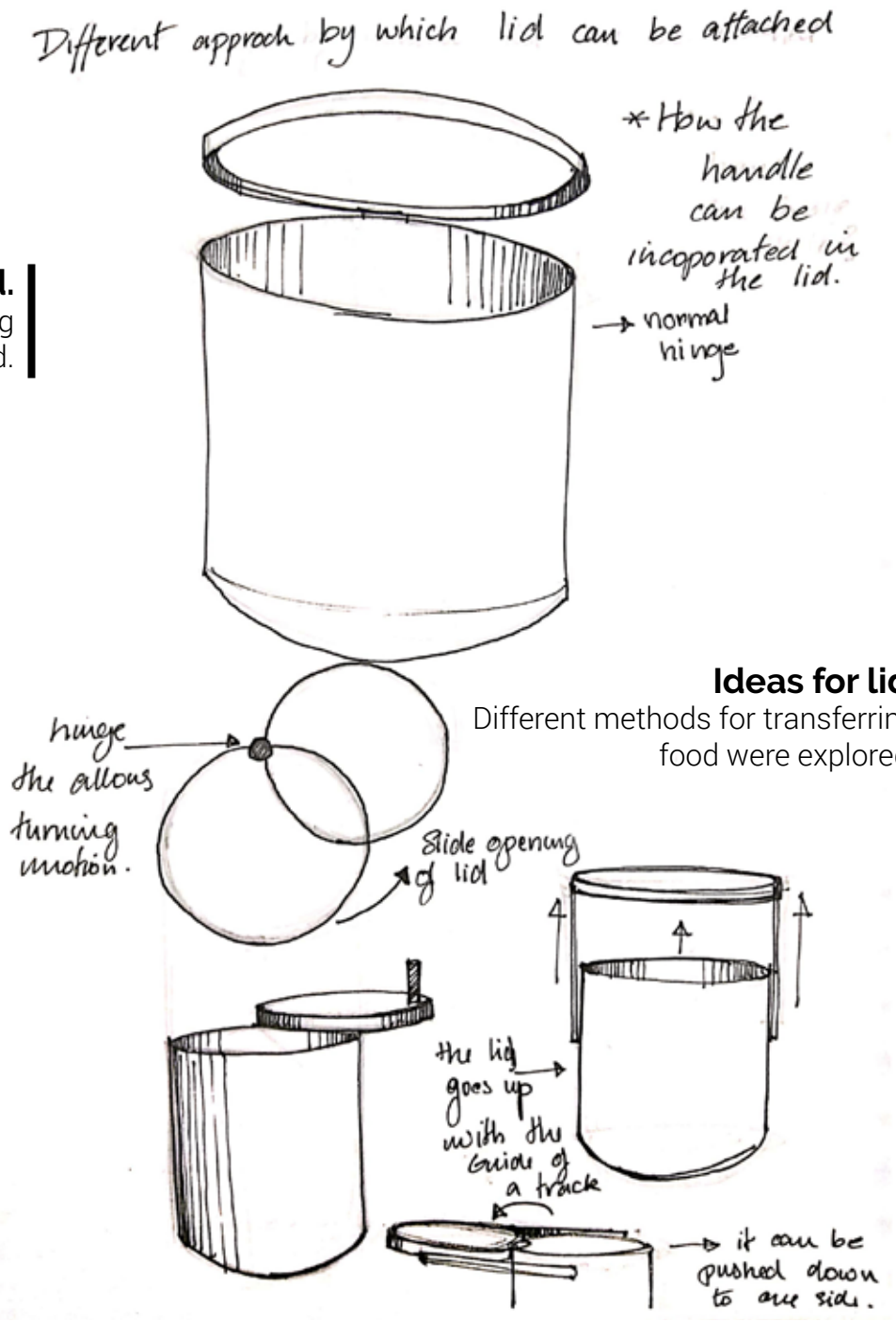
Initially ideas were generated taking individual aspects that were found from the observations. Further more ideations were done combining one or more ideas that was initially done.



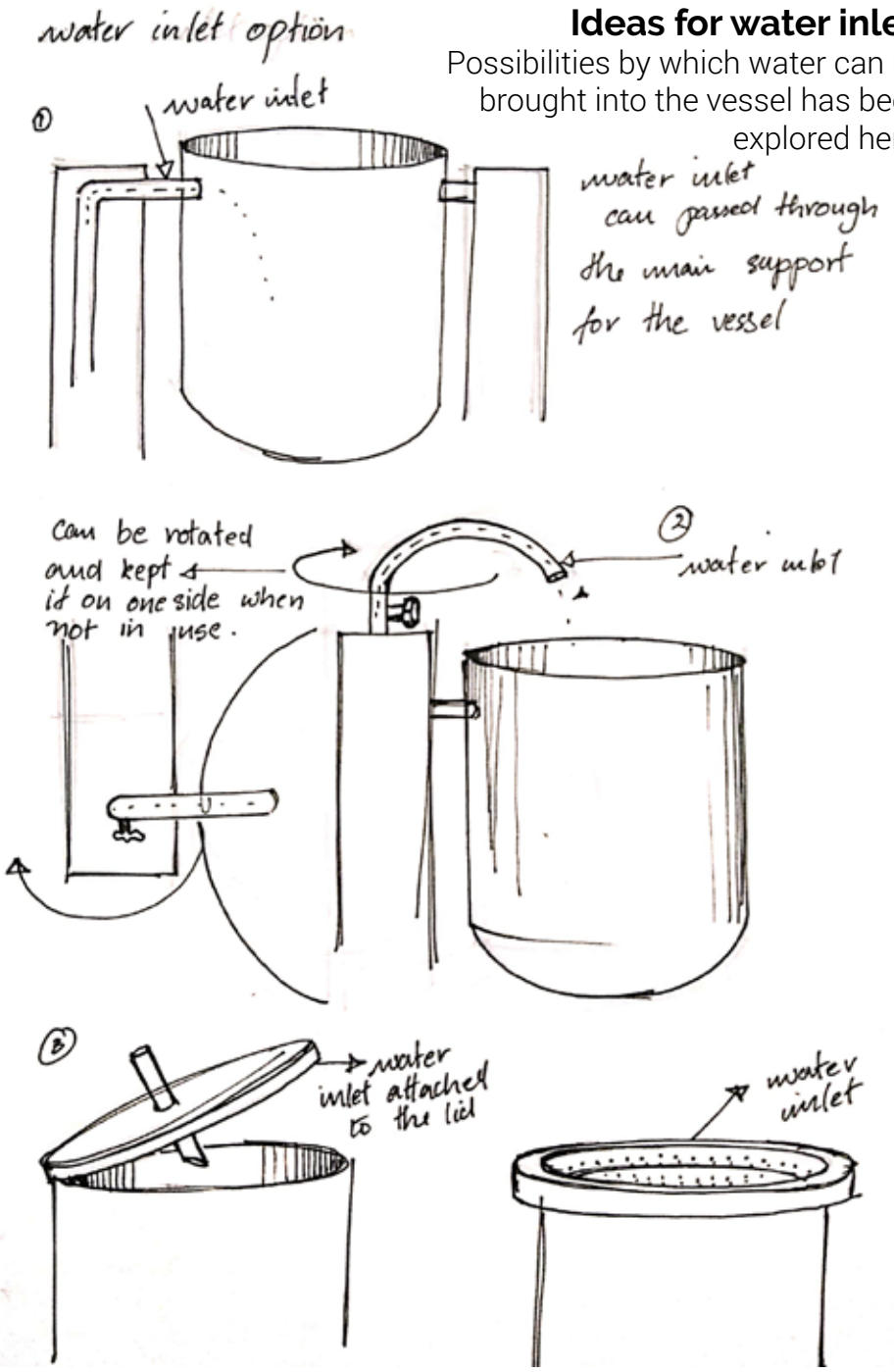
Ideas for stirrer/mixing.
Quick ideas were done on different ways by which stirring can be done.



Ideas for transferring food.
Different methods for transferring food was explored.

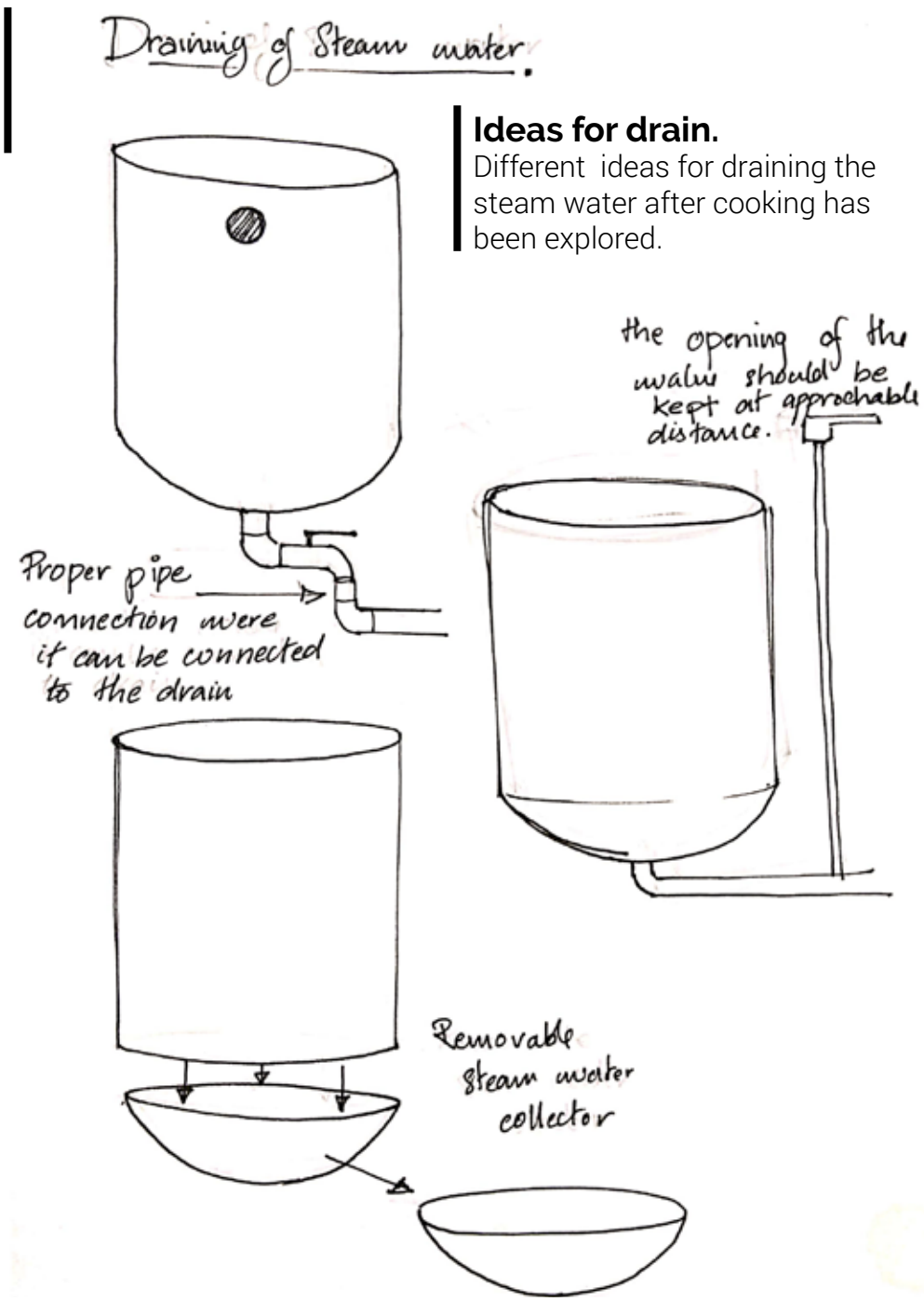


Ideas for lid.
Different methods for transferring food were explored.



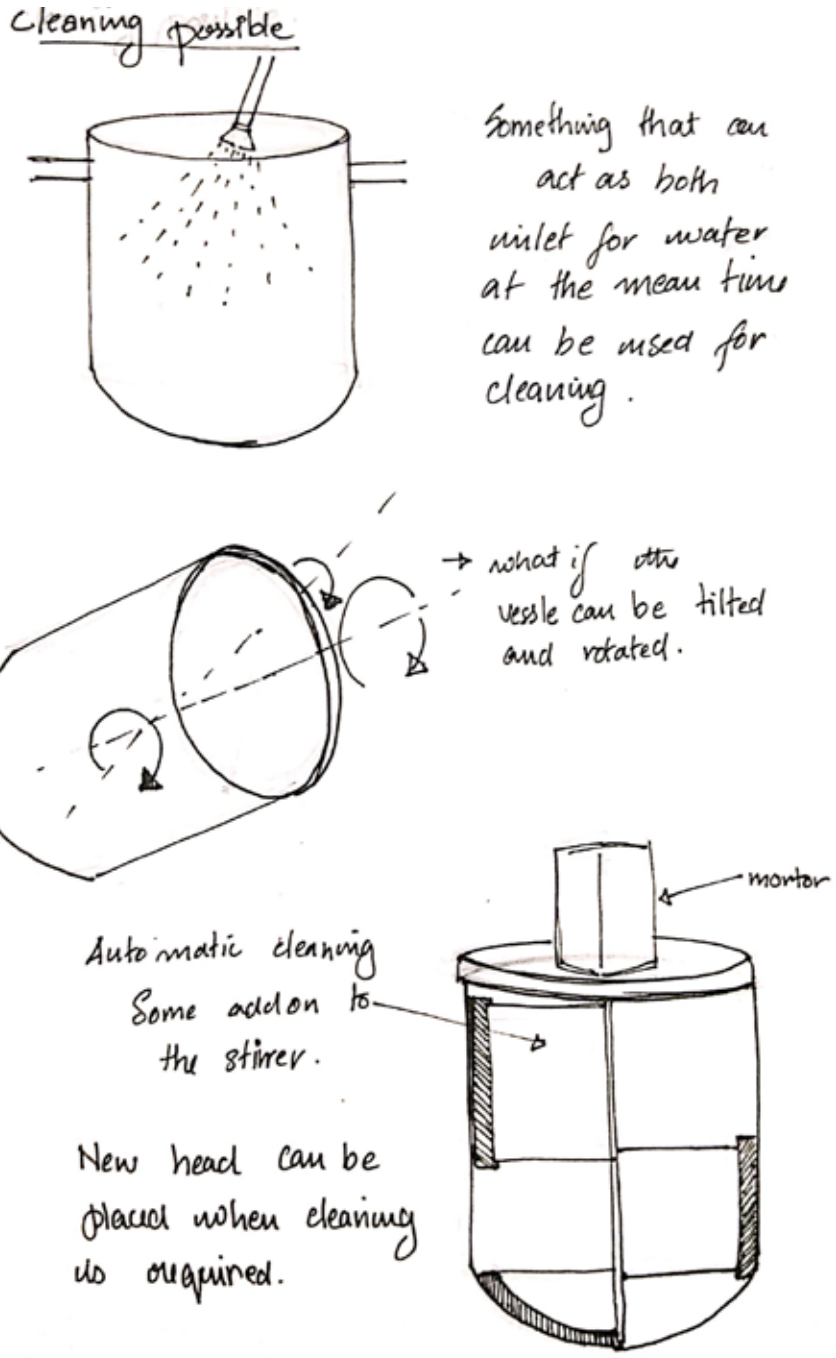
Ideas for water inlet.

