Concept Design

Group No. 12

Faculty of Technology and Bionics

Barteolla
The Cocktail Mixer

Submitted by:

Kevin Ayebare, 29278
Electrical Engineering

Larissa Chifu Nchang, 30701
Industrial Engineering

Muhammad Murtaza Motiwala, 24476
Mechatronics Systems Engineering

Tinotenda Chadzinya Gurajena, 28030
Mechanical Engineering

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Statement of Originality

The students listed below solely wrote and produced this report themselves, and all the text passages and other content in the report represent their original work and references attached to the report.

Kleve, 05 December 2023

Kevin Ayebare
Nchang Larissa
Muhammad Murtaza Motiwala
Tinotenda Chadzinya Gurajena

Project Supervisors:

Christian Berendonk, Thorsten Brandt, Alexander Gerber, Martin Hellwig, Fabrice Kirsch, Kai Masuch, Angelika Michel, Karsten Schacky, Dirk Untiedt, Andreas von Bubnoff

Executive Summary

Our report introduces Barteolla, the automated cocktail machine. Our machine elevates the mixology experience and effortlessly dispenses cocktails in a short amount of time. Our well-crafted programming code enables this machine to demonstrate compatibility with multiple ingredients, handling various alcoholic beverages and mixers, thereby removing the need for manual measurements. Selecting the favorite cocktail is a quick "Tap and swipe" thanks to the user-friendly seven-inch touchscreen display that facilitates seamless interaction between the user and the interface; this enhances accessibility. The in-built auto-clean function simplifies the cleanup process. This feature is automatically activated a few moments after dispensing each cocktail, offering consistent drink quality. Barteolla is engineered for time-efficient usage and precise dispensing of our cocktails by careful selection of pumps and motor drivers. As a result, each cocktail is perfectly mixed, eliminating overly concentrated or diluted drinks. In the unlikely case of any device malfunction, our cocktail machine features an "emergency stop*”* push button, a critical safety feature to halt operation quickly. Our target market for Barteolla is designed mainly for household usage and we intend to sell at least 1000 units in Germany, within its first year of launch.
Barteolla is a high-quality personal bartender machine, catering to both cocktail enthusiasts and casual drinkers. Its capability makes it a suitable addition to any home.

Keywords:

-Multi-Ingredient Compatibility
-Auto-Clean Function
-User-Friendly Touchscreen Interface
-Time Efficient
-Precise Dispensing

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1 Introduction

In congested environments, the bartending procedures are less effective, resulting in increased wait times. The cocktail making process is not just time-consuming; it demands a specific skill set and a consistent approach. The difficulties typically revolve around precise ingredient measurement, memorizing recipes, and mastering techniques. Today's world is getting more digitalized, so every designed object must be up-to-date, faster, and reliable. People tend to buy things that will solve their problems and are willing to pay more for things that work perfectly without their supervision due to the rising demand for convenience. Additionally, the demand for well-crafted cocktails has been on the rise. According to the report (Cocktail Mixers Market Trends Size Share Growth Report 2023-2030, 2023.), cocktail mixers are estimated to grow globally at a rate of 8.7% annually and a value of about 18.2$ billion by 2030 with the dominant market in the USA, Canada, Mexico and Germany.

Considering this insight regarding the cocktail mixer market, it was challenging to develop an automatic cocktail mixer that can make at least six different cocktails, which is efficient, time-saving, and convenient. The following technological aspects are essential in the design phase:

- Ingredient dispensing mechanism with accuracy and speed.
- The mixing mechanism provides a layered cocktail.
- The touchscreen interacts with the users.
- The machine self-cleans itself after each dispensed drink, and it has a few detachable parts to clean precisely at the end of the day.

Our main objectives are:

- Maintain uniformity, consistency, and accuracy in cocktail recipes.
- Design a user-friendly interface, aesthetically pleasing automated cocktail mixer capable of preparing a variety of cocktails and fit in a home setting.
- Reduce the time and labour for mixing cocktails and accurately dispensing liquid ingredients.

The Automated cocktail mixer project is an exciting fusion of creativity and technology aiming to transform the cocktail preparation experience and provide a solution that is accessible and efficient. We look forward to embarking on this journey of exploration and innovation.

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2 Marketing Plan

2.1 Market Analysis

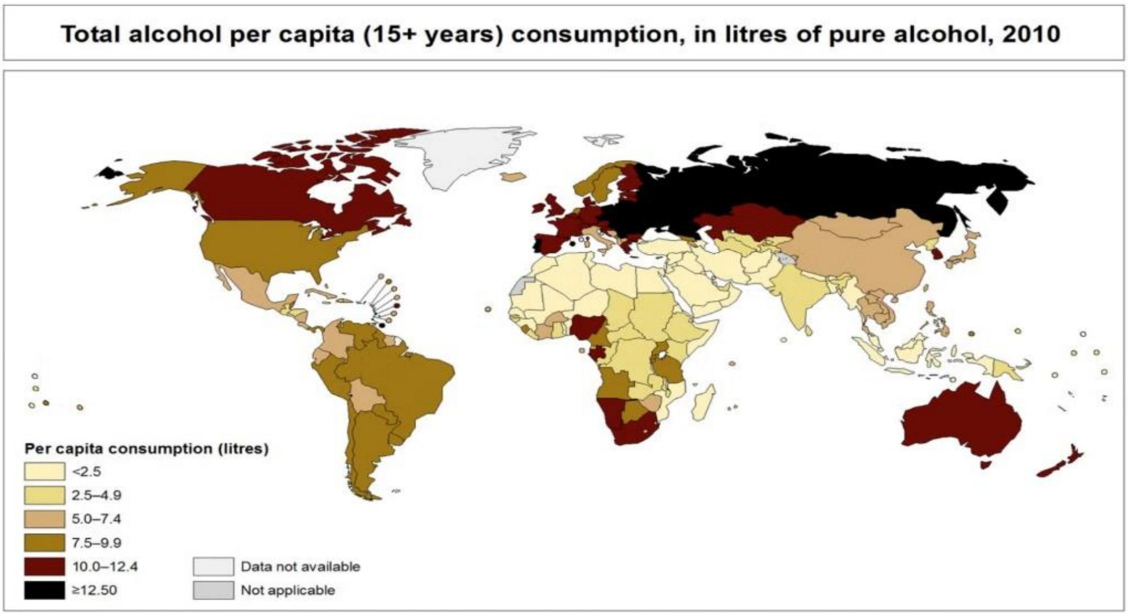


Figure 2.1 - Highlighting the significant potential market for automatic cocktail machine based on alcohol cosumption

The rising popularity of cocktails aligns with evolving lifestyle trends, particularly among millennials and the post-millennial generation. During holiday seasons, the demand for cocktails surges and the most recent advancement in this sector is the automated cocktail machine, which simplifies the drink-making process with the press of a button. The market potential for such a product will be in countries with high alcohol intake and drinking capabilities.

According to Figure 2.1, Europe and Russia consume the highest amount of alcohol. The robust presence of alcohol-related traditions fosters a conducive atmosphere for the European market's interest and need for cocktail mixers.

2.2 Market size and share

The market size of cocktail mixers in 2021 was 8.6$ million and is predicted to grow from 9.35$ million in 2022 to 18.2$ million by 2030. Our target market is aimed at household usage, like for home entertaining enthusiasts and busy individuals/working parents. The total population in Europe is 742 million, with 198 million households. Our product will be sold above average price, so we are considering the socio-economic status. The upper middle class is about 35%(259 million people). Narrowing our group further, we will target our first sales year to Germany before expanding into the European market.

The global overview of our cocktail machines is expected to grow annually at rate of 4% as seen on Figure 2.2 below. (Prime PRWire, 2023)

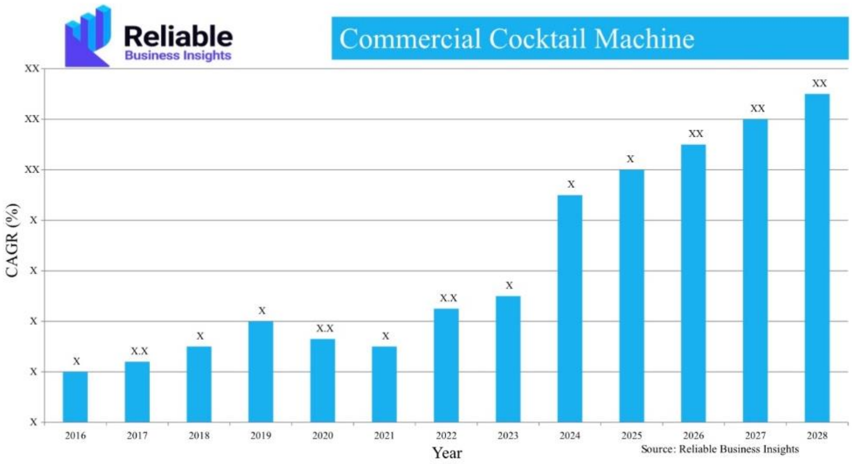


Figure 2.2 - Global market overview of cocktail machine market

2.3 Competitive Analysis

Our research analysis concludes, our direct competitors are the Bartesian automated cocktail mixer which was mentioned by Forbes(Bajarin, 2021). Bev by Black and Decker also qualifies for quality cocktail mixer products affecting the Cocktail Mixer market.

Direct Competitors			
		Bartesian	**Black and Decker**
Company Highlights	Company profile	Founded 2014 in Chicago Illinois	Founded in 1910, in Maryland USA
Market information	Target market	Residential use and busy professionals aged 21-50	Households and small parties
	Market share	4%	5.83%
	Marketing and strategy	Sponsorship + ads (google ads)	Organic traffic with millions of visitors per month
Product information	Products and services	An automatic cocktail mixer using cocktail capsules	An automatic cocktail machine
	Pricing	369$	300-399
	Distribution channels	Direct and carefully chosen associates. (Walmart)	Direct on website and other affiliates (like Amazon)

Table 2.1- *Comparison between two major direct competitor profile, the pioneers in the cocktail mixer market*

Based on the reviews and customer feedback on our two main competitors we could see that they faced clash backs on;

- Water Dispensing Issues:
  Several customers experienced problems with the water dispenser, causing issues in the mixing process.
- Reliability issue:
  Several customers reported issues with the machine's durability and reliability; problems such as white screen, leakage.
- Missing Pieces:
  Some customers reported devices with missing stabilizing parts, leading to an unstable unit highlighting potential quality control issues.
- Logistics and Customer Support issues:
  Few customers are facing slow shipping times and customer response times.

In order to improve the highlighted issues faced by our competitors, we will ensure to address them efficiently.

- ➢ Water Dispensing Solutions: Highlight any improvements to address water dispensing issues, emphasizing a smoother and more efficient mixing process.
- ➢ Value Proposition: Provide a clear value proposition in your marketing materials, addressing cost-effectiveness. Explain how the product offers value for its price and why it's a worthwhile investment.
- ➢ Address Build Quality: Invest in improving the build quality to ensure the product is durable and long-lasting.
- ➢ After purchasing our product, we will send a technician from our team to install the product This will be free of charge as a special give-back offer to our consumers.

2.4 Planned Sales Volume

Sales volume means the total number of units that our company sells over a specific time, and it is only recorded in our inventory account. Initially, we plan to start with Germany, and later we expand our operations globally. So, to shorten the selling cycle and reinvest back into the market, we plan target Cologne, North-Rhein Westphalia, the most populated city in Germany with about 18 million inhabitants. (Michael, 2023)

In the beginning phase of our product launch, we will produce 300 units and once our target of selling the first 300 units in 4 months is reached, we will start the production of the next set based on customer reviews and the demand. Our further production will depend upon the law of supply and demand. By maintaining a regular check and balance on the sales matrix and the defined Key Performance indexes like the Sales Qualified Leads, Sales cycle length and so on, will ensure the success of our product.

For the first year, we want to sell at least 1000 units of our products in Germany which can be achieved by faster shipping rates, faster customer response time, durability, and efficiency of our product.
We plan on going into the European market by our third year and becoming the best robotic bartender manufacturing company.

2.5 Sales structure

A sales plan is a strategic plan where we specify our sales goals, tactics, challenges, target market and steps we take to execute the plan.

2.5.1 Phase 1: Initial Launch and Market Penetration (Months 1-4)

The automated cocktail market is driven by the growing demand for convenience, precision, and versatility in cocktail preparation. As technology continues to advance, the market is likely to witness further growth and diversification. Our goal is to create cash flow and profitability by selling at least 300 units of our products and to acquire 100 new customers.
We will hire and train a sales team with expertise in our product and industry and keep an eye on our direct competitors' activities and adjust sales strategies as necessary. Then in the development and prototyping phase, we will launch our company website and start advertising our products digitally. For example, we will run google ads, social media marketing, email marketing, and customer outreach (Phone calls and direct visits). We plan on analyzing our sales performance, customer reviews, establishing Key Performance Indicators (KPI) to track the next sales period and also carrying out the SWOT Analysis to know the Strength, Weakness, Opportunities, Threats, Trends of our product.

2.5.2 Phase 2: Growth and Market Expansion (Months 4-8)

Now after penetrating the market, we are looking for ways to grow, so we improve lead conversion rate by developing more targeted sales messages and nurturing leads more effectively and implement a CRM system to better manage customer relationships. We plan on providing discounts or incentives to encourage more purchases and focus on retaining existing customers through loyalty programs or exceptional customer service.

2.5.3 Phase 3: Consolidation and Long-Term Strategy (Months 8-12)

We will continue to expand and target new markets in other regions by creating long-term sales strategies, including partnerships, collaborations, selling to wholesalers and retailers and exploring international markets. Then we will implement advanced analytics and reporting tools to make data-driven sales decisions. Also carrying out a SWOT analysis and investing in training and skill development for our sales team. Furthermore, we will make realistic long-term sales goals and objectives based on the lesson learned from the first two sales periods.

2.6 Planned Market Price

The market price of our automated cocktail mixer is the price at which the quantity supplied equals to the quantity demanded. Since we are the manufacturers, a profit margin of 30-40% should be obtained. The range of prices for existing models is between 300€ *to* 600€*. Price skimming (entering the market with the* highest possible price and reduce as time goes) is a great option if we plan to release newer versions of our product frequently like Apple. But for now, *we don't*, and we will decide after our first sales period based on our customer reviews.
As manufacturers, we decided on the competitive based pricing system by setting our prices higher than our competitors based on the higher value of our products (enhanced features and expert customer service). Our product will be priced based on;

- The price of commercial-off-the-shelf (COTs) components.
- The cost of making parts.
- Production, manufacturing, and assembly costs.
- Labour costs.
- Cost of advertising and marketing.
- Location (rent) costs.
- Research and development costs.
- Profits.
- Overhead costs.

The cost of our buy components is seen from our table below.

Table 2.2 – Total cost listing for all "buy-part" components and their respective suppliers.

	List of components	Quantity	Cost per unit (€)	Total (€)	Supplier (Brand)
1	TB6600 stepper motor drivers	8	9.99	79.92	Amazon.de
2	Arduino Mega board	1	42	42	Arduino official store
3	Peristaltic pumps	8	19.09	152.72	Alibaba.com
4	12V Power supply	1	23	23	Amazon.de
5	LCD touchscreen	1	46.32	46.32	Exp-tech.de
6	On/Off switch and power connector module	1	4.89	4.89	Conrad.de
7	Emergency stop button	1	10.30	10.30	Reichelt.de
8	Power supply cable	1	5.84	5.84	Amazon.de
9	Silicon tubes	4(meters)	3.7	14.8	Aliexpress.com
11	DC/DC converters	2	2.51	5.02	Reichelt.de
12	Electrical wiring	10(meters)	7.88	7.88	Amazon.de
Total cost:	*392.69€*				

Our selling price of our mixer is set at 1,000€*, thereby highlighting* the superior quality our product and our eco-friendly packaging. Our profit margin will be 50€*.Considering our buy parts to be 392.69€, it allows for additional variable* costs, cost of production and per unit measurement of fixed costs to achieve a *maximum allowed cost of 950€.*

2.7 Revenue Forecast

Based on our market research, our target market will have a population of 18 million people and million households. So, during the first period, we have a targeted sales of 200 units. Assuming 40% of households buy our products, we are left with 3.4 million households. Our target sales volume for a year is 200 units for the first sales period,300 units for the second and 500 for the third making it 1000 units.

Future Sales Revenue = Sales price per unit * volume

= 1000 units x 99*0€* = **990,000€**

Gross Profit = Sales Revenue - (Total cost per unit * sales volume)

990,000€ - *(950€* 1000)* = **40,000€**

3 Overall Product Concept

Barteolla cocktail mixer, makes the process of combining different drinks easier and provides a vast variety of cocktail and drink options. Multiple possible design options were considered to develop an automatic cocktail maker, but considering different challenges and options, a top-down bottle orientation was selected for its benefits and premium look. The housing is made with steel to enhance the premium look for the machine, with removable tray made with plastic for easy cleaning and one push button operation for smooth user experience. The self-cleaning feature uses the water used as one of the inputs to the machine.

