Redesigning of fuel dispenser

Project II
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ACKNOWLEDGMENTS

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Appreciation to all other PD faculty members for their valuable suggestions and feedbacks on the project. I am also thankful to my friends and colleagues, for their support and valuable inputs.
At last but not least I am grateful to my family, who have supported me throughout.

Name - Chitranshu Verma

Roll No - 186130009

Date - 11-11-2019

Sign

TABLE OF CONTENTS

Introduction

Introduction

Fuel dispensing system

A fuel dispenser is a machine at a filling station that is used to pump gasoline, petrol, diesel, CNG, CGH2, HCNG, LPG, LH2, ethanol fuel, biofuels like biodiesel, kerosene, or other types of fuel into vehicles.

History and Evolution of Fuel Dispensers:-

It was 1885 in Fort Wayne, Indiana where kerosene pump inventor, S.F. Bowser sold his first, newly invented kerosene pump to the owner of a grocery shop. This was to solve the problem and mess of a storekeeper ladling flammable liquid into whatever random container the customer brought.

It was just for kerosene to fuel stoves and lamps and at that time gasoline was just a volatile by-product of refining kerosene, plus the automobile wasn't invented and commercially available until around 1910.

Bowser's invention, which reliably measured and dispensed kerosene – a product in high demand for nearly 50 years – soon evolved into the metered gasoline pump.

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figure 1 https://www.saferack.com/evolution-gas-pump/

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Timeline:

1890 to 1900 – hand pump with no measurement device

1900 to 1910 – hand pump, some with clockface for measurement

1910 to 1920 – hand pumps with minimal colour. Some with clockface (possibly attached visible attachment)

1920 to 1930 – hand pumps, some with colour, some with clockface, some with glowing marketing globe on top

1930 to 1940 – art deco styled with colour, some with both clockface and glass cylinders, glowing globe on top

1940 to 1950 – square styling and colour, electronic with clock face and cylinder, some with sight glass (smaller cylinder), still has glowing globe on top

1950 and on – box style only, glowing computerized measurement and price calculation

Fuel pump in Vienna, Austria.
Figure 2 https://commons.wikimedia.org/wiki/File:Zapfs%C3%A4ule_BP_Wien.jpg

Once the Second World War ended, cars got lower and therefore it became an obstacle trying to view meters from the car's new lower perspective. As a result, new, shorter gasoline pumps were designed, which were called low-profile pumps. For the most part, these pumps featured rounded edges, stainless steel trim, large meter faces, and simpler details than what was seen in the Art Deco designs of the 1930s.

Continuing into the 1950's the trend continued to move away from rounder edges and the stainless-steel pump was popular. The hardware was shorter, squarer in shape, and featured unpainted, stainless steel surfaces. The top part of the pump was often larger, setting atop a narrower, tapering base. The units were often set up adjacent to one another in long rows, providing different types of fuels and services.

The Tokheim Company, which had brought out one of the very first gas pumps, introduced the variator's successor in 1975-electronic measurement. Instead of wheels that turned, and interior electronic device calculated the amount and price, and displayed this information on a small screen. Today's pump uses virtually the same system, except that many pumps can also handle other sophisticated transactions, such as debiting the user's bank account.

Figure 3
Antique diesel fuel pump located at Roscheider Hof Open Air Museum, Konz, Germany.

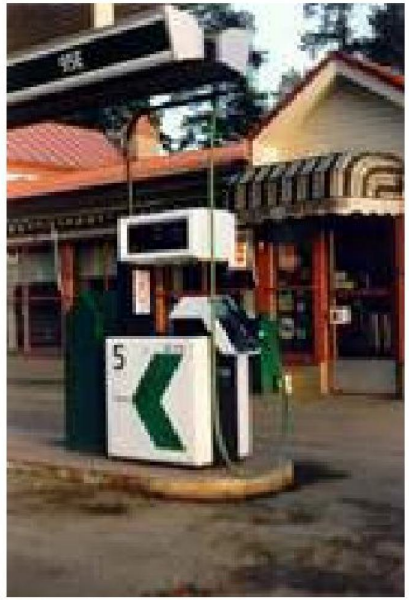


Figure 4
A 1991 photograph of a fuel pump in Ömossa village, Kristinestad, Finland.

Figure 5
Old Soviet Union fuel pumps.

Design of fuel dispensing system

A modern fuel dispenser is logically divided into two main parts — an electronic "head" containing an embedded computer to control the action of the pump, drive the pump's displays, and communicate to an indoor sales system; and secondly, the mechanical section which in a 'self contained' unit has an electric motor, pumping unit, meters, pulsers and valves to physically pump and control the fuel flow.
In some cases, the actual pump may be sealed and immersed inside the fuel tanks on a site, in which case it is known as a submersible pump. In general, submersible solutions in Europe are installed in hotter countries, where suction pumps may have problems overcoming cavitation with warm fuels or when the distance from tank to pump is longer than a suction pump can manage.
Fuel dispensers has a very wide range of designs to solve the mechanical problems of mechanical pumping, reliable measurement, safety, and aesthetics.

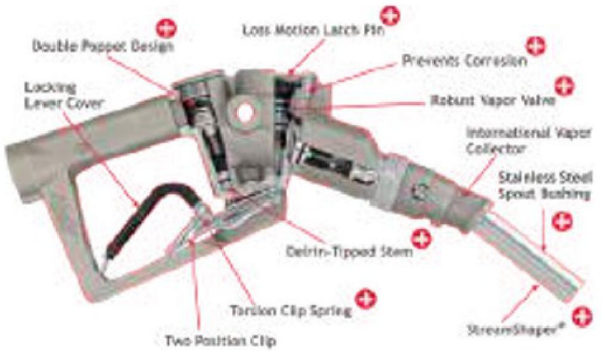


figure 6
https://www.husky.com/husky/conventional-nozzles/husky-1a-metal-handguard/

Fuel Nozzles

- Fuel Nozzles are attached to the pump via flexible hoses, allowing them to be placed into the vehicle's filling inlet. The hoses are robust to survive heavy wear and tear, including exposure to weather and being driven over, and are often attached using heavy spring or coil arrangements to provide additional strength.

figure 7
http://www.clker.com/clipart-gasoline-pump-nozzle.html

The nozzles are usually color-coded to indicate which grade of fuel they dispense; however the color-coding differs between countries or even retailers.

Breakaway valves

- Hoses are attached with these safety valves. Safety Break-away couplings are used to prevent pull away accidents, protect terminal and loading/unloading equipment and eliminated unwanted product release. The break-away couplings have a diverted breaking point which will break at a determined break-load where upon the internal valves will automatically close on both sides. This will in a longer time frame minimize down time, save money, equipment and the environment.

Figure 8
Breakaway valves.

Vapour recovery system-

Vapor recovery is the process of recovering the vapours of gasoline or other fuels, so that they do not escape into the atmosphere. This is done at filling stations in order to reduce noxious and potentially explosive fumes and pollution.
The negative pressure created in the (underground) storage tank by the withdrawal is usually used to pull in the vapours. They are drawn-in through holes in the side of the nozzle and travel through special hoses which have a return path.

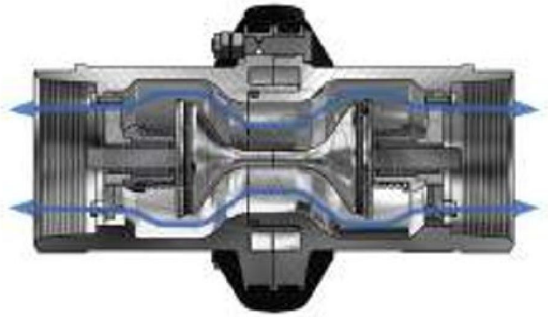


Figure 9
Vapour recovery system

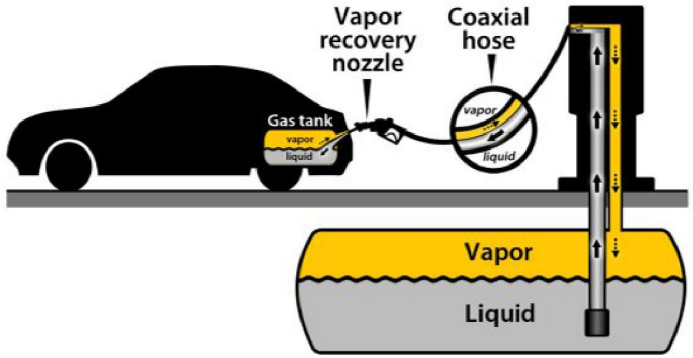


Figure 10

Study and Research

Market research-
Current contemporary technology- Flow meters

Currently using technology is a positive displacement pump

For future technology

I study the new technology, flow meter which gives accuracy to the next level its has
flow sensors,
software

Figure 12
Coriolis Mass Flow Meter

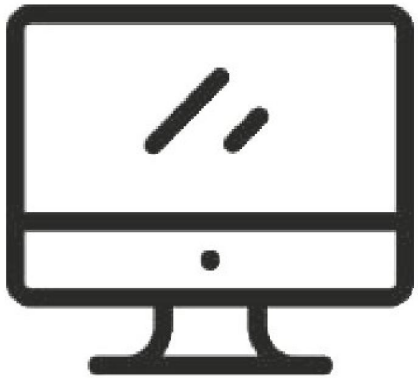
Figure 13
Aalborg Mass Flow Meter

Figure 14
Thermal Mass Flow Meter

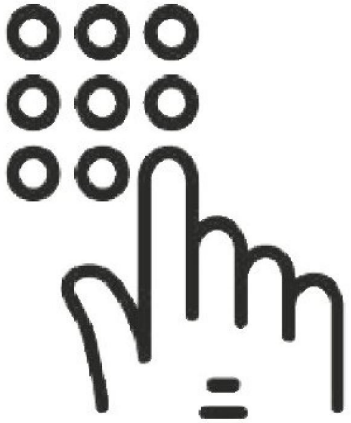
https://www.indiamart.com/proddetail/fuel-dispenser-for-diesel-pump-17521925755.html

Market research-
Components study- Fuel dispenser

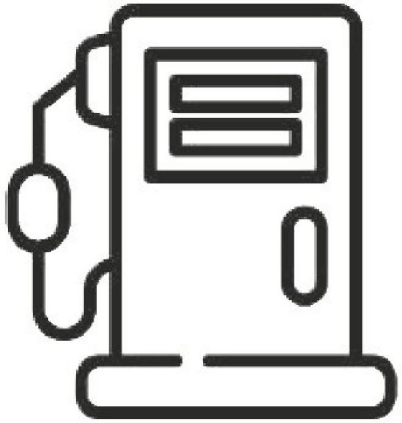
Dispenser Hose



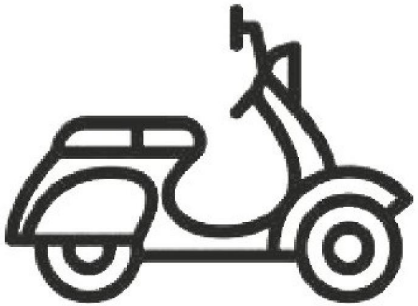
Displays



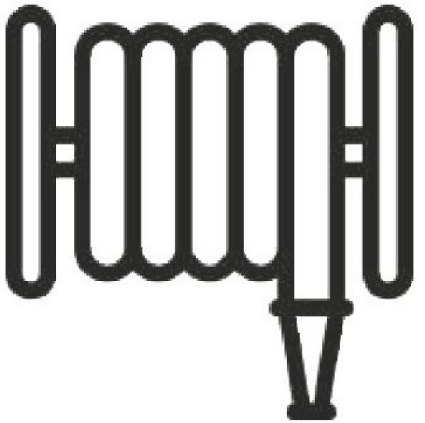
Keypad



Dispenser Body



Supporting Equipment



Hose Pipes

Making the hydraulics

The electromechanical devices that bring the gas from its storage tank to your car are usually made from either cast aluminum or cast iron. The iron or aluminum is melted and poured into moulds, then allowed to cool. Workers then remove the parts from the moulds and clean them by abrasion. Other parts may be stamped in a die. Sheets of metal are fed into a machine that punches out a piece in the desired shape. Metal tubing is placed in machines that bend it according to specifications. Workers using welding irons assemble smaller pieces into larger ones. In making the hydraulics, groups of workers trained in a few specialized skills work together in a cell—a unit of perhaps four to 50 workers—to produce parts that are consistently high quality. Each cell makes specific parts, and the parts are then passed on to other cells that specialize in assembling the parts in order.

Electronics assembly

The electronics for a gas pump control the display that tells consumers how much gas is being pumped and what the cost is. Many pumps also have electronic scanners that can read credit cards and debit the customer's account. These devices are micro-processors similar to those used in computers and calculators. The electronics manufacturer produces these by running small, stiff pieces of non-conducting material—typically cardboard or ceramic-through a solder printer, which imprints a pattern of circuit paths on the board. Other parts are placed by hand or automatically, and the board is heated in an oven. The oven melts the solder paste put down by the solder printer, forging electrical connections. The gas pump manufacturer might not do any of this, but buy the circuitry according to specifications. Workers at the gas pump plant may assemble the electronics by snapping or soldering pieces together. These workers, like the hydraulics workers, typically would be assigned to a cell responsible for the head of the pump.

Housing

After the hydraulics and electronics are completed, workers bring the parts over to the housing area of the plant. Here, doors, panels and outer walls are cut from sheet steel. These are then sent to a painting area. Workers apply a high-quality, corrosion-resistant paint to the housing, according to a design specified by the customer. The painted parts are sent through an oven to dry, and then cleaned. Next, the hydraulics are fitted to the electronic head, and the whole pump is encased in the housing. Hoses are attached, and gaskets or seals applied. The sections of the housing are welded together or attached with hinges. The unit is cleaned, and the paint may be touched up. Next, the unit is inspected and tested, then sent to the customer for installation

Types of fuel output

A. Blended-

System producing blended product can mix two fuels together before dispensing. These systems are used to: -

1. Add oil to petrol for two-stroke motorcycles, to produce an intermediate octane rating from separate high and low octane fuels.
2. Blend hydrogen and compressed natural gas (HCNG).

The benefit of blending for retailers is that it allows them to offer 3 grades of fuel while only having to maintain inventory of two grades.

B. Multi product-

These are common now-a-days. These systems can dispense more than two fuels out of single dispensing machine. These are further categorised as: -

1. Multi hose multi product dispenser- In this system, there are separate nozzles for each fuel in single dispensing machine.

2. Single hose multi product dispenser-

In this system, there is a single hose for all the fuels in single dispensing machine. Fuel discharge lines are mani folded into one casting at or near the hose outlet fitting.