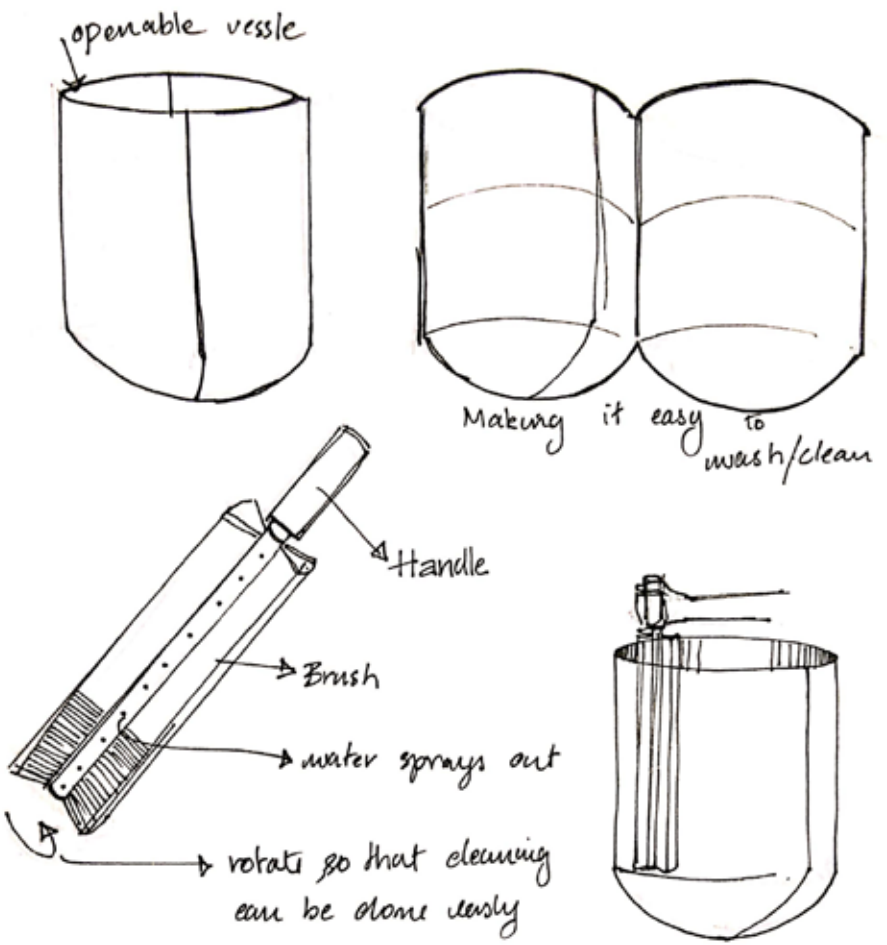
Possibilities by which water can be brought into the vessel has been explored here.



Ideas for drain.

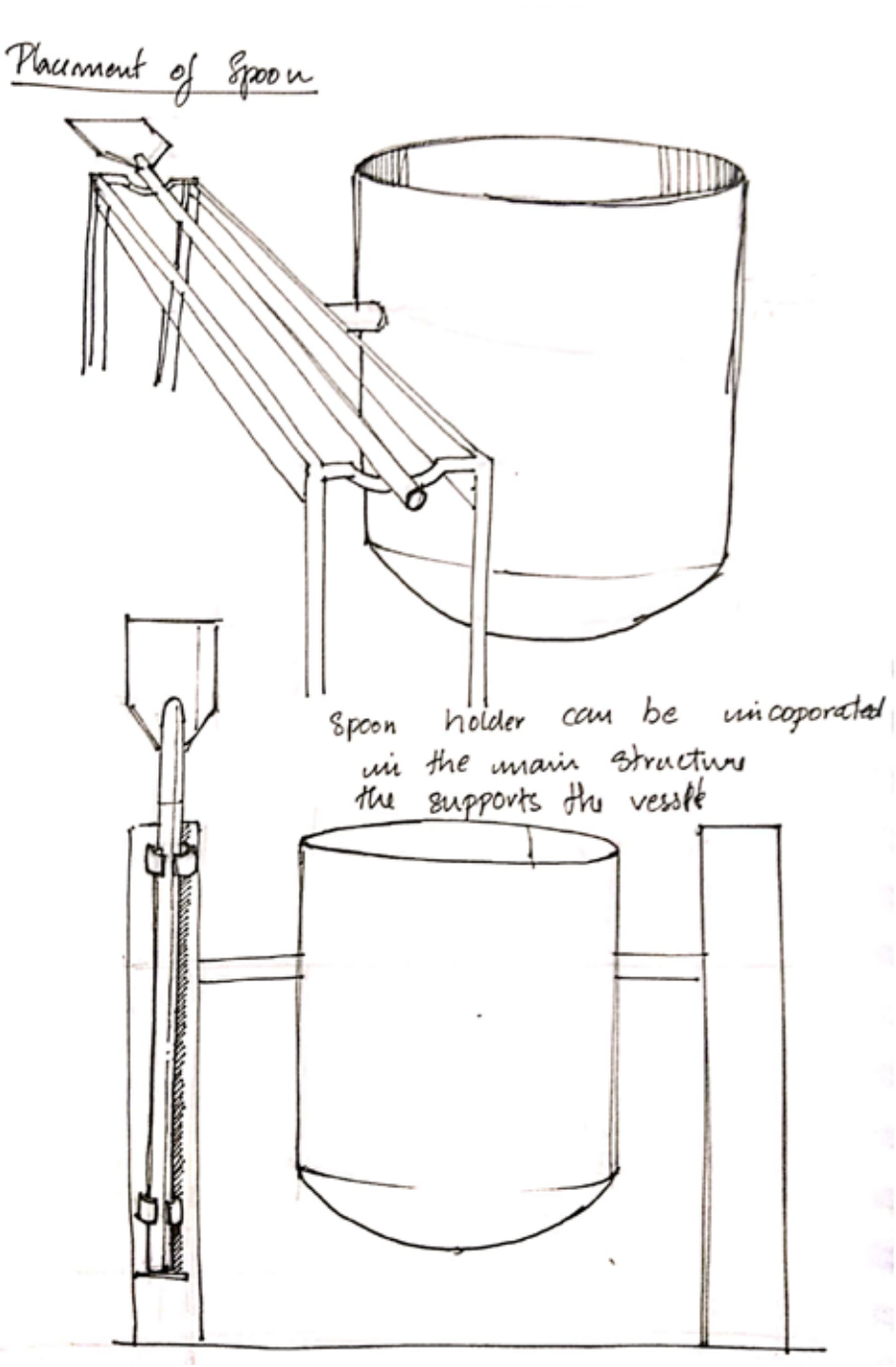
Different ideas for draining the steam water after cooking has been explored.





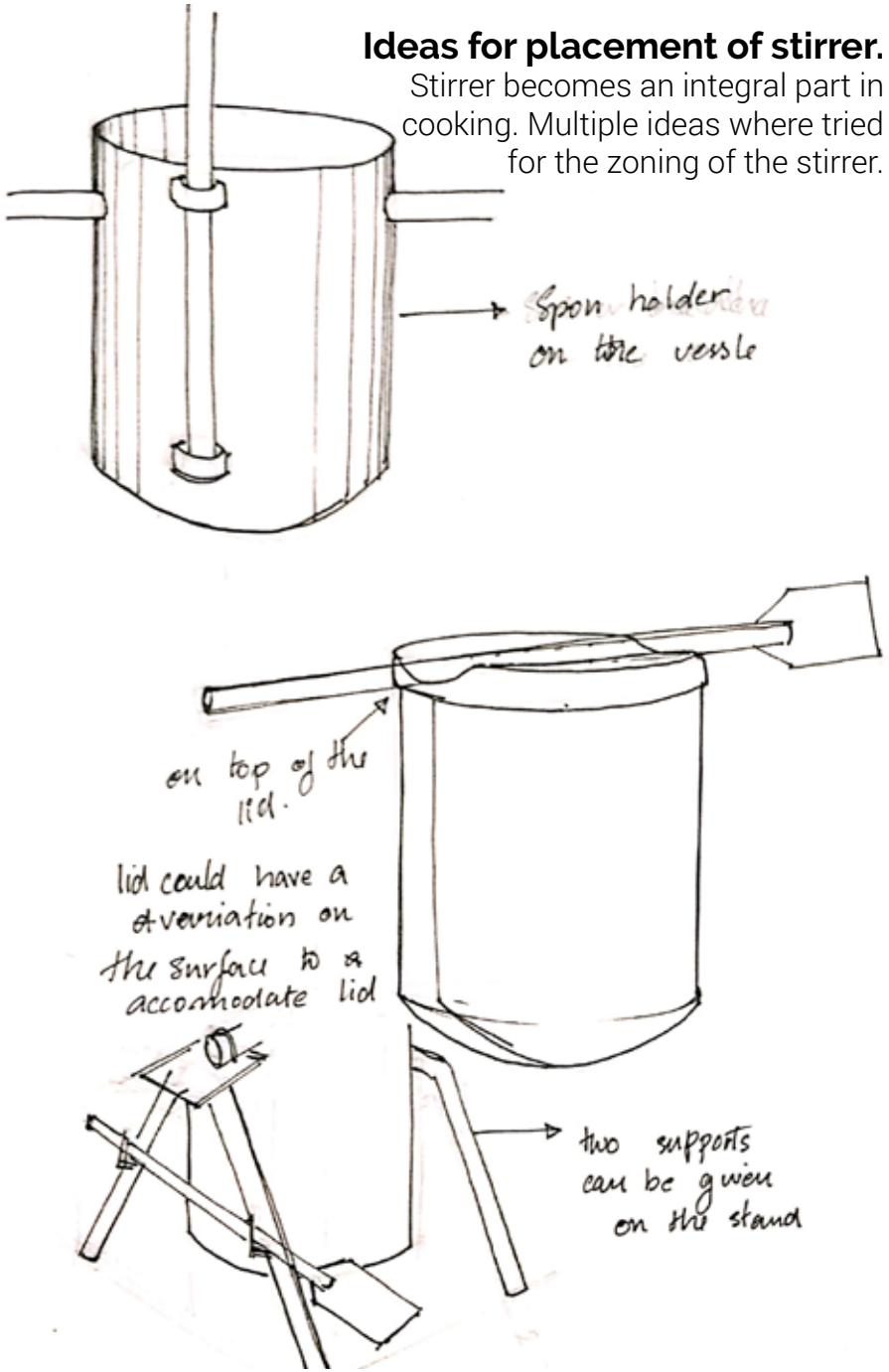
Ideas for cleaning.

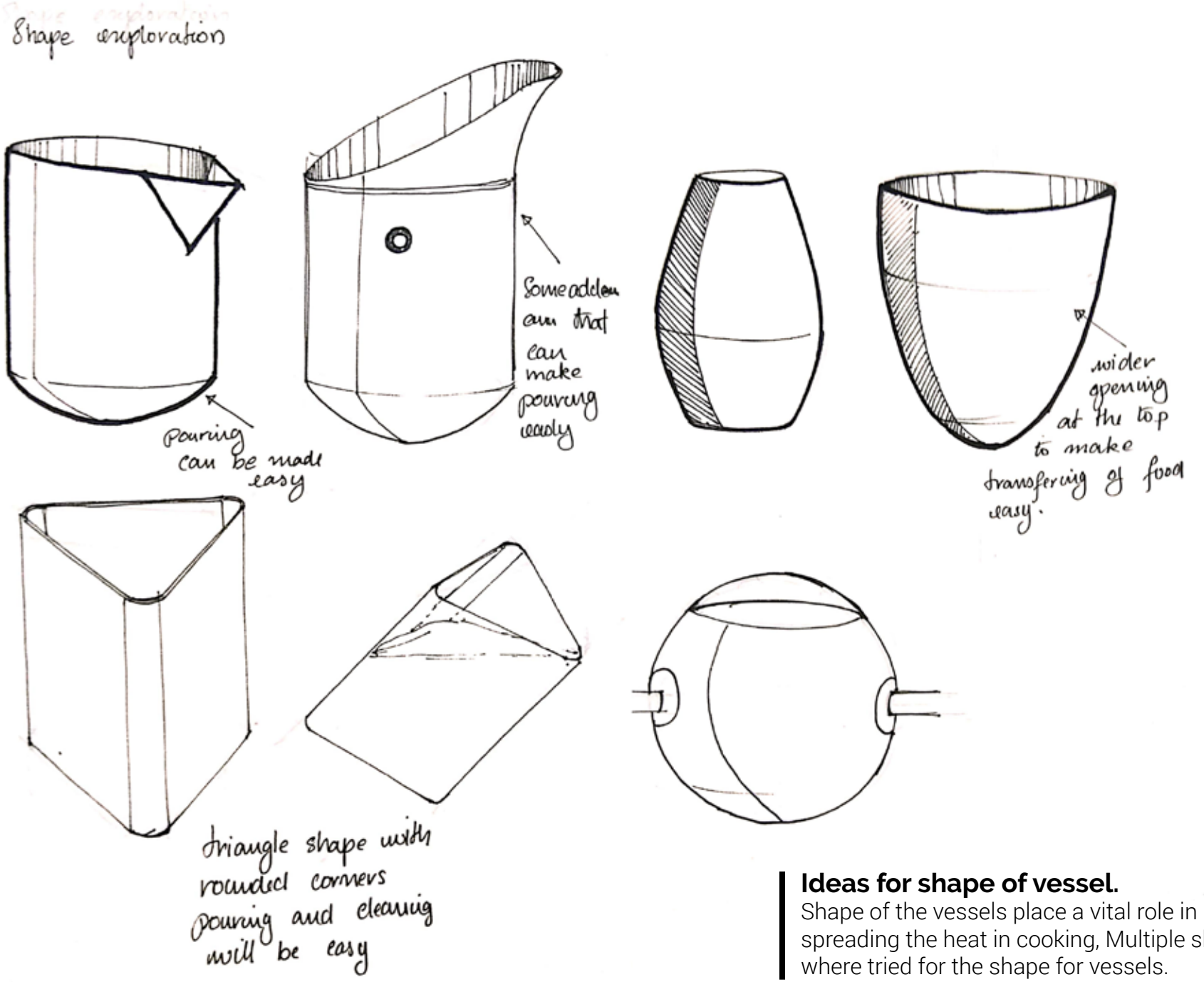
Cleaning is always a concern especially when its a cooking device. Different methods of vessel cleaning were tried out.



Ideas for placement of stirrer.

Stirrer becomes an integral part in cooking. Multiple ideas where tried for the zoning of the stirrer.

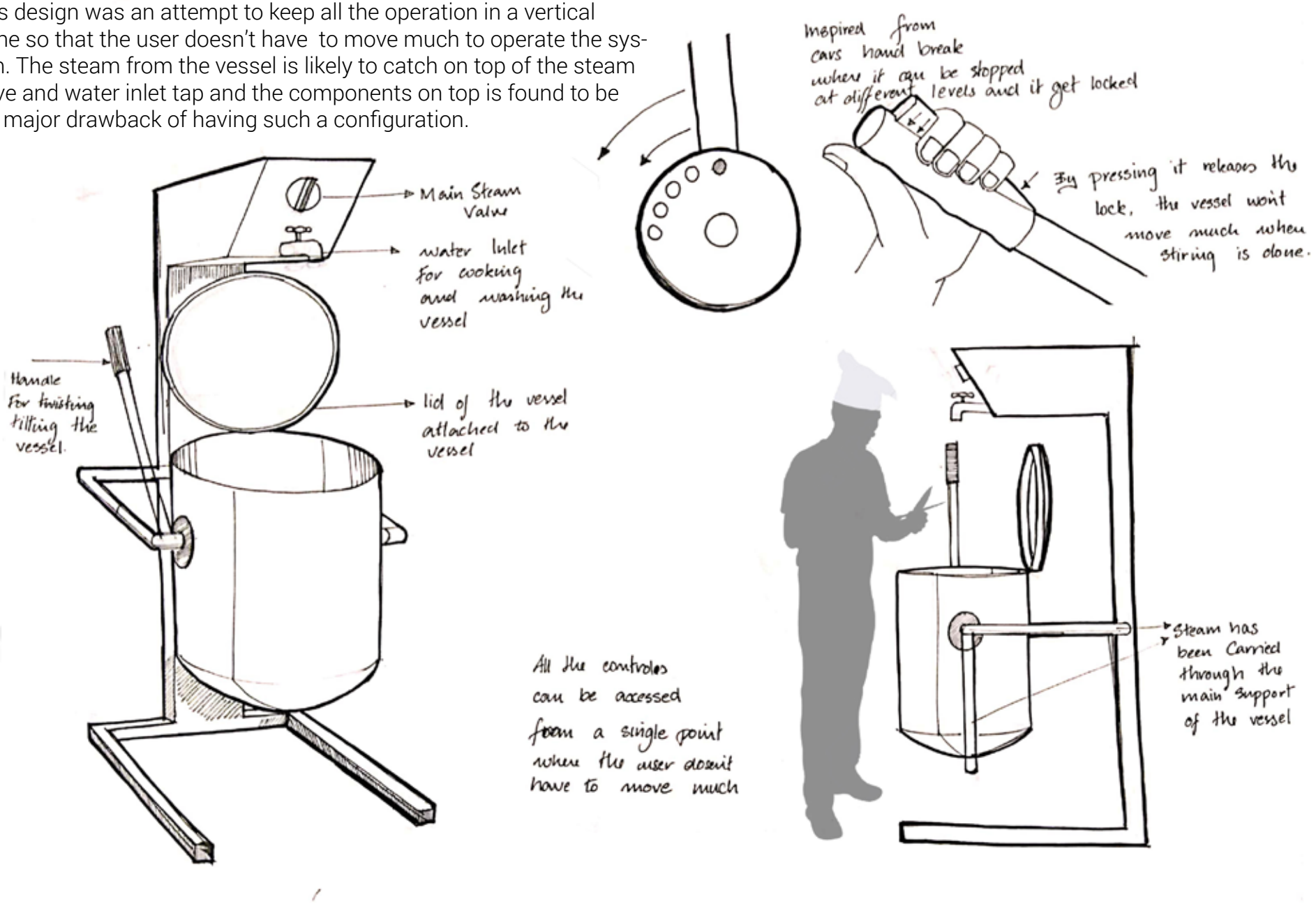




Ideas for shape of vessel.
Shape of the vessels place a vital role in spreading the heat in cooking, Multiple shapes where tried for the shape for vessels.