3.1 Requirement List

- High quality housing made of ABS plastic for lightweight design and durability.
- Most components are screwed together for easy assembling and disassembling.
- Seven-inch touch screen used for user interaction with Tap and Swipe feature to create quick drinks.
- Detachable drip tray for easy cleaning the overflow fluids.
- Self-cleaning mechanism, automatic cleaning process after each cocktail dispensed.
- Eight different input options to create unique cocktails.
- Using water bottle as one of the bottle inputs for self-cleaning mechanism.
- Rubber cog with self-closing mechanism suitable for upside down orientation and to prevent leakage.
- 220 - 240V power supply
- Ergonomic design should be considered in CAD modeling.
- Bottle holder should be in steps for better usability and ease to change bottle.
- The machine should have proper ventilation for airflow for electronic components.
- Device Dimensions: 400 mm x 400 mm x 500 mm
- Screen Dimensions: 7-inch screen - 155 mm x 89 mm
- Glass Dimensions: 90 mm x 200 mm
- Standard 750ml Bottle Dimensions: (75 mm x 300 mm) (Derick, 2021)

3.2 Material Considerations

- ABS Plastic Housing
- Silicon Tube
- Market standard glass bottles

3.3 Main Components List

Table 3.1 –Mechanical Components part list with their respective part number and quantity

Part No.	Mechanical Components	Material	Units
1	Housing – Front	ABS Plastic	1
2	Housing – Front Cover	ABS Plastic	1
3	Housing – Back	ABS Plastic	1
4	Housing – Back Cover	ABS Plastic	1
5	Housing – Top Holder	ABS Plastic	1
6	Bottle input adapters	ABS Plastic	8
7	Funnel	ABS Plastic	1
8	Drip Tray Housing	ABS Plastic	1
9	Drip Tray Part	ABS Plastic	1
10	Drip Tray Cover	ABS Plastic	1
11	Cog	Rubber	8
12	Tubes	Silicon	16
13	Screws	Stainless Steel	76
14	Motor holder	ABS Plastic	2
24	Bottles	Glass	8

Table 3.2 - Electrical Components part list with their respective part number and quantity

Part No.	Electrical Components	Units
15	Arduino Mega board	1
16	On/Off Switch and power connector	1
17	Peristaltic pumps	8
18	LCD touchscreen	1
19	TB6600 Stepper motor drivers	8
20	Power supply	1
21	Power supply cable	1
22	Emergency stop button	1
23	DC/DC converters	2

3.4 Concept Idea Sketch

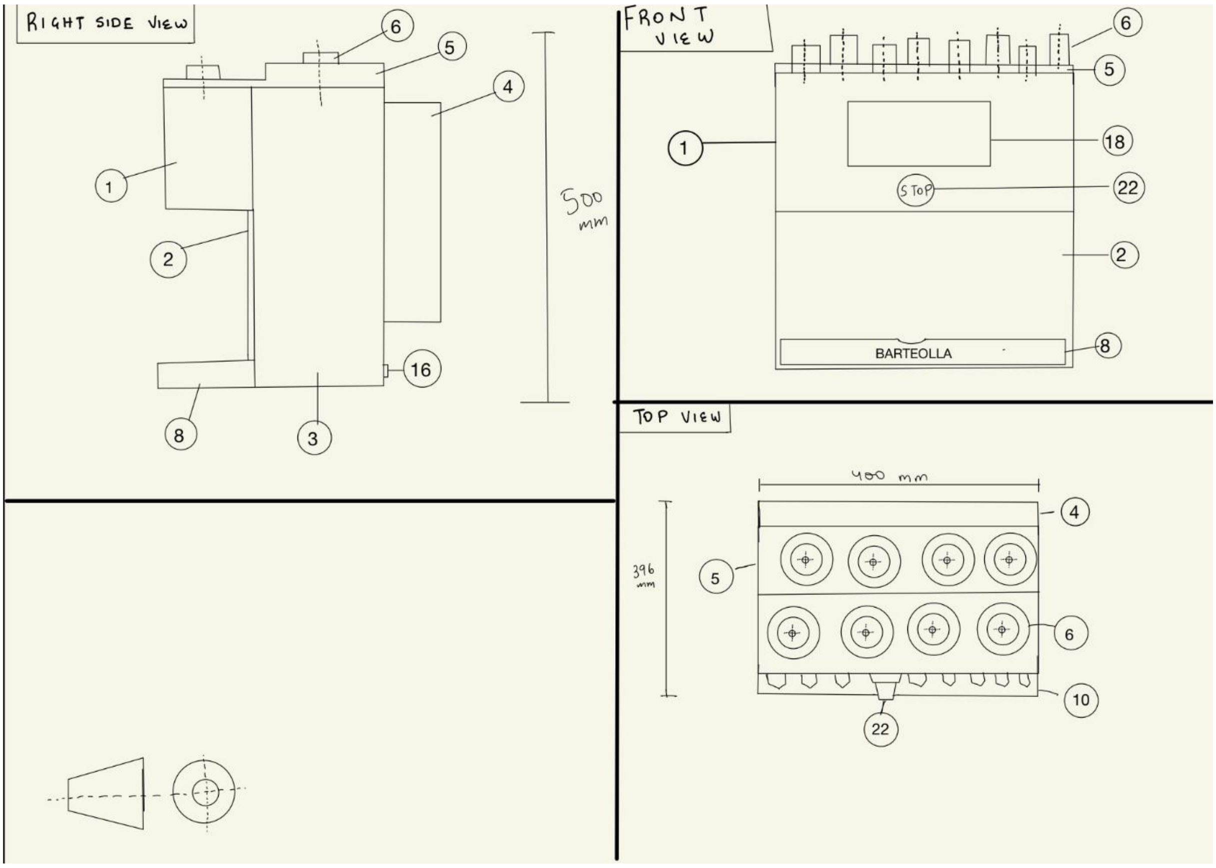


Figure 3.1 - Rough sketch for Barteolla Cocktail mixer, first angle projection with front, top and right-side view

Morphological box

Table 3.3 - Morphological box with different options and final decision considered for this machine functions and feature.

Category	Subcategory	Option 1	Option 2	Option 3
Design	Bottle Orientation	Sideways orientation	Upright Straight	Upside down
	Water Source	Water Dispenser	Water bottle as input	Water connection from hose
	Material	Stainless Steel	Aluminium	ABS Plastic
	Machine Shape (Form factor)	Circular	Cube	Cuboid
	User interface	Touchscreen	Screen with button input	Rotating dial with buttons
	Bottle Inputs	7	8	10
Cleaning	Cleaning Mechanism	One cleaning button	Automatic Cleaning after each use	Manual cleaning
	Detailed Cleaning System	Automatic	Manual	Both
Drinks	Bottle type	Large bottles	Custom Designed	Market standard
	Bottle quantity with machine	2	4	8
	Drink Cooling system	Ice used by customer	Ice dispenser	Cooling coils
	Drink Process	Separate dispenser for each input	Funnel with all inputs	
	Cocktail recipes variety	6	8	10

4 Functional structure

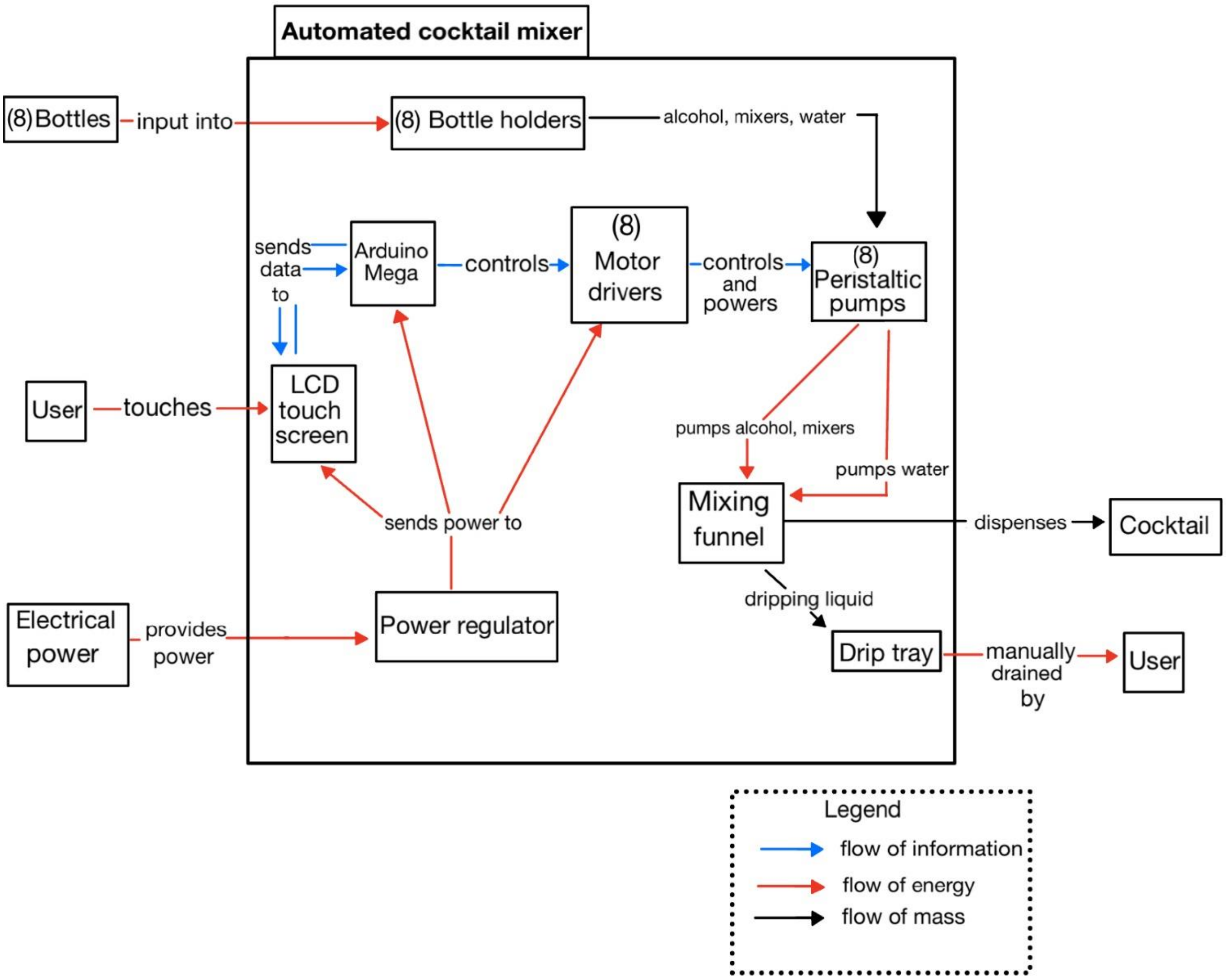


Figure 4.1 - Complete functional structure diagram along with the flow lines.

Table 5.4.1 - D - FMEA table providing complete detailed analysis.

5 D-FMEA

Components	Function	Potential Failure Mode	Potential Effects of Failure Mode	SEV	Potential Causes	OCC	Current Detection	DET	RPN	Recommended action
Housing Steel	Holding bottles Housing the internal mechanism	No function: cannot hold the bottles. No function: cannot mount the internal mechanism	Cannot attach the bottles to the machine. Machine cannot be assembled and function	2 5	Wrong tolerances when manufact-uring Wrong tolerances when manufacturing	1 1	Failing to mount the bottles onto the housing. inside mechanism failing to mount on the housing	1 1	2 5	High precision equipment must be used High precision equipment must be used
LCD touchscreen	To select which cocktail to make	No function: Pixel failure	Display screen not responding to touch	8	Physical damage	1	Crack on the screen	1	8	Replace the display screen

Bottle input adapter	For connecting bottle to the machine	Under function: Leakage	Leaking of liquids and damaging electrical parts	2	Damage during installation	1	No tight fitment to the bottles and to the machine	2	4	High quality and high strength material should be used Replace the adapters
Bottles	For storage of the liquids	No function: Breaking of the bottles	No liquids stored in the bottles to make the cocktails	2	Poor material quality used to make the bottles	2	Crack on the bottle and unable to store the liquid	1	4	Uses high quality bottles or replace the bottles
On/Off switch	To switch the machine on or off	No function: No response	Cannot switch on/off	1	wrong connections	1	Machine unable to start when switch is on	2	2	Replace the buttons or checking for wrong connections

Emergency Stop button	For emergency stop	No function: No response	Cannot stop the machine	1	wrong connections	1	Machine unable to stop	2	2	Replace the buttons or checking for wrong connections
Silicon Tubes	For transporting the liquids	Under function: Leakage	Damage to inside parts and no liquids flowing	2	High flow pressure Damage on the tubes or poor-quality tubes	1	Liquids escaping through the machine	2	4	High strength material should be used during manufacturing and pressure test before assembly
Arduino Mega board	To control the motor drivers and analyze input and output of display	Unintended function: Bugs in the Arduino code	Inaccurate cocktail mixing	8	Syntax errors in the code	2	Wrong cocktail produced from the one selected	1	16	Lengthy code reviews and testing

					Rushed code testing		Unbalanced cocktail mix produced			
Peristaltic pumps	Suction of the liquid from the bottles to the mixing station	Under function: No liquid being pumped through the system	Suction speed of the liquid is low	7	Low current is getting to the motor	2	Emergency stop button signal is displayed on the LCD	3	42	Crosscheck for improper connections of wiring
		Over function: Too much liquid being pumped through the system	Suction speed of the liquid is too high	4	Defect on the motor	2	Smoke coming from the pump	8	64	Replace the pumps in case of defect detected
Funnel shaped Mixing station	For collection and mixing of the liquids	Under function: Leakage	Spillage of liquids inside of the machine	2	Loose sealing on the mixing station	1	Liquid found on machine floor and outside wall of the mixture	6	12	Repair will be done by our technician Replace the mixer

Plastic Drip Tray	To dispose excess liquids from machine	No functions: Crack on tray	Leakage into making damaging electrical components	1	Damage during manufacturing or installation	1	Detected by observed	2	2	Use high strength material during manufacturing or replace the tray
12V Power Supply	To supply current to the machine	No function: Wrong wire size used for the cable	No current flow to the machine and machine not switching on	6	Mistakes made during the manufacturing	2	Quality control check	3	36	Replace the cable
DC/DC convertor	To step down the 12V input voltage to 8V and 5V.	Over function: Aging of capacitors at the output voltage.	Unstable output voltage to the electrical components	2	Thermal effects from the circuit beyond which the capacitors can handle	2	Random low and high brightness of the LCD display	3	12	Ensure proper selection of converter circuits that have capacitors with appropriate temperature settings.
TB6600 stepper motor drivers	To control the motor speed and supply the motors with power	Over function: The motor driver heats up	Innacurate volume of liquid pumped by the motor pump	4	Fluctuations in power supply voltage	2	Emergency stop button signal displayed on LCD screen	5	40	Ensure a stable power supply to the stepper motors

		Under function: The motor driver does not function	No liquid is pumped through the pump	5	Undervoltage	5	Emergency stop button signal displayed on LCD screen	2	50	Ensure a proper wiring connection between the power supply and motor driver

6 Project Plan

Milestone	Starting Date	Deadline
Concept Design	10 Oct 2023	07 November 2023
Product Design	07 November 2023	05 December 2023
Project Documentation	05 December 2023	16 January 2024

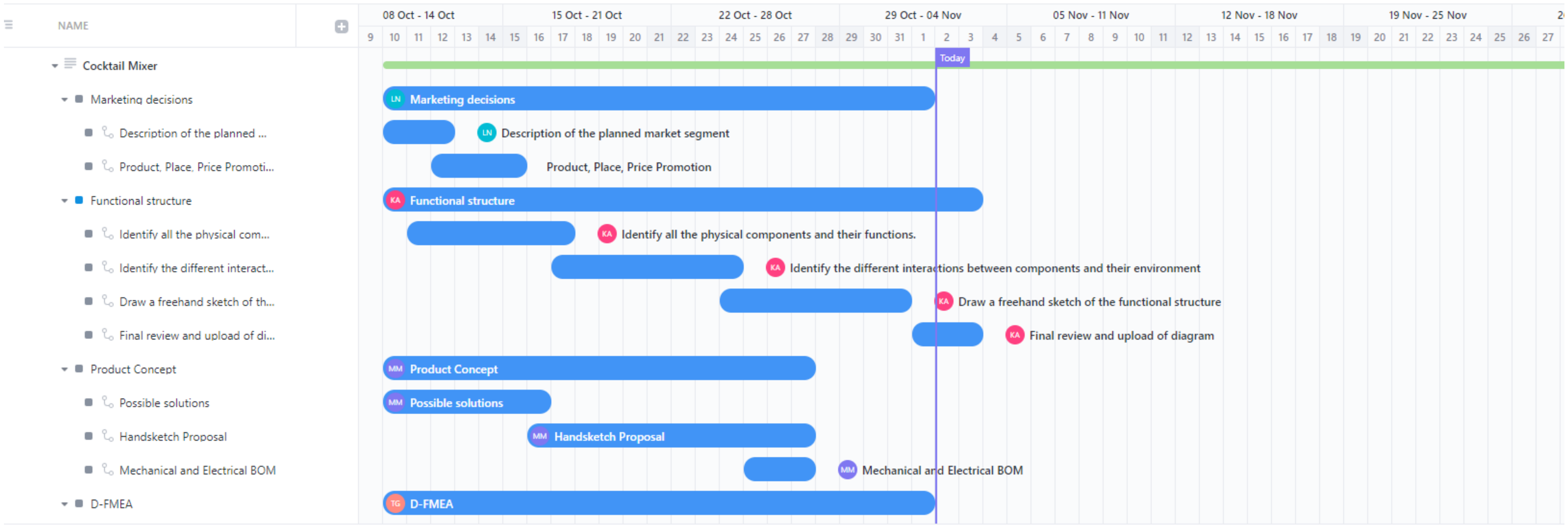
6.1 Gantt Chart (Clickup App)