Figure 15
Range of Fuel Dispensers

Working components of the fuel dispensing machine and schematic diagram
Following are the working components of a fuel dispensing machine: -

1. Motor
2. Pump
3. Filter and Air separator
4. Flow regulating valves
5. Pulsar
6. Fuel flow meter
7. Electronic Unit

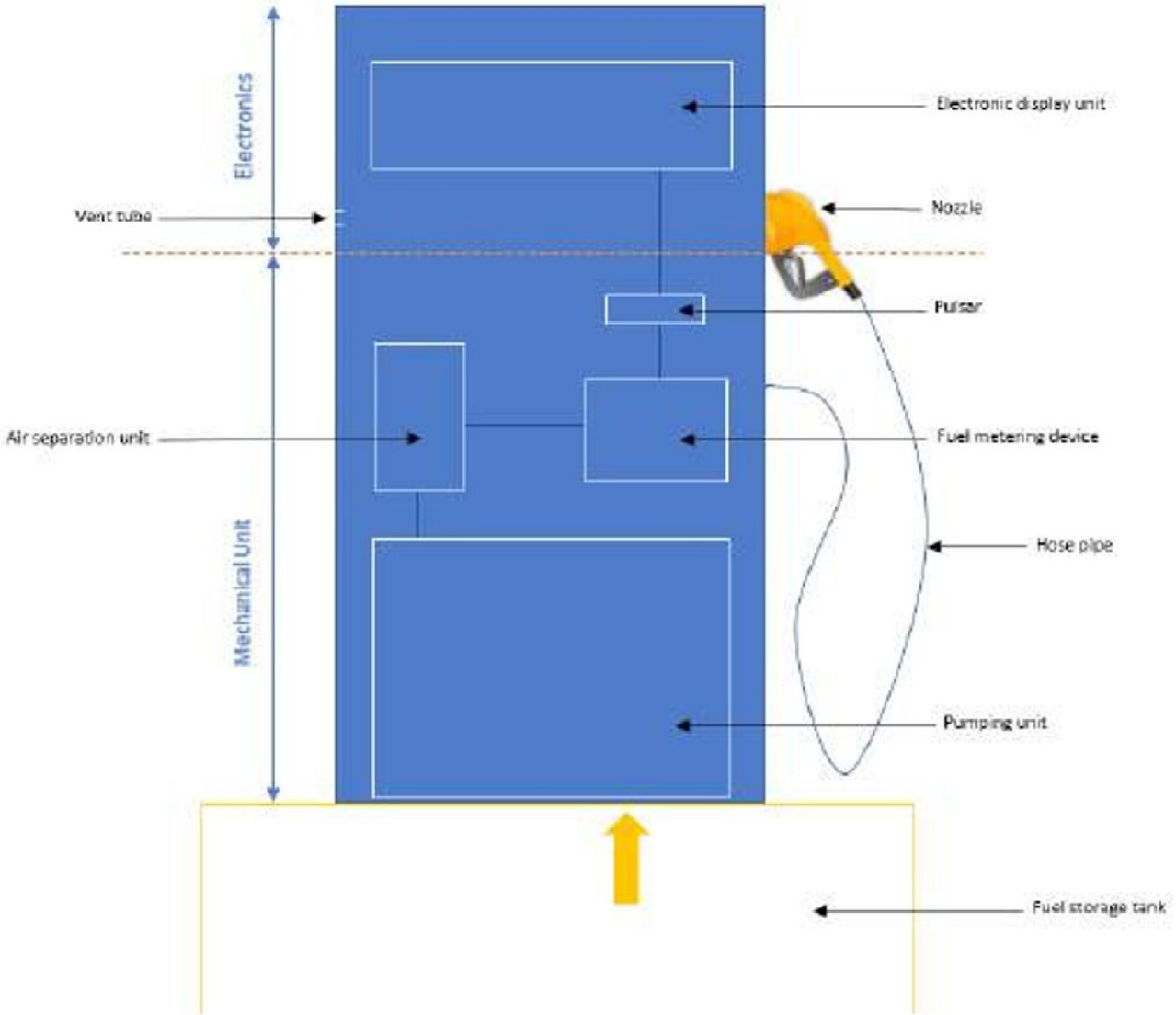


Diagram 1
Fuel Dispensers

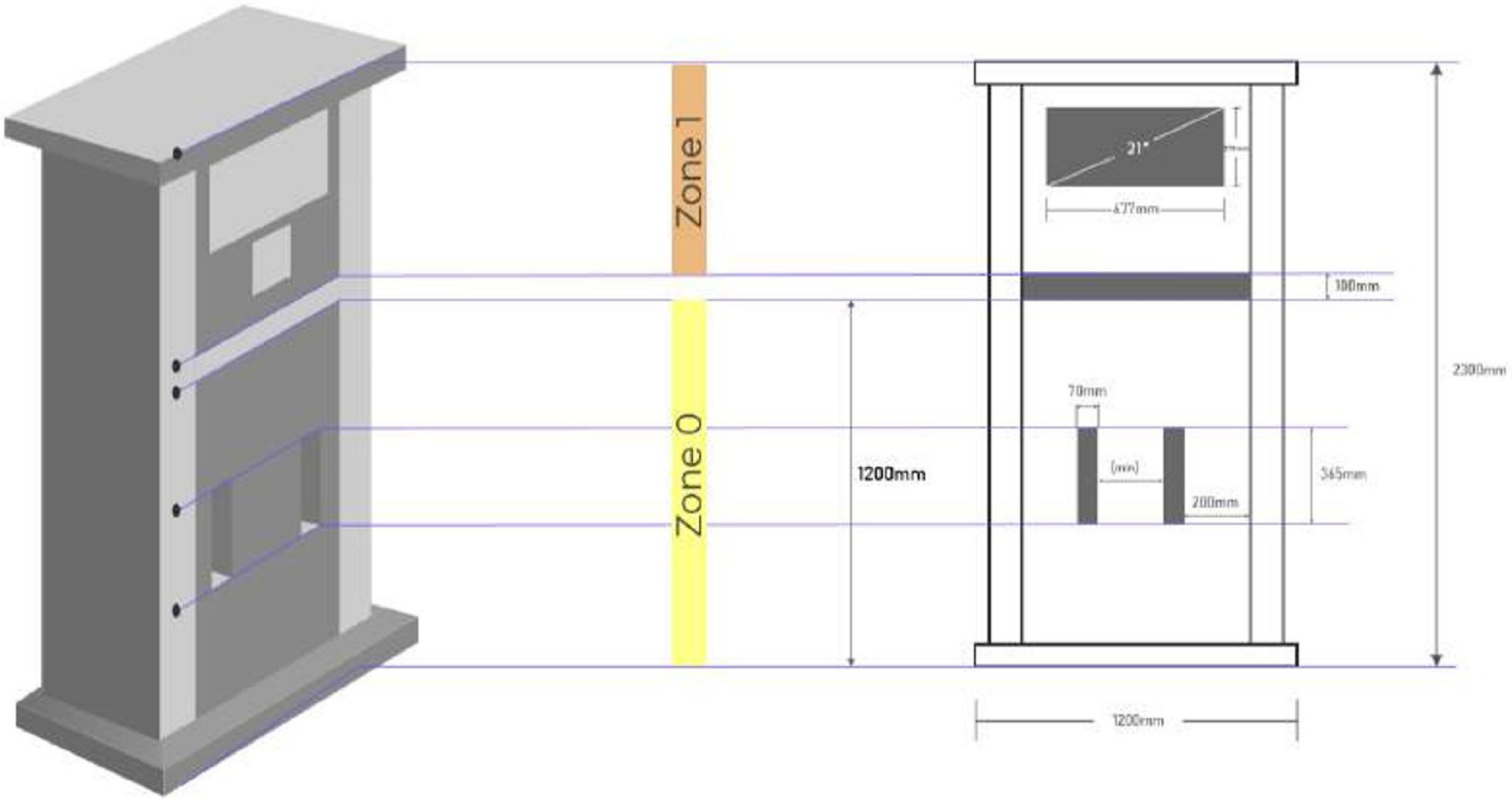


Diagram 2
Fuel Dispensers

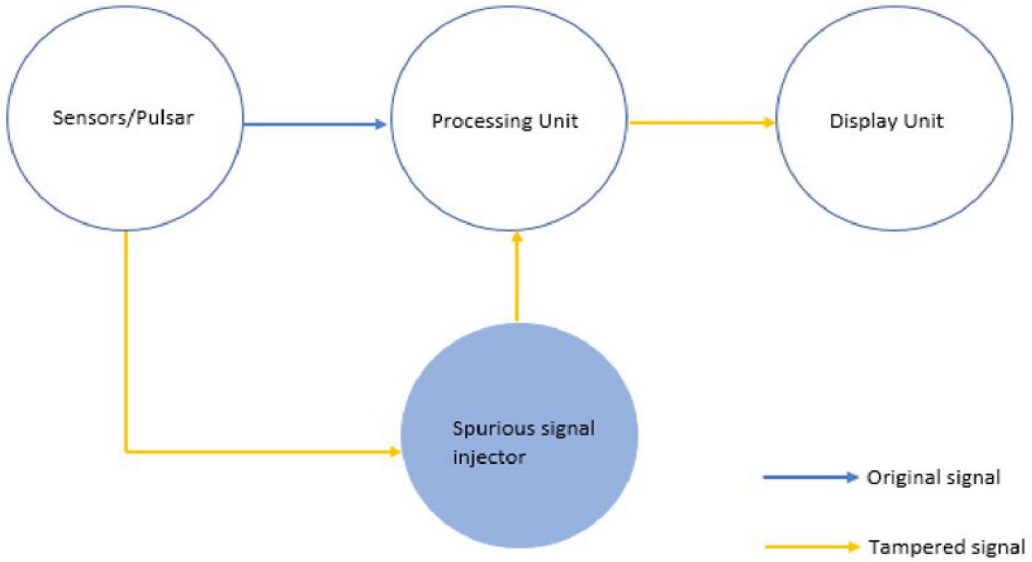
Operation flow

1. A motor driven pump takes out the fuel from the storage tank.
2. Fuel then enter the filtration unit where solid contaminants are separated.
3. Filtered fuel enters the air separator unit where the vapours and air are extracted away.
4. Clean fuel is fed into metering unit via control valves.
5. Action of metering unit is translated into electronic display by the means of pulsar attached directly between electronic display unit and f fuel meter.
6. Finally, the fuel is dispensed out through the nozzle.

Security considerations

1. Meter Sensors- Prone to removal and opening
2. Mechanical Adjustment Device- Prone to opening
3. Connection between pulsar and electronic indicating device- Prone to manipulation
4. Electronic Adjustment Device- Prone to unauthorised calibration (Dip switch box)

5. Electronic Indicating Device- Prone to opening and removal (Totalizer, Volume indicator, Price indicator)



Case study

Case Studies

Z-Line (1989)

Z-line fuel dispenser is one of the finest examples of a successful product innovation achieved in a collaborative team. The product encompasses innovations in all aspects as proposed in the sunflower innovation model – material, manufacturing, technology, user interface, cost, marketing, distribution and product attributes. This section details out the design process involved (studying the company, the market, material and manufacturing technologies and the users) that created the synergy between the various aspects of the sunflower model. The product design was undertaken in 1989 by Prof. B. K. Chakravarthy during his tenure at Larsen & Turbo.

Design Features
- The Z-line pump evolved created a completely new image.
- The sloping column of the pump gave the product a very dynamic look.
- The hi-tech look of the pump was achieved by highlighting the electronic display of the pump.
- An array of pumps in a station projected a friendly and inviting look.

Display Features
- The pump has a microcomputer based system which gives the flexibility of having multi display models.
- In the single display the pump displays in the normal mode and on the actuation of the membrane switch the rate and sale values are flashed.
- In a two display pump one display shows litres and the other the sale price. The rate is flashed when the sale price is zero.
- In a three display pump the litres, sale and rate are simultaneously displayed.

User-Friendly Features

- The pump has an easy to open top; making maintenance quick.
- Three side access provides much better visibility.

Innovative Shape
- Unique shape led to the demand of the product.
- Shape helped in generating better maintenance access.
- Shape gave a new image to the Boxy old pump (children sketch the petrol pump as a Z line now).

Bullet (1998)

Multi-domain innovations in process, materials, manufacturing, technology, user needs, cost, marketing and distribution and synergized into the Bullet fuel dispenser. As envisaged, Bullet outpaced its competitors in a short time becoming the new market leader of the industry. The breakthrough differentiation was brought in through innovation in cost and service. CAD played an important role to increase the efficiency and accuracy of the design process.

High Hose Design

- Faster Fuel Dispensing
- Unique and elegantform
- High quality electronics and software
- Modular design digital Design
- Chassis based design
- Innovative shape
- Convenient for Mass production
- Large display fascia
- Satisfies international norms for safety

Figure 15
Fuel Dispensers

Figure 16
Bullet fuel Dispensers

Figure 17
Fuel Dispensers

Design of MIDCO MULTI PRODUCT DISPENSERS – MPD (2001)

The design of the MPD (Multi-Product Dispenser) shows a bright example of how Computer Aided Design can be used to come up with an innovative design. The project was undertaken in 2001 by Prof. B. K. Chakravarthy who was a design Consultant to MIDCO while being a Professor at IIT Bombay.

- Multi Product from same pump
- Saves space
- Convenient to user
- Uses single display
- Both sides dispensing
- Can be used by submersible pumps

Innovation by Design
- Large Market Penetration
- Gave tough competition to L&T
- Started Exports
- 10 time increase in turnover of the company
- Reached Rs 120 crores with 6 crores profit in 2007

Figure 18
MPD Fuel Dispensers

Design brief

Design Brief-

Design a futuristic fuel dispenser using contemporary and futuristic technology to bring the next level of innovation in fuel pumps for city users.

Filling experience

Making the filling experience user-friendly and digital to match the current digital technology trends.

Hose handling

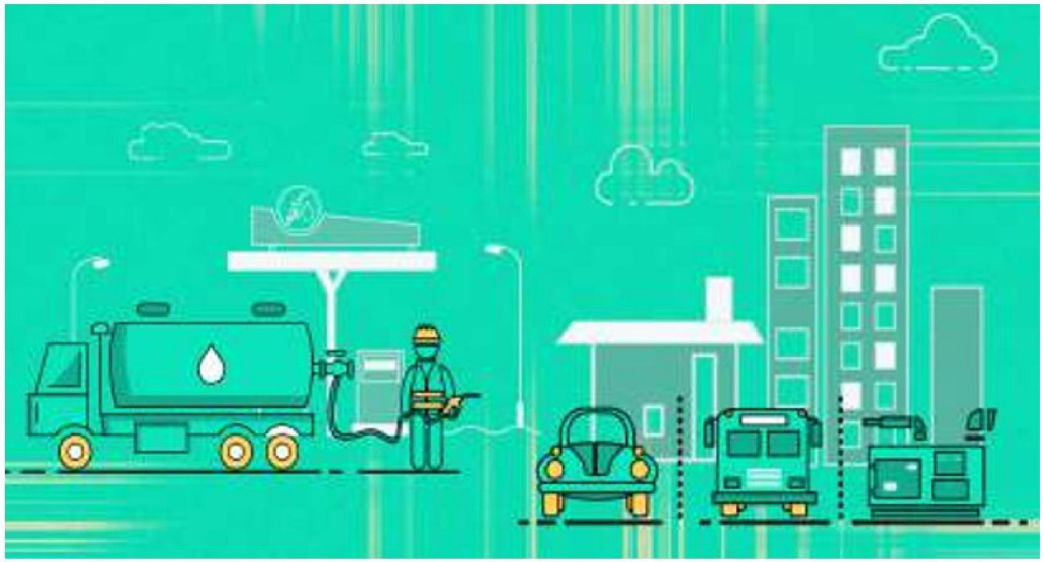
Hose handling should be smooth, the treatment of the hose.
The hose should be hidden.
should be hung from the top.
Should have good swing and reach.
And it should be easy to use.

Display

The display should be well protected
It should be convenient in orientation to the driver in multiple positions.

Visibility

Clear visibility.



Field visit of petrol pumps in mumbai

Field Visit (Bharat Petroleum)

We visited the nearest fuel pump to understand the actual problems faced by customers and service providers.
We understood how machine works with respect to display, keypad and hose pipe.
We critically analysed vehicles, dispensing machines, space and layout around the fuel station.
Clicking pictures of the dispensers was not allowed.