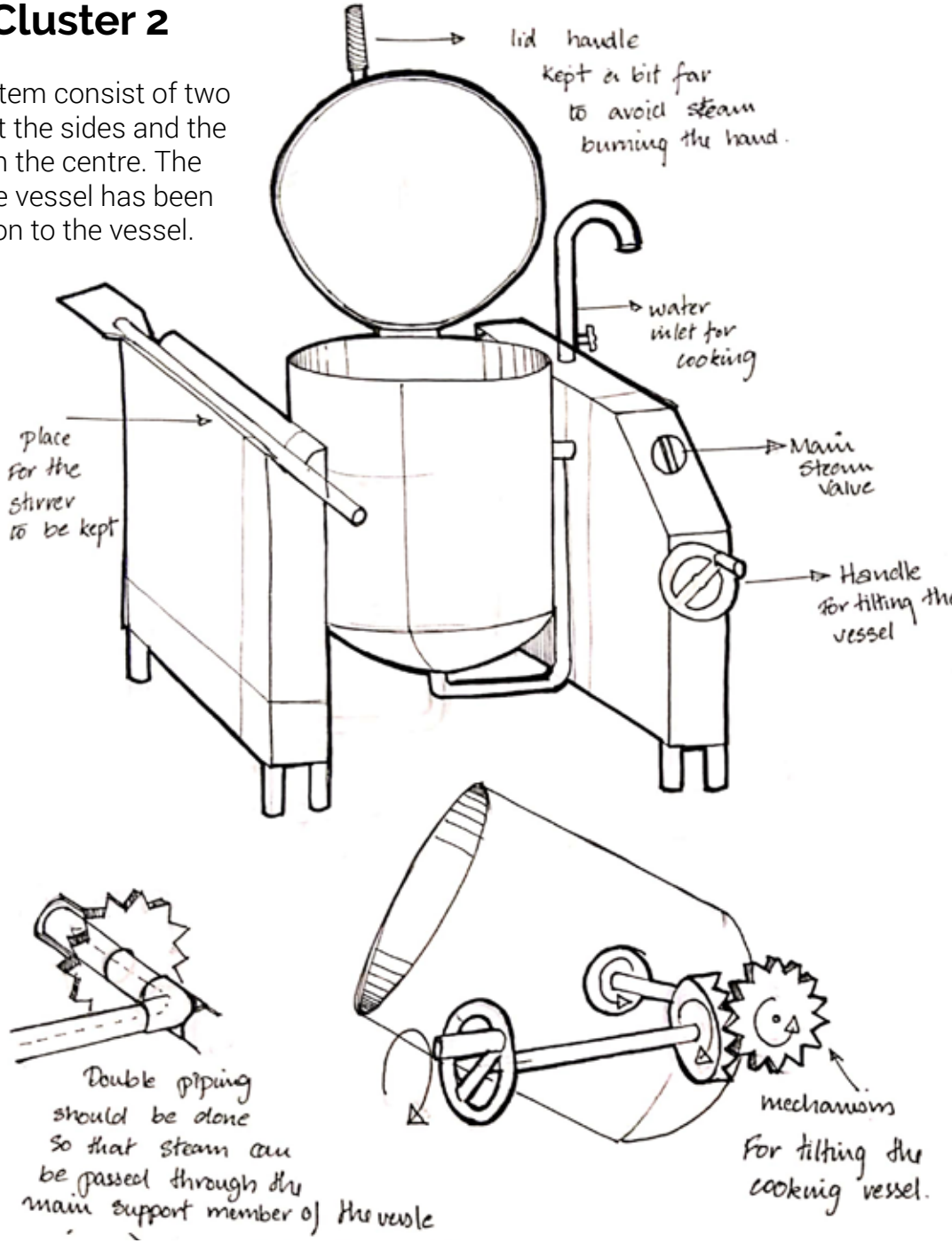
5.1. Cluster 1

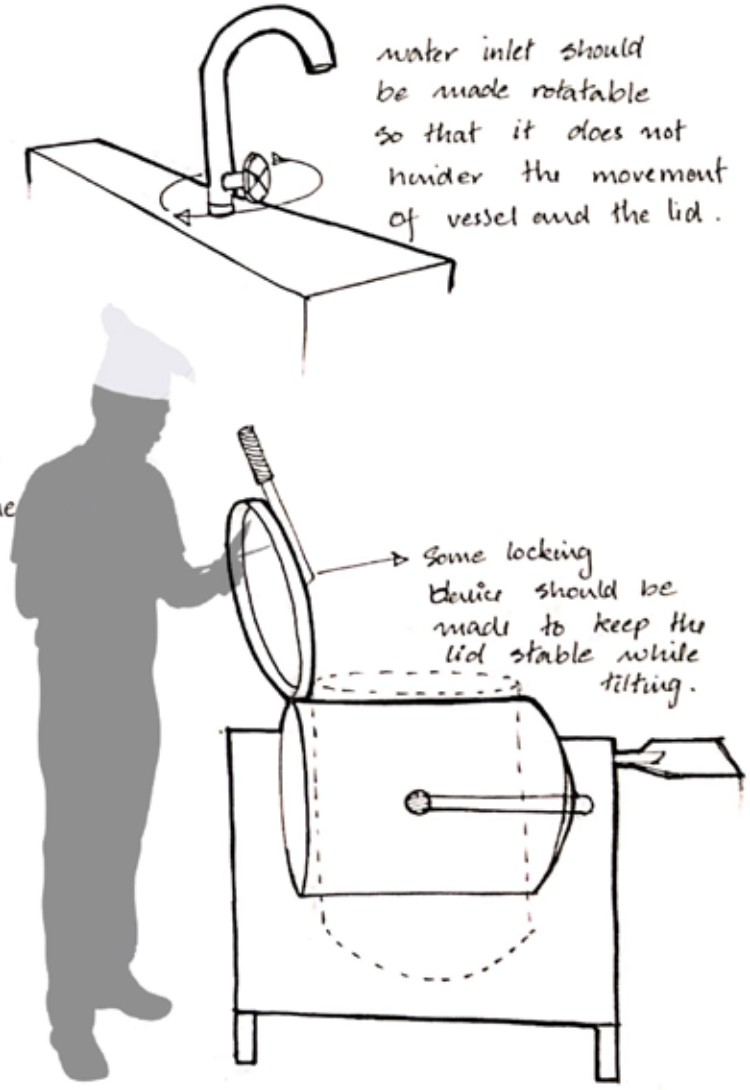
This design was an attempt to keep all the operation in a vertical plane so that the user doesn't have to move much to operate the system. The steam from the vessel is likely to catch on top of the steam valve and water inlet tap and the components on top is found to be the major drawback of having such a configuration.



5.2. Cluster 2

The system consist of two boxes at the sides and the vessel in the centre. The lid of the vessel has been hinged on to the vessel.

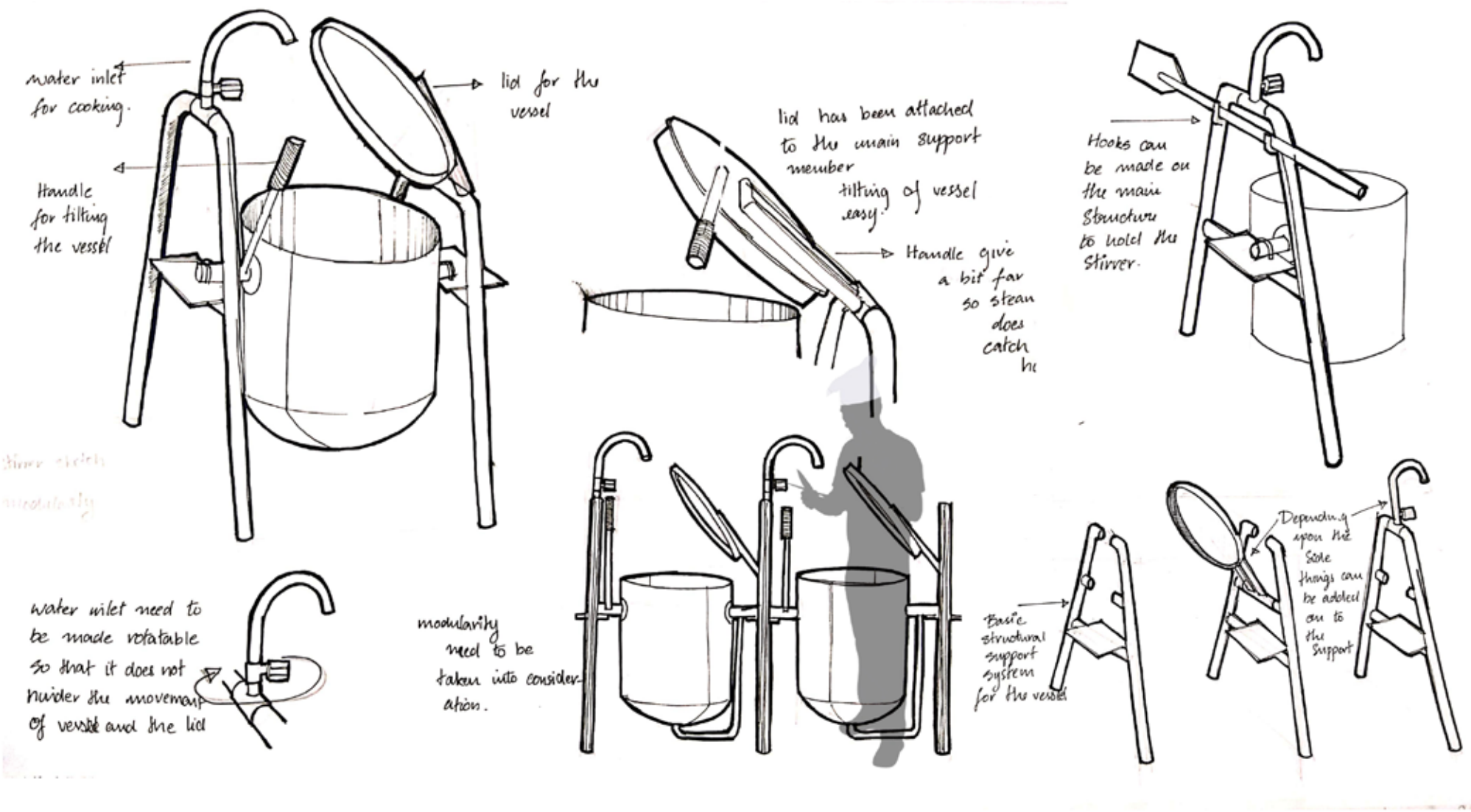




The vessel has a hole need to be tilted keeping the lid hinged to the vessel makes it difficult for tilting.

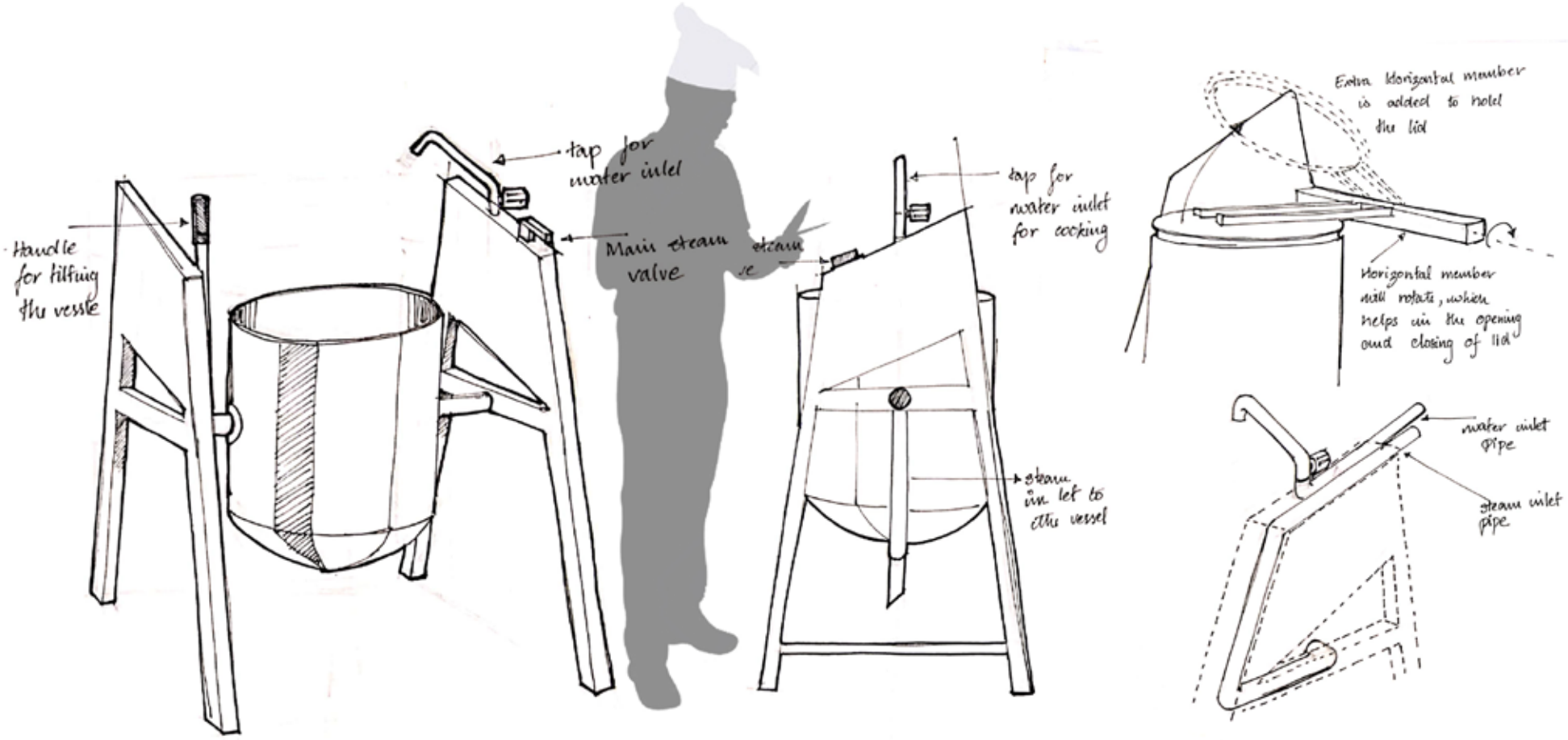
5.3. Cluster 3

Modularity was considered as a major factor in this ideation. The main structural member is designed in such a way that more vessels can be attached side by side. Making it modular helps in breaking it down to smaller components when in time of transportation.