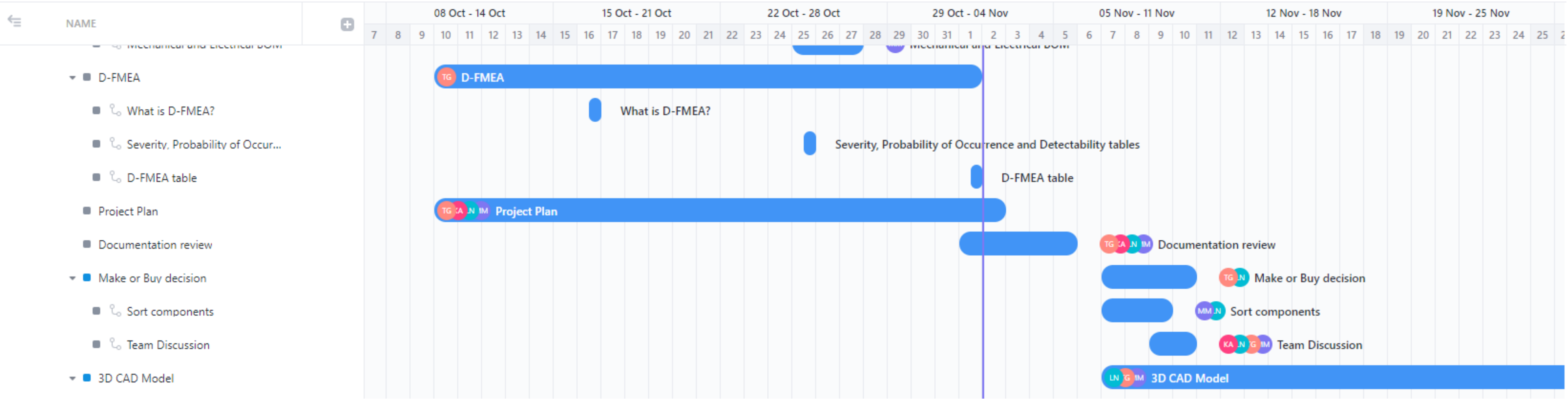
KA Kevin Ayebare

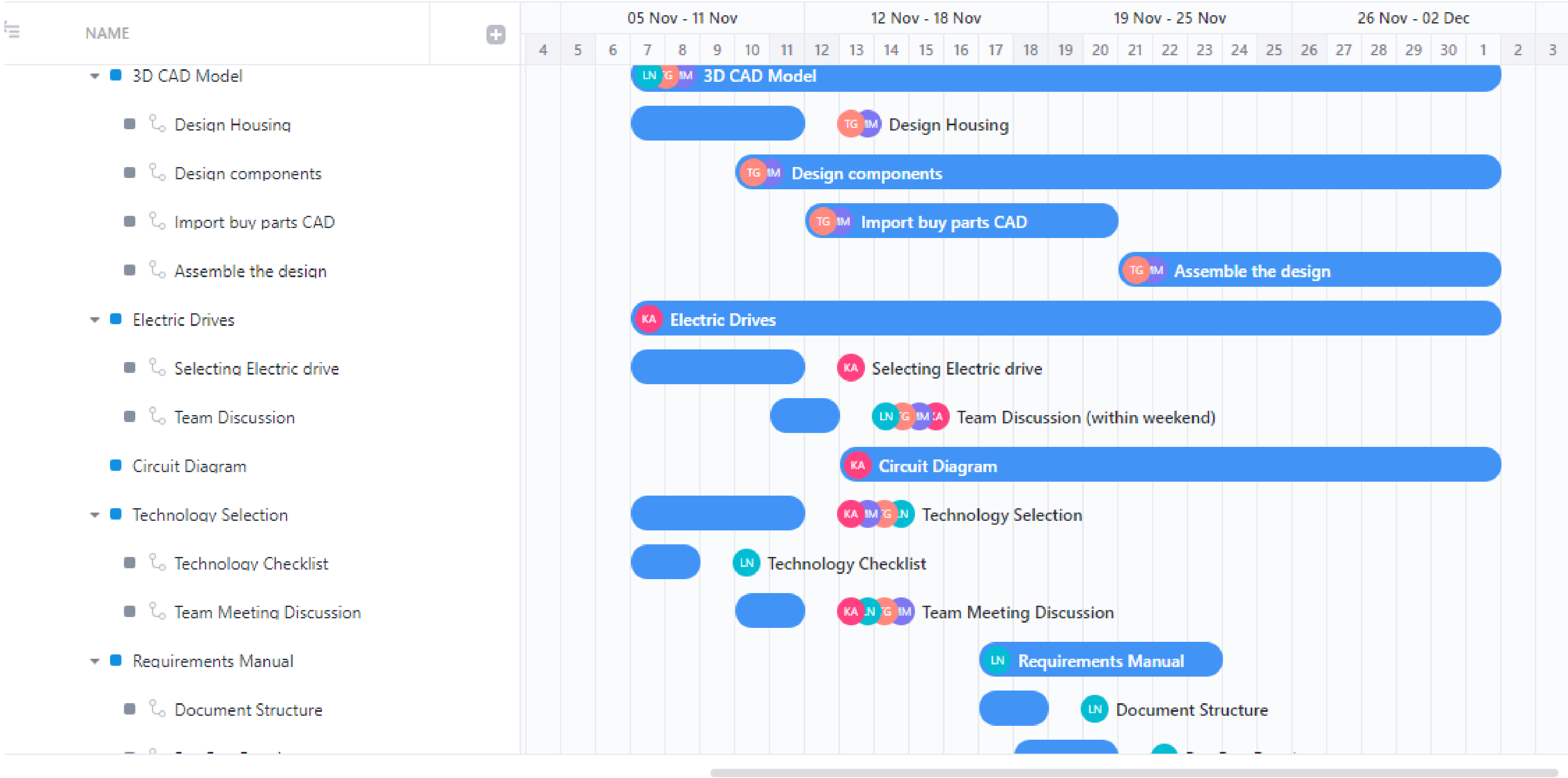
LN Larissa Nchang

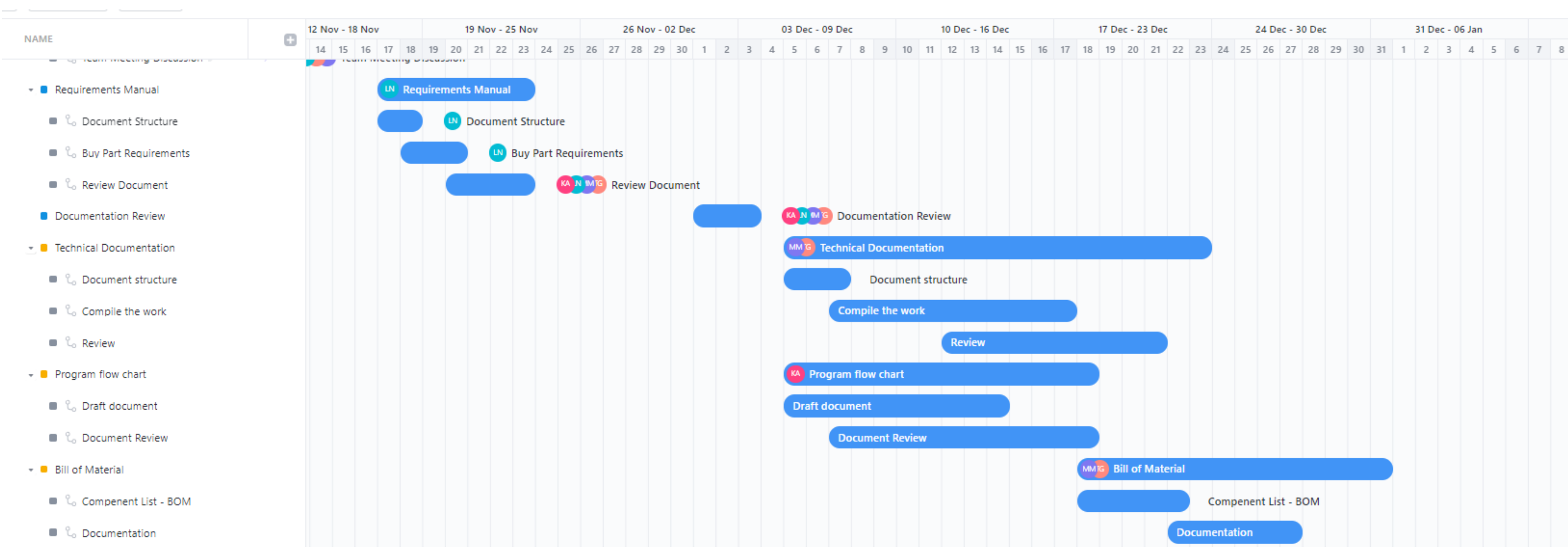
TG Tinotenda Gurajena

MM Muhammad Murtaza


NAME
08 Oct - 14 Oct
15 Oct - 21 Oct
22 Oct - 28 Oct
29 Oct - 04 Nov
05 Nov - 11 Nov
12 Nov - 18 Nov
19 Nov - 25 Nov
Today
Cocktail Mixer
Marketing decisions
Description of the planned ...
Product, Place, Price Promoti...
Functional structure
Identify all the physical com...
Identify the different interact...
Draw a freehand sketch of th...
Final review and upload of di...
Product Concept
Possible solutions
Handsketch Proposal
Mechanical and Electrical BOM
D-FMEA
Marketing decisions
Description of the planned market segment
Product, Place, Price Promotion
Functional structure
Identify all the physical components and their functions.
Identify the different interactions between components and their environment
Draw a freehand sketch of the functional structure
Final review and upload of diagram
Product Concept
Possible solutions
Handsketch Proposal
Mechanical and Electrical BOM
D-FMEA


NAME
08 Oct - 14 Oct
15 Oct - 21 Oct
22 Oct - 28 Oct
29 Oct - 04 Nov
05 Nov - 11 Nov
12 Nov - 18 Nov
19 Nov - 25 Nov
D-FMEA
What is D-FMEA?
Severity, Probability of Occur...
D-FMEA table
Project Plan
Documentation review
Make or Buy decision
Sort components
Team Discussion
3D CAD Model
Severity, Probability of Occurrence and Detectability tables


NAME
05 Nov - 11 Nov
12 Nov - 18 Nov
19 Nov - 25 Nov
26 Nov - 02 Dec
3D CAD Model
Design Housing
Design components
Import buy parts CAD
Assemble the design
Electric Drives
Selecting Electric drive
Team Discussion
Team Discussion (within weekend)
Circuit Diagram
Technology Selection
Technology Checklist
Team Meeting Discussion
Requirements Manual
Document Structure


NAME
12 Nov - 18 Nov
19 Nov - 25 Nov
26 Nov - 02 Dec
03 Dec - 09 Dec
10 Dec - 16 Dec
17 Dec - 23 Dec
24 Dec - 30 Dec
31 Dec - 06 Jan
Requirements Manual
Document Structure
Buy Part Requirements
Review Document
Documentation Review
Technical Documentation
Document structure
Compile the work
Review
Program flow chart
Draft document
Document Review
Bill of Material
Compenent List - BOM
Documentation

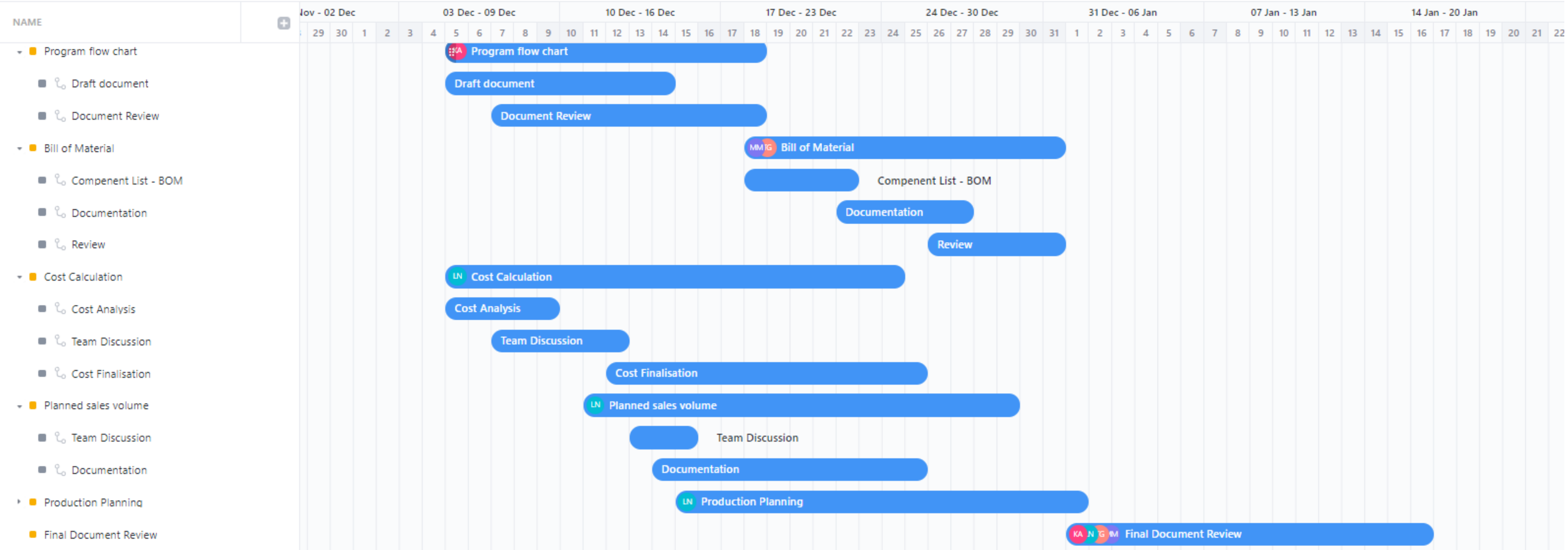


Figure 6. 1 - Gantt chart explaining the Project plan using Click up App online to collaborate and organise work.

Milestone 2 – Product Design

7 Functional Principle

Assembly with Back housing and Front housing

Back housing(3) and the Front housing(1) are the main housing assembly parts, the major parts of the machine structure. These parts are responsible for accommodating the funnel(7),tubes(12),motor pump holder(14),pumps(19),LCD touchscreen(18),power supply(21),emergency stop button(22) and the on/off button(16) .There is a transition fit where the back housing and the front housing joins. The two housing parts are further secured by screws.

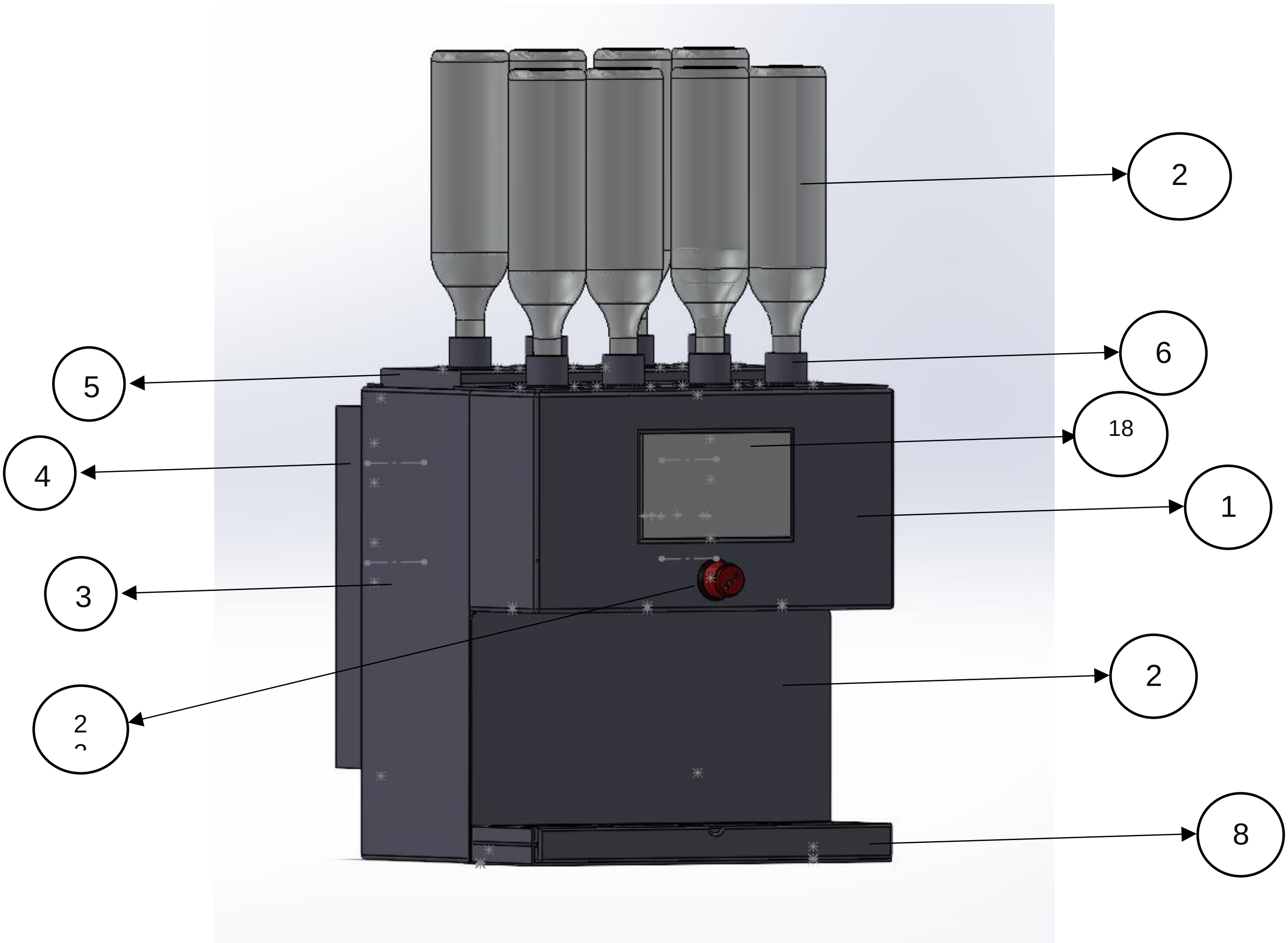


Figure 7.1 - Isometric View of the complete assembly with eight bottles

The figure 7.1 highlights the importance of the main housing part and the outer view of the major assembly. Figure 7.2 emphasizes on the section view of the overall assembly.

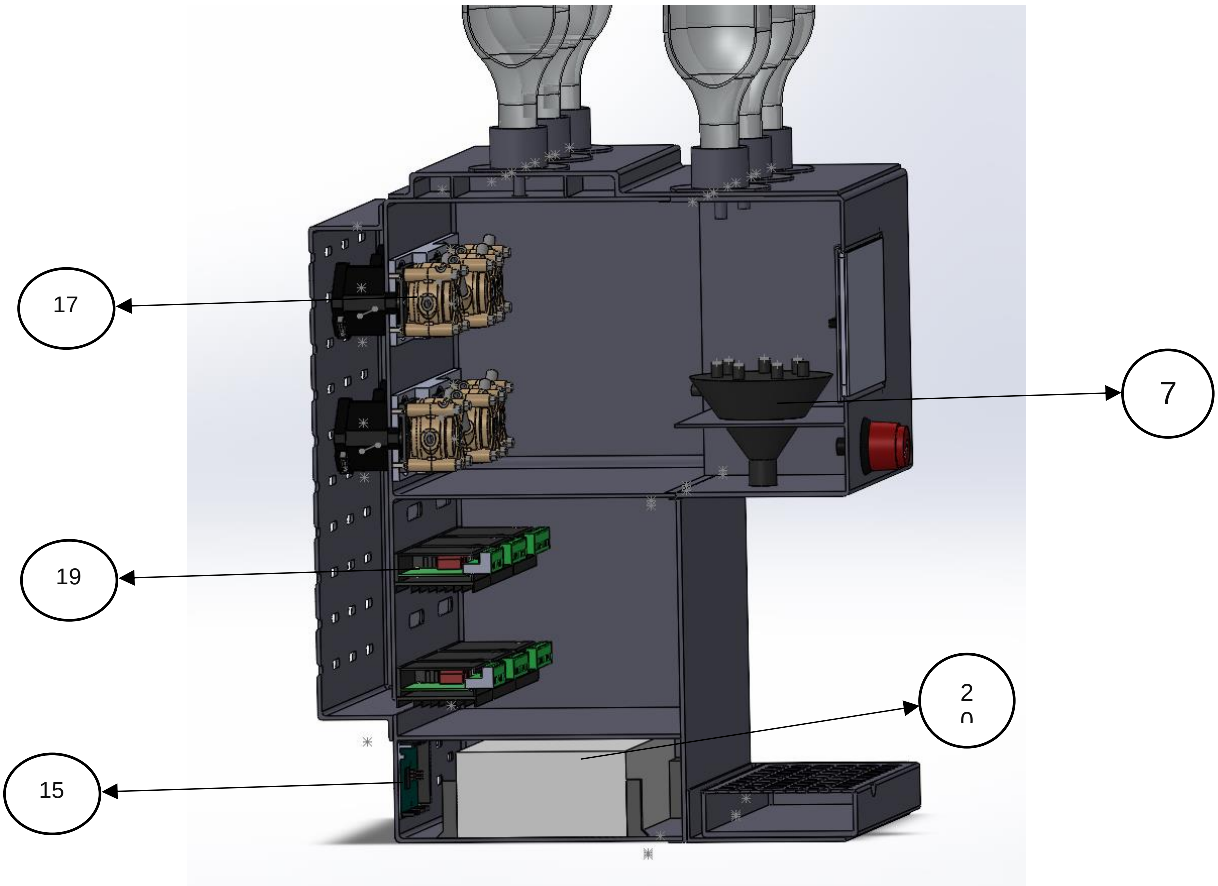


Figure 7.2 - The section view for the complete assembly with major subcomponents.