Observation on Bharat Fuel Pump Station

- Jumbling of pipes used in dispensers due to their long length.
- Hose pipe blocks the display of the dispenser.
- Visibility problem for cars and heavy vehicles.
- Only one keypad for 4 hose dispensing machine creates problem to service provider.
- No proper way for heavy and light vehicles

Figure 19
Bharat petrol pump station

Fuel station layout comparison

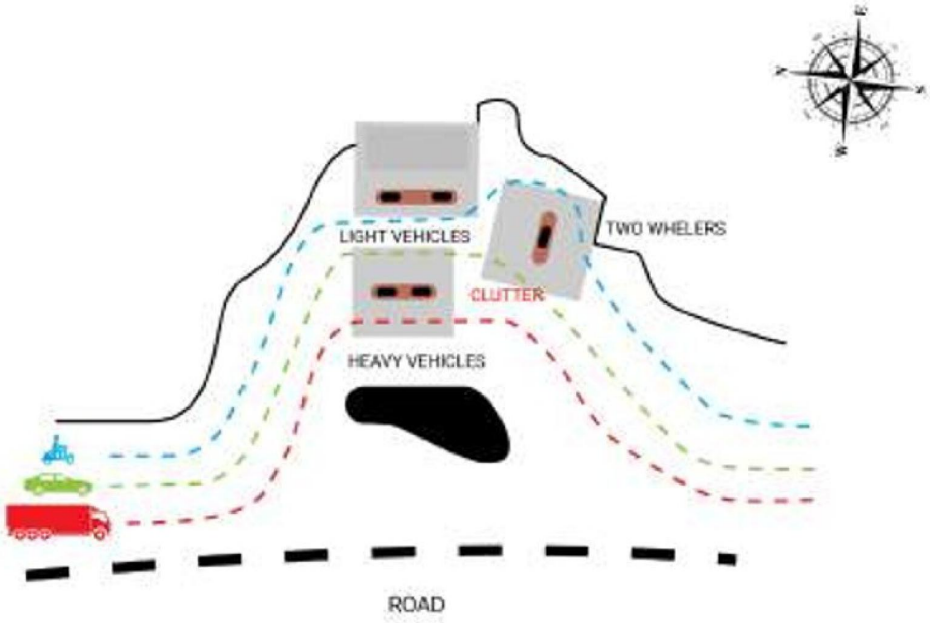


Diagram 3
layout of abhishek service centre bharat gas

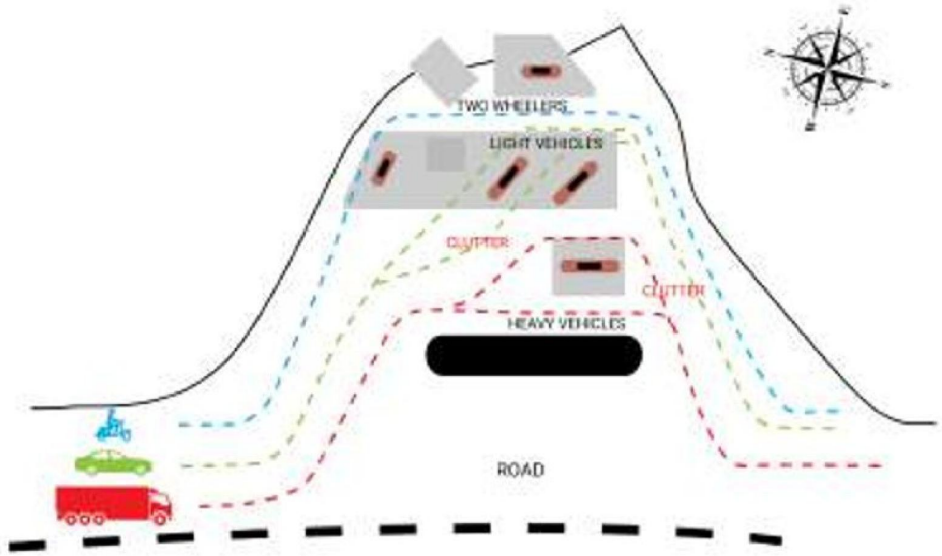


Diagram 4
layout of om vedant bharat petroleum


ANK
येस बँक
One Stop Solution
PUC


DIESEL
PETROL
इंडियनऑयल
IndianOil
XTRAPREMIUM

Field Observation -

Observation on Bharat Fuel Pump Station

- Jumbling of pipes used in dispensers due to their long length.
- Hose pipe blocks the display of the dispenser.
- Only one keypad for 4 hose dispensing machine creates problem to service provider.
- No proper way for heavy and light vehicles

- Installed pumps- Tokheim, Gilbarco, Midco surefill
- Products Delivering- Diesel, High speed diesel, Petrol, High speed petrol
- Dispenser types , Two hose single dispenser, Four hose single dispenser
- Station had 3 fuel reservoir tanks.
- Proximity of 6 meters to 8 meters was maintained between

- The display is not clearly visible from a distance
- Trust issues with the attendant due to unclarity on the display screen.
- Due to huge traffic, it becomes difficult for the users to find the availability at the petrol pump.
- The hose pipes are quite long and many a times the pipes come along the drive-way.

- The fuel tank location.
- Difficult for the user to look at the display screen.

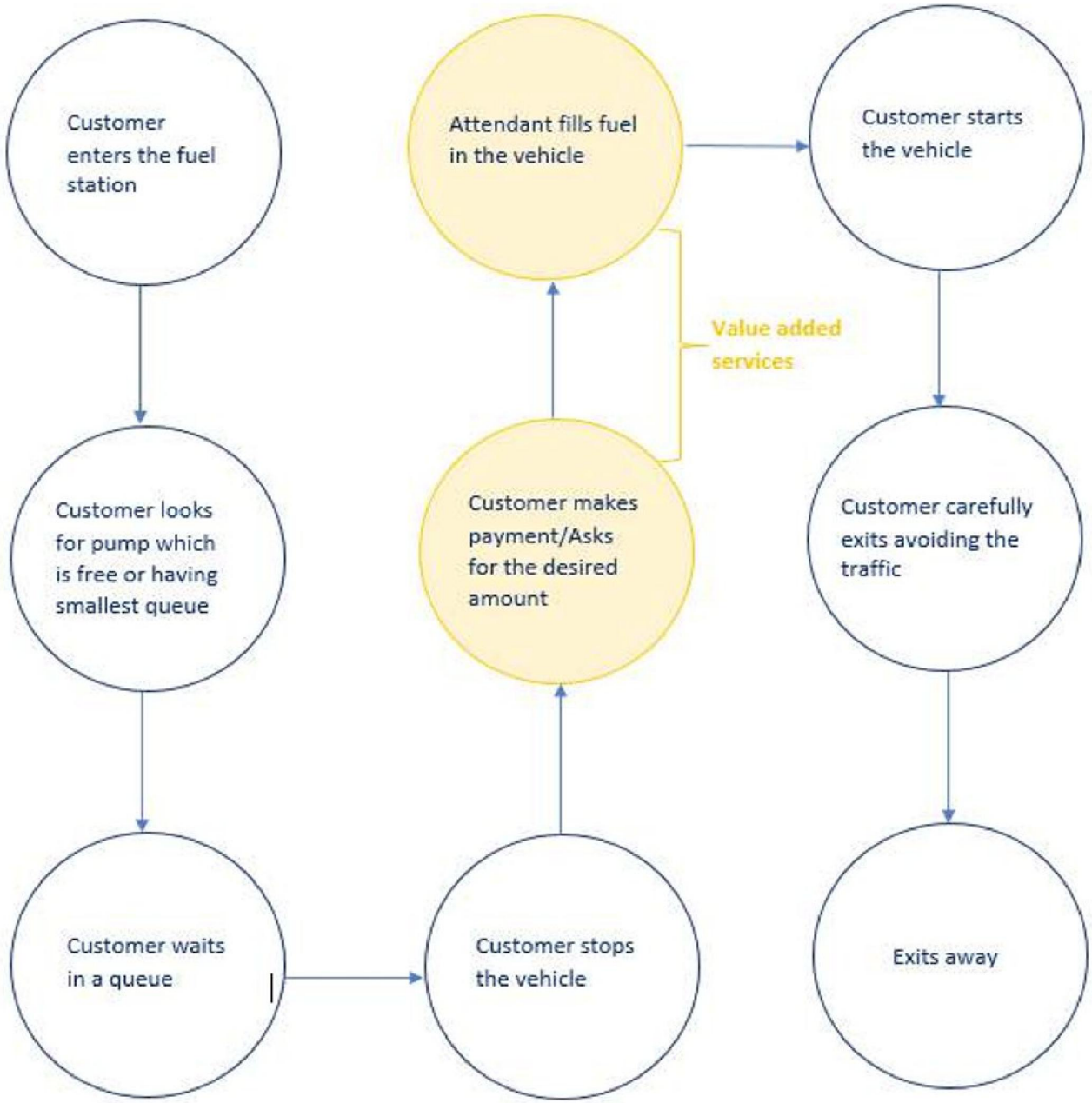
- As the length of the trucks is quite long, the display screen is not easily visible.
- There isn't enough space for the trucks.

- The display screen is not clearly visible in day-light.
- Payment method.
- The hose pipe is quite heavy for the attendant to move freely

Insights

- Aesthetically appealing
- Planning of fuel station
- Proper signage and queue manager.
- Sense of accuracy
- Ease of payment, hazel free transaction
- Automated
- Big Display
- Retractable hose pipe

User journey map



Preliminary Ideations

Brainstorming Ideas

Open brainstorming without taking constraints into consideration. tried to explore languages of different art movements to design a box. read case studies to know the important components of dispenser.