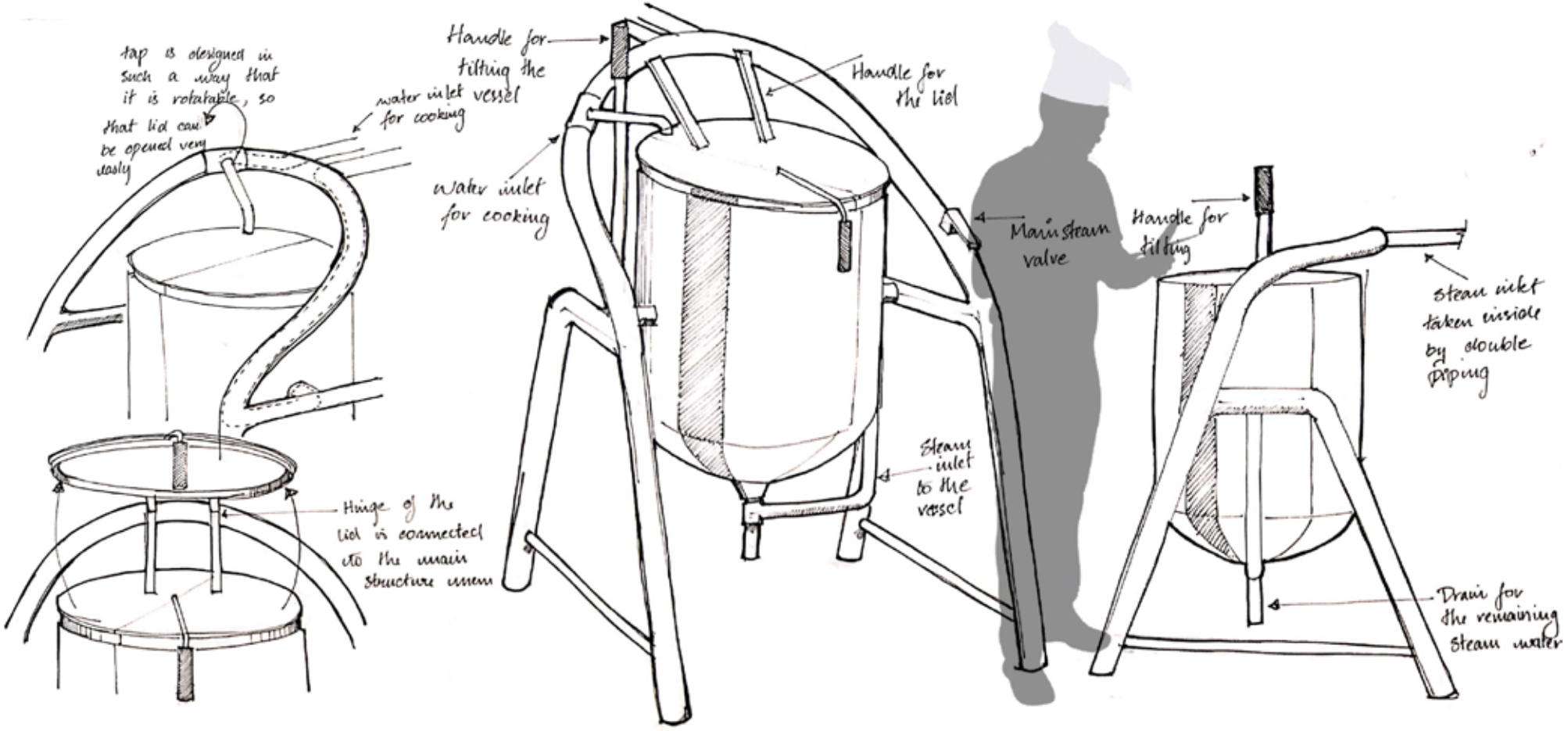
5.4. Cluster 4

The main structure has been designed using square box section which is considered to be strong but for kitchen purposes it is better to go for seamless surfaces so that it becomes easy to maintain and clean. It would be preferred to avoid corners which cant be reached by hands because it can cause contamination.



5.5. Cluster 5

The technique of double piping has been used in this ideation. The main steam pipe and the water inlet pipe is passed through the main structural member. The drawback of the design was, all the controls are scattered.



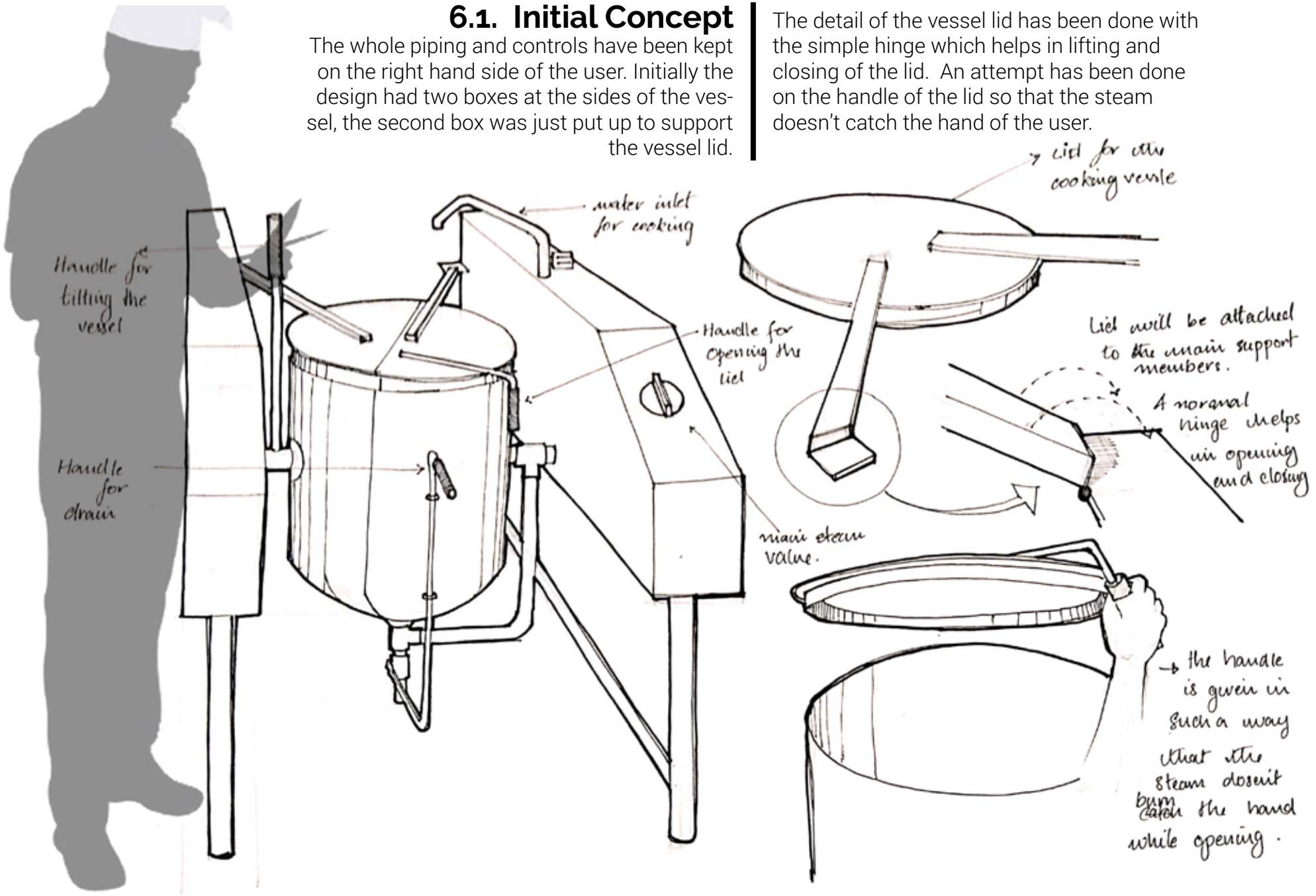
6. Final amalgamation of ideation - Concept

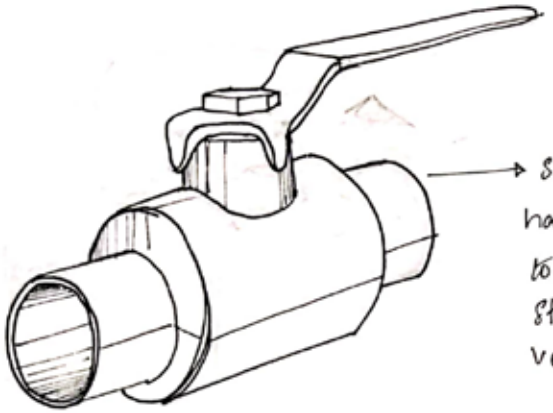
From the initial ideations and the inference made from those, the final concept has been arrived. The idea was to keep all the main controls and valves in a single side rather than scattering them all over which makes it easy to handle the device and to keep the design as simple as possible.

6.1. Initial Concept

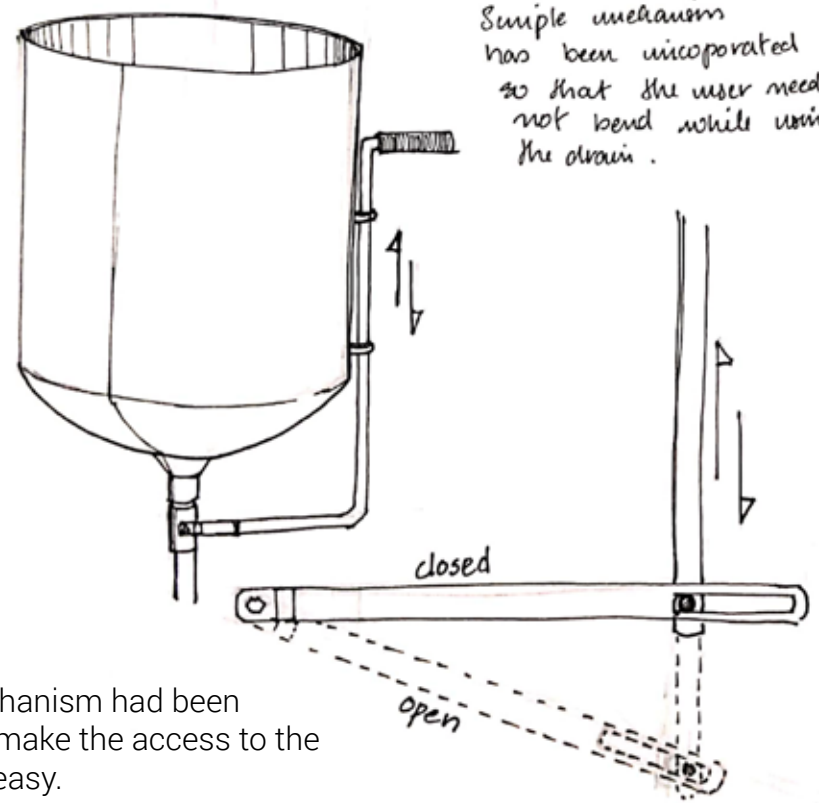
The whole piping and controls have been kept on the right hand side of the user. Initially the design had two boxes at the sides of the vessel, the second box was just put up to support the vessel lid.

The detail of the vessel lid has been done with the simple hinge which helps in lifting and closing of the lid. An attempt has been done on the handle of the lid so that the steam doesn't catch the hand of the user.



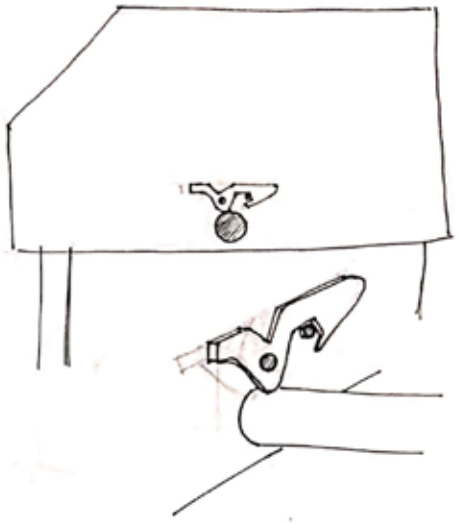


Standarid Valve has been used to to drain the excess steam/water in the vessel

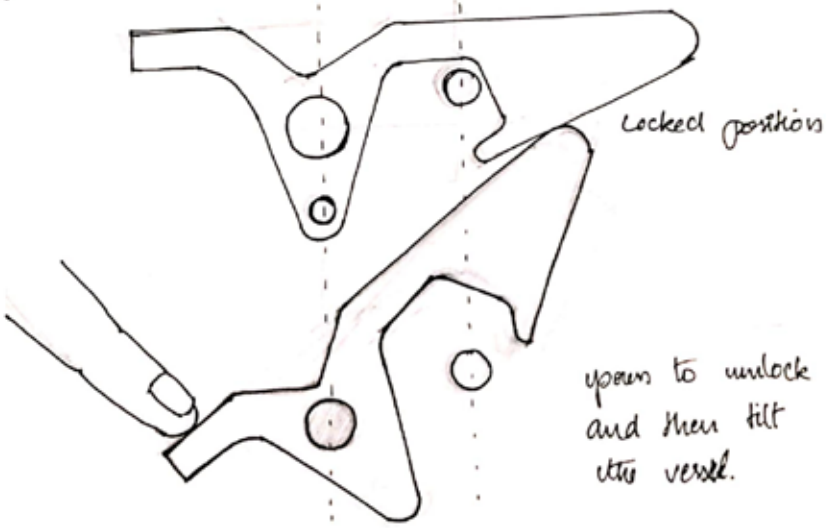


Simple mechanism has been incoporated so that the user need not bend while using the drain.

Simple mechanism had been tried out to make the access to the drain valve easy.



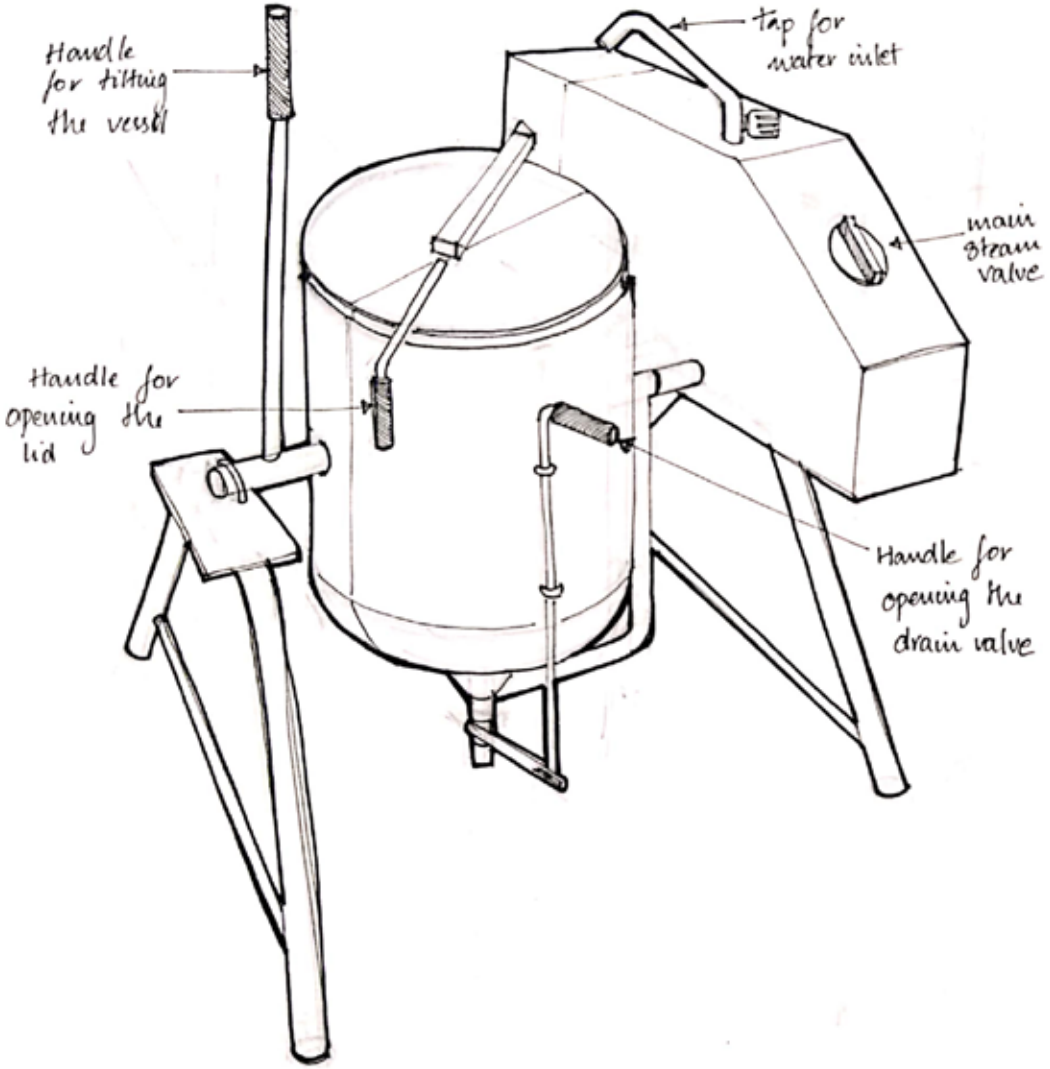
marine locking system has been used to lock the vessle in place.