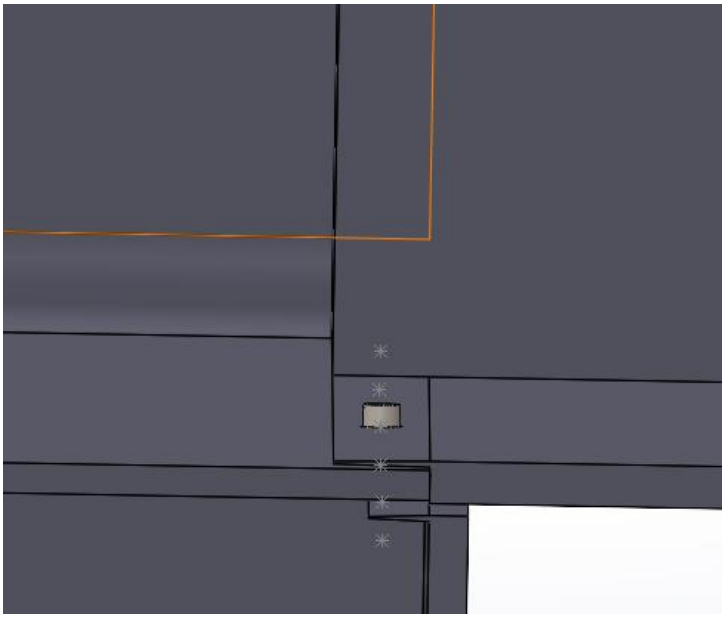


Figure 7.3 - The screwed connection between back and front housing parts with transition fit.

Top holder housing and bottle adapter

The top holder part (5) is responsible for accommodating the bottle input adapters. It is mounted on top side of the back housing and front housing using screws. Figure 7.4 shows the top connection between the three parts along with bottle adapters.

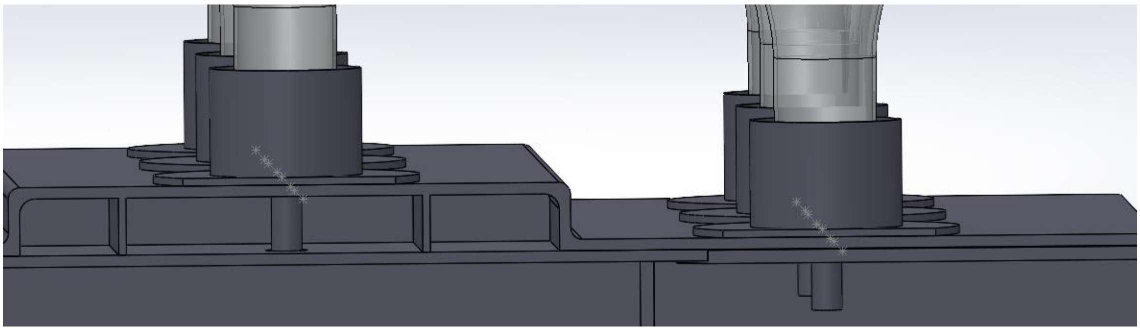


Figure 7.4 - The bottle holder and bottle adapter connection with the main housing with screws.

The top holder (5) has a support structure with ribs to sustain the load added by eight input bottles(24). Figure 7.5 highlights the significant support structure and the holes for the input adapters(6) connection. The figure also highlights the step between every four input bottles for better visibility and easy handling for the user.

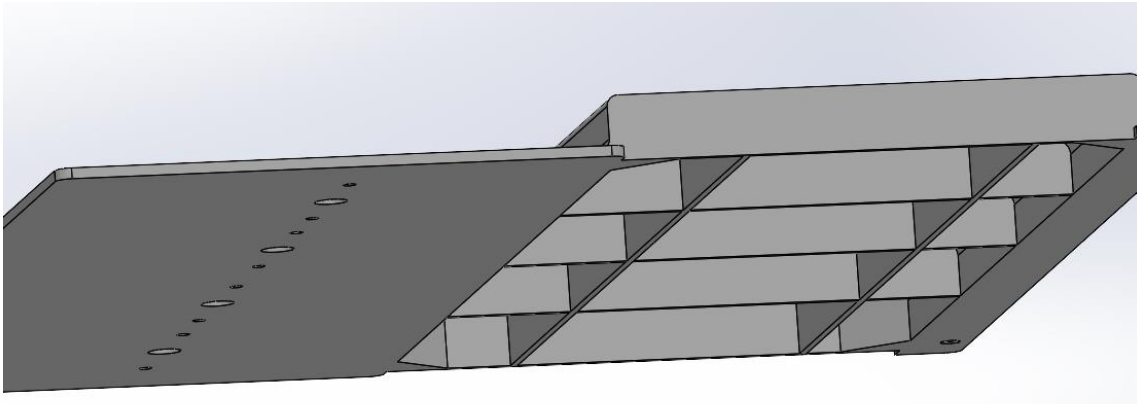


Figure 7.5 - It represents bottle holder support structure, step size and even distribution of holes for the input adapter

Drip tray housing, Drip tray part and Drip tray cover

The drip tray housing (8) holds the drip tray part (9) .There is clearance fit between the two allowing the the drip tray part to slide in and out the drip tray housing. The drip tray housing is mounted on the front cover(2) using screws. The drip tray cover(10) goes on top the drip tray part(9) and there is a clearance fit between them so the drip tray cover comes off with ease. The major purpose for the drip tray is to conveniently store the overflow liquid and user convenience. The sliding mechanism makes it easier for the user to manually clean the drip tray. The drip tray also stores the fluid discharged after the autocleaning mechanism function operates. Figure 7.6 – 7.8 highlights the significant features of the drip tray subassembly.

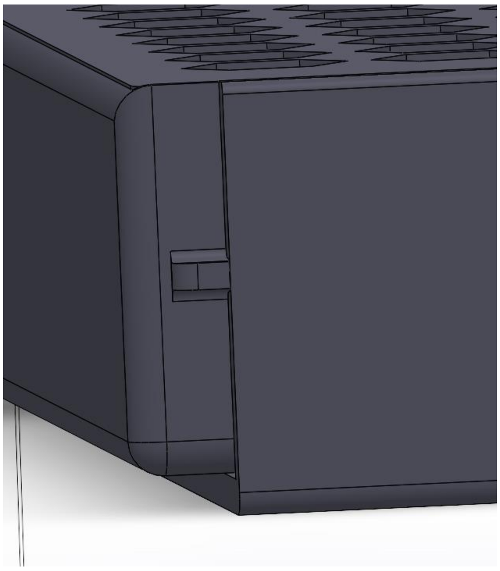


Figure 7.6 - Highlighting the sliding mechanism for the drip tray

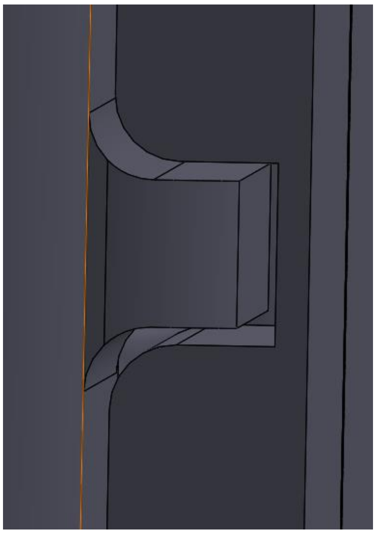


Figure 7.7 - Highlighting the clearance fit in sliding mechanism for the drip tray and drip tray housing

Figure 7.8 - The screwed connection between front cover and sliding tray housing

Front cover

It covers the front of the machine hiding the inside components. It is secured at the bottom with screws to the back housing(3).

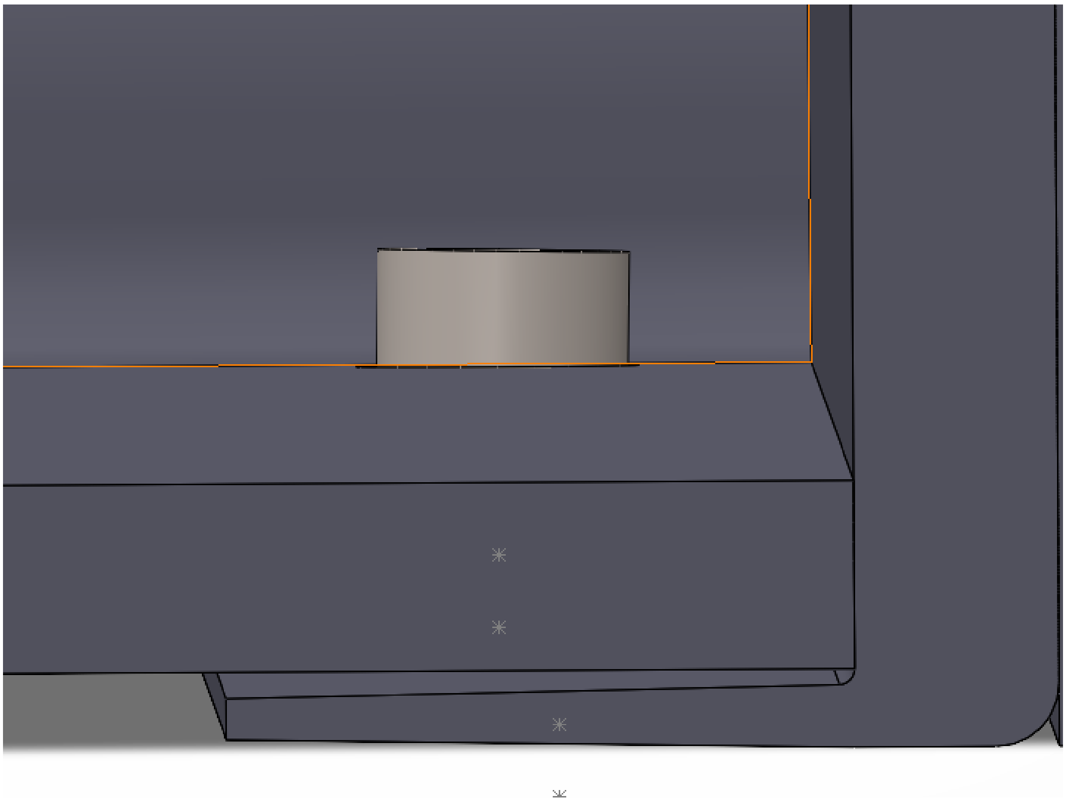


Figure 7.9 - Screw connection for the front cover and back housing.

Bottle input adapters

They hold the bottles along with cog inside with transition fit to allow bottle and machine connection. They are mounted on top of the top holder(5) using screws. Figure 7.10 – 7.11 shows the connection between the bottle and input adapters. The bottles can easily be replaced after they are empty.

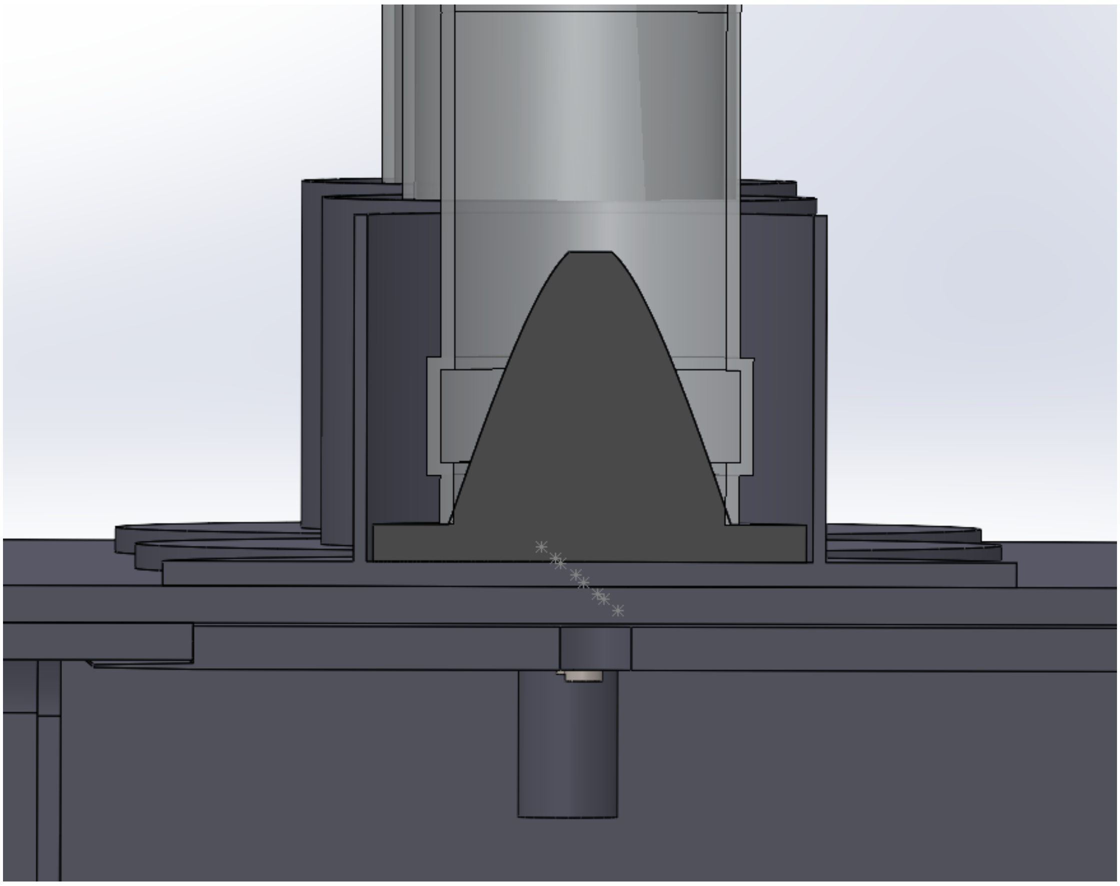


Figure 7.10 - Section view showing input adapters, bottles and cog connection.

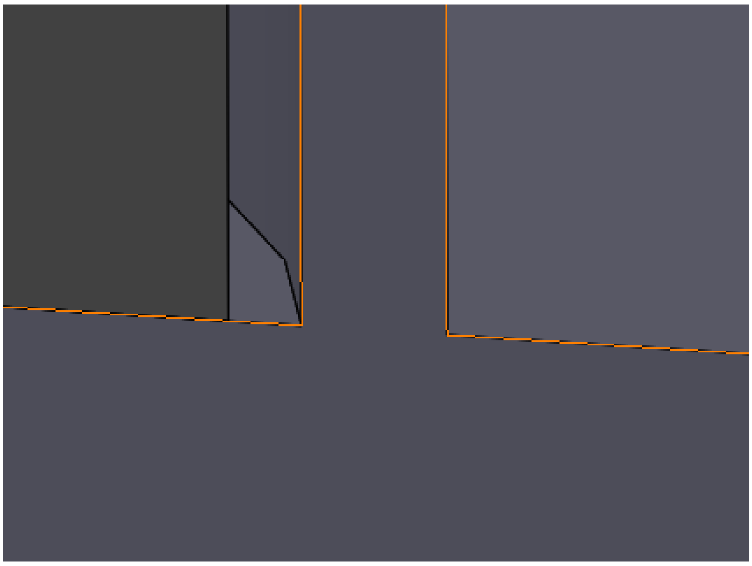


Figure 7.11 - Transition fit between cog and bottle input adapters

Cog

It prevents the liquid from flow out of the bottle when being placed to the bottle input adapter.It is connected to be bottle using an interference fit so that it does not slide off.It also responsible for connecting the bottle to the bottle input adapter(6) using an transition fit. Figure 7.10 and 7.11 clearly shows the connection in the section view above.

Back cover

It covers the pumps which come out from the back housing. It has multiples holes on its design for ventilation purposes. It is mounted to the back housing using screws. Figure 7.2 shows the section view of the assembly housing with the pumps. Figure 7.12 shows the connection and the part design.