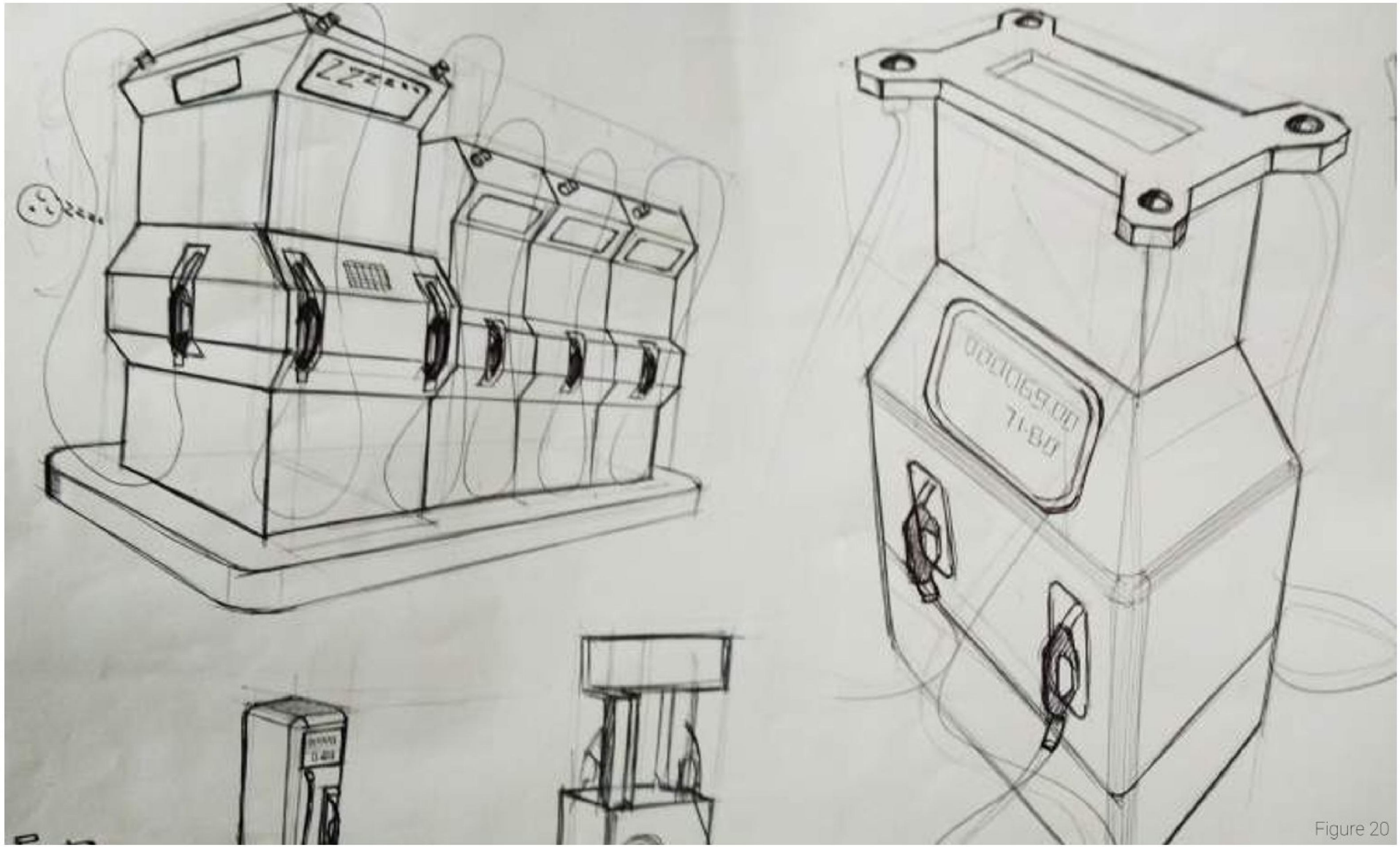


Figure 20

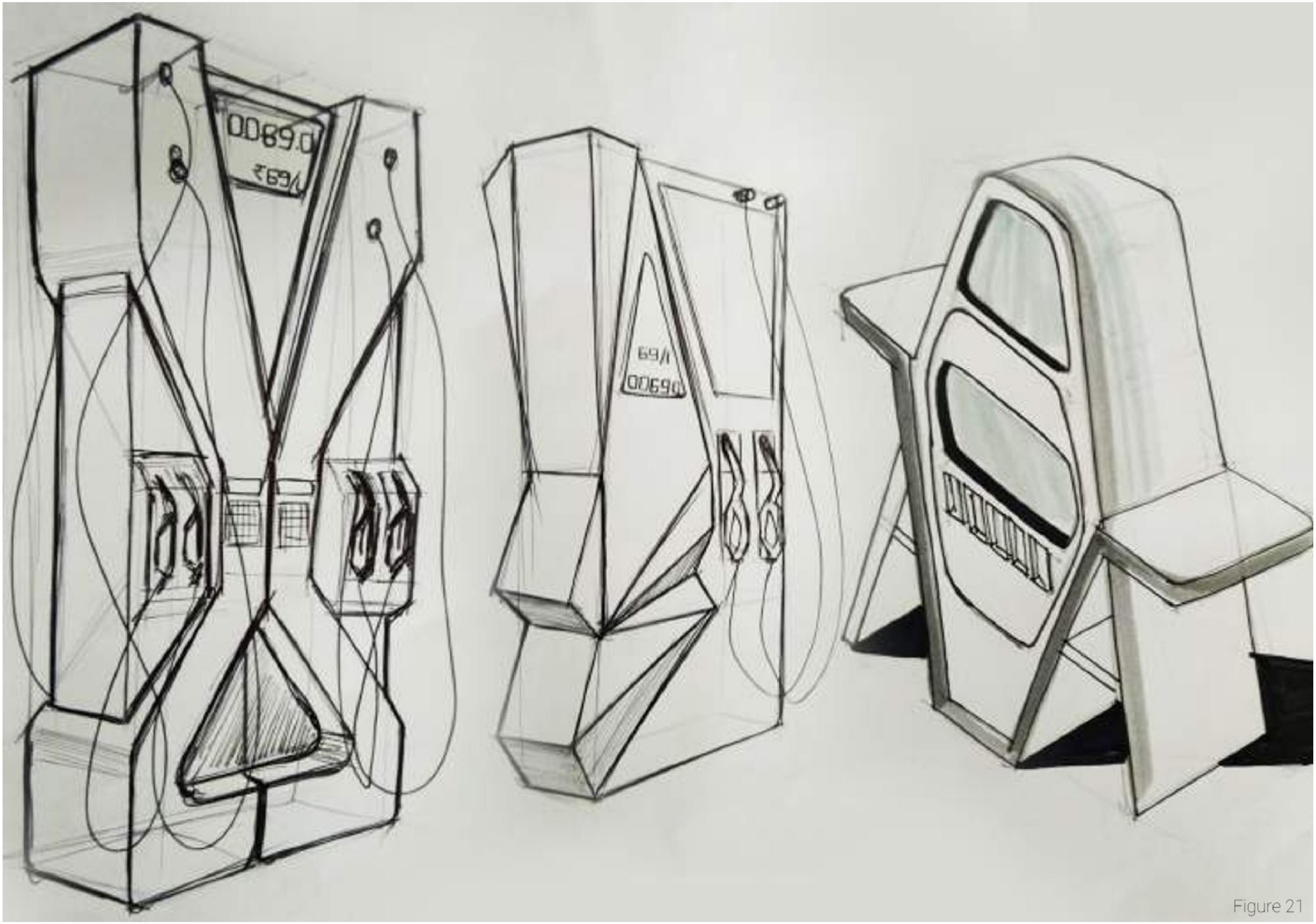


Figure 21

Mockup model

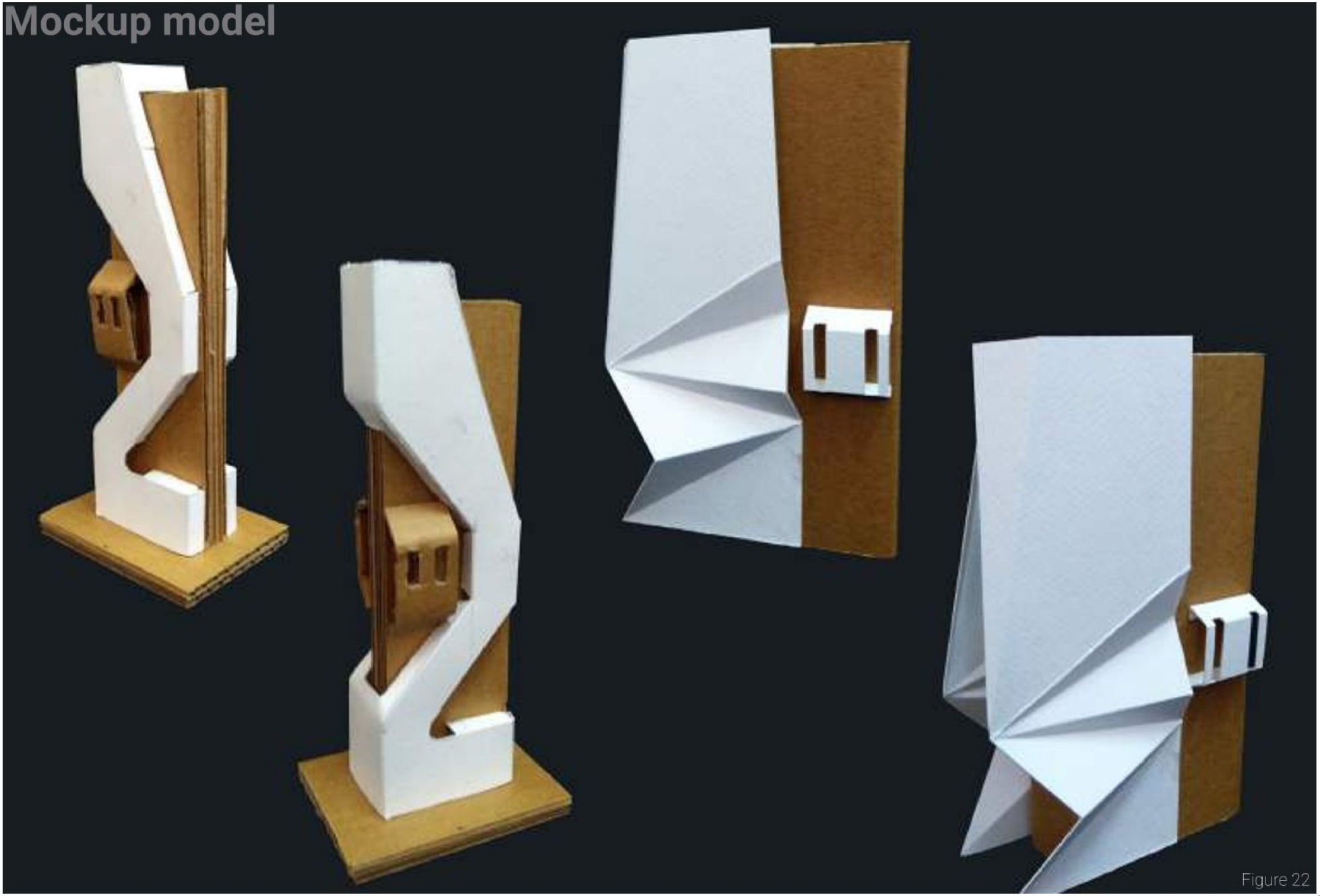


Figure 22

Figure 23

Company visit to understand next-generation fuel pumps

Company Visit

Visit the new company which is looking at the new technology to understand next-generation fuel pumps and their philosophy toward the latest technology and unique components of fuel dispenser

Bangalore's visit was the most critical phase in my design journey.
I got to understand -
What today's company wants?
What do people need?
What are the design constraints?

Design Phase
Developed the concepts keeping constraints in mind?
Critics and opinions on ideas.

Design Directions

1. Replacement of keyboard to make it improve its accessibility and usability.
2. Displays had compromised visibility during day time.
3. Management of the long hose pipe.
4. Security of the fuel dispenser.
5. Surety to the customer about accurate serve.
6. Monotonous design.
7. Clutters occur during rush time gives scope for designing the whole space.
8. Ease of Manufacturability, Transportation and Assembly.
9. Value Added Services

After Company Visit Ideations

Figure 25 Ideations

Pump and Motor ‘A’

Pulse and Check valve ‘B’

Flow meter ‘C’

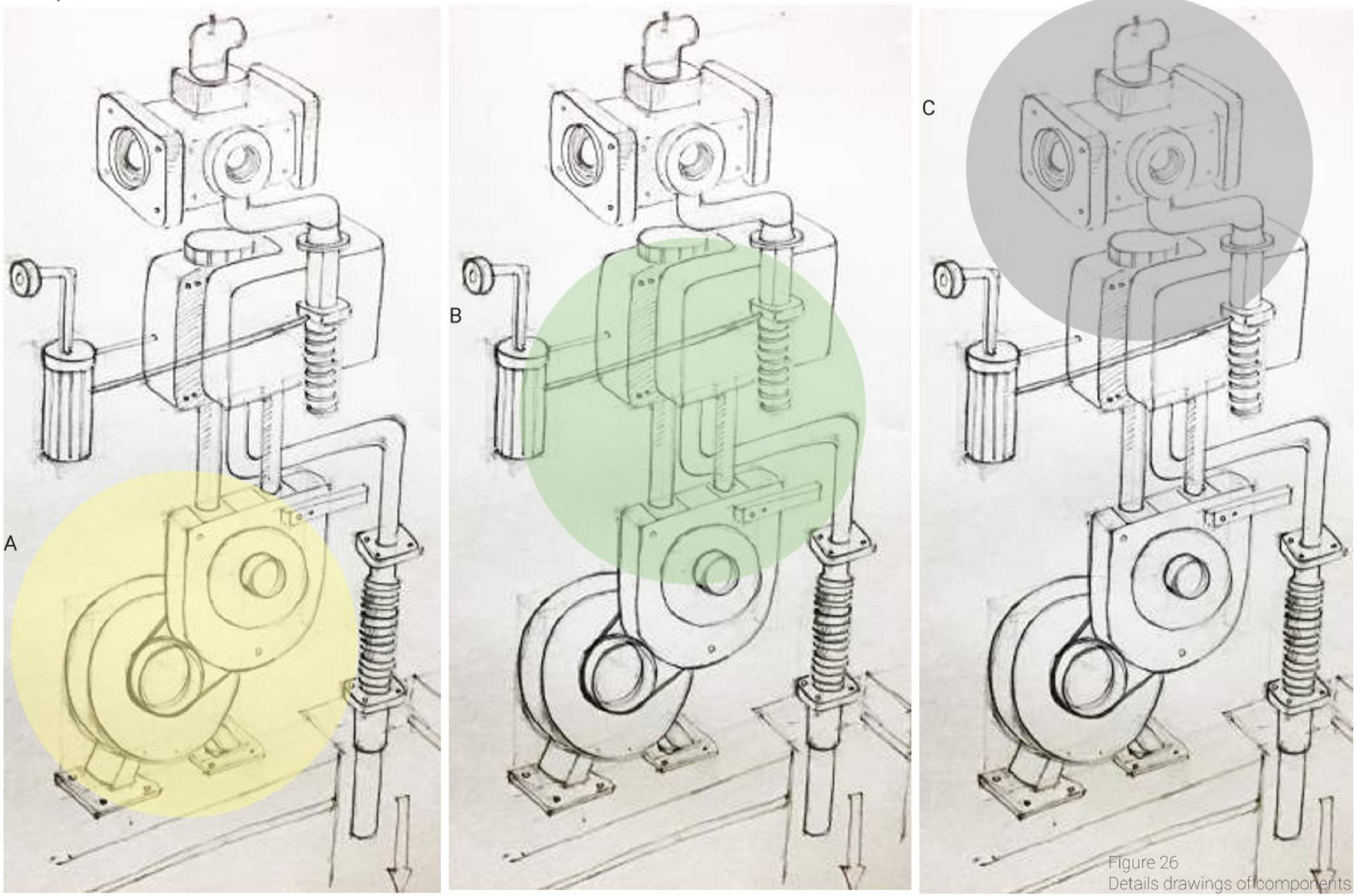
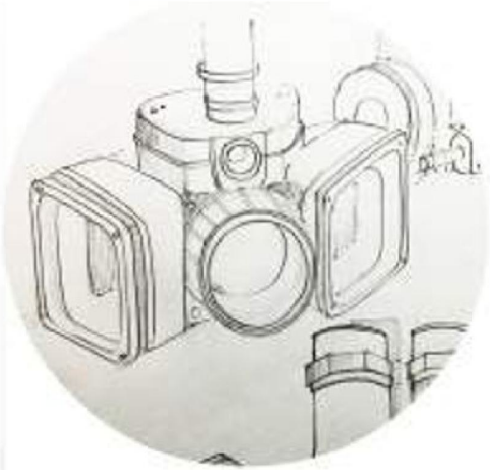
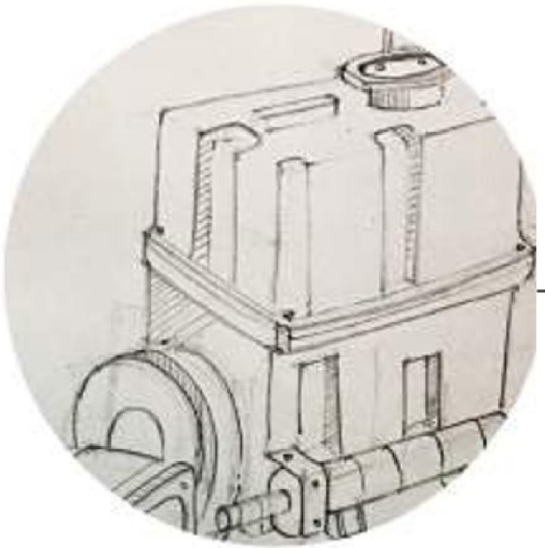


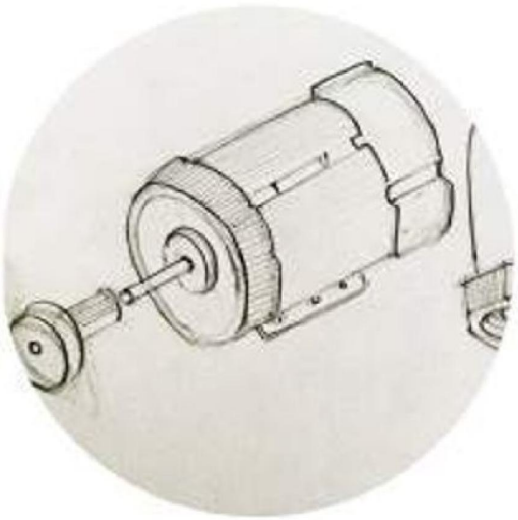
Figure 26
Details drawings of components



Flow meter



Pulse and Check valve



Pump and Motor

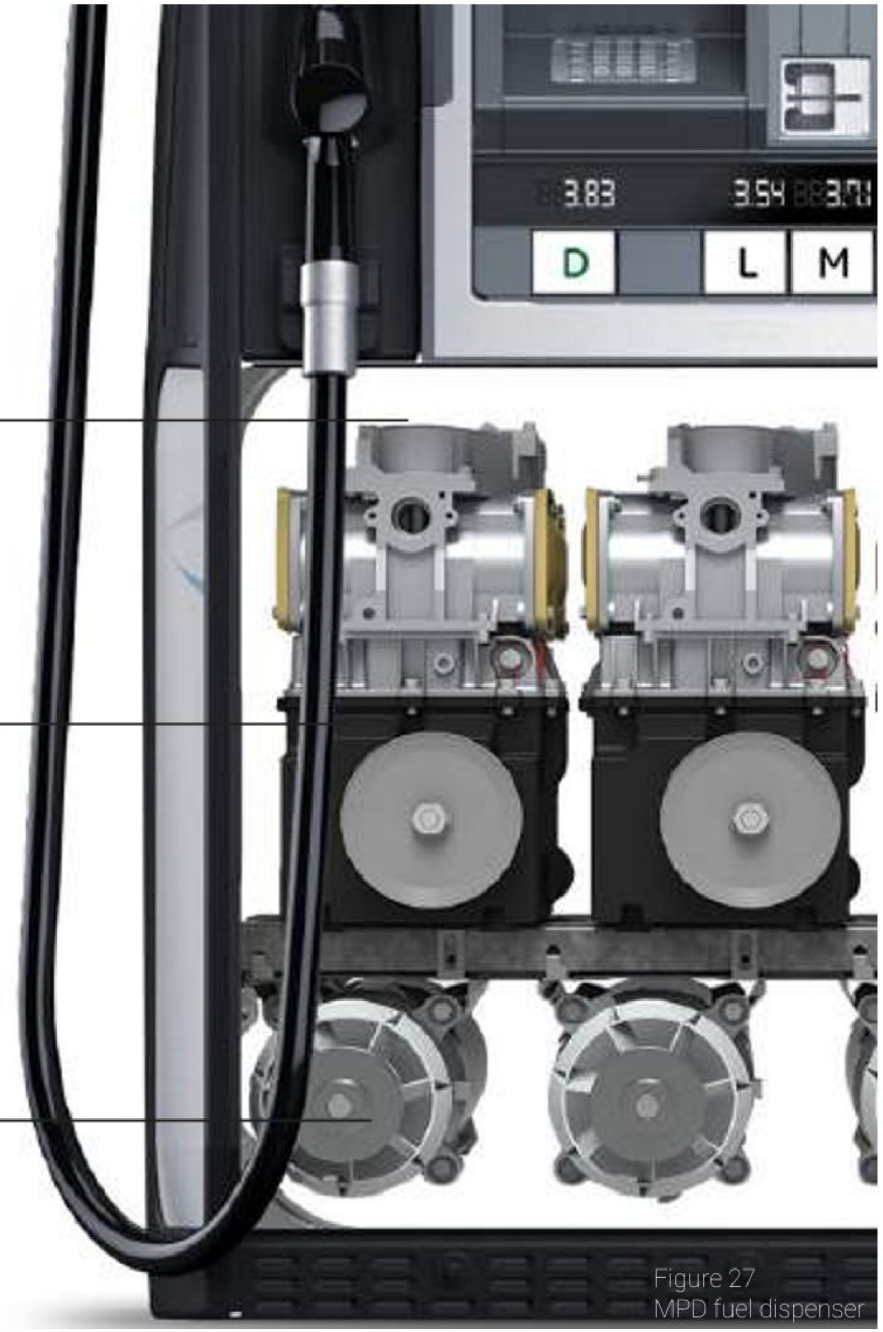


Figure 27
MPD fuel dispenser

Ideation 1

Figure 28

- Retractable hose pipe.
- App-based fuel dispenser

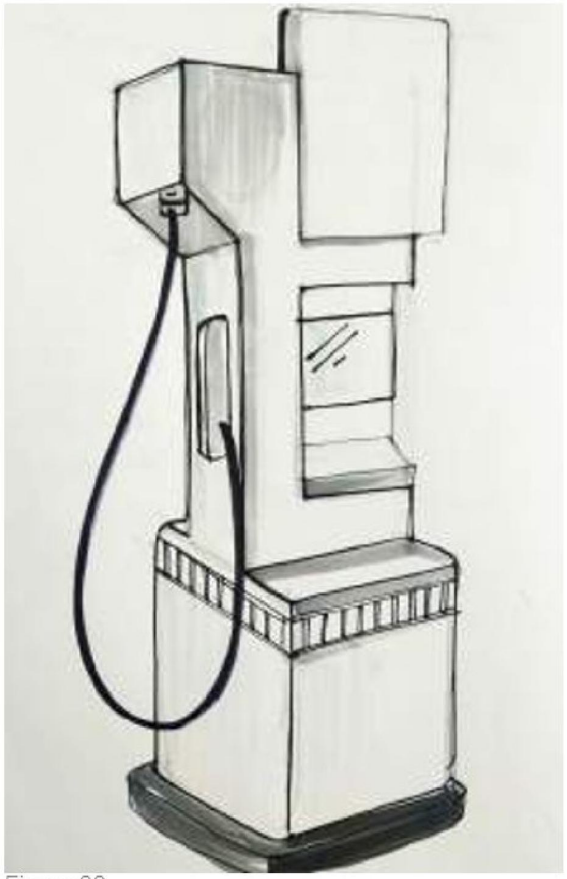


Figure 29

- Bigger display.
- Compact in size as compare to other.