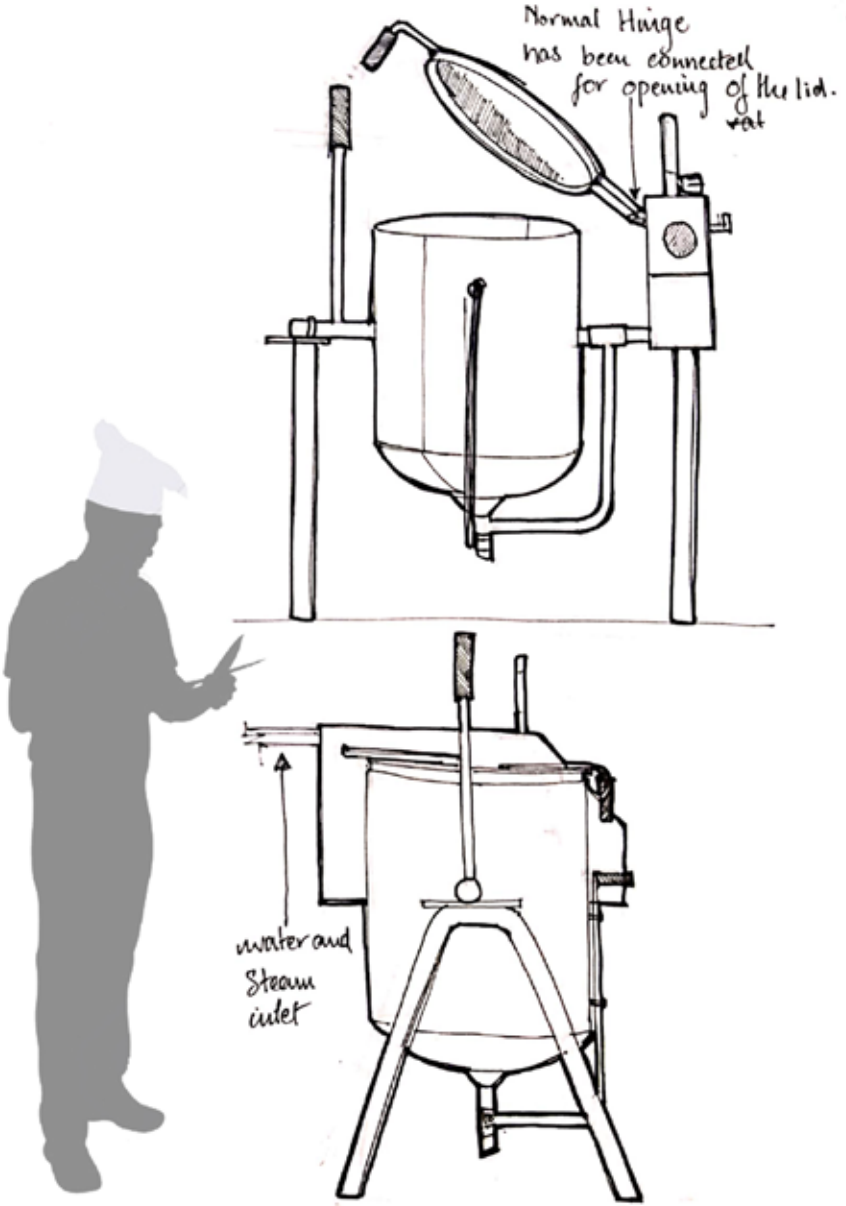


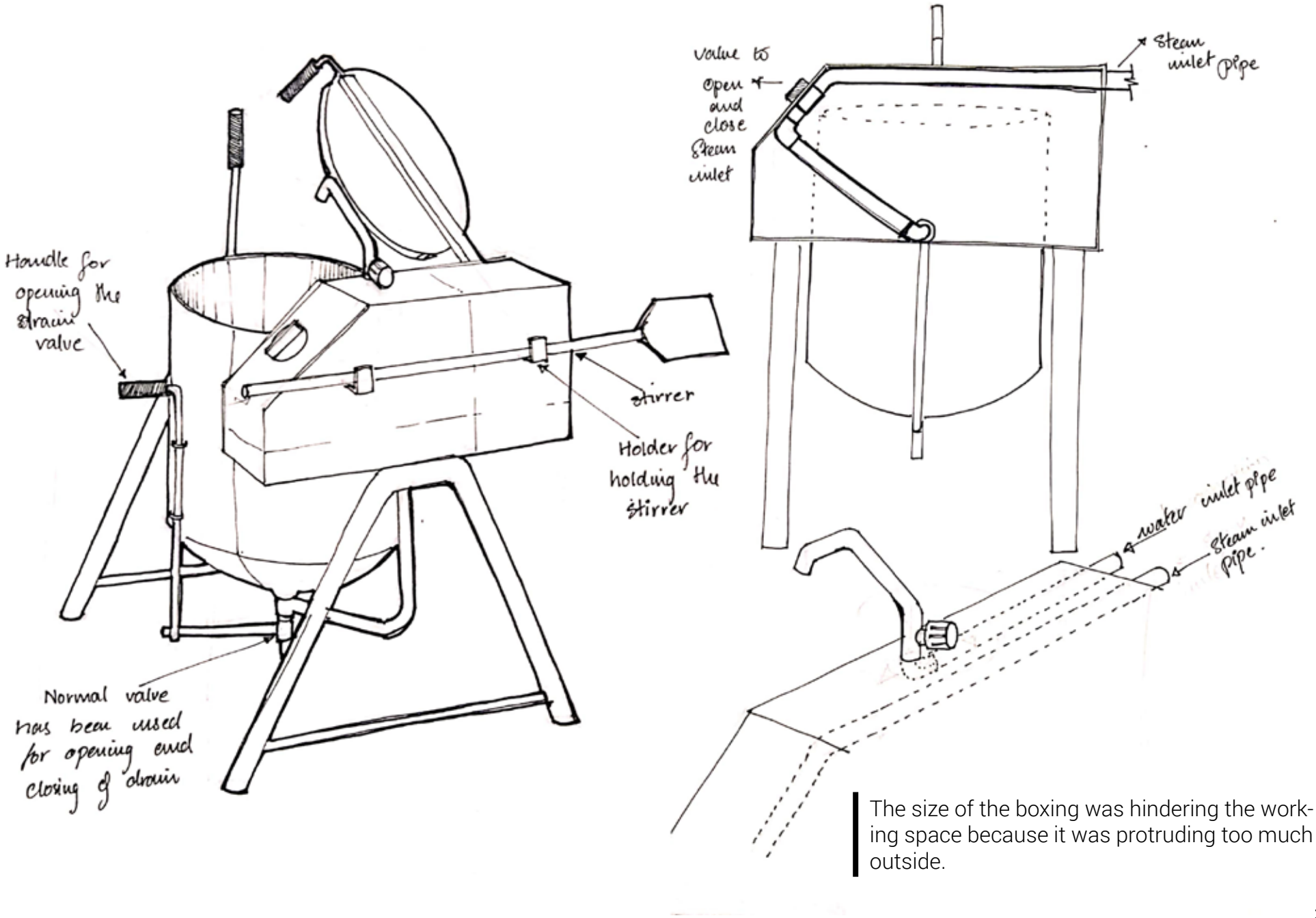
Marine locking system has been used as the locking mechanism for the vessel to hold in place.

6.2. Concept Refinement 1

Slight changes in the design has been tried by removing the boxing at one side, trying to bring down the materials used. Bring the support of the vessel lid just to one side.



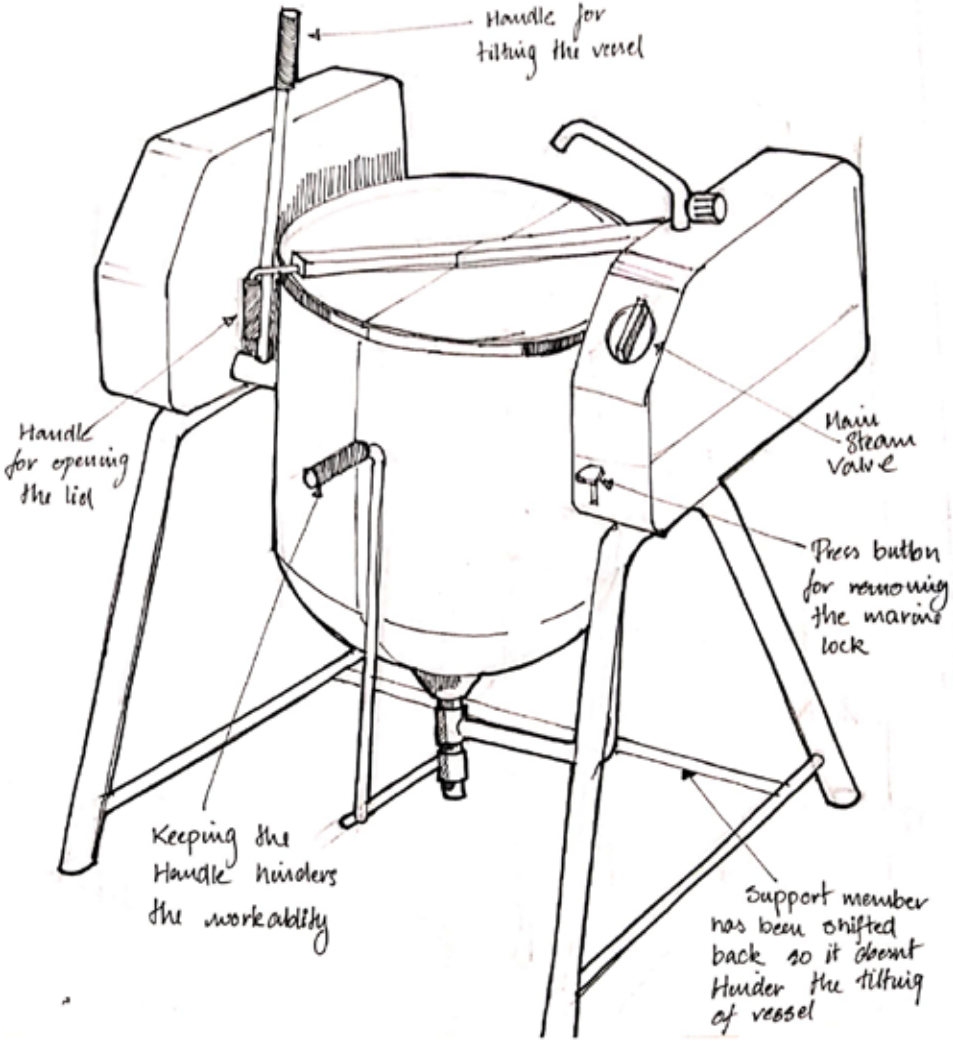


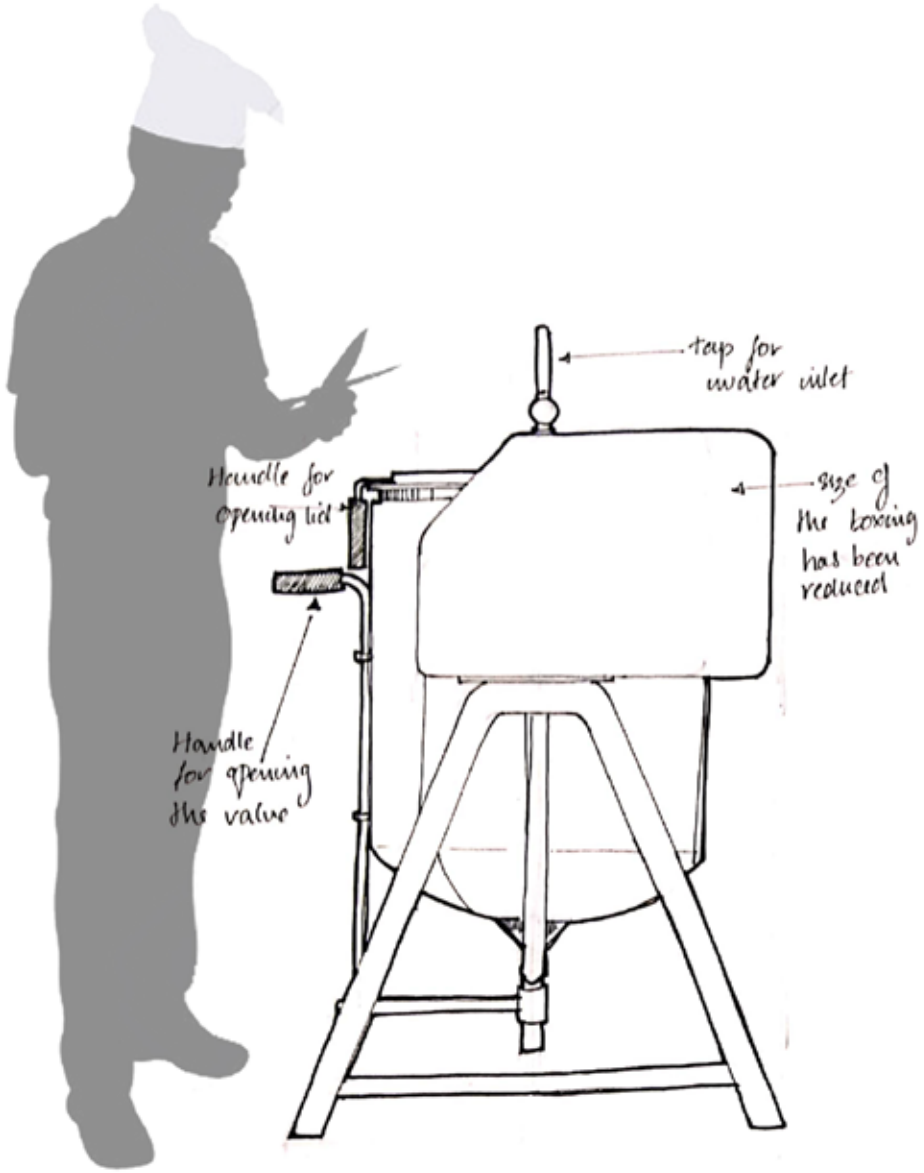


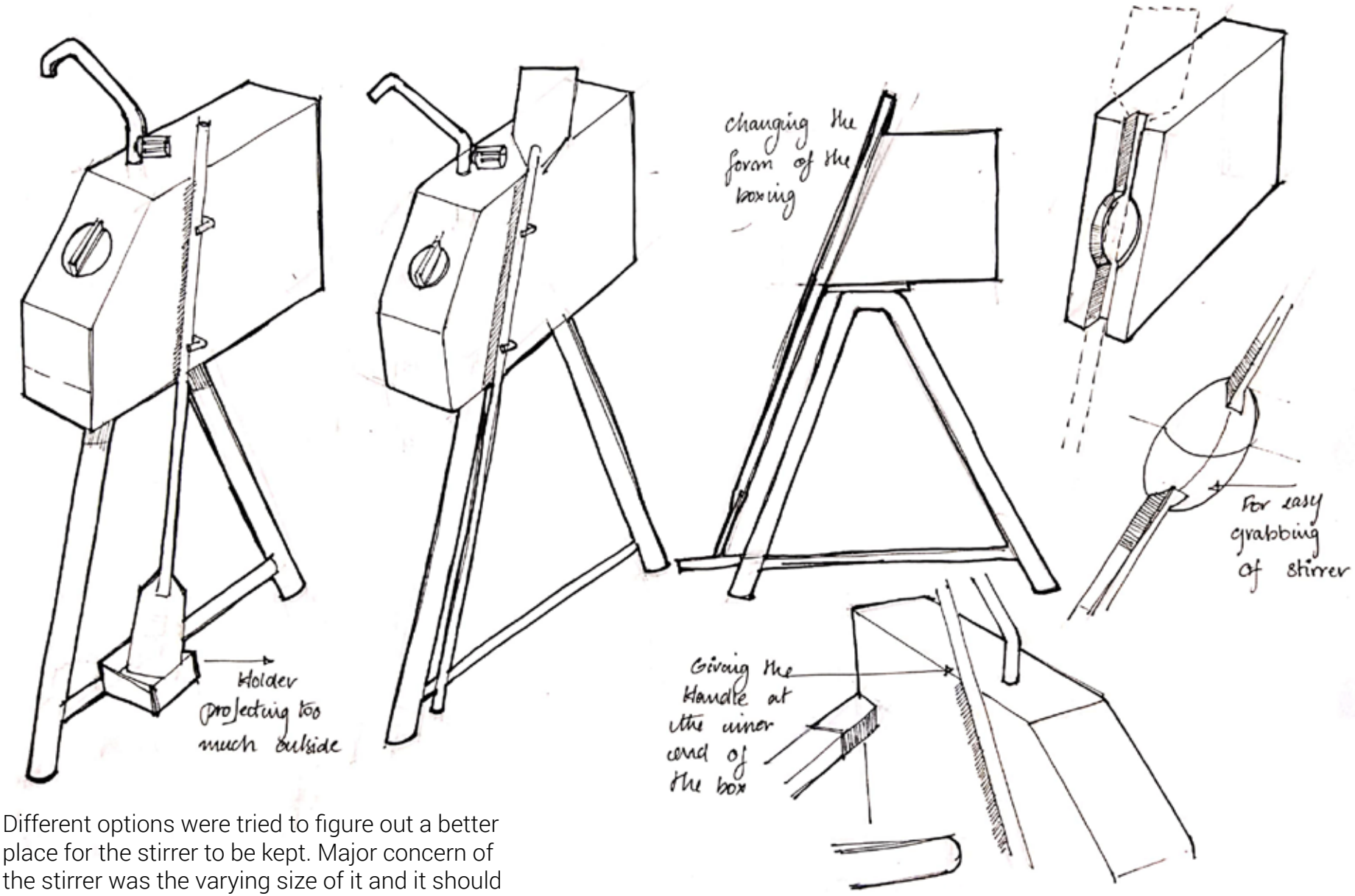
The size of the boxing was hindering the working space because it was protruding too much outside.