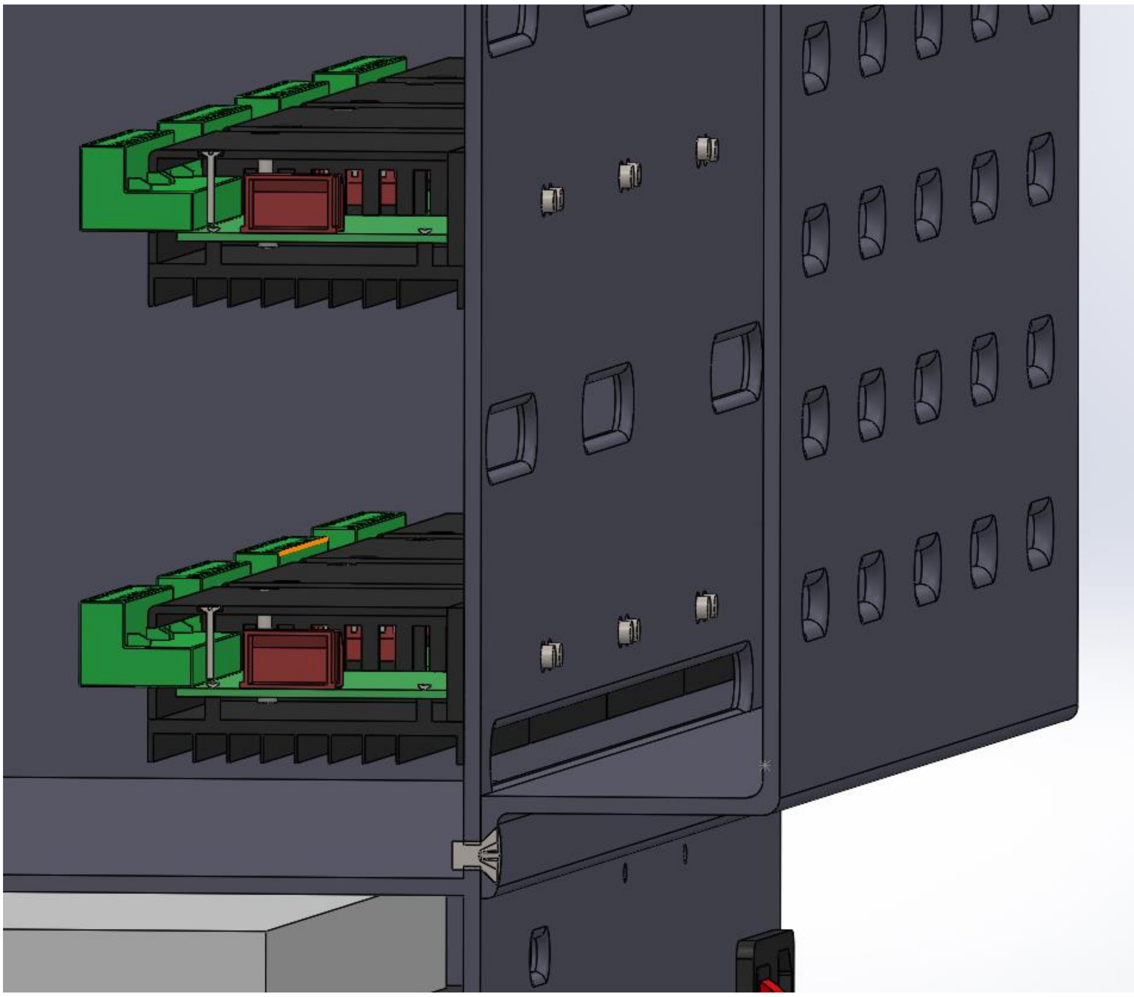


Figure 7.12 – Section view of the machine with back cover for the and highlighting screwed connection to the back housing part.

Emergency stop button and On/off button

The emergency stop button is for stopping the machine when there is a malfunction. It is mounted to the front housing part below the touchscreen using clip and has a clearance fit.
Figure 7.13 shows the connection for the mounting of stop button.

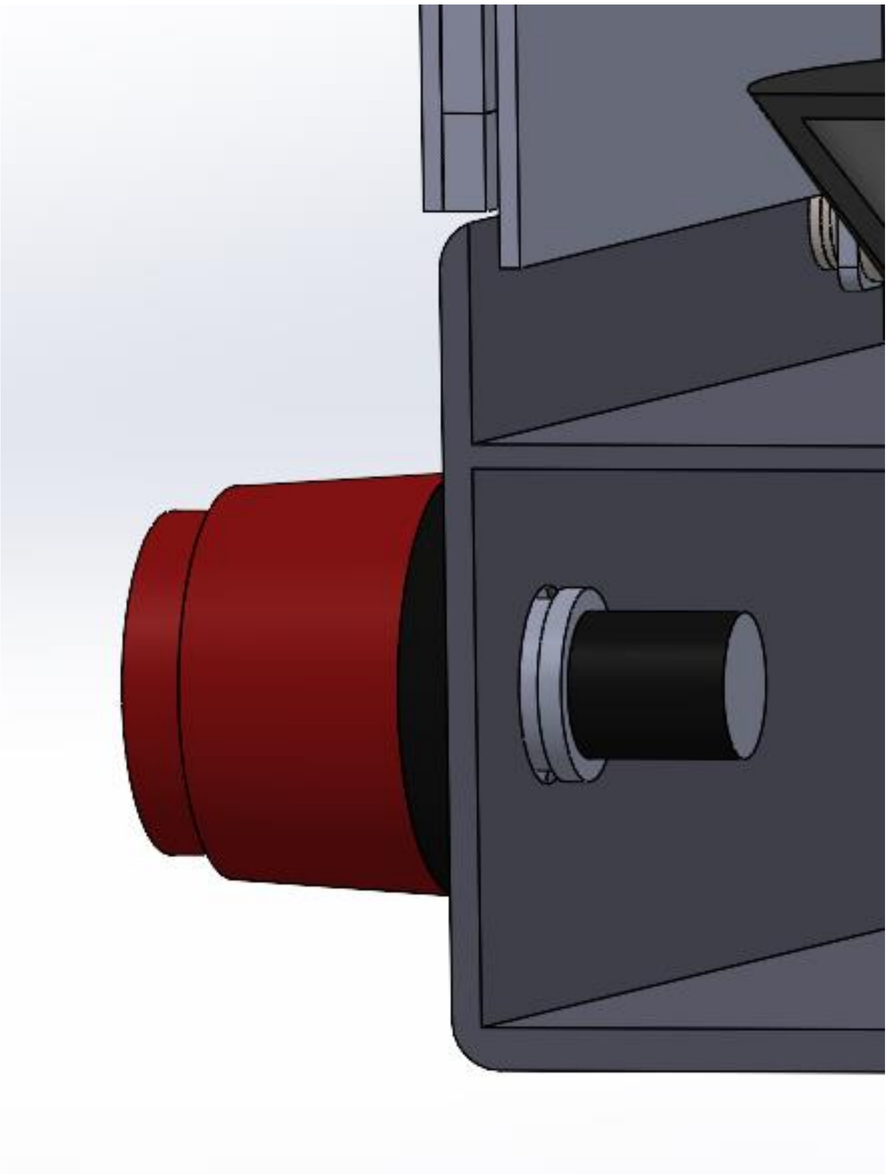


Figure 7.13 - Stop button mounted on the front housing part

The on/off button is responsible for switching the machine on and off. It is mounted to the back housing using clip and has snap in fit between them. Figure 7.14 shows the connection between the back housing and the on/off switch.

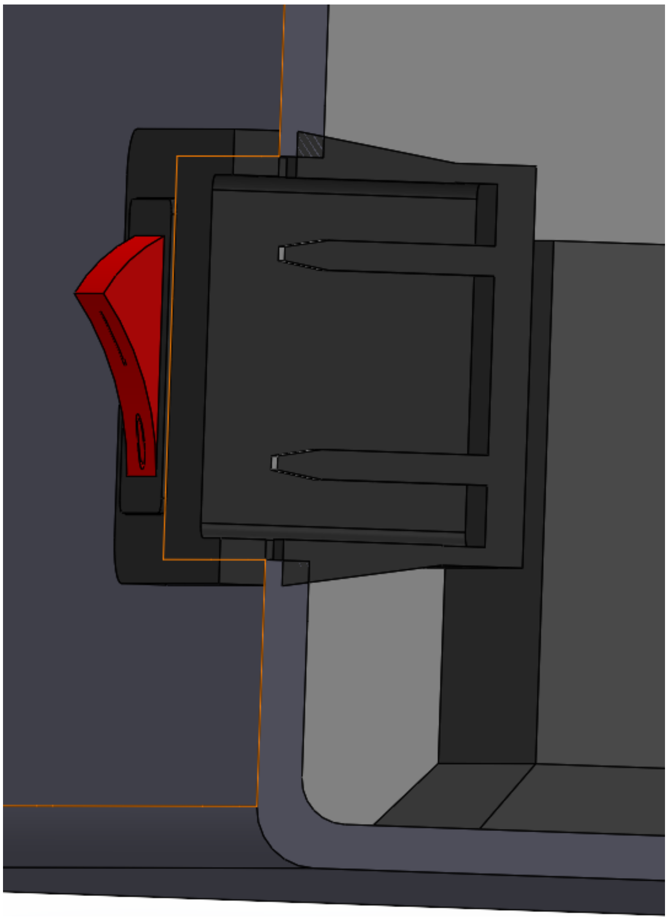


Figure 7.14 - The connection between the back housing part with the on/off switch.

Funnel

It acts as a collecting point for all the liquids and then dispenses them to the cocktail glass. It is mounted to the front housing using adhesive chemical connection. The support structure also holds the funnel shown in Figure 7.15. The value on the side is designed for water flow with pressure to clean the funnel. The funnel has seven inputs holes on the top which connects with the pumps via silicon tube and one input on the side to use water for cleaning purpose.

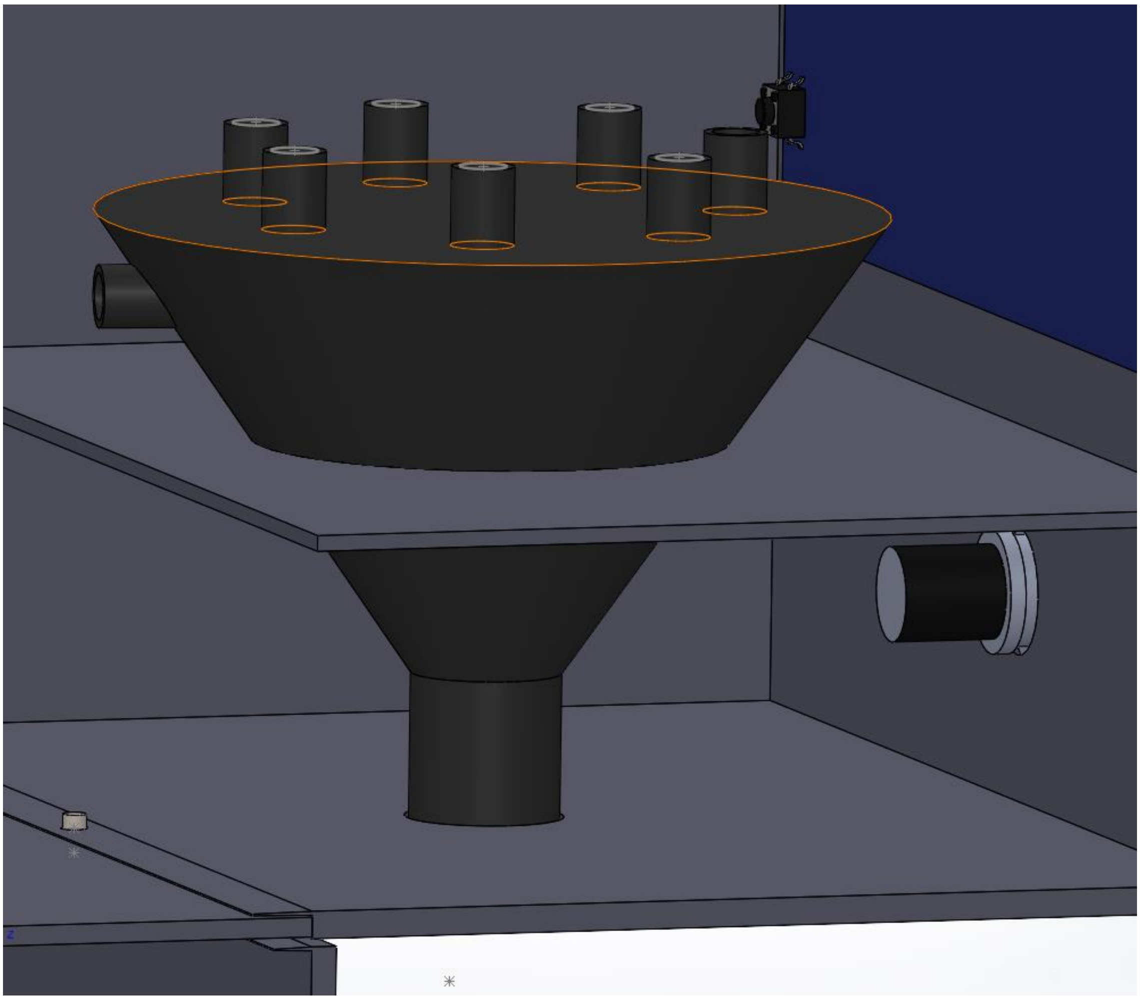


Figure 7.15 - The figure shows the funnel connected with front housing part along with adhesive connection.

Pump holder

It is designed to hold pumps. The pumps are mounted to it using screws. It has stepping for easy assembly of silicon tubes. It is also mounted to the back housing using screws. It makes the assembly process easier and quicker.

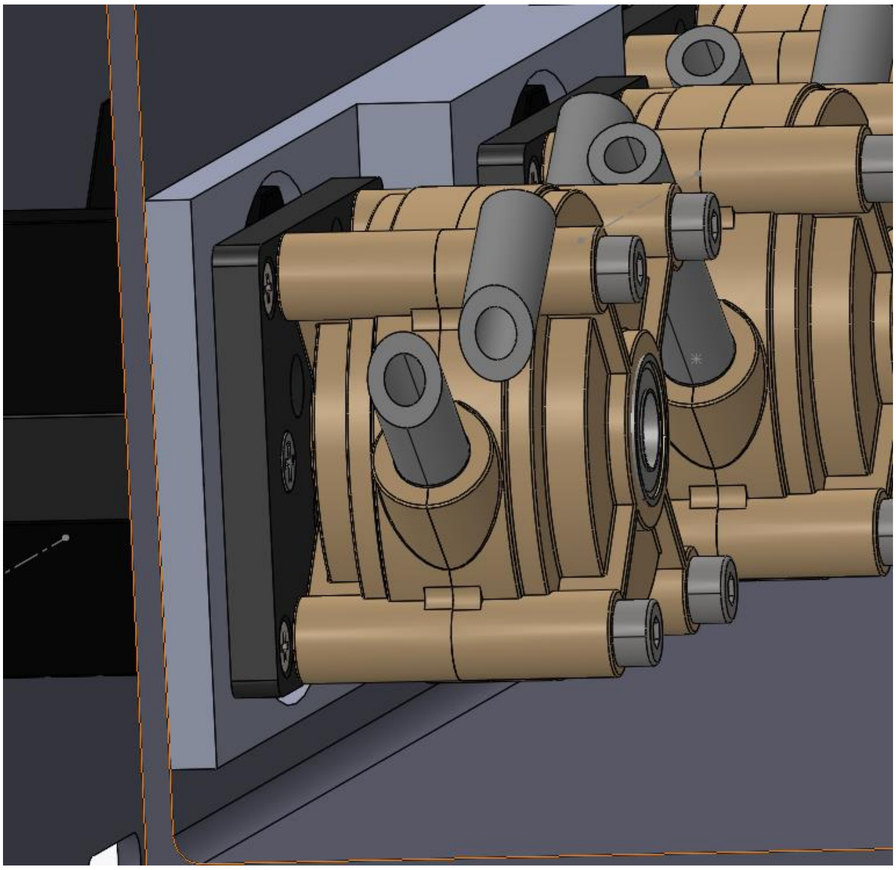


Figure 7.16 - The pump with the holder along with the stepping for easier pipe connectivity.

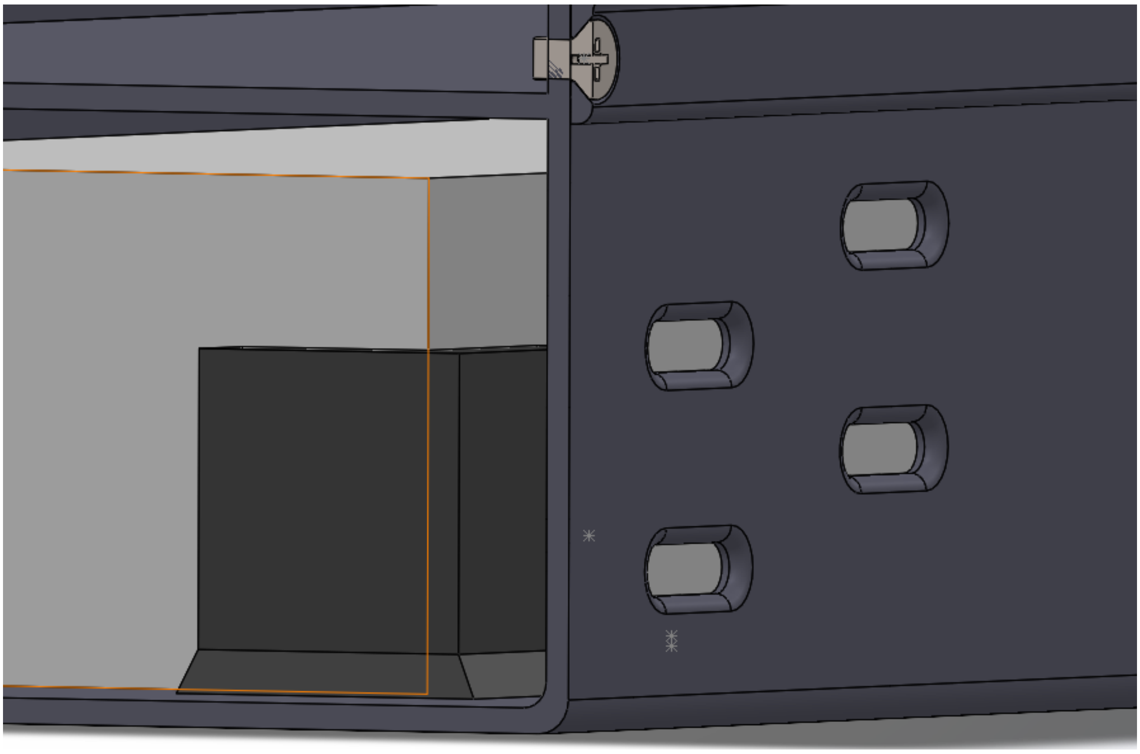


Figure 7.17 - The ventilation cutouts from back housing part for the power supply heat dissipation.

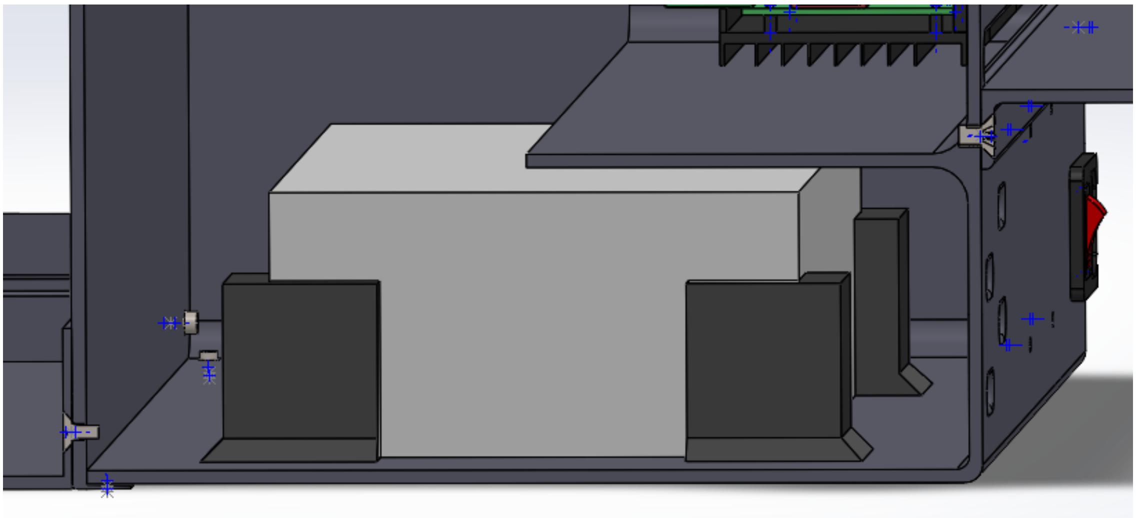


Figure 7.18 - Power supply sliding in the lower part of the back assembly supported by rubber parts having adhesive connection with the base.