Figure 30

Ideation 2

Figure 31

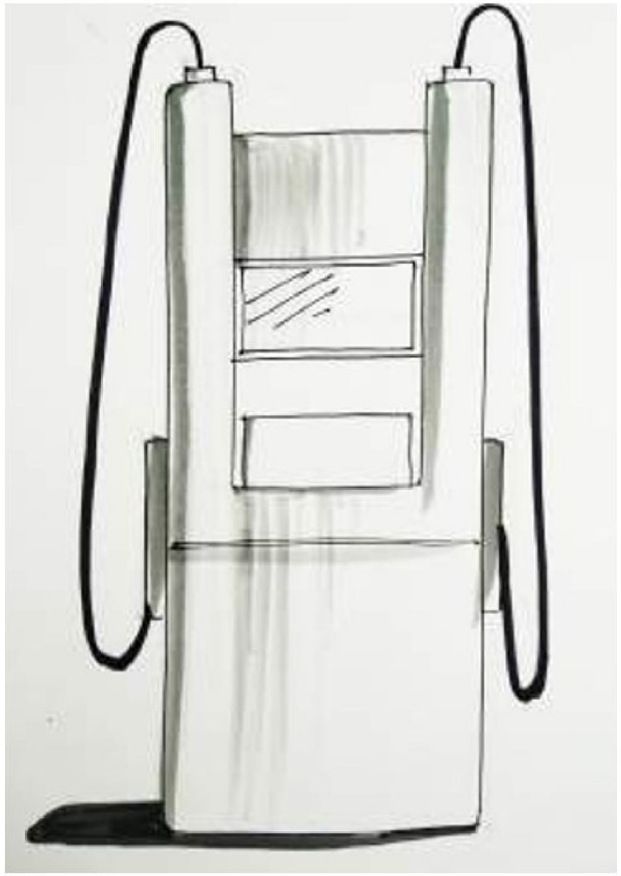


Figure 32

Figure 33

- Hose pipe on the side of the fuel dispenser.
- Bigger display
- Removable electronic hub for maintenance

Ideation 3

Figure 34

- Unibody
- Retractable hose pipe

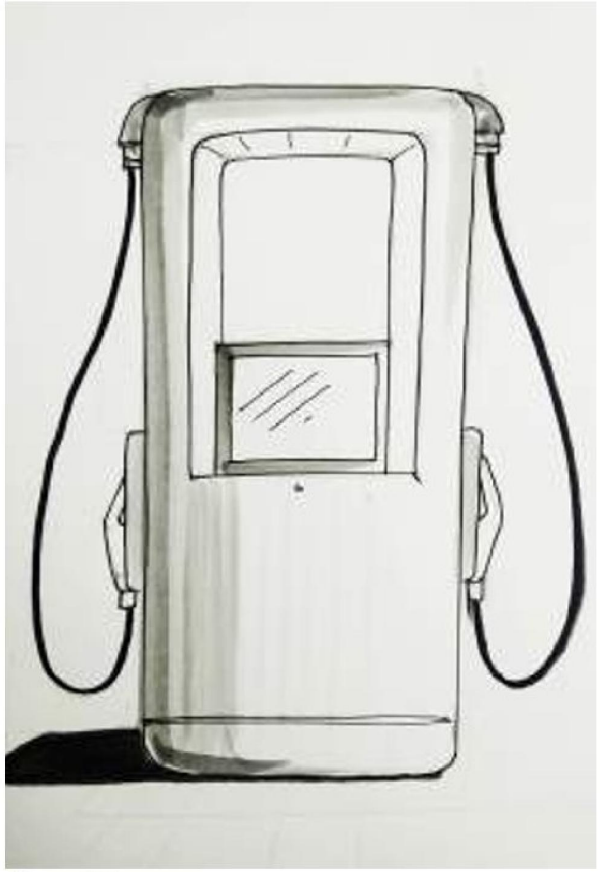


Figure 35

- App-based fuel dispenser
- Bigger display

Figure 36

User feedback and comparison

Figure 37

- Compact design.
  A retractable hose pipe is not suitable for the Indian context.

Figure 38

Figure 39

- Sense of security
  Unibody easy to maintain.
  Online payment and app-based fuel dispenser is a good option.

Render Models

Figure 40
Render

Figure 41
Render

Insights -

After Bangalore's visit, I got some ideas on the fuel dispenser,
parts and its dimension and how it works.
I study all components of fuel dispenser detailed study of dispensing systems and new technology..
After so many user reviews on each ideation and design, they want a user-friendly design that gives hassle-free fuel dispensing. Sleek design not bulky as the previous design and the display.

Refined ideations for the futuristic look

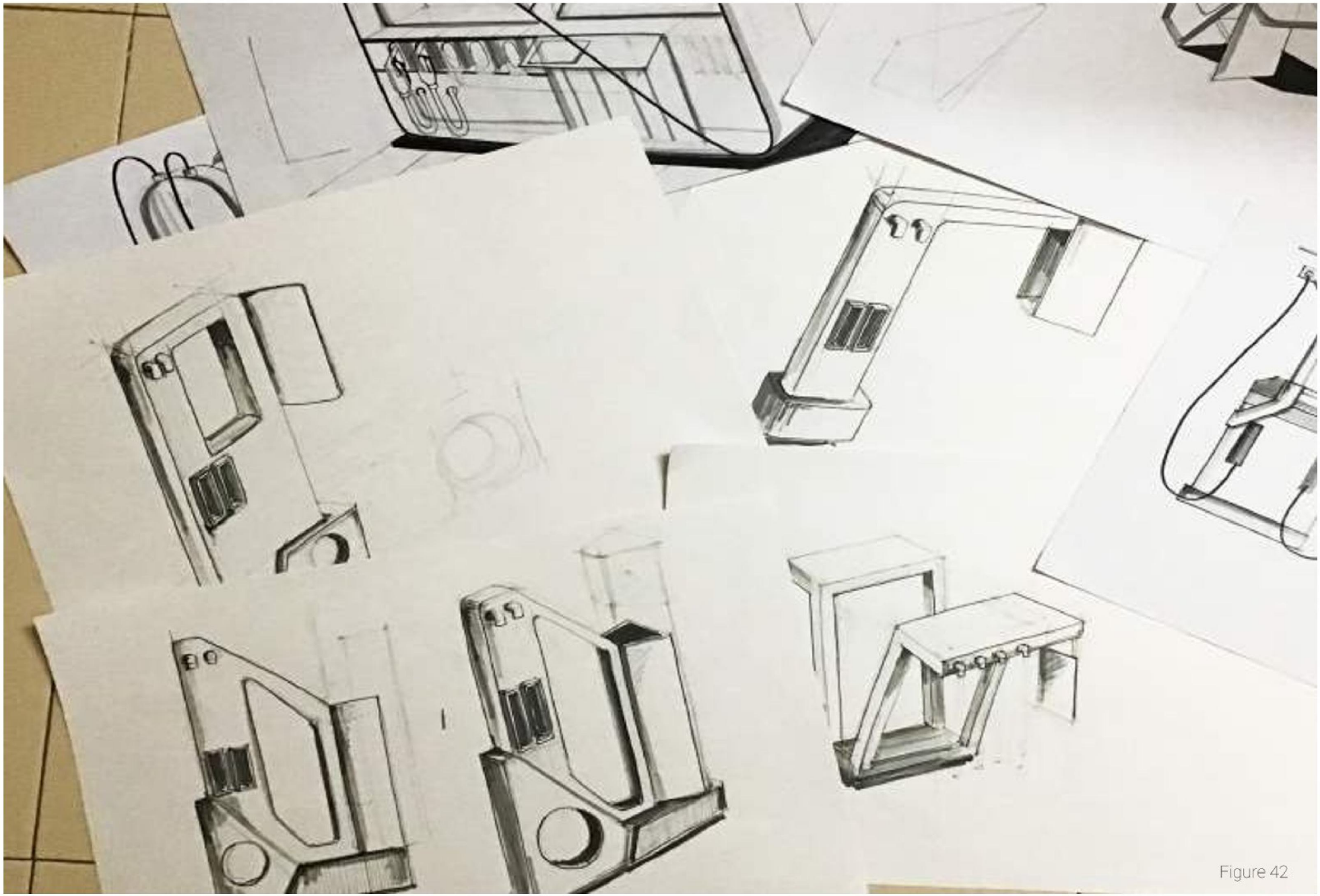


Figure 42

Advantages of taking down the machine.

Advantages of taking down the whole machine and pumps part of the fuel dispenser is that sleek design
And the opportunities to explore different forms in it.
More space will be there in the fuel pump for attendant. compact design user-friendly and more appealing look to gave futuristic design because in the previous one there is some constraint.

Concept -1
Angled display Dispenser

In this concept, I have separated the zone 0 and zone 1. Above the ground level, there is only exhaust of the dispenser and below that the whole pump and mechanism. In the upper part, there is a big display in an angle to give better visibility to the user and the atendant.
I this idea the compactness is also the factor, the current fuel dispenser width is generally 650 to 700 mm, but in this idea, the width is reduced to 200 to 250 mm.

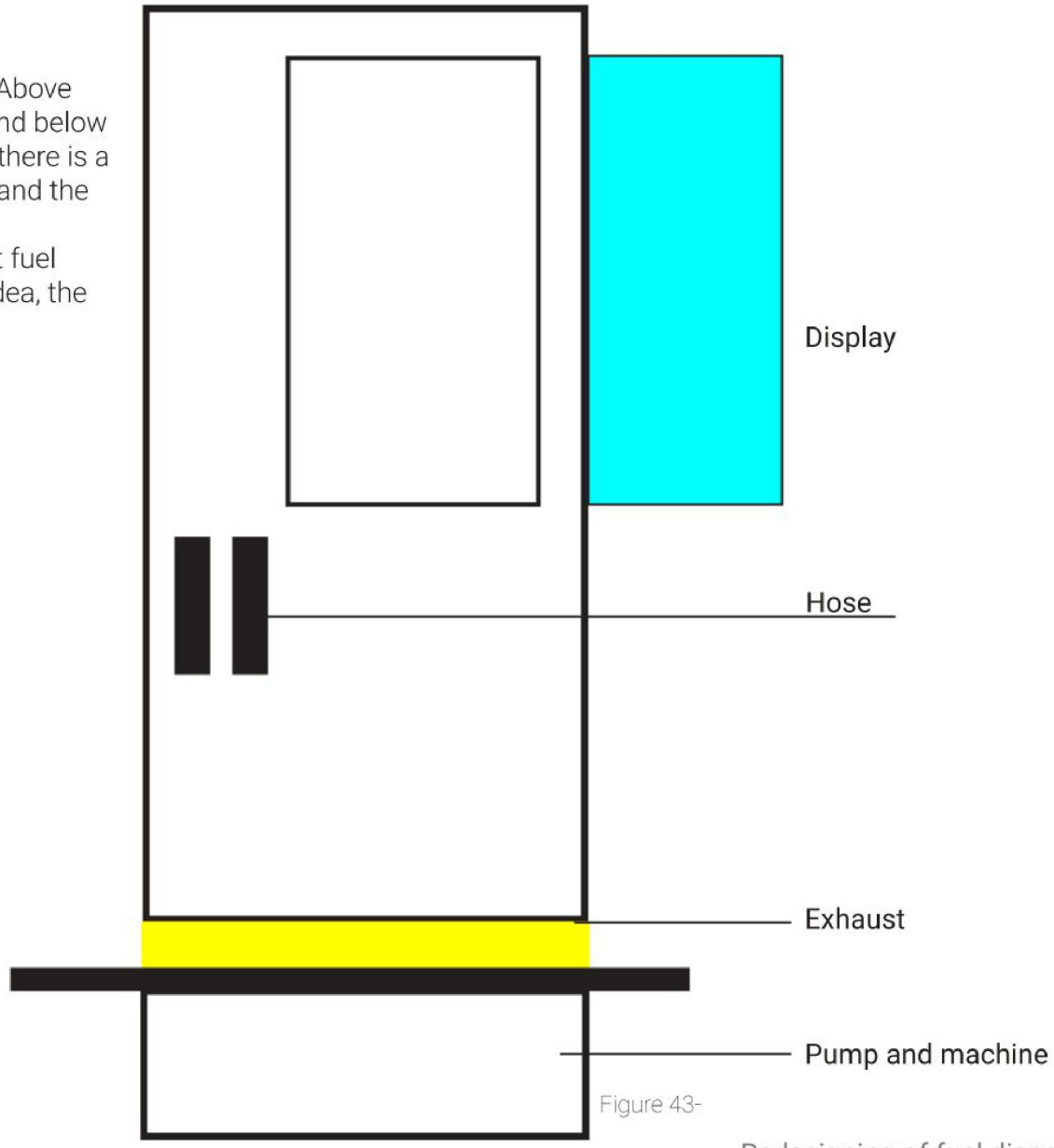
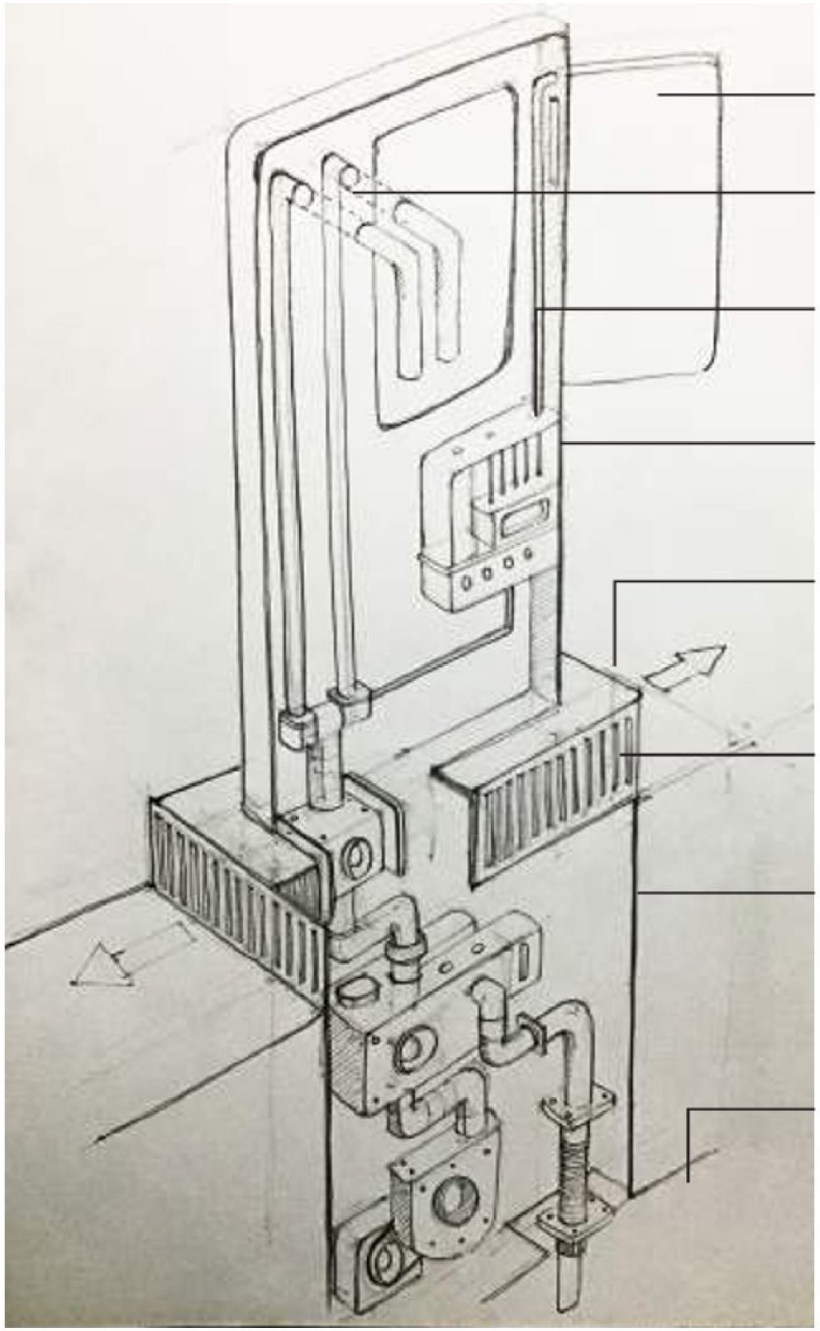