6.3. Concept Refinement 2

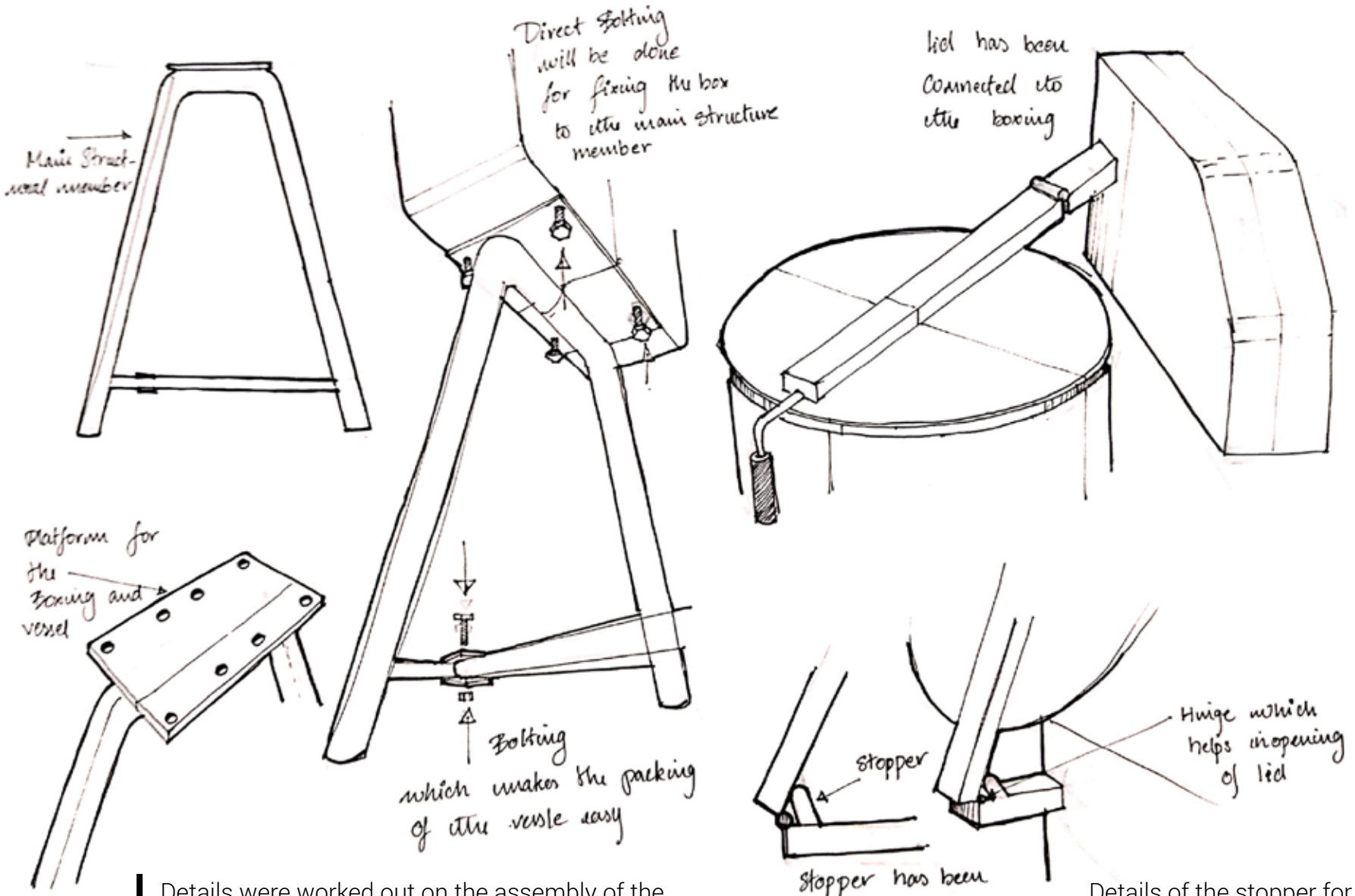
The size of the boxing was made smaller and the boxing was given on both the sides for hygienic purpose. Boxing would not add a major burden on the costing of the system.







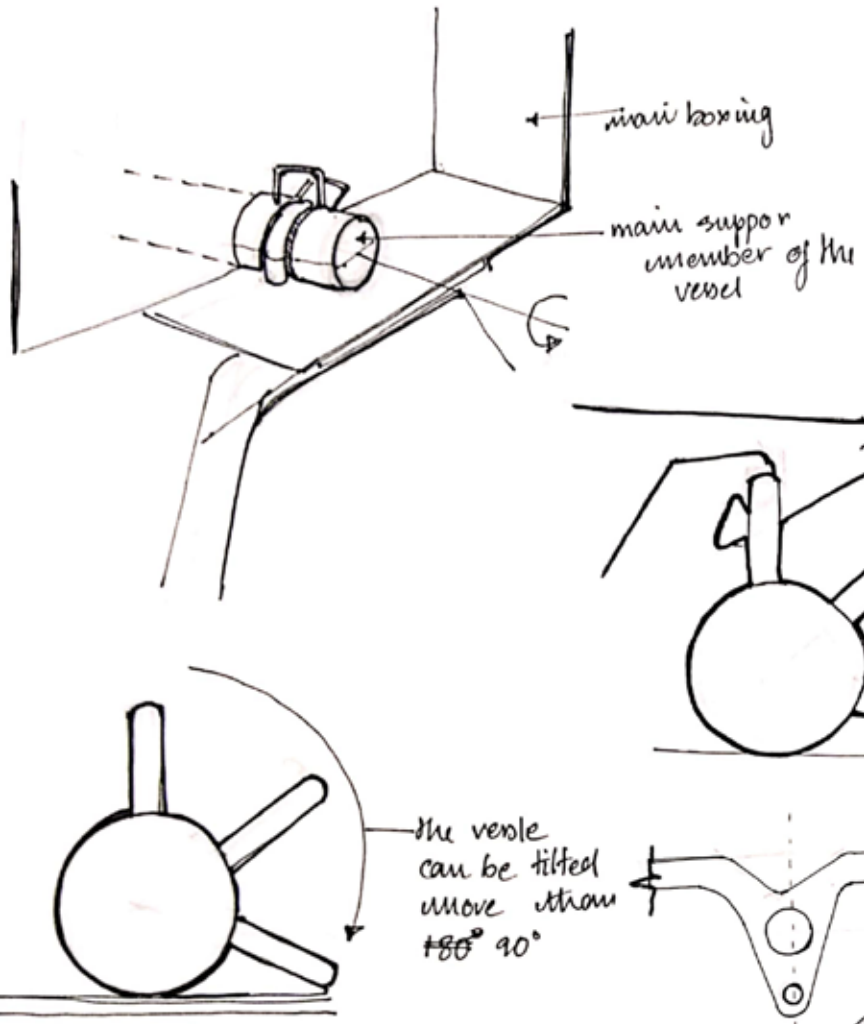
Different options were tried to figure out a better place for the stirrer to be kept. Major concern of the stirrer was the varying size of it and it should not hinder the other function of the system too.

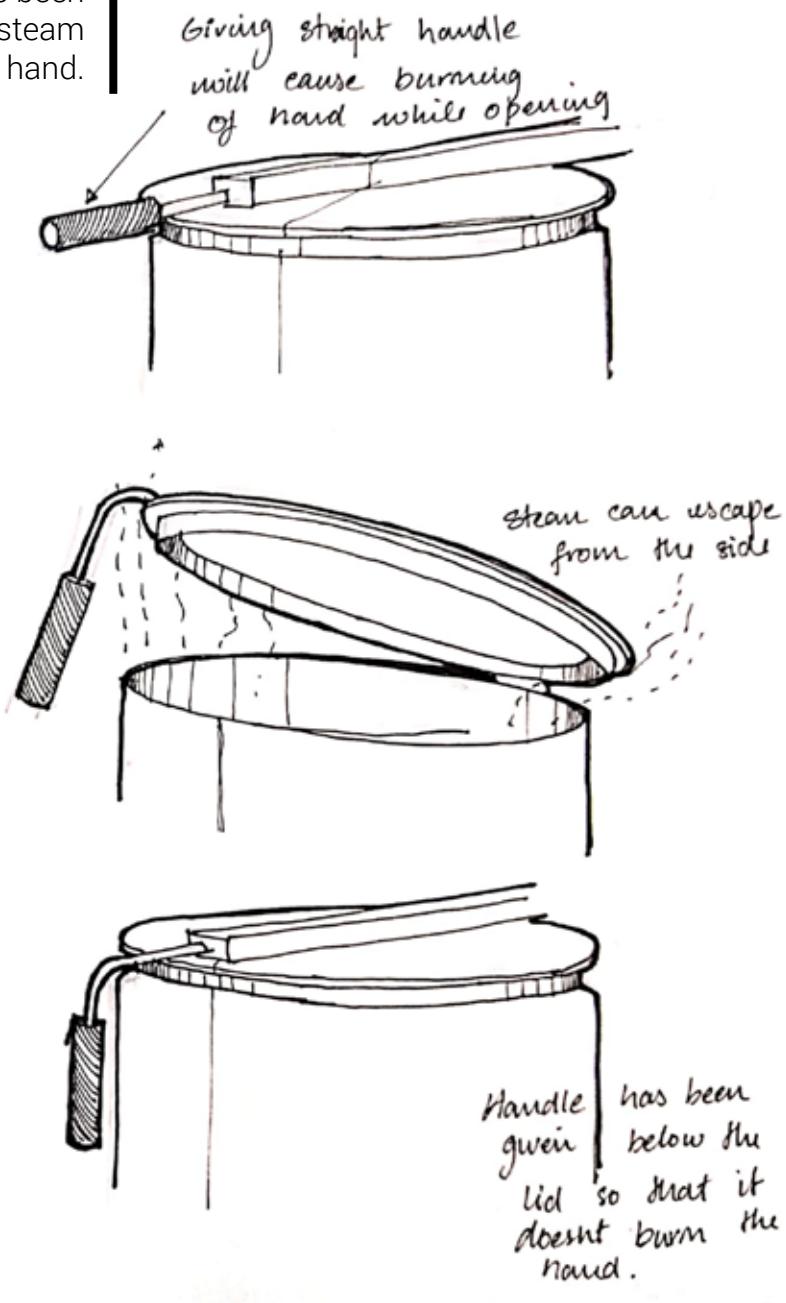


Details were worked out on the assembly of the product and it can be brought down into smaller components.

Details of the stopper for the lid of the vessel considering the reachability for it.

Detail for the vessel that has been worked out considering the steam falling to the hand.





The locking system has been designed is such a way that it gets locked in three positions. One when the vessel is upright one in the middle and the other position when it is completely tilted.

6.4. Mock up scale models.

Fig47. Mock up model of the initial concept.

Fig48. Mock up model of the first refinement

Fig49. Mock up model of the second refinement

Fig50. Front view of the mock up model from second refinement

Fig51. Lid open position of the mock up model.

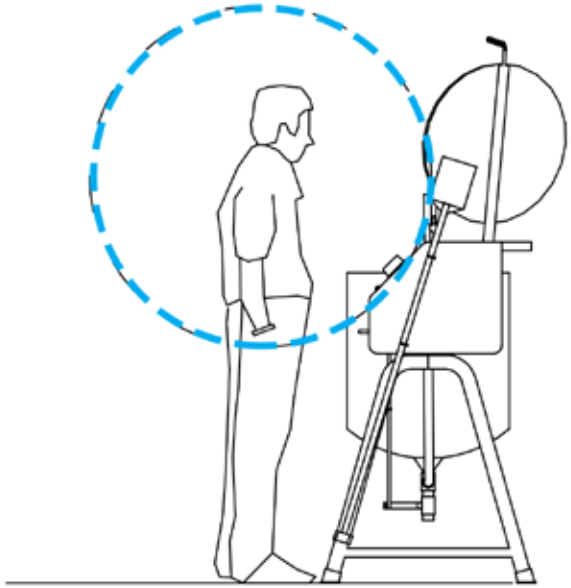
Fig52. Tilting vessel position of the mock up model.

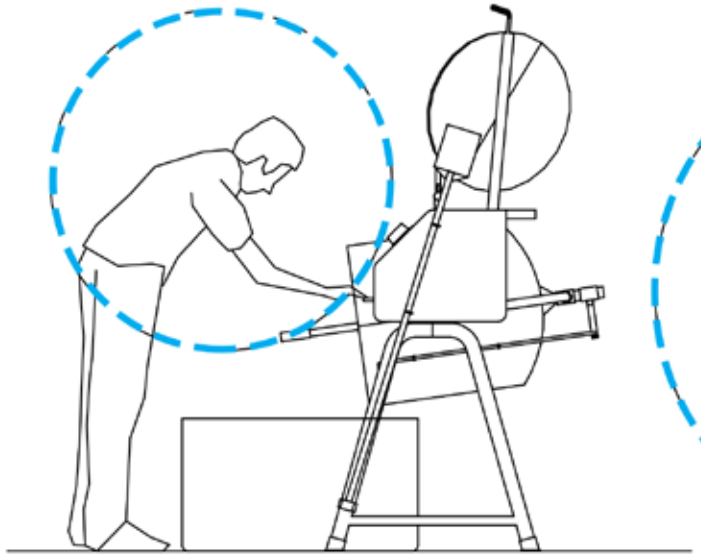
6.5. 3D renderings of the final look and feel of the vessel.

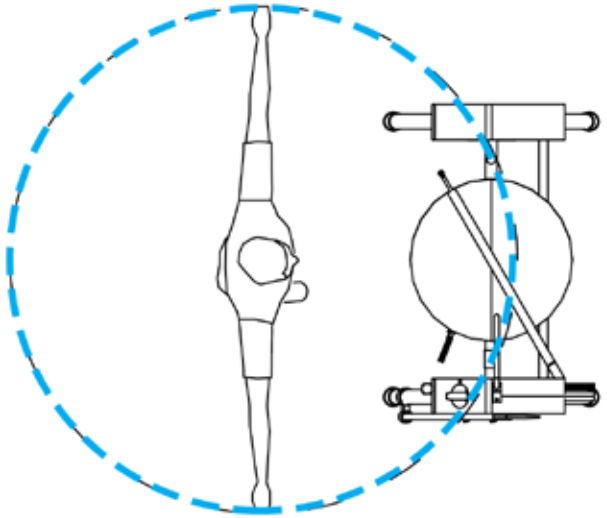
6.6. Ergonomics in the design.