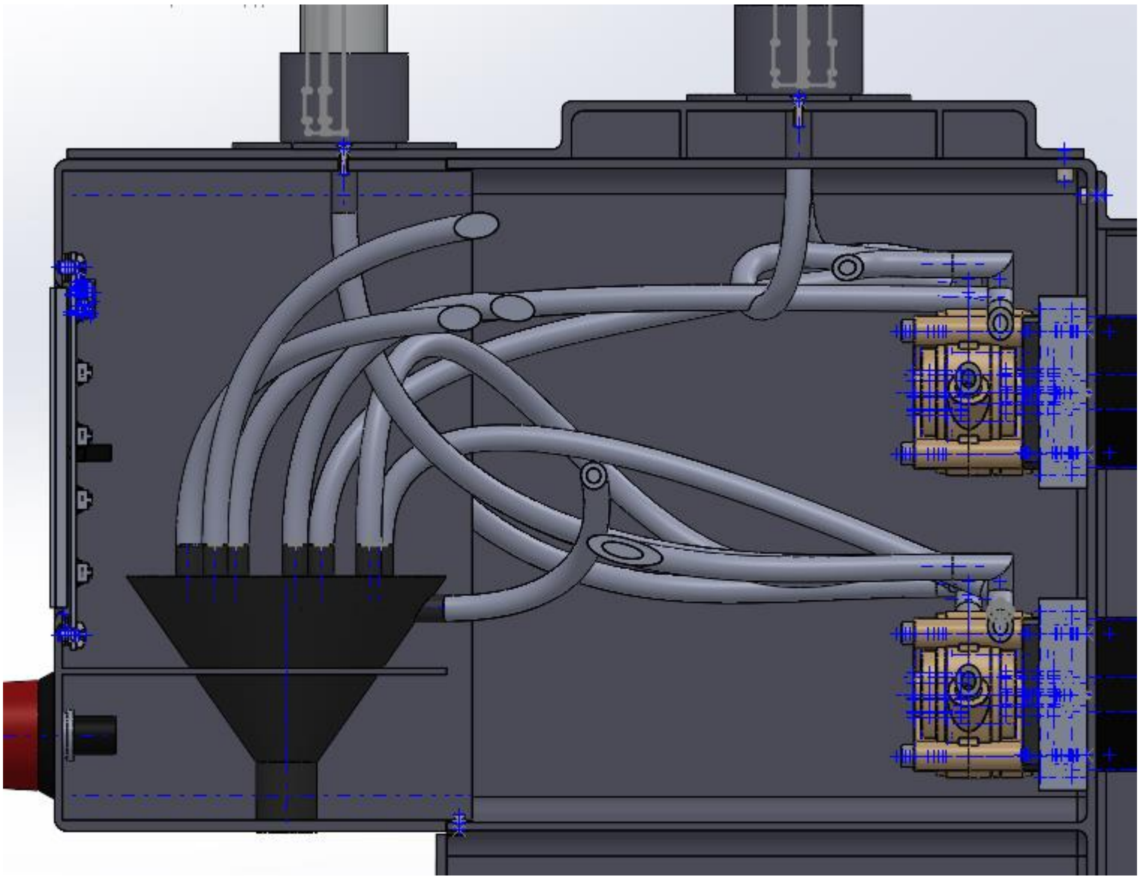


Figure 7.19 - Silicon tubes connection from input adapters to the pumps and onwards to the funnel

Figure 7.19 shows the funnel connection to the output from the pumps and the connection between the bottle adapter output and input to the pumps. Pump motor is used to regulate the fluid flow for making the perfect cocktails.

8 Electric Drives/Components.

The calculations made are based on theoretical analysis and review of electrical component data sheets. Limitations such as lack of safety factor analysis are as a result of lack of feedback from consultation attempts to the manufacturers of the electrical components.
Total power consumed by the automated cocktail machine is the sum of the individual power consumption of the pumps, one running at a time, the arduino board and the LCD touchscreen.

<u>Peristaltic pumps</u>
Voltage: 12V
Current: 1A through each pump.
Power = 12V X 1A = 12W
Considering the peak efficiency of the pump of 90%,
Output Power = 12W X 90%
P_{pump} = 10.8W

<u>TB6600 Stepper Motor drivers</u>
Operating voltage: 12V
Current: 2A through each stepper motor.
This current setting is configured on the dip switch to 2A because it is suitable for the pump that requires a current of 1A.
Power = Voltage x Current
Power = 12V X 2A = 24W
Considering their efficiency of 80%:
Power = 24W X 80%
P_{driver} = 19.2W
This power is sufficient to operate the pump that consumes 12W.

<u>Arduino Mega board</u>
Operating voltage: 8V
Recommended current per I/O pin: 20mA
Power = 8V X 20mA
P_{board} = 0.16W

<u>LCD touchscreen:</u>
Operating voltage: 5V
Current: 1A
Power = 5V X 1A
P_{screen} = 5W

<u>DC/DC convertors:</u>
Power consumption = Input power – Output power
Since both convertors draw 2A,
Power consumption = (Input voltage, $V_{in,}$ – Output voltage, V_{out}) x Current
<u>8V voltage regulator DC/DC convertor:</u>
V_{out} = 8V

V_{in} = 12V
Current = 2A
P = (12V – 8V) X 2A
= 8W
Considering its peak efficiency of 80%:
Power = 8W X 80%
P_{8V} = 6.4W
This is sufficient to operate the Arduino mega board that consumes 0.16W of power.

<u>5V voltage regulator DC/DC convertor:</u>
V_{out} = 5V
V_{in} = 12V
Output current = 2A
Power = (12-5) V X 2A
= 14W
Considering its peak efficiency of 70%:
Power = 14W X 70%
P_{5V} = 9.8W
This is sufficient to operate the LCD touchscreen that consumes 5W of power.

Total power the machine can consume, considering one pump, the LCD touchscreen and Arduino board is active is:
$P_{total} = P_{board} + P_{screen} + P_{pump}$
P_{total} = 15.96W

We have chosen a 12V 20A switching power supply to supply power to the machine and with the efficiency of the power supply rated at 80%,
The maximum power the power supply can draw is:
P_{supply} = (12V X 20A) X 80%
P_{supply} = 192W
The power intakes of the motor driver and the two DC/DC convertors, connected to the power supply, is: 24W + 14W + 8W = 46W.
Hence the chosen power supply is suitable for the cocktail machine. It would only need to supply a current of 4A to 5A.

The total energy required to make a single cocktail and perform the self-cleaning function is computed in the calculations below:

Power consumed by the machine, P_{total}
$P_{total} = P_{board} + P_{screen} + P_{pump}$
P_{total} = 15.96W

Considering a random cocktail our machine can produce, this cocktail requires 3 ingredients hence 3 pumps are active, one at a time.
The time to make one cocktail is dependent on the flow rate of our pump which is 24 ounces/minute, and the range of volume of our cocktails is 6 to 10 ounces. 8 ounces is chosen for this time measurement.
Taking one ingredient to be 2.5 ounces,
24 ounces = 1 minute
2.5 ounces = (1/24) x 2.5

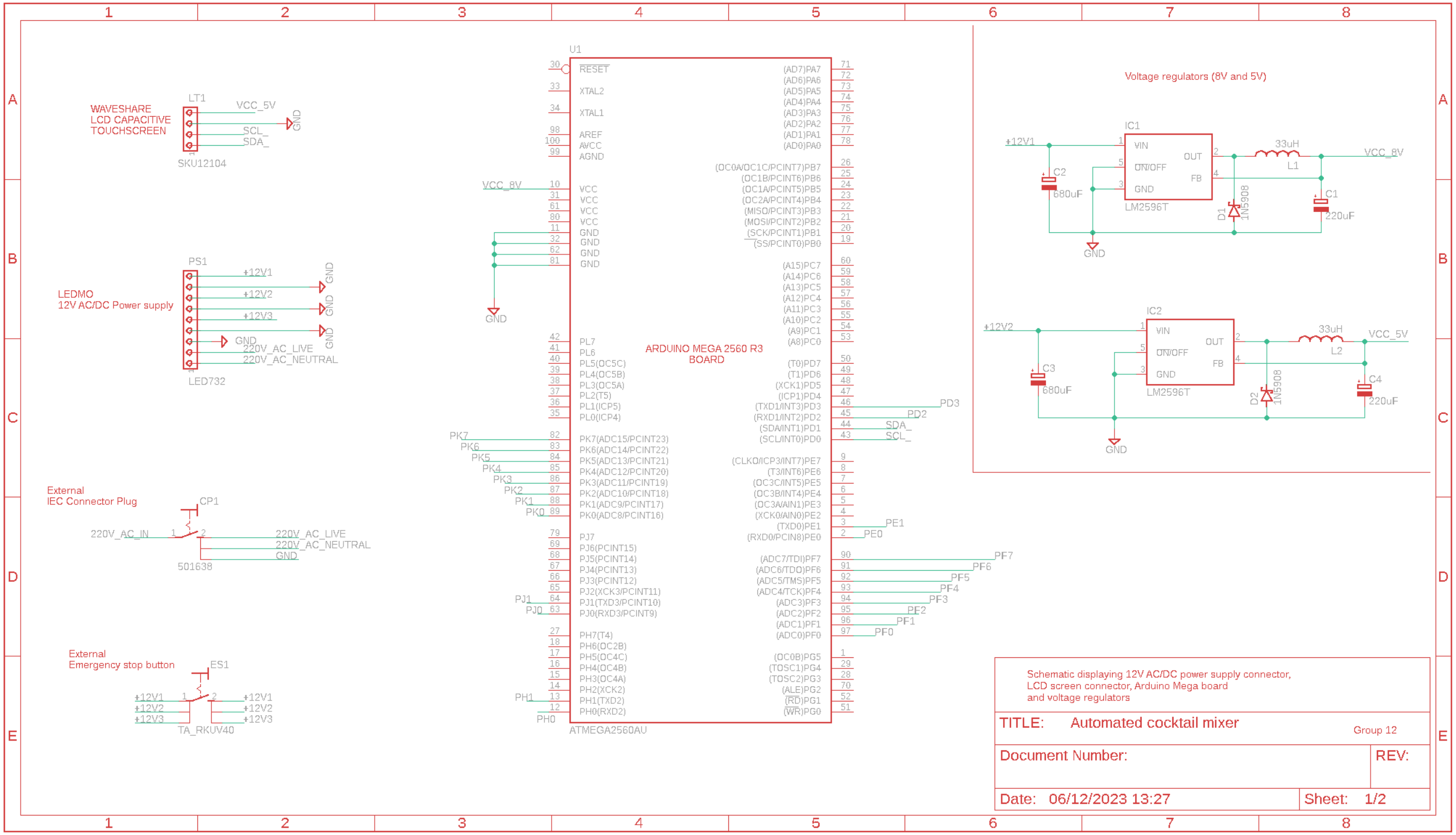
= 0.1041667 minutes
This is about 6.25 seconds to dispense one ingredient.

Energy to dispense one ingredient = P_{total} x time
E = 15.96W X 6.25 s
E = 99.75Ws
Total energy for the whole cocktail = E X 3 ingredients
$E_{cocktail}$ = 299.25 Ws

Additional energy for self-cleaning = P_{total} x 10 seconds
10 seconds is a good time estimate to pump water in the mixing funnel and flush it completely.
$E_{cleaning}$ = 15.96W X 10 seconds
= 159.6Ws

The total energy required to make a single cocktail and perform the self-cleaning function:
$E_{total} = E_{cocktail} + E_{cleaning}$
E_{total} = 299.25Ws + 159.6Ws = 458.85Ws

9 Circuit Diagram



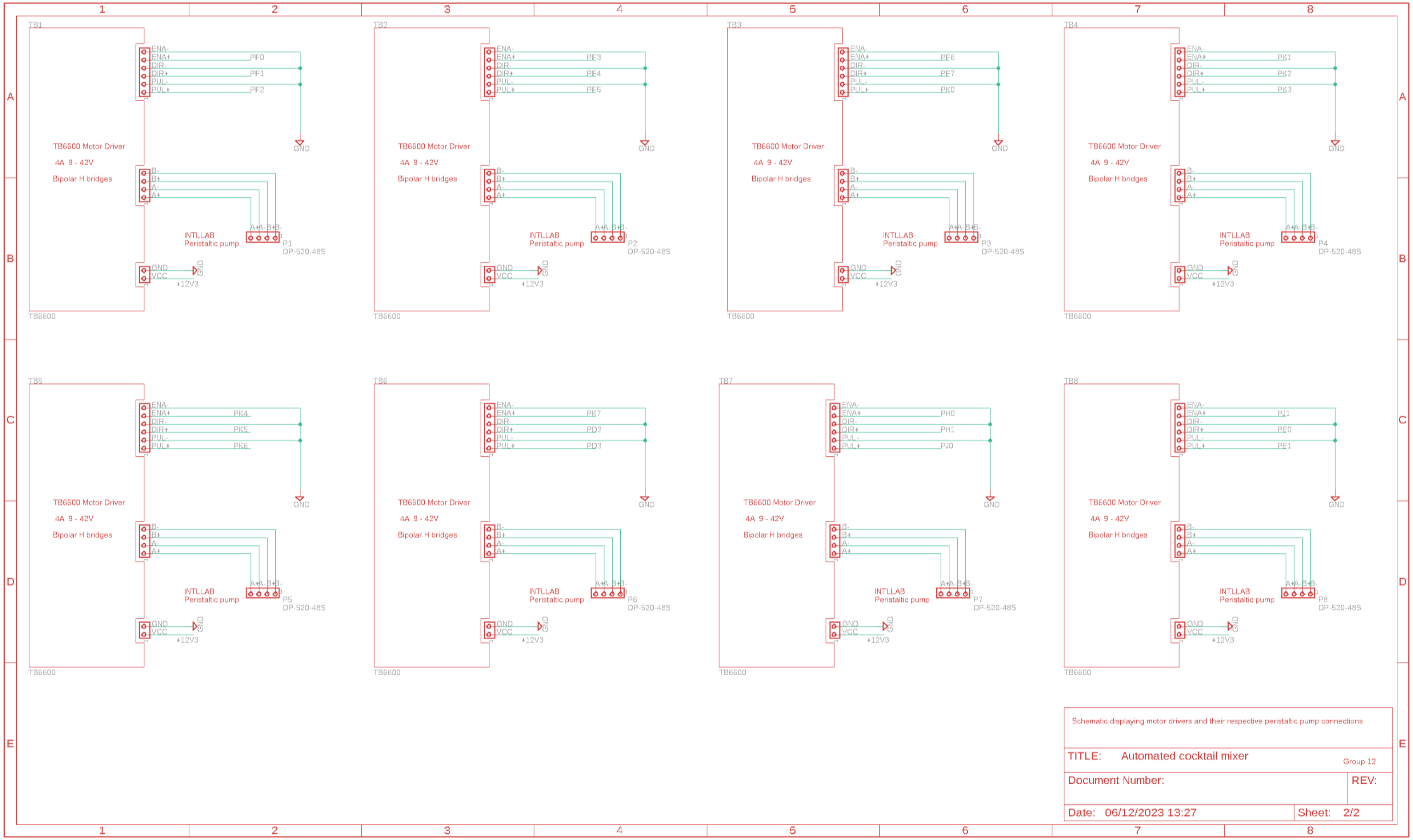


Figure 9.1 - Schematic diagram for the Barteolla machine

9.1 Bill of Materials for Electrical components

Table 9.1 - Detailed BOM for the electrical components in the cocktail machine.

Parts	Value	Device	Package	Description
D1, D2	1N5908	1N5908	C4111-15	DIODE
C1, C4	220uF	CPOL-EU085CS-1AR	085CS_1AR	POLARIZED CAPACITOR, European symbol
IC1, IC2	LM2496T	LM2596T	T05D	SIMPLE SWITCHER Step-Down Voltage Regulator
U1	ATMEGA2560AU	ATMEGA2560AU	TQFP100	Atmel 100-pin 8-bit uC
C2, C4	680uF	CPOL-EU085CS-1AR	085CS_1AR	POLARIZED CAPACITOR, European symbol
L1, L2	33uH	L-US0204V	0204V	INDUCTOR, American symbol
LT1	SKU12104	SKU12104	-	WAVESHARE LCD capacitive touchscreen
PS1	LED732	LED732	-	LEDMO 12 AC/DC power supply
CP1	501638	501638	-	IEC connector plug
ES1	TA_RKUV40	TA_RKUV40	-	Emergency stop button
TB1,TB2, TB3, TB4,	TB6600	TB6600	-	TB6600 stepper motor driver

TB5, TB6, TB7, TB8				
P1, P2, P3, P4, P5, P6, P7, P8	DP-520-48S	DP-520-48S	-	INTLLAB Peristaltic pump
Electric cables	-	-	-	High-purity solid tinned copper wires

10 Requirements Manual for “Buy” (CotS) Parts

10.1 Arduino Mega board

- Type: Arduino Mega 2560 R3

Table 10.1 - Arduino Technical data

Microcontroller	ATmega2560
Operating Voltage	8V
Input Voltage (recommended)	7-12V
Length	101.52 mm
Width	53.3 mm
Reason selected	This microcontroller has more digital I/O pins (54 available) than other microcontroller types and this can accommodate the 8 stepper motor drivers that take up a total of 24 digital I/O pins.

10.2 Peristaltic Pumps

- Type: INTLLAB Peristaltic dosing pump

Table 10.2 - Technical data for Peristaltic Pumps

Package dimensions	5.2 x 3.86 x 3.46 inches
Flow rate	600 - 710ml/min
Current	1A
Operating voltage	12 Volts
Efficiency	90%
Reason selected	The flow rate of these pumps is 600 – 710ml/minute and this is within our specification to make a cocktail in 60 seconds or less.

10.3 12 V Power Supply

- Type: LEDMO Switching Power Supply

Table 10.3 - Technical data for power supply

Dimensions	22.5 x12 x 6 cm
Current	20A
Operating voltage	12V
Wattage	240W
Efficiency	80%
Reason selected	Availability of three dedicated 12V DC outlets that is suitable to supply power to the LCD touchscreen, the Arduino and stepper motor drivers.