Figure 43-


Display
Hose pipe
Electronic hub
Zone 1
Ground-level +-0
Exhaust
Zone 0
Fuel tank

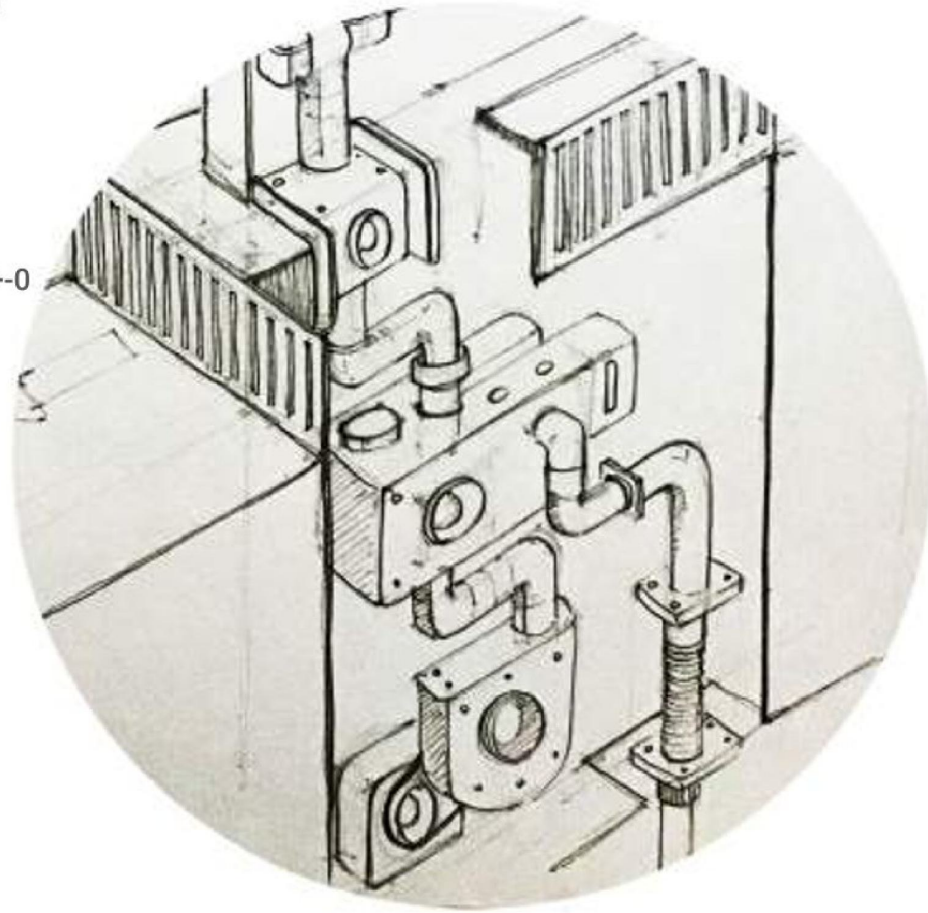


Figure 44

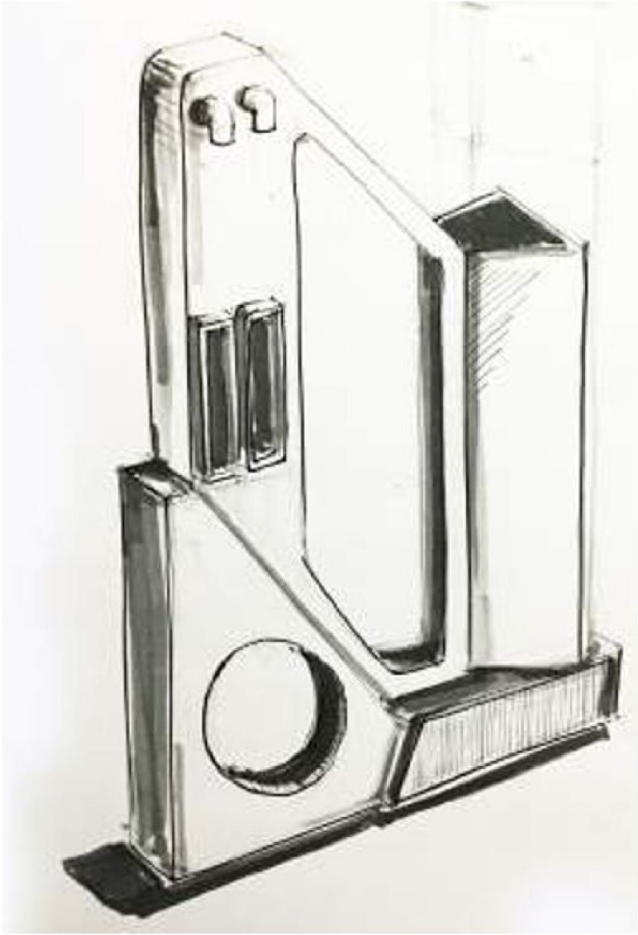


Figure 45 source Author

Figure 46- source Author

Figure 47- source Author

Figure 48 -source Author

Figure 49- source Author

Figure 50 -source Author

Concept -2

Dual body Dispenser

In this concept, I have separated the zone 0 and zone 1. Above the ground level, there is only exhaust of the dispenser and below that the whole pump and mechanism. In the upper part, there is a big display that is totally a different entity, to give better visibility to the user and the attendant.
In this idea the compactness is also the factor, the current fuel dispenser width is generally 650 to 700 mm, but in this idea, the width is reduced to 200 to 250 mm

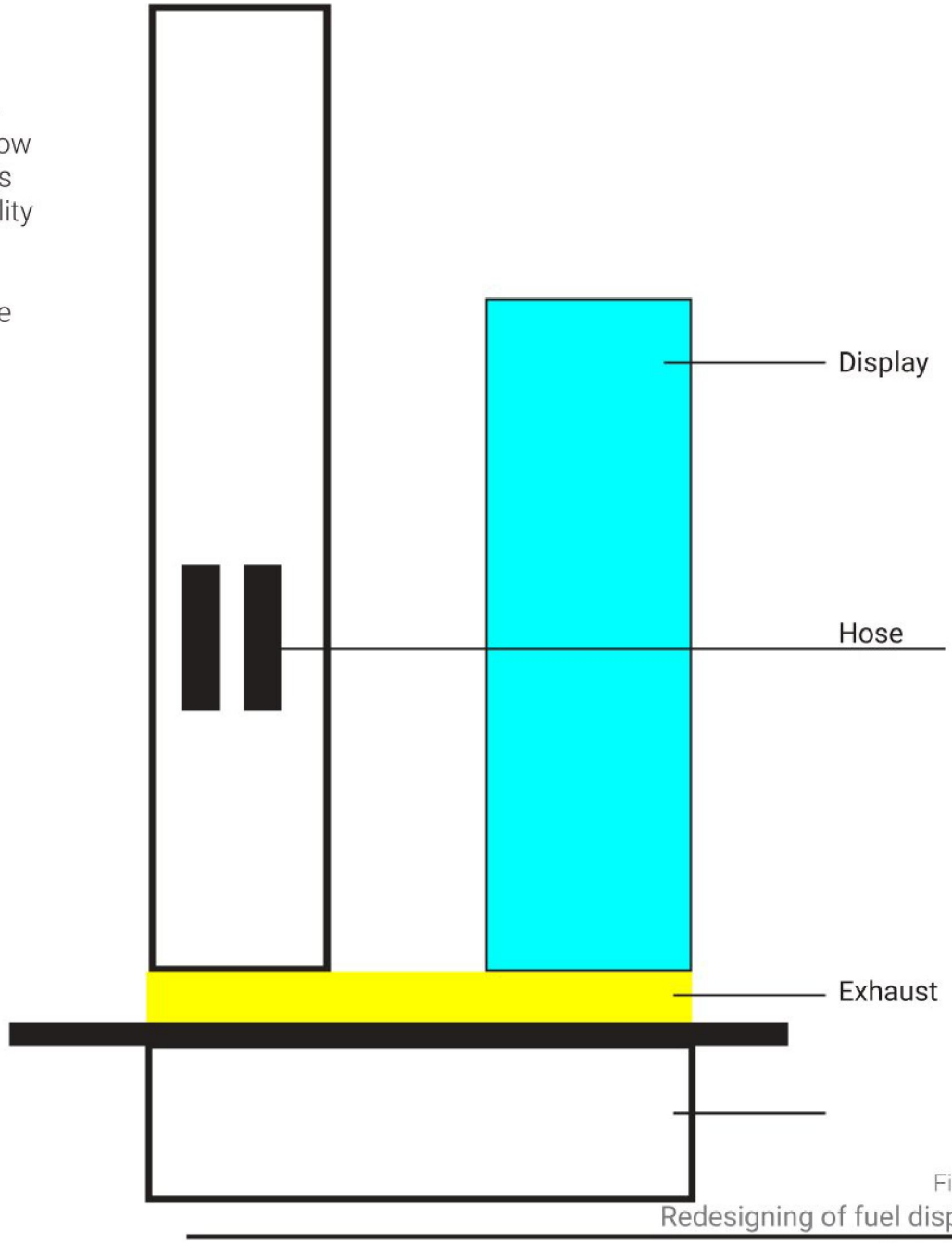


Figure 51

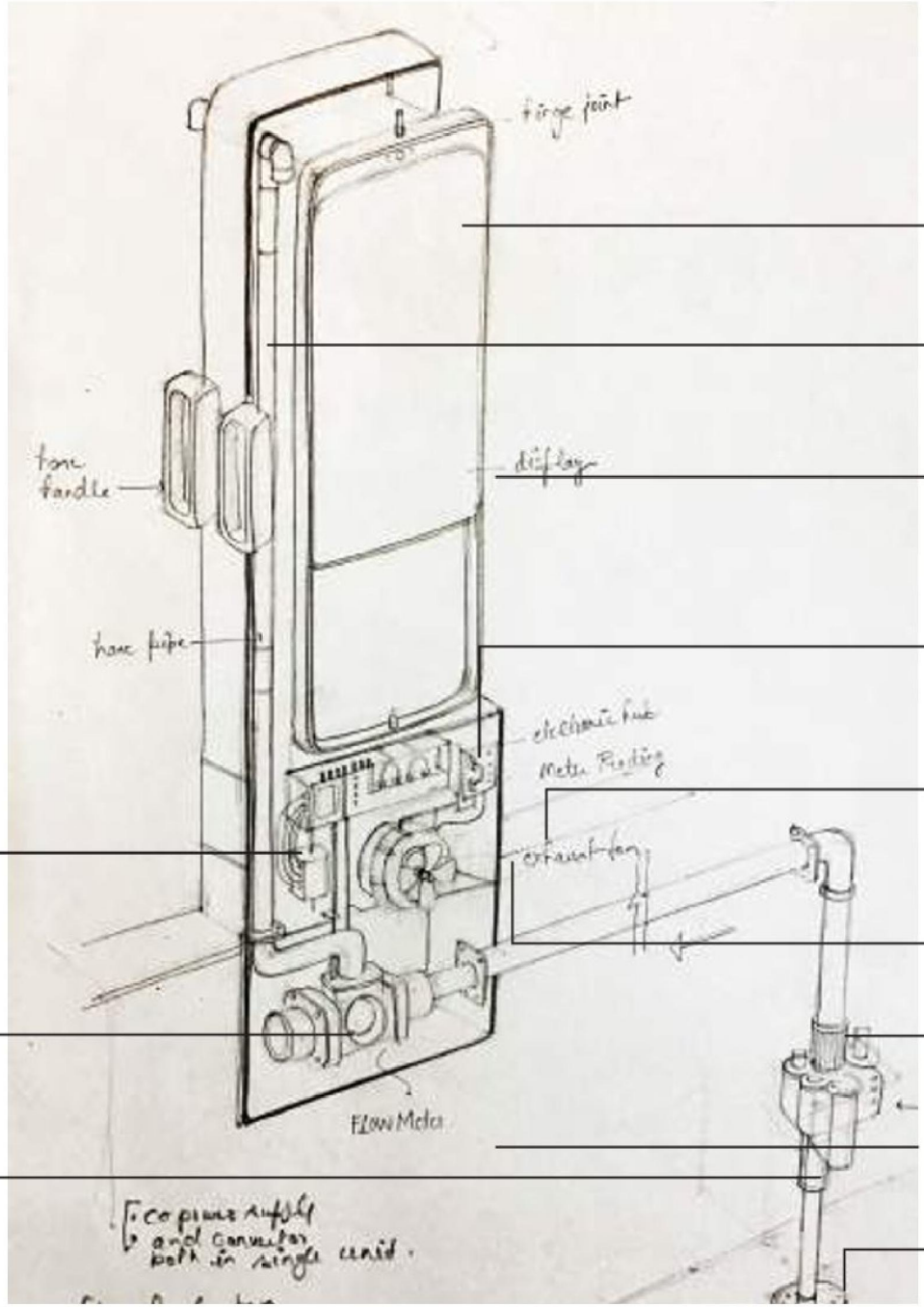
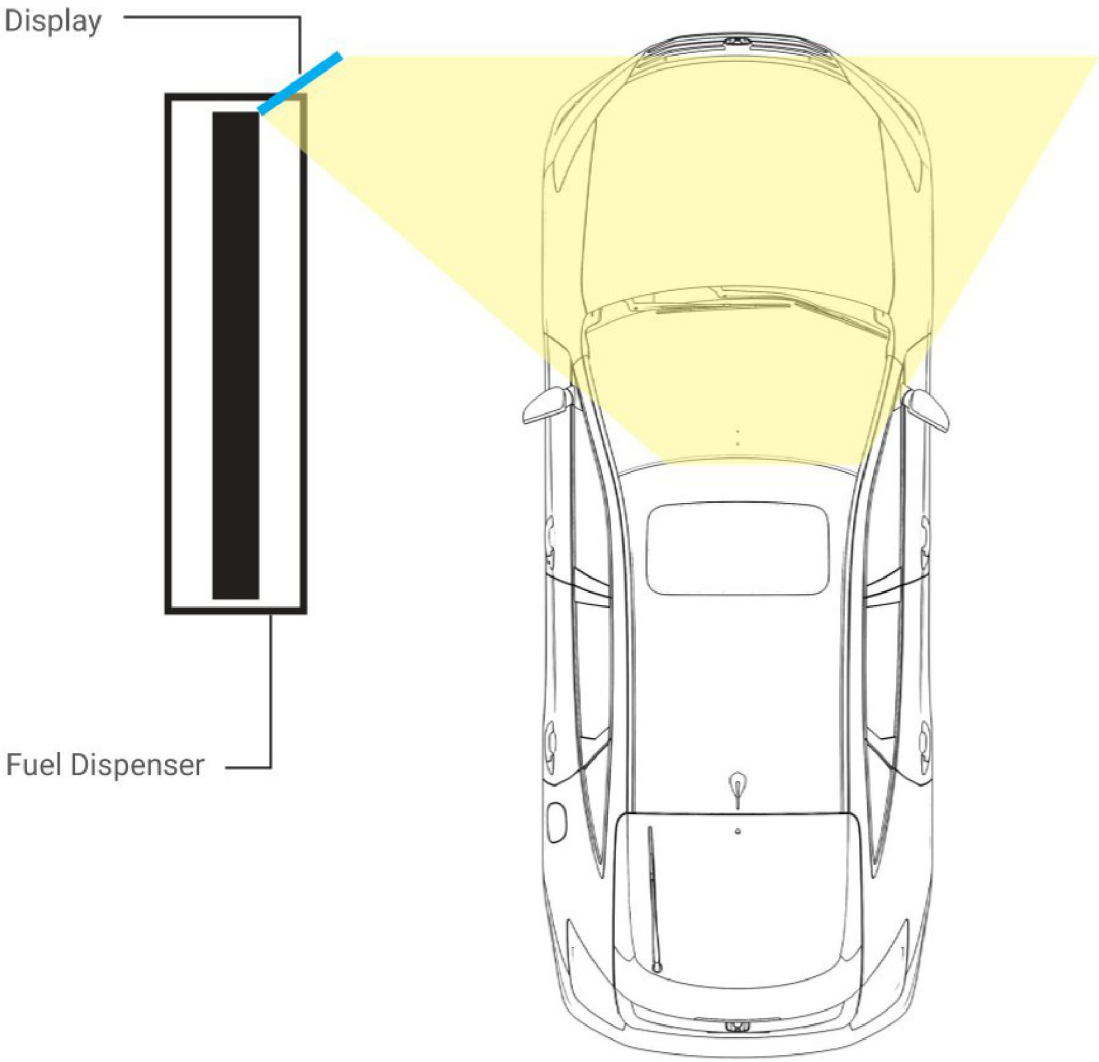