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

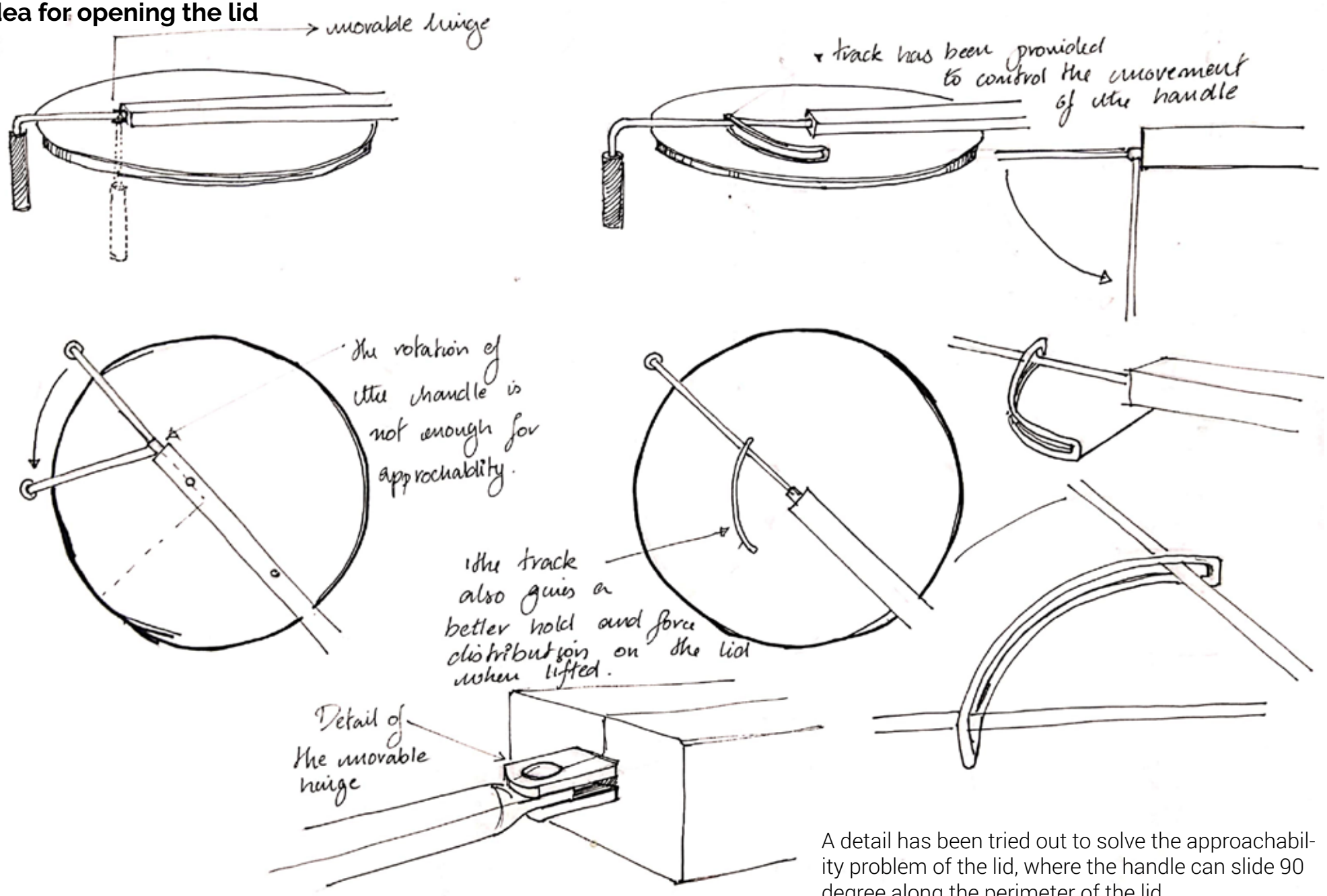
Parameters		Percentiles		
		50th	75th	90th
Stature (Height)	Male	1648	1691	1781
	Female	1517	1567	1632
	Combined	1619	1673	1771
Span	Male	1684	1739	1829
	Female	1549	1599	1679
	Combined	1659	1724	1809
Acromion to stylion length (hand length)	Male	555	583	645
	Female	516	557	606
	Combined	548	579	635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





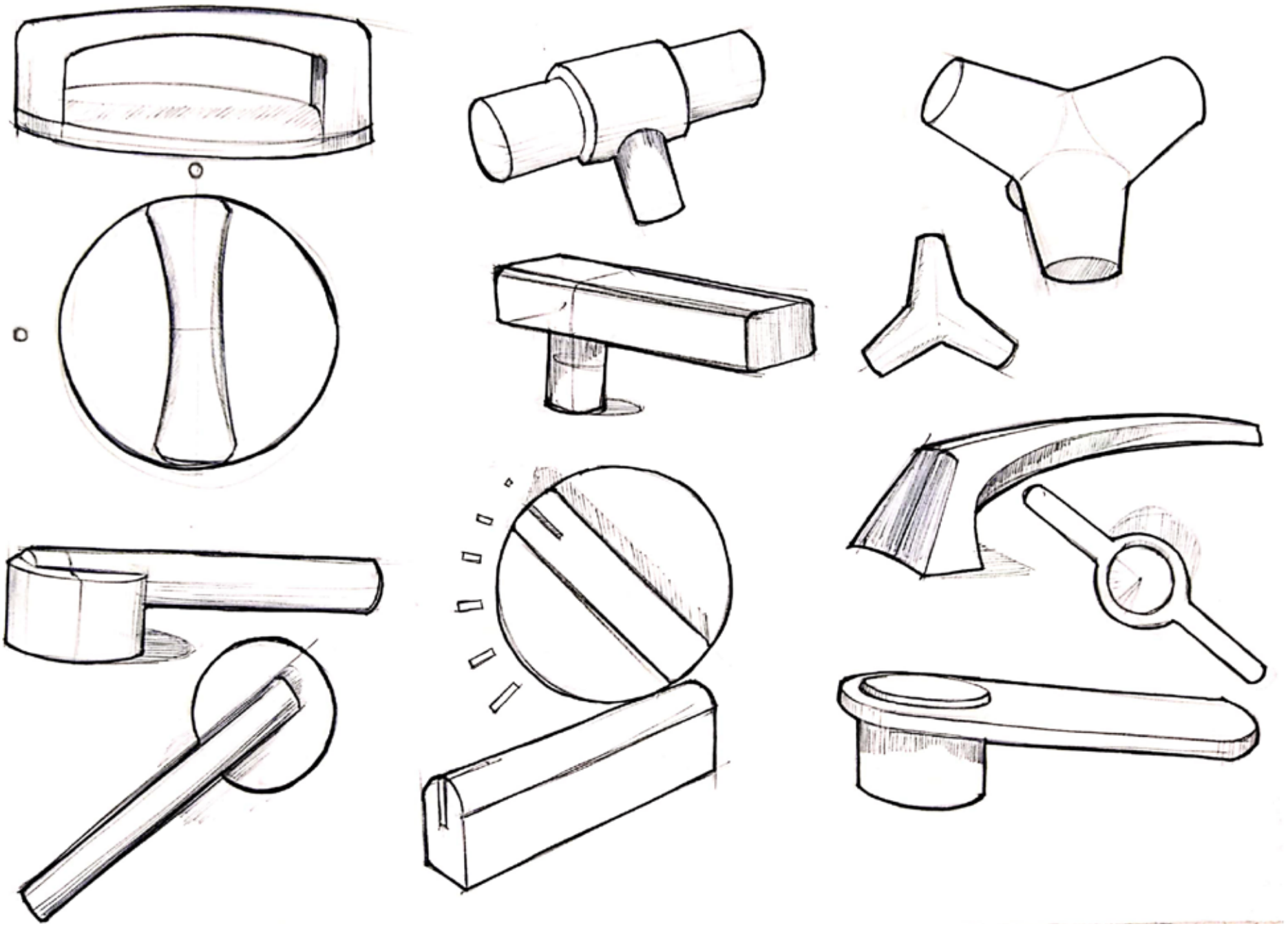


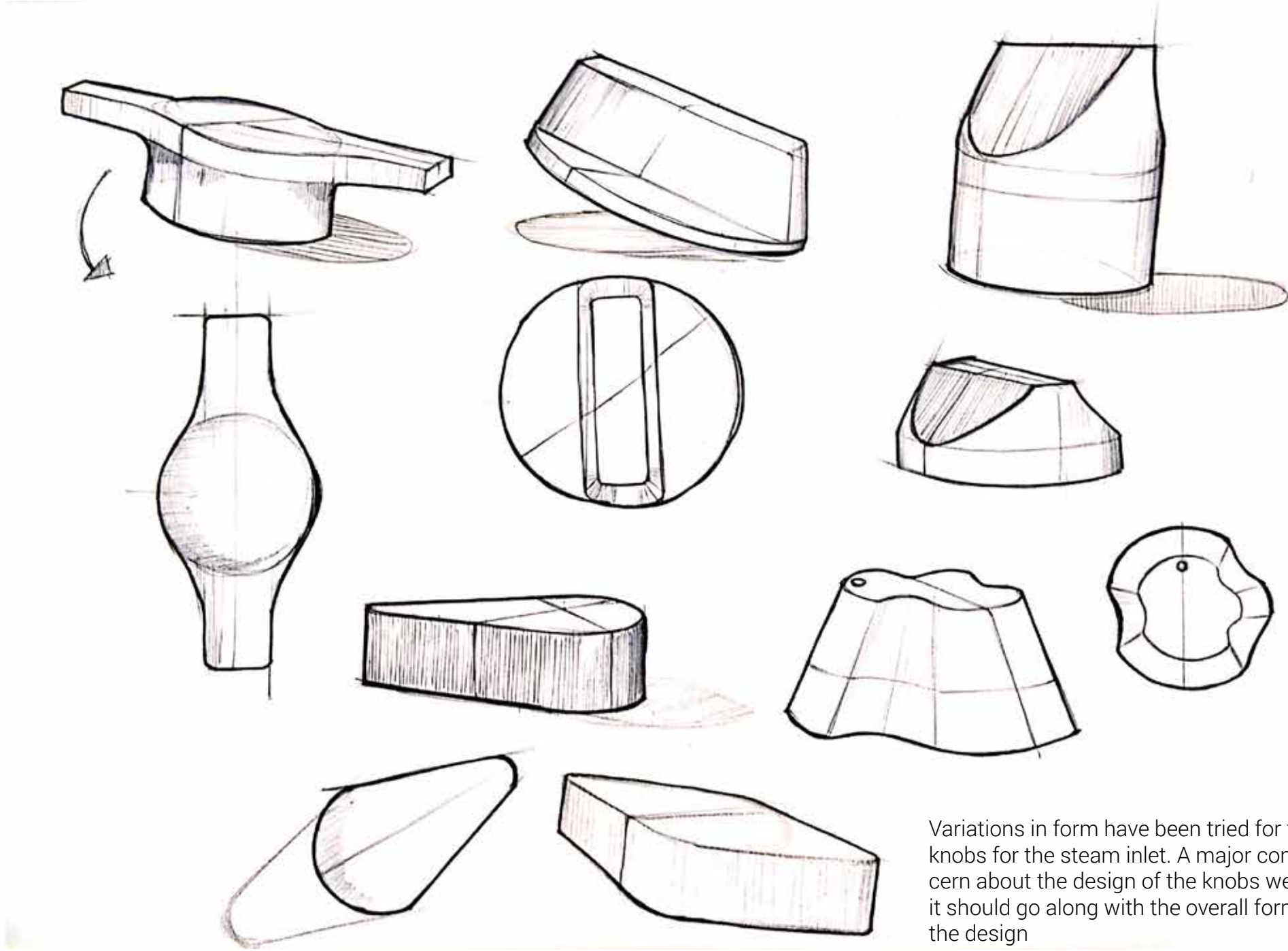
Idea for opening the lid



A detail has been tried out to solve the approachability problem of the lid, where the handle can slide 90 degree along the perimeter of the lid.

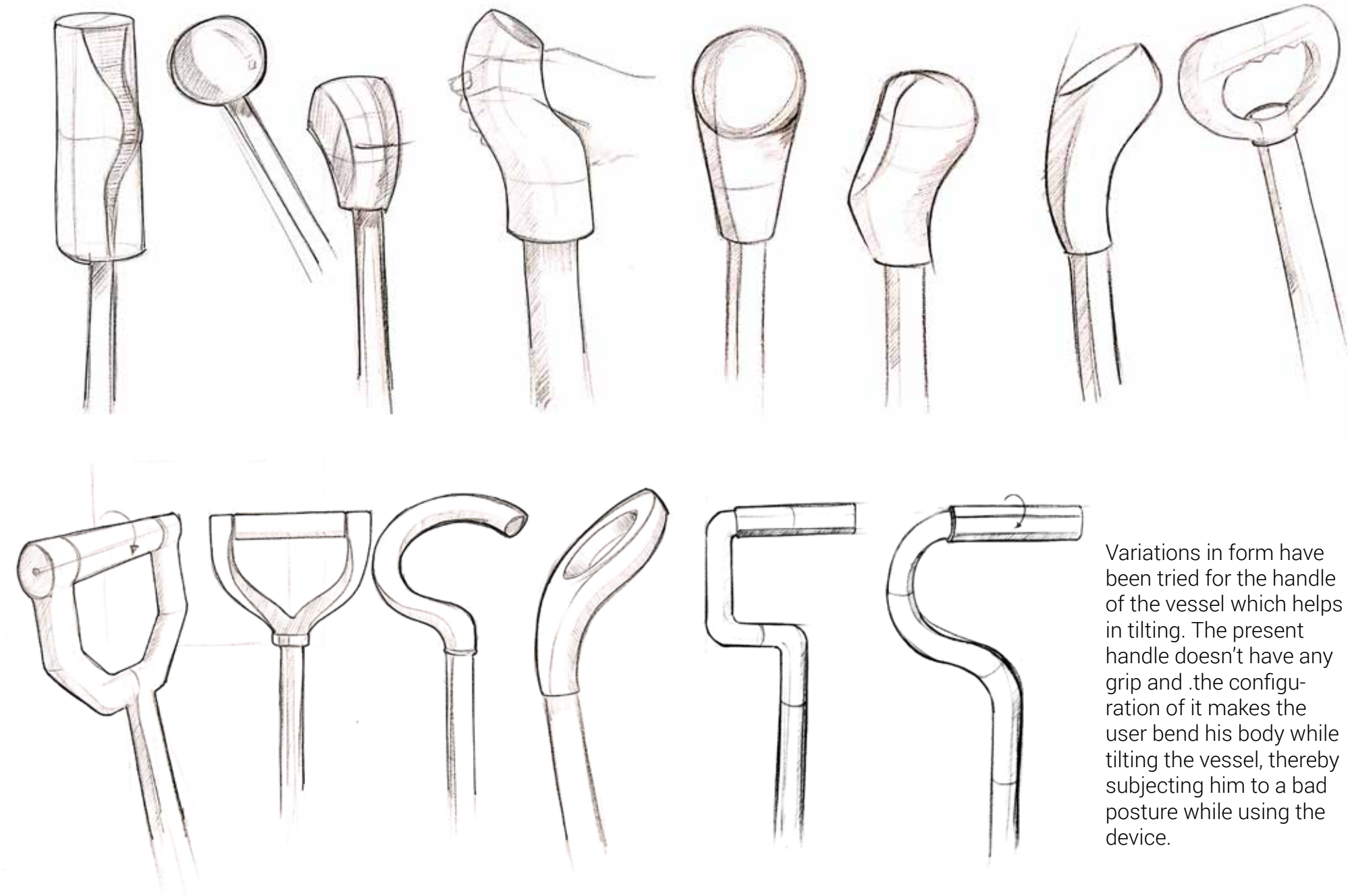
Details of knobs for the steam valve.





Variations in form have been tried for the knobs for the steam inlet. A major concern about the design of the knobs were, it should go along with the overall form of the design

Handel for tilting the vessel.