10.4 TB6600 Stepper Motor Driver

- Type: Two phase hybrid stepper motor driver

Table 10.4 - Technical data for Stepper Motor driver

Dimensions	95 X 72 X 28mm
Voltage	9 - 42 V DC
Efficiency	80%
Reason selected	It is able to handle higher voltage levels from 9V up to 42V, and that is sufficient in our circuit since it is supplied with 12V input voltage.

10.5 Emergency stop button

- Type: Emergency stop button

Table 10.5 - Technical data for emergency stop button

Height	29.4 mm
Depth	19.2 mm
Mounting method	Front panel mounting
Reason selected	This button can be easily mounted at the front of the machine for easy visibility.

10.6 LCD touchscreen

- Type: 7-inch HDMI LCD Capacitive Touchscreen

Table 10.6 - Technical data for LCD touchscreen

Product dimensions	16.65 x 12.46 x 1.84cm
Resolution	1024 x 600 pixels
Operating voltage	5V
Reason selected	The screen size is large enough to properly display all the features designed by the software team.

10.7 Silicon tubes

- Type: Food Grade Transparent Silicone Rubber Tube

Table 10.7 - Technical data for Silicon tubes

Size	9 x 12 mm
Temperature	-60°C to +180°C
Kind	Hose line
Reason selected	--------------

10.8 Screws

Table 10.8 - Screw description based on specification and quantity.

Type	Length in mm	Supplier
ISO 1046-1 M4 x 2	6	Screwerk
ISO 1046-1 M5 x2	8	Screwerk
ISO 1046-1 M3 x16	10	Screwerk
ISO 1046-1 M3 x3	5	Screwerk
ISO 1046-1 M3 x24	4	Screwerk
ISO 1046-1 M5 x2	10	Screwerk
ISO 1046-1 M5 x4	8	Screwerk
ISO 1046-1 M4 x4	5	Screwerk
ISO 1046-1 M3 x4	12	Screwerk
ISO 1046-1 M4 x16	8	Screwerk

10.9 Washers

Type: ISO 10669-3.55
Amount: 12
Supplier: Screwerk

10.10 DC/DC converter

- Type: LM2596 step down converter

Table 10.9 - Technical data for DC/DC converter

Input voltage	4.75 - 24V
Output voltage	0.93 - 18V
Size/Dimensions	45 x 32 x 16 mm
Max. conversion efficiency	70 - 80%
Reason selected	Both the LCD touchscreen and the arduino board require lower voltages to operate and these high efficiency convertors ensure stable voltage supply to these parts.

11 Technology Selection for the "Make" Parts

We decided to buy all the electrical components, as determined by the "Make-
or-*Buy" selection. Therefore, we only include the technology and materials* selection for making the parts of mechanical components in the following task.

Material: Acrylonitrile Butadiene Styrene (ABS Plastic)
3D printing.
Machine Used: FDM/FFF Printer
Why ABS Plastic?

- Impact Resistance
- Chemical Resistance
- Fully recyclable
- Easy to Paint and Glue
- Excellent High and Low-Temperature Performance
- Great Electrical Insulation Properties

Manufacturing Processes

Several criteria, including lead time, material qualities, cost concerns, and production volume, influence the choice of manufacturing process for plastics. Thermoplastics are favored due to their ability to undergo numerous cycles of melting and solidification. These materials are typically supplied in compact pellets, which can be melted to attain the desired shape through diverse manufacturing techniques. The process is reversible, ensuring that properties remain unchanged even after multiple treatments. Several manufacturing processes, including 3-D printing, CNC machining, vacuum forming, injection molding, extrusion, and blow molding, are available. Each of these methods offers distinct degrees of flexibility, leading to variations in both cost and production time.

3D Printing
3D printing uses a 3D CAD model to create a part layer by layer until the final product is manufactured. ABS plastic is one of the most common materials for 3-D printing due to its resistance to impact and high temperature.
Process:
1. Print setup: Print preparation software is used for orienting and laying out *models within a printer's build volume, adding support structures (if needed),* and slicing the supported model into layers.
2. Printing: The printing process depends on the type of 3D printing technology. For our parts Fused Deposition Moulding/Fused Filament Fabrication (FFF) is used which melts the plastic and then molds it to the desired shape.
3. Post-processing: Once the part is made, it is cleaned, washed, and treated *additionally to maximize materials' physical properties.*

Electroplating
Electroplating is a process that involves depositing a thin layer of metal onto the surface of a substrate, such as plastic, to provide a decorative or functional finish. The most common metal used for electroplating plastic to achieve a shiny look is chrome.
Process:
Ensure that the plastic object is clean and free of any contaminants, oils, or residues then we use acetone to clean the surface of the printed part. We add a base coat then later a conductive paint.
Then set up the electroplating tank and place the part inside the tank towards the anode. Turn on the current which causes metal to be attracted to the plastic surface.
Finally remove the part, wash and polish it.

11.1 Bottle Adapters

Material: Acrylonitrile Butadiene Styrene (ABS Plastic)
Manufacturing Process: 3D printing
3D Printing using FDM since the process delivers accurate dimensions and is efficient in mass production. Here molten filament is deposited on the build platform layer by layer to create our defined design. Supports here helps us create the overhang and small intricate features avoiding warping.

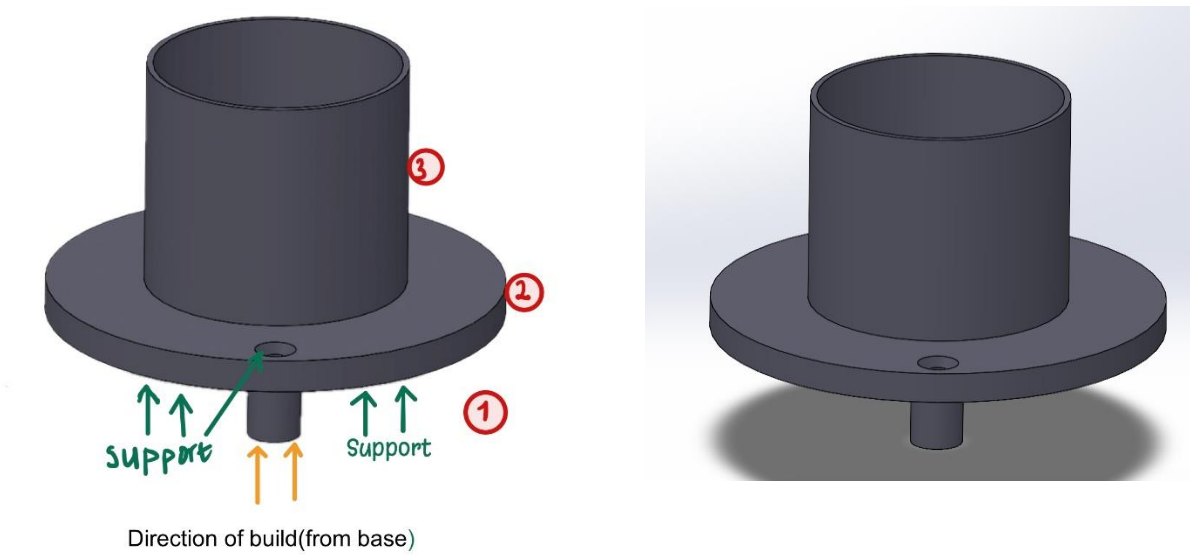


Figure 11.1 - Input Adapter part with 3D printing layer details, support structure details and showing the isometric view of the part .

11.2 Liquid Drip Tray

Material: ABS Plastic
Manufacturing Process: FDM – 3D printing
3D Printing using FDM because it's an efficient manufacturing method that provides precision, consistency, and cost-effectiveness, making it a preferred

choice to produce plastic trays, especially when high volumes and intricate designs are involved.

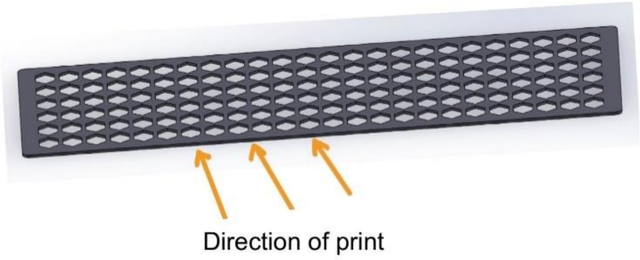


Figure 11.2 - The drip tray cover explaining 3D printing direction

11.3 Funnel shaped Mixer

Material: ABS Plastic
Manufacturing Process: 3D Printing
FDM is a widely used 3D printing method that deposits melted plastic layer by layer to build up the object.
We will use this method because it is widely available, and most suitable for Abs plastic.

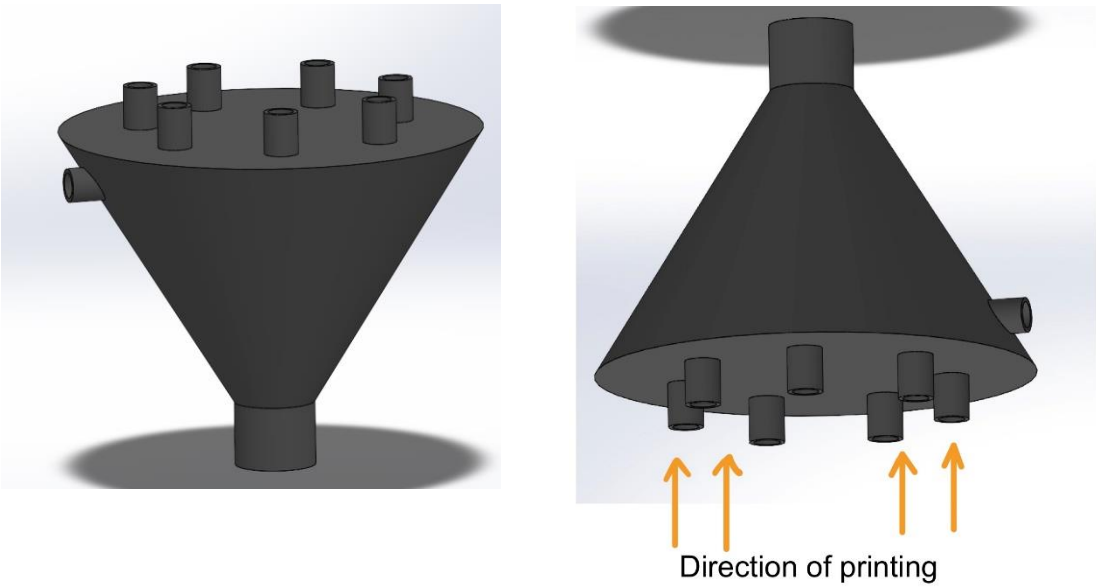


Figure 11.3 - Isometric view of the funnel showing the direction of the print

11.4 Front Housing

Material: ABS plastic
Manufacturing Process: 3D printing FFM
Fused Filament fabrication because our shape is complex and it allows us to produce our parts cost effectively. *Here the printer's nozzle moves according to* the design depositing molten ABS filament layer by layer to build up the object.

We make our material have a better surface finishing by using vapor-smoothing. We then use a copper paint and add acetone to the mixture and airbrush our print.
We will then add a metal coating by electroplating.Electroplating is depositing of dissolved ions of a metal unto another surface (in our case ABS plastic). The advantages of electroplating our housing is to make it look aesthetically pleasing with a shiny metallic look, resisting chemical damages and corrosion and it increases the strength of our material. Support structures help to create

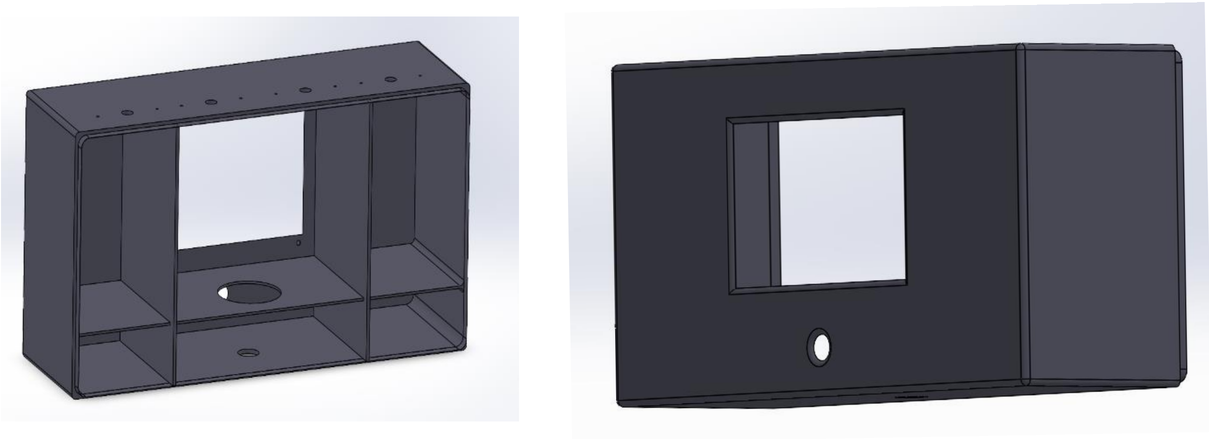


Figure 11.4 - Multiple views of the front housing part to show the details of the part.

our holes and improve the accuracy of printing which will then be removed at the end.

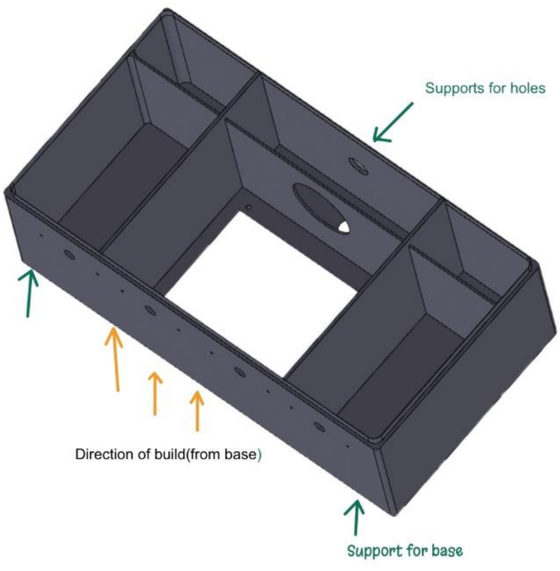
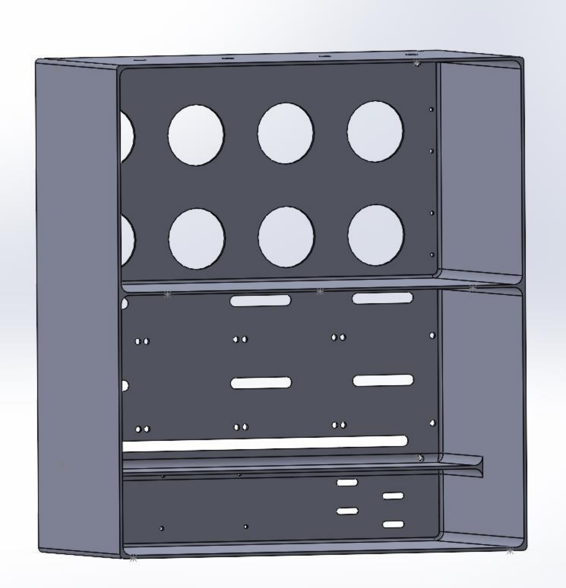


Figure 11.5 - Isometric view of the part showing the print orientation and direction with support structure.

11.5 Housing Back

Material: ABS plastic
Manufacturing method: 3D printing using FFF
Layer Delamination can easily occur so the must be well heated. It's same process with FDM just another name.



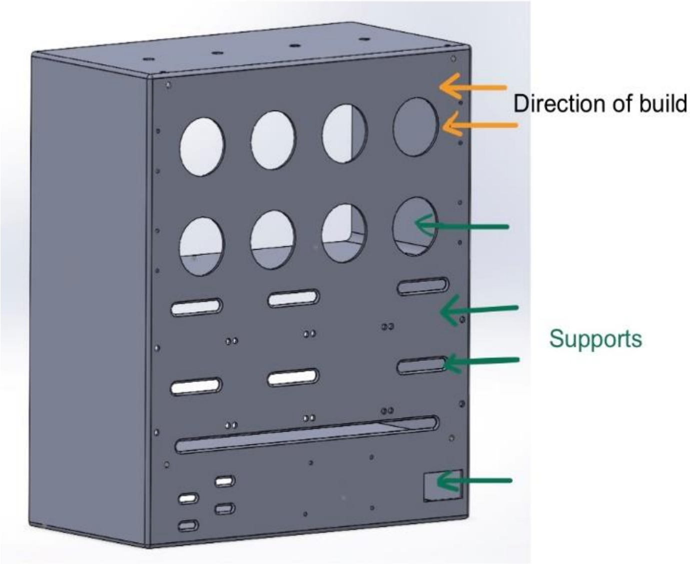


Figure 11.6 - Isometric view of the part highlighting the direction of build and highlighting the location where supports are needed.

11.6 Back Cover

Material: ABS Plastic
Method:3D Printing using FDM

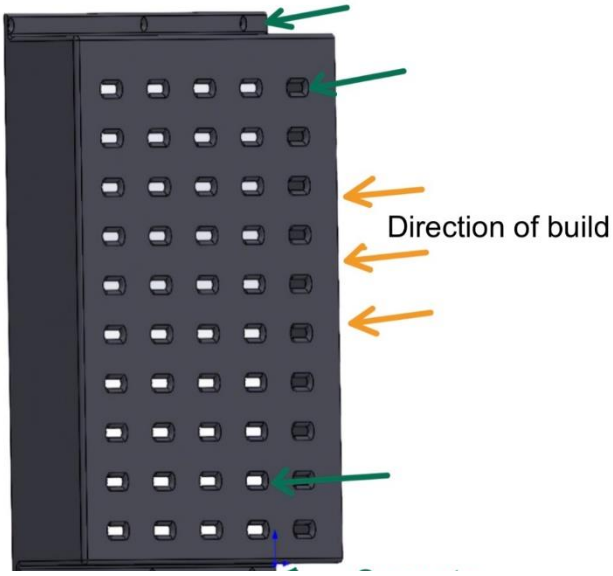


Figure 11.7 - Isometric view of the part highlighting the direction of the build and area that needs to be supported.