Figure 52
Detail drawings

User testing -



Human view angle

Figure 53

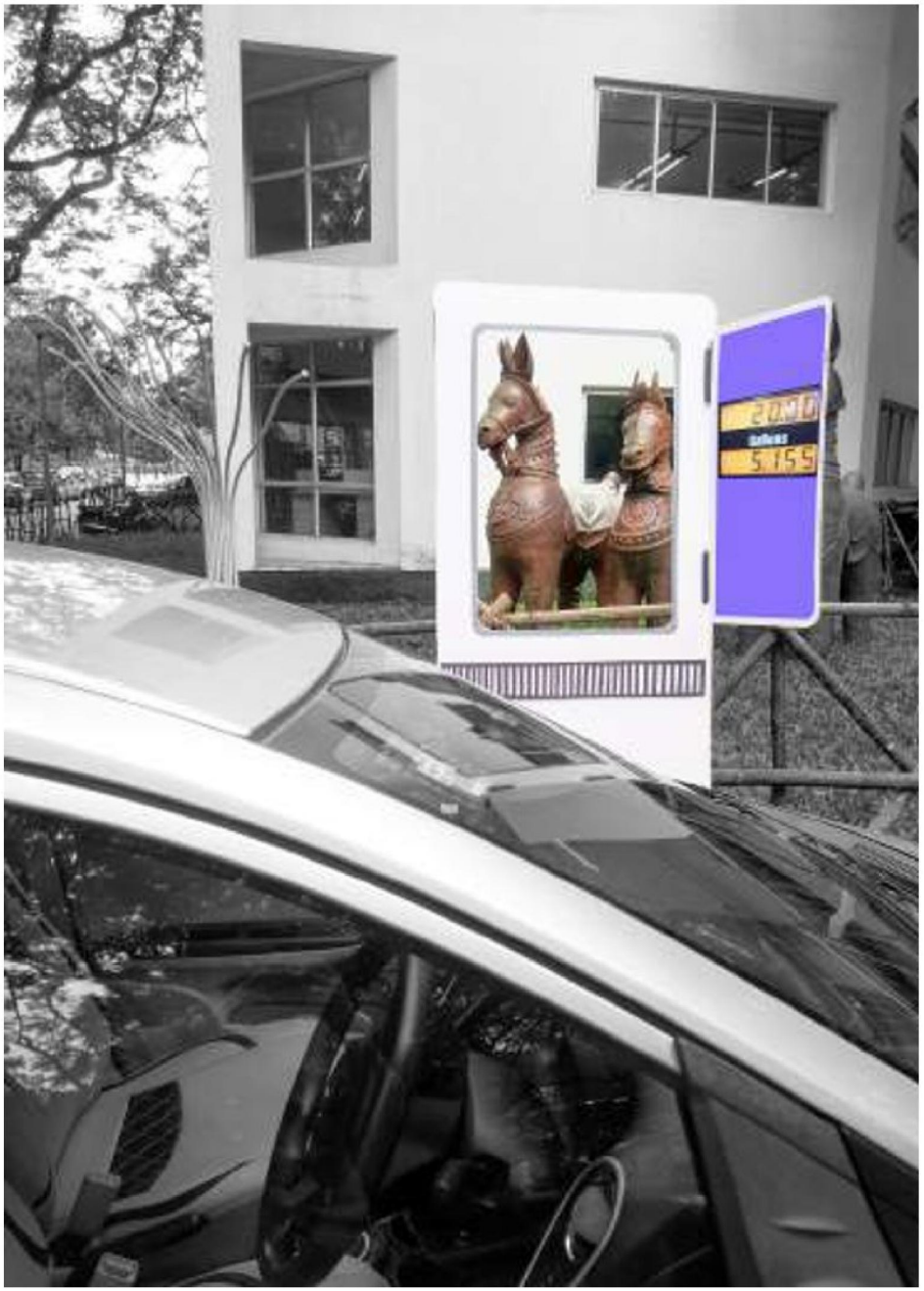
Display visibility

FromTwo Wheeler

Figure 54

Display visibility

From Four Wheeler



Insights -

1. Problem while walking around dispenser.
2. Fragile design of display.
3. Angled display increases the visibility of the screen for four wheeler users.
4. By putting a pump assembly hub under the ground, it creates lots of space above ground level.
5. It also reduces the width of the dispenser and make it sleek and compact design.

Advantage

Sleek design
Compact
More user-friendly
Bigger display
More visibility to the driver
Angled display

Disadvantage.

Angled display
Angled display make inconvenient to attendant around the fuel pump.
The dispenser width is the same as the previous design.
Rectangular form hides the useful features of the fuel pump.

Finalizing the concept among the other ideations

Taking down the machine underground concept with bigger display

Advantages of taking down the whole machine and pumps part of the fuel dispenser is that sleek design
And the opportunities to explore different forms in it.
More space will be there in the fuel pump for attendant. compact design user-friendly and more appealing look to gave futuristic design because in the previous one there is some constraint.