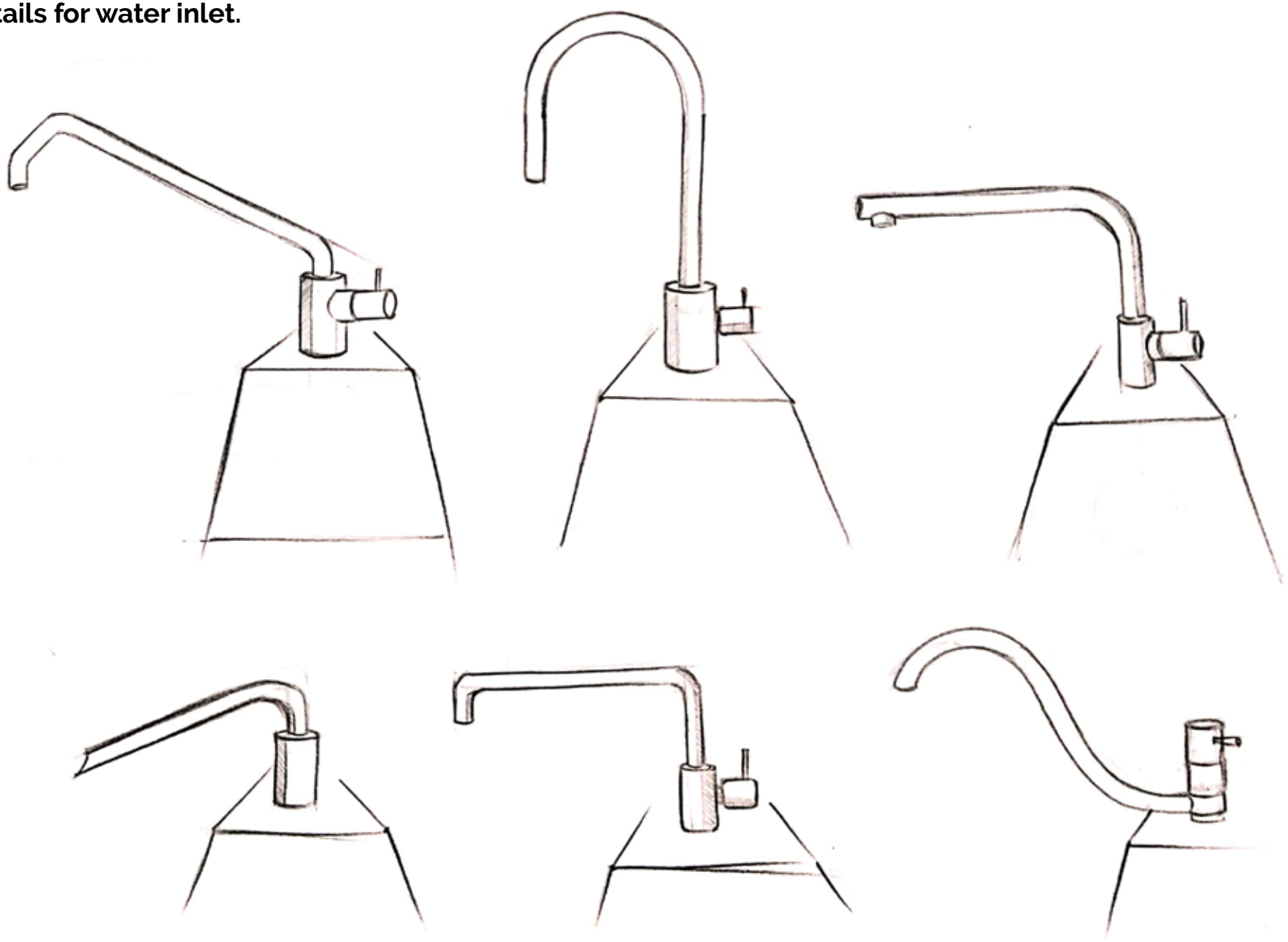


Variations in form have been tried for the handle of the vessel which helps in tilting. The present handle doesn't have any grip and .the configuration of it makes the user bend his body while tilting the vessel, thereby subjecting him to a bad posture while using the device.

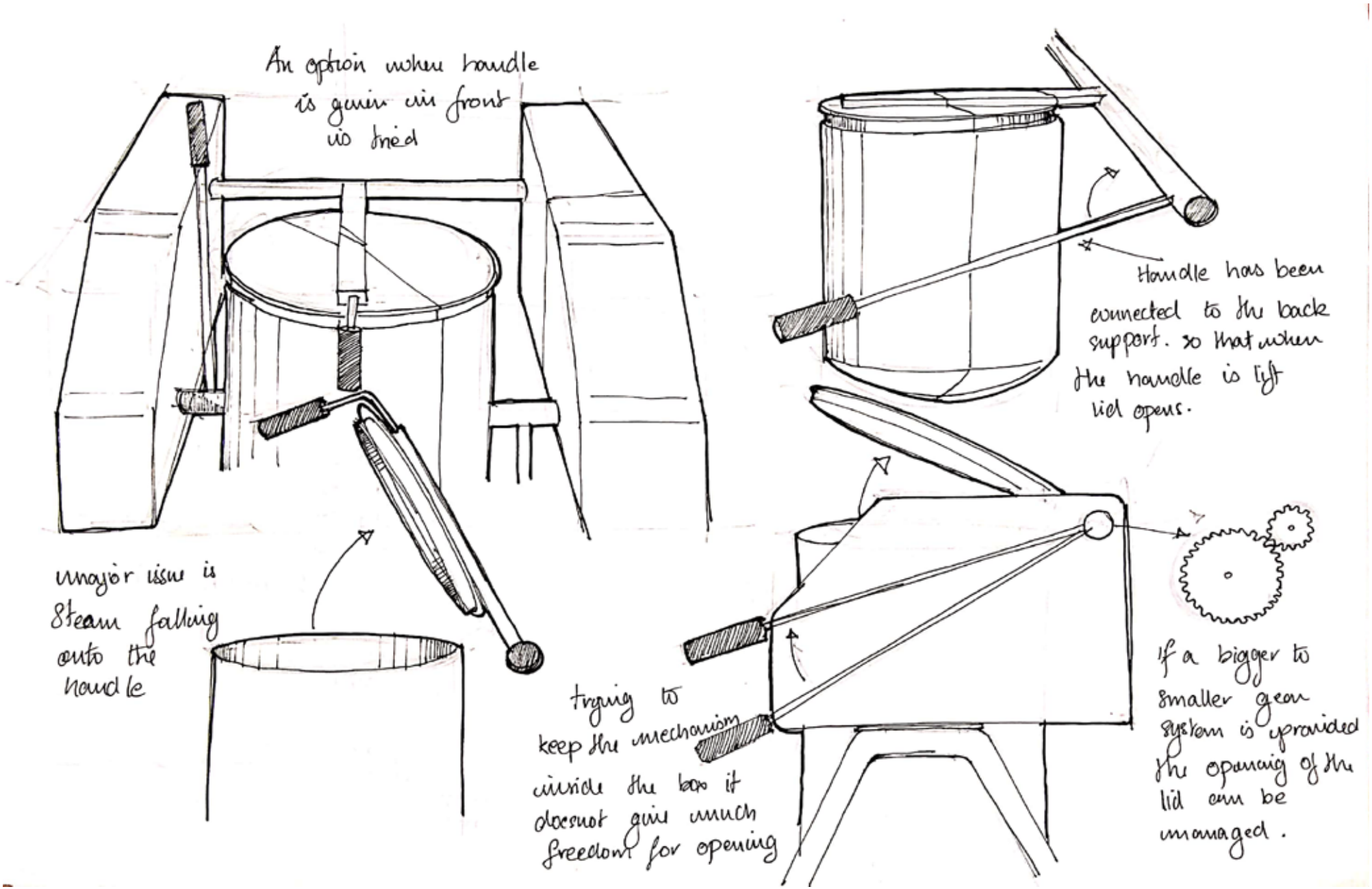
Mock up model made for the handles




Details for water inlet.



Idea for opening the lid

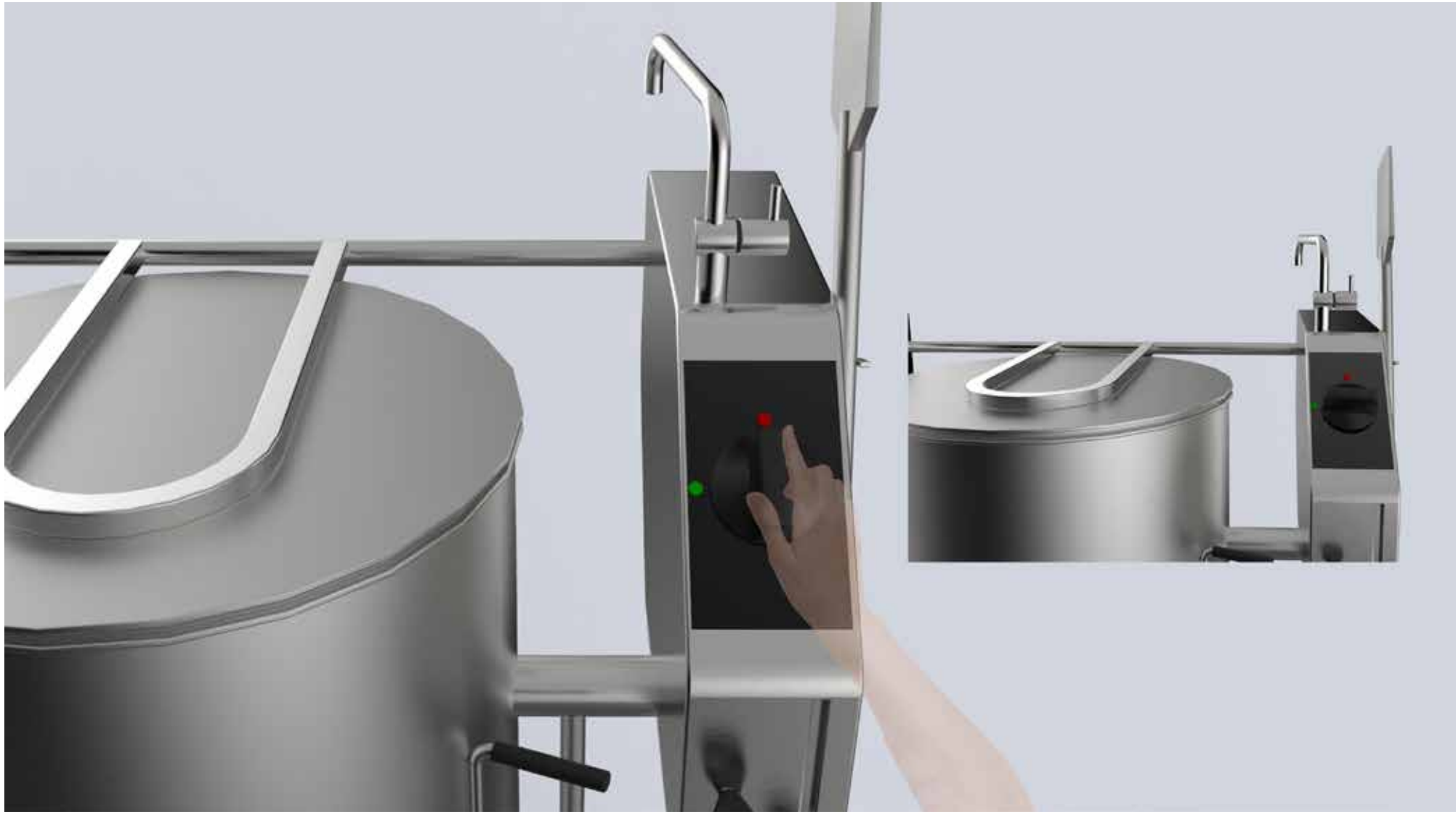


6.7. Final design.

Process 1

The water inlet valve has been open to fill the water into the vessel. Once the water is filled the tap is rotated in 90degree to any of the sides in such a way that it doesn't hinder the lid from closing. The lid is then closed by pushing the lever up.

Process 2



Once the lid is closed the steam valve is turned on. Two indicators have been provided to indicate the on and off position of the valve.

Red indicates that the steam in let is off and green indicates that one has turned on the steam to the vessel.

Process 3

The lid is kept closed till the water gets boiled, once the water gets boiled washed rice is been transferred in to the cooking vessel using a big spoon. Then the lid is again closed using the lever.

Process 4

Once the rice is boiled for a while then the lid is opened and using a stirrer the consistency of the rice is checked. For the placement of the stirrer an extra element has been provided which can be easily fitted on to the supporting legs of the vessel and adjusted according to the height of the stirrer used.

Process 5

Once the rice is cooked then the remaining water needs to be drained out. The handle attached to the vessel is pushed down to open the drain valve, the excess water is drained out through it.

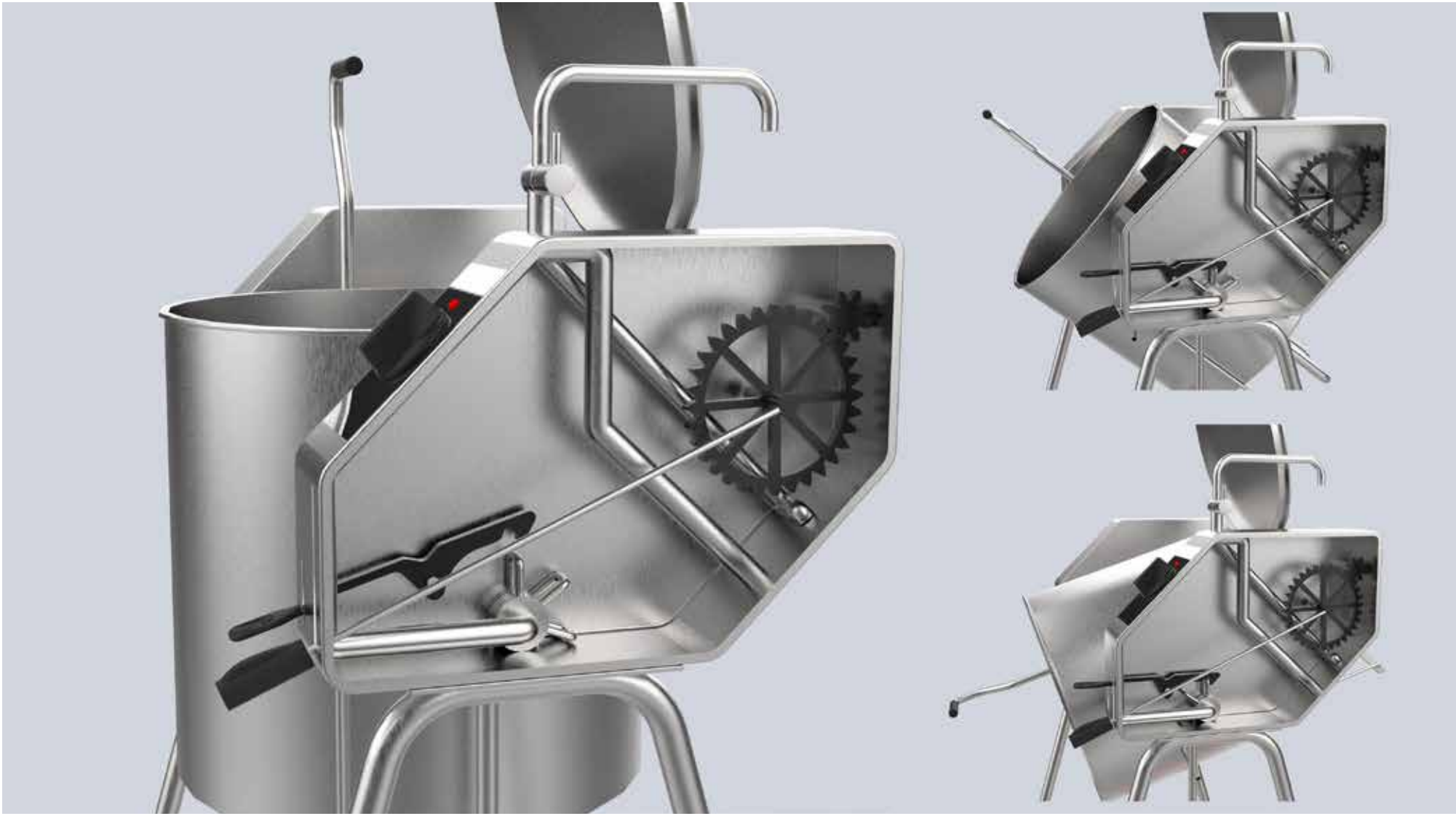
Process 6

When the water is completely drained out the marine lock is removed by pressing the small knobe on the boxing and the vessel is tilted completely and the food is transferred to a vessel, ready to serve.

Mechanism of the lid

Detail showing the mechanism for opening of the lid of the vessel. 1:4 gear system has been given here because the movement of the lever is limited. the lid in this design opens up to an angle of 70 degree, which gives enough space for the user to interact with the vessel.

Mechanism of the locking system



Marine locking system has been designed for the locking of the vessel. The vessel locks at three positions mainly one at the upright position for cooking one at 45degree and last one at 110degree where the food is completely taken out. The intermediate locking helps in cleaning the vessel easily letting the user reach the extreme parts of the vessel easily.

Combining different units together

The units has been designed in a way were different units can be easily combined together by just replacing one boxing from a side. By this way it helps to save a lot of space in the community cooking space. also reducing the use of material.

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