11.7 Drip Tray part

Material: ABS plastic
Manufacturing method: 3D printing FDM

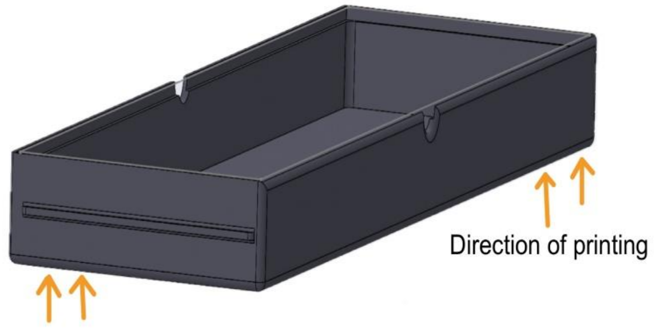
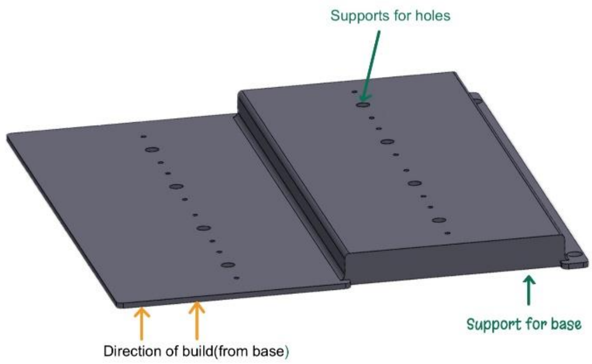


Figure 11.8 - Isometric view showing the direction of the print for the drip tray.

11.8 Top bottle holder

Material: ABS Plastic
Manufacturing Method:3D printing FDM



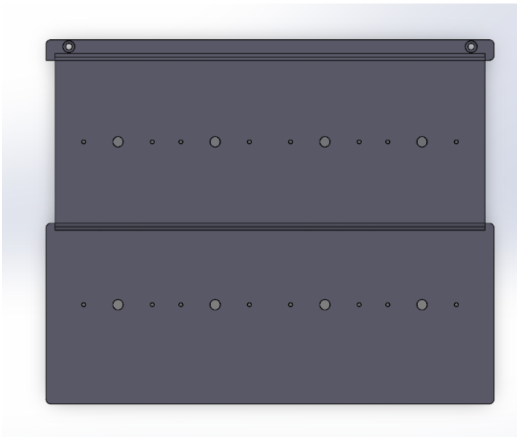


Figure 11.9 - Isometric view of the part highlighting the direction of printing and holes that need to be supported.

11.9 Bottle Cog

Material: Rubber
Manufacturing method: 3D printing (FDM)

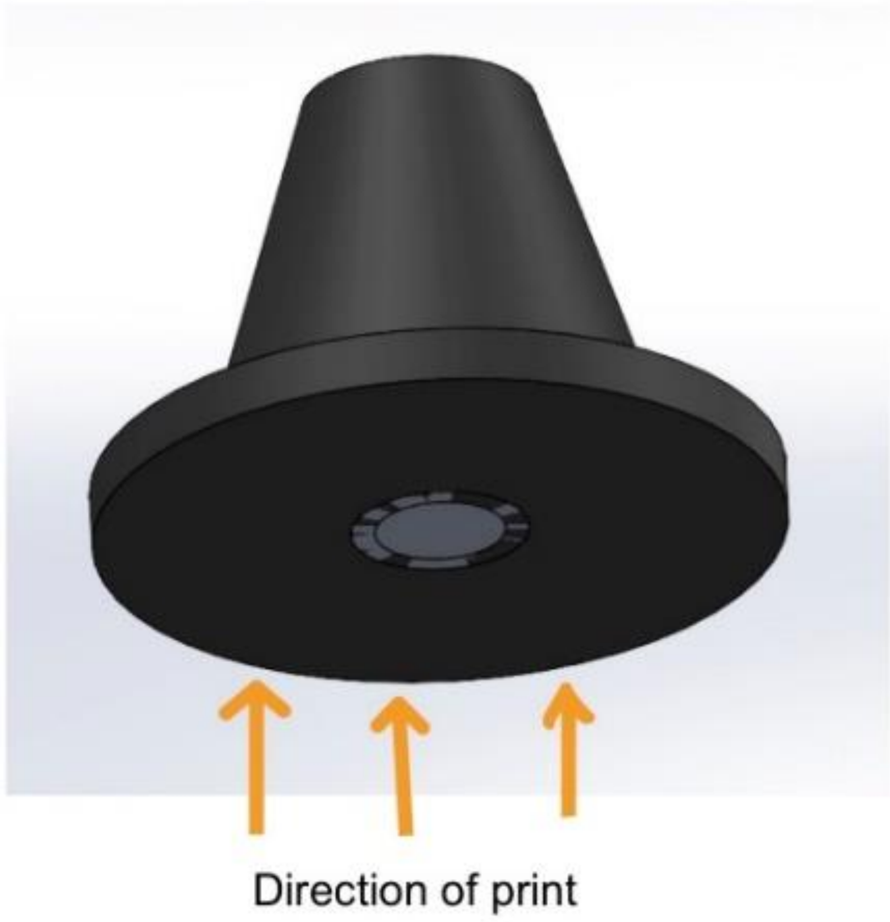
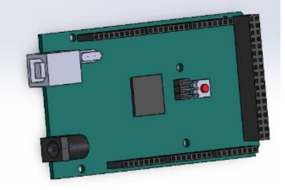
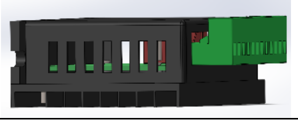


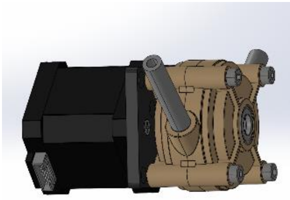
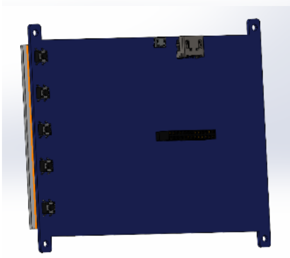
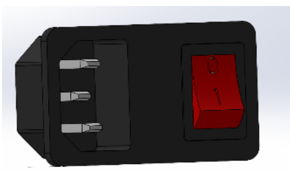
Figure 11.10 - Isometric view of the rubber cog highlighting the direction of build.

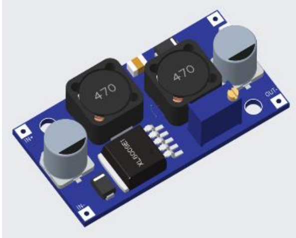
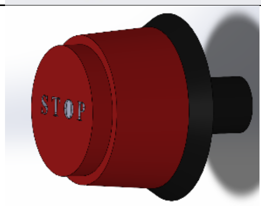
12 Make and Buy Decisions

This section explores the various components present in the Barteolla cocktail mixer. The components are listed in tables and categorized into "make" and "buy" groups. The fundamental approach is to incorporate numerous standard "off-the-shelf" components that are readily available, have consistent market prices, and are easily procured at competitive rates when purchased in large quantities. "Make" components are specifically crafted for the product and their production is optimized using lean manufacturing principles.

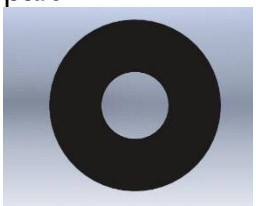
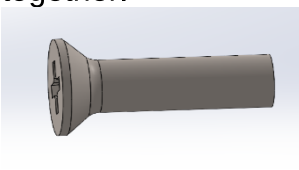
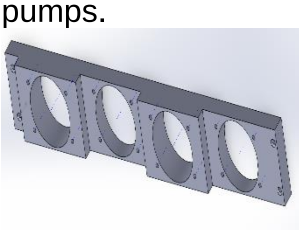
Table 12.1 - Make and Buy decision for electrical components

Electrical Components				
Name of Part	**Qty**	**Description**	**Make or buy decisions**	**Short Explanation/ Explanation**
Arduino Mega board	1	It is located at the bottom of the housing back. This microcontroller interprets data from the LCD screen. It controls the motor drivers that power the motor. 	Buy	It is used to program electronic components. It is more cost effective to buy since our supplier has lower manufacturing costs due to the higher volume of production.
TB6600 Stepper motors drivers	8	Located at the housing back of the machine, they control and supply power to the peristaltic pump motors. 	Buy	These specific motor drivers have a microstepping feature that allows for smoother motion and precise control of the motor it drives.
Peristaltic pumps	8	Lined up in the housing back, they pump liquid from	Buy	Due to tubing friction, pumps require high starting torques and this is an important factor for

		the bottles to the mixing funnel. 		selecting this pump because it has a high torque at low speeds.
12V Power supply	1	This is placed at the bottom of the housing. It converts AC input power into 12V DC power suitable for powering the LCD, Arduino and the motor drivers.	Buy	This power supply has 3 dedicated 12V DC outlets that is suitable to power the LCD screen, the Arduino and stepper motor drivers, with a good efficiency of 80%.
LCD Touchscreen	1	Located on the front housing, this is used as a touch interface by the user to select different cocktails and their respective levels of strength of alcohol in the cocktail.  	Buy	Purchasing LCD touchscreens offers advantages in terms of quality, cost, time, and reliability. It allows our team to leverage the expertise of specialized manufacturers while concentrating efforts on other critical aspects of cocktail mixer production.
ON/OFF Power Button	1		Buy	It is an affordable, common electrical component that is used widely in the industry. Buying this part ensures better quality assurance.

DC/DC convertors	2		Buy	It is relatively procurable on *the market and it's high* efficiency is very essential in stepping down the 12V voltage.
Emergency stop button	1		Buy	The button can be easily located by the user. They are widely used in the market and its inexpensive part so saves us production time and overall manufacturing costs.

Mechanical Components				
Name of Part	**Qty**	**Description**	**Make or buy decisions**	**Short Explanation**
Housing	1	Encloses all the components including the pumps, sensors and everything	Make	The shape of the housing and the measurement are customized and cannot be easily found in the market.
Bottle input adapters	8	Located at the top of the outer housing.It connects the bottles to the machine	Make	We can easily make this using injection molding since its not complex and we need it to match our overall specifications and goals.
Funnel shaped Mixer	1	Located inside the machine but attached to the housing by adhesive bonding.	Make	We need to bring our design to life and by using FDM, it will be cost efficient for us.
Silicon fluid tubes	16	Located used to take the drink from the bottle to the mixer	Buy	Silicon is very food safe and doesn´t contain toxic BPAs and is also popular in the food industry

				thereby making it cheaper to buy this part due to manufacturing costs than to make.
Liquid storage tray	1	Located at the bottom of the machine to collect the waste liquid	Make	The dimensions and shape of the tray should be customized, so we need to manufacture them with our chosen design.
Plain washer	12	Used together with the screws to join part 	Buy	They are widely used in the machinery market and can be purchased in large quantities at a cheap price.
Flat head Screws (M4 x 5,M8,M4)	61	Used in joining the different parts together. 	Buy	They are widely used in the machinery market and can be purchased in large quantities at a cheap price.
Motor holders	2	Holds the Peristaltic pumps. 	Make	The dimensions and shape of the motor holders should be customized, so we need to manufacture them with our chosen design to fit the pumps.
Bottles	8	For the drinks and are placed upside down on our	Buy	We buy standard bottles in the market. It is more cost effective to buy

		machines. 		since our supplier has lower manufacturing costs due to higher volume of production.

Milestone 3 - Technical Documentation

13 Bill Of Materials (BOM)

item	qty.	description	specification	material
1	1	BACK HOUSING	XXXXXXXXX	ABS
2	1	FRONT HOUSING	XXXXXXXXX	ABS
3	1	FRONT COVER	XXXXXXXXX	ABS
4	1	TOP HOLDER	XXXXXXXXX	ABS
5	2	PUMP HOLDER	XXXXXXXXX	ABS
9	8	PUMPS	5.2x3.86x3.46 inches	ABS
14	54	FLAT HEAD SCREW	ISO 7046-1 - M3 X 10 - Z - 10N	STEEL
16	1	LCD TOUCHSCREEN	16.65x12.46x1.84cm	XXXXX
17	4	PLAIN WASHER	ISO 10669-3.55-N	STEEL
18	8	PLAIN WASHER	ISO 10673-3.6-N	STEEL
19	5	PAN HEAD SCREW	ISO 7045 - M4 X 5 - Z - 5N	STEEL
20	1	FUNNEL	XXXXXXXXX	ABS
21	8	BOTTLE ADAPTER	XXXXXXXXX	ABS
22	1	ON/OFF BUTTON	XXXXXXXXX	
23	1	EMERGENCY STOP BUTTON	29.4x19.2x16mm	XXXXX
24	8	STEPPER MOTOR DRIVERS.	95x72x28mm	XXXXX
30	1	ARDUINO MEGA BOARD	XXXXXXXXX	
31	4	POWER SUPPLY HOLDER	XXXXXXXXX	Rubber
32	1	POWER SUPPLY	22.5x12x6 cm	
33	1	DRIPTRAY HOUSING	XXXXXXXXX	ABS
34	6	FLAT HEAD SCREW	ISO 7046-1 - M5 X 8 - 7 - 8N	STEEL
35	1	DRIP TRAY PART	XXXXXXXXX	ABS
36	1	DRIP TRAY COVER	XXXXXXXXX	ABS
37	16	PAN HEAD SCREW	ISO 7045 - M4 X 8 - Z - 8N	STEEL
38	4	PAN HEAD SCREW	ISO 7045 - M2.5 X 4 - Z - 4N	STEEL
39	1	BACKCOVER	XXXXXXXXX	ABS
40	2	FLAT HEAD SCREW	ISO 7046-1 - M4 X 6 - Z - 6N	STEEL
41	2	FLAT HEAD CREW	ISO 7046-1 - M5 X 10 - 7 - 10N	STEEL
42	3	FLAT HEAD SCREW	ISO 7046-1 - M3 X 5 - Z - 5N	STEEL
43	8	BOTTLE	750ml	Glass
44	8	COG	XXXXXXXXX	Rubber
45	2	TUBE EXTENSION 1	9x12mm	Silicon
46	1	SILICON TUBES	9x12mm	Silicon
47	6	TUBE EXTENSION 2	9x12mm	Silicon
48	5	TUBE EXTENSION 3	9x12mm	Silicon

Technology & Bionics	GROUP 12	Tinotenda	13/01/2024	GROUP 12
HOCHSCHULE RHEIN-WAAL		BARTEOLLA		
This drawing is the exclusive property of Rhine-Waal University. It is not to be transferred, communicated, disclosed or copied, unless specifically authorized by Rhine-Waal University		99999-ME.2.2701.01	bill of material	
		200124-01-001	00	1/14/2024	1 /1

Figure 13.1 - Complete Bill of Material for the assembly.

Electrical BOM (Section 9.1)

14 Technical Drawing

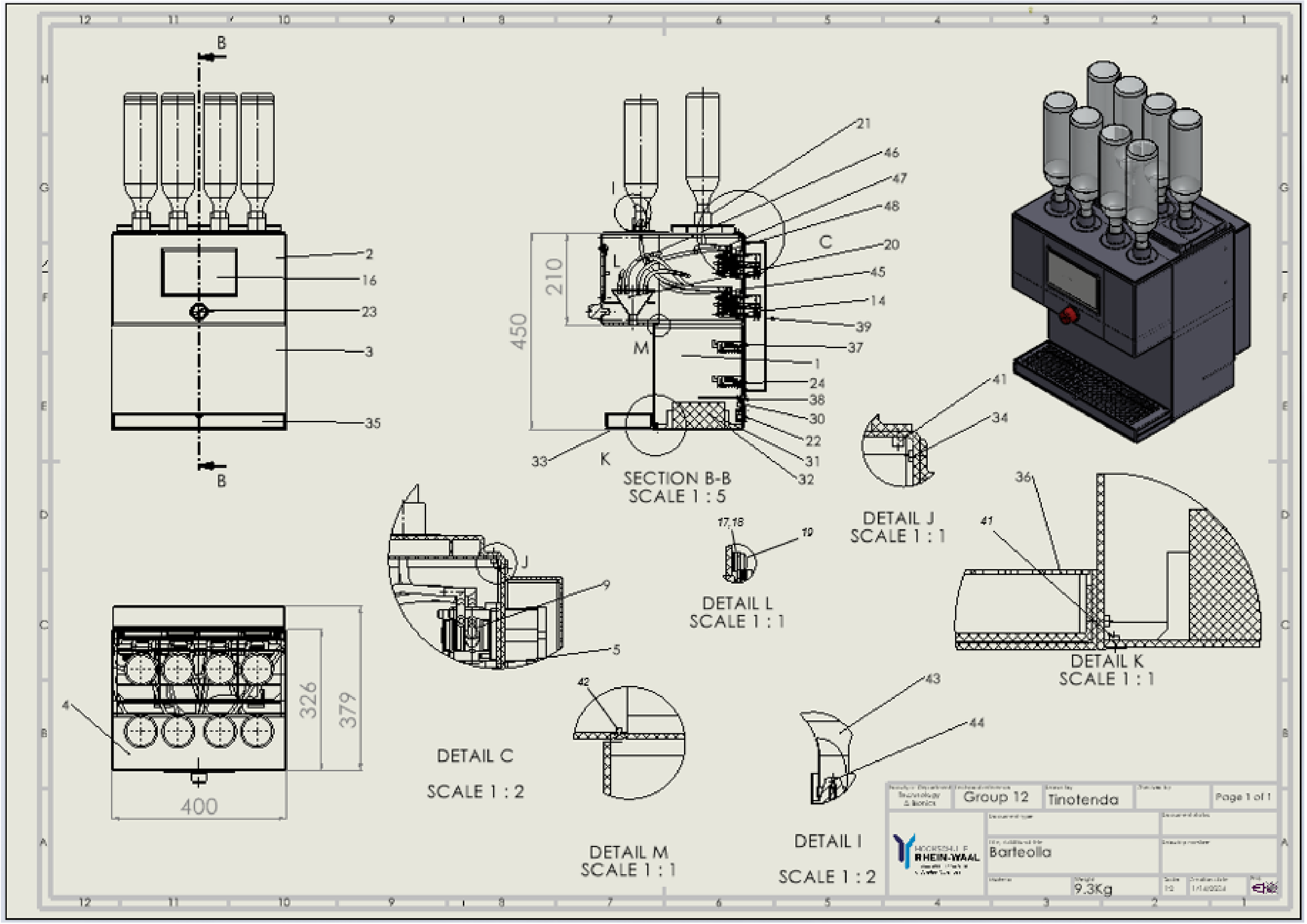


Figure 14.1 - Technical Drawing for the cocktail mixer assembly.

15 Program flow chart