Concept -3

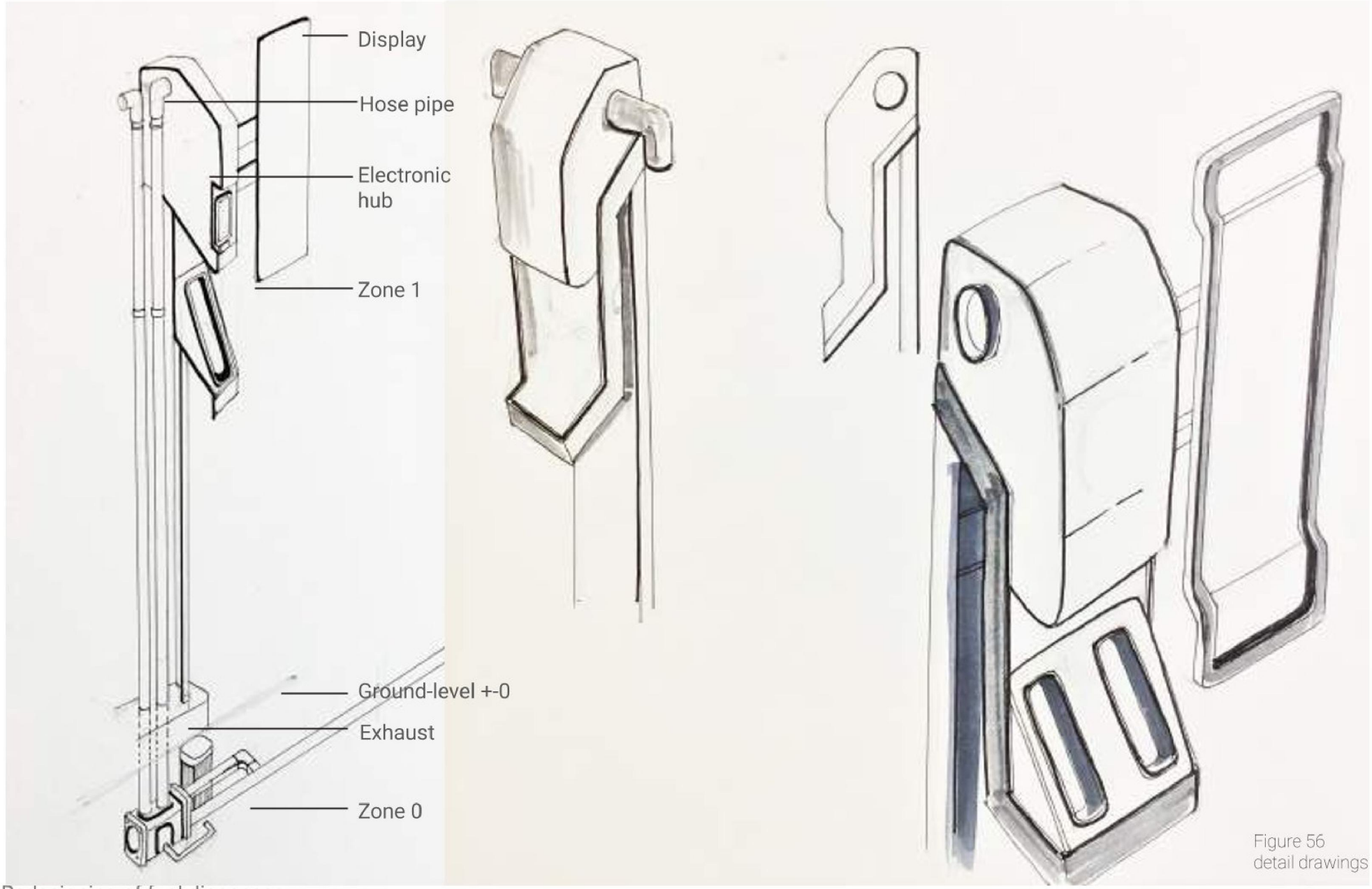


Figure 56
detail drawings

Figure 57
Render

Detail Diagram -

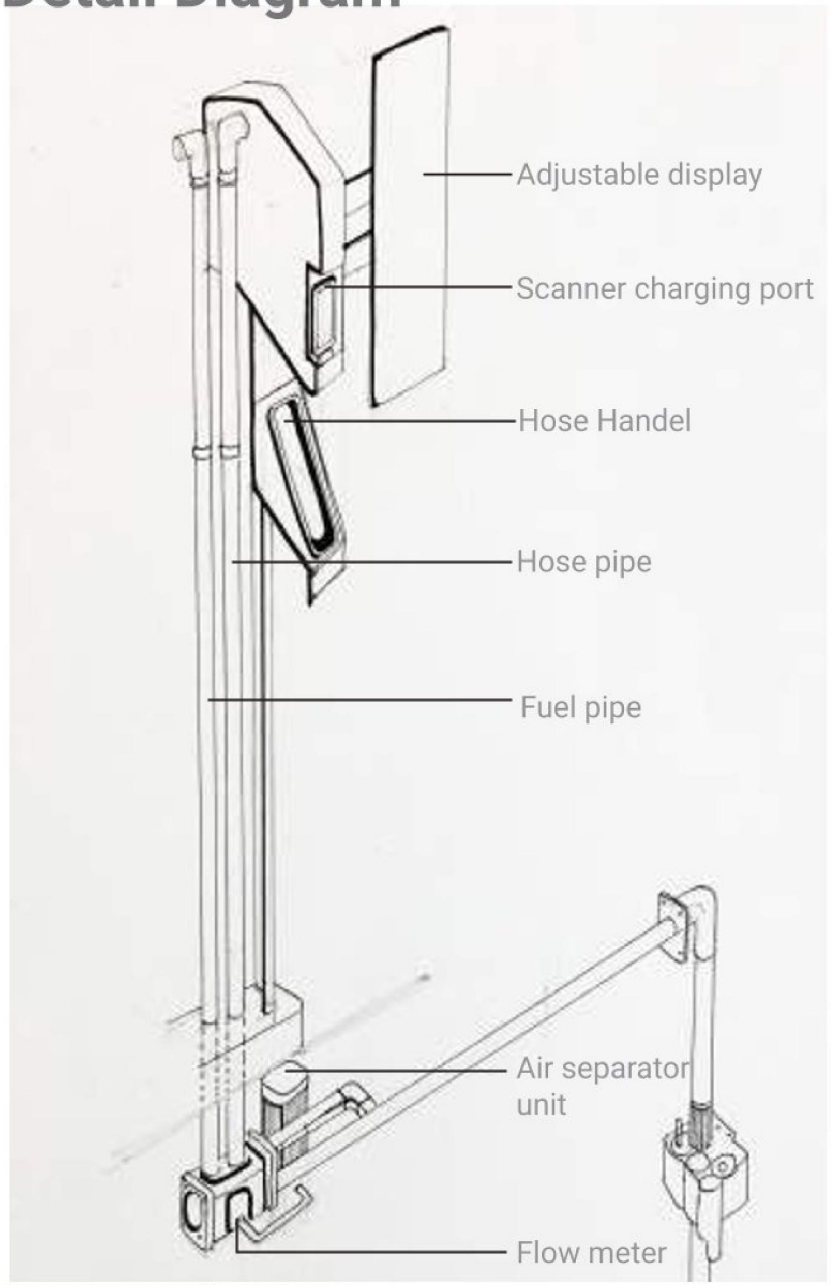


Figure 58
Pump section

Figure 59
Red jacket pump

Figure 60
Render

Figure 61
Render

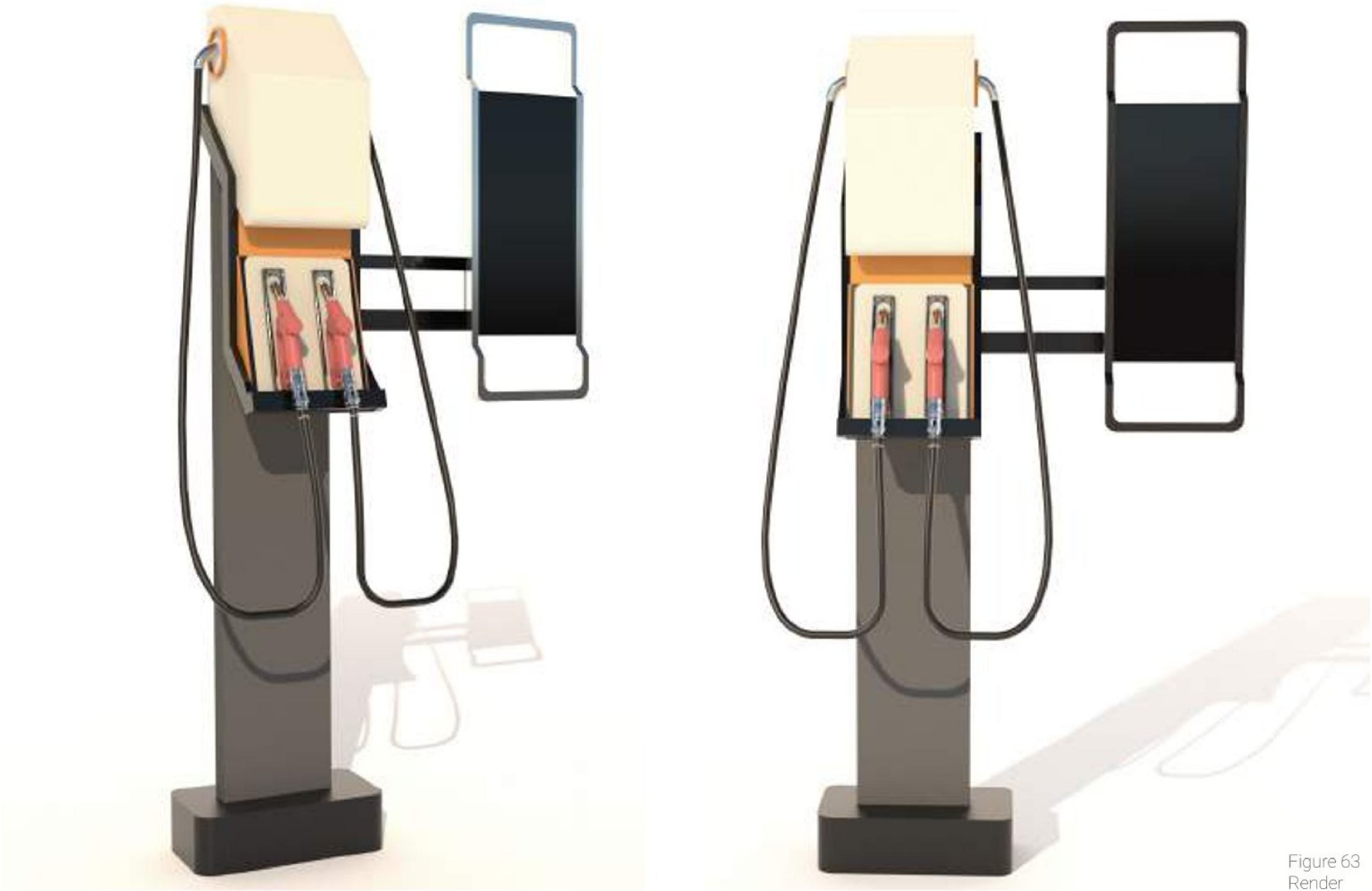


Figure 63
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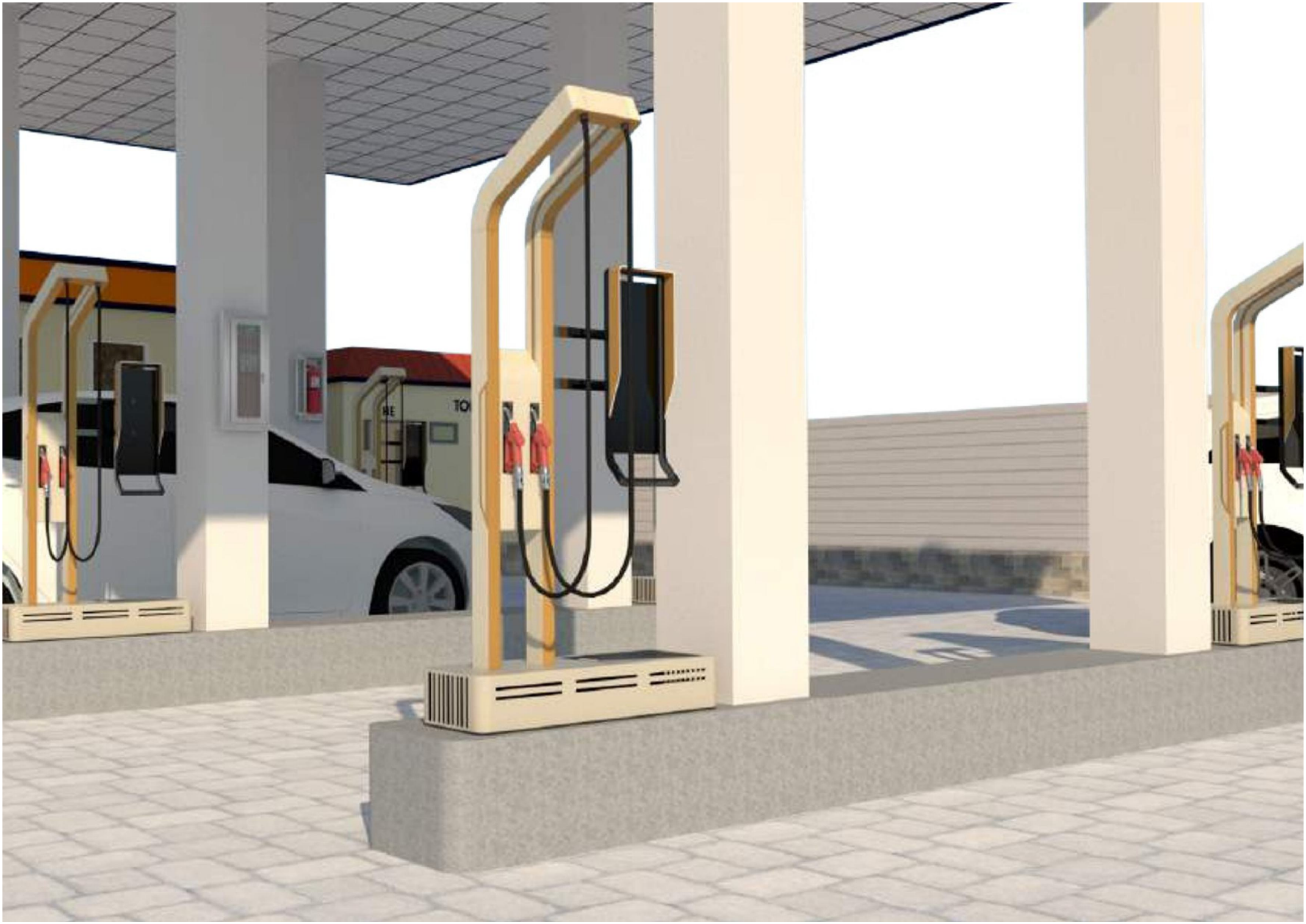
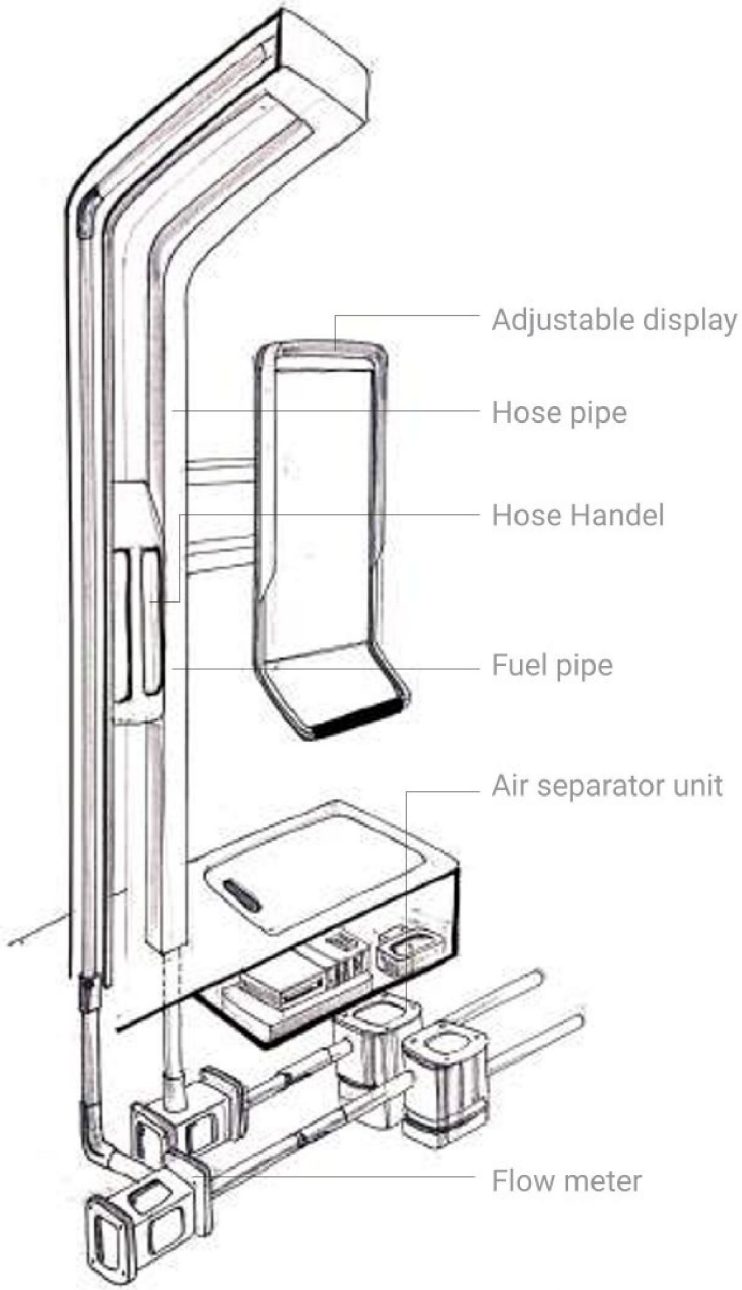
Final concept

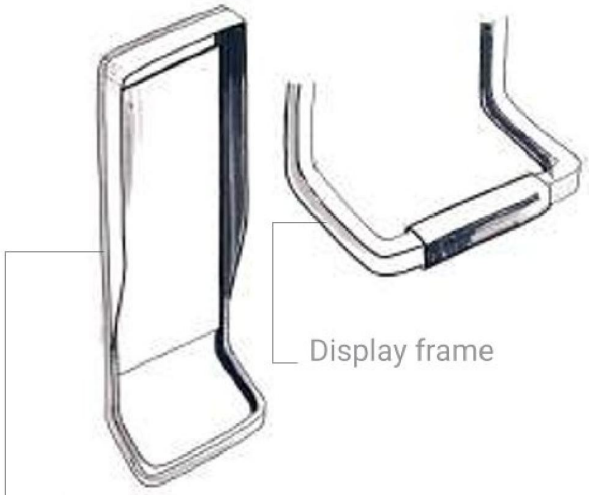


Final Design _

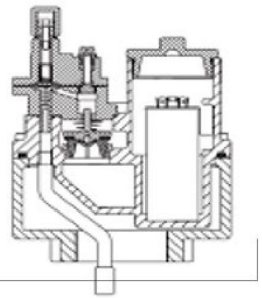
In this design, I have separated the zone 0 and zone 1. Above the ground level, there is the only exhaust, and below that, the whole pump and its mechanism. A prominent display, which is slightly away from the hose and the dispenser body because of avoiding the display hindrance from the hose pipes. In this design, the compactness is also the factor, the current fuel dispenser width is generally 650 to 700 mm, but in this design, the width will be reduced to 150mm.



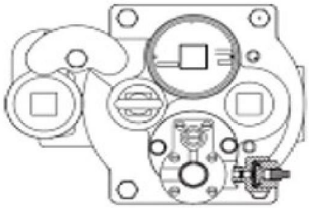
Hose pipe detail



Red jacket pump



Submersible pump



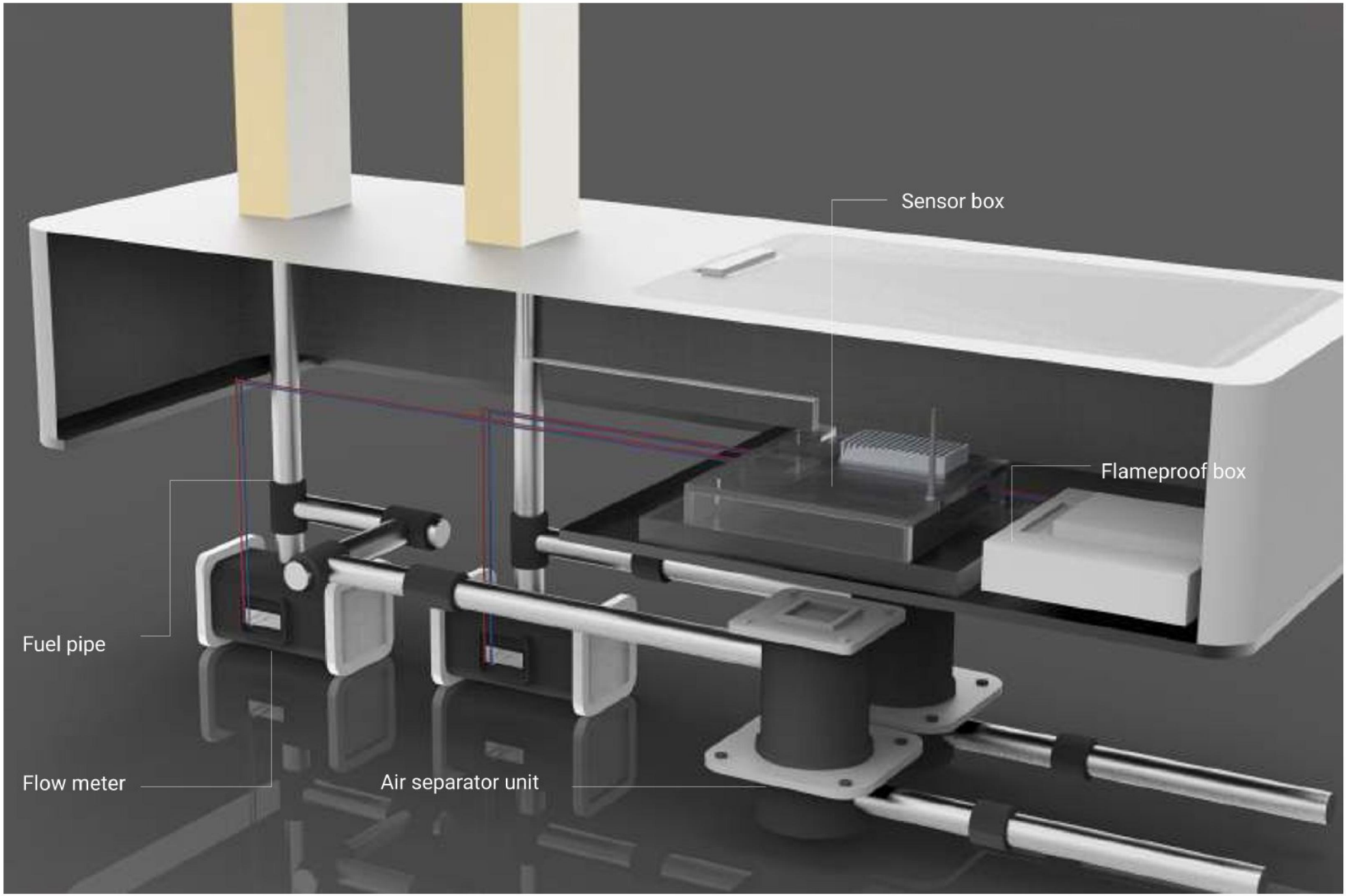

Sensor box
Flameproof box
Fuel pipe
Flow meter
Air separator unit

Figure 64
Render

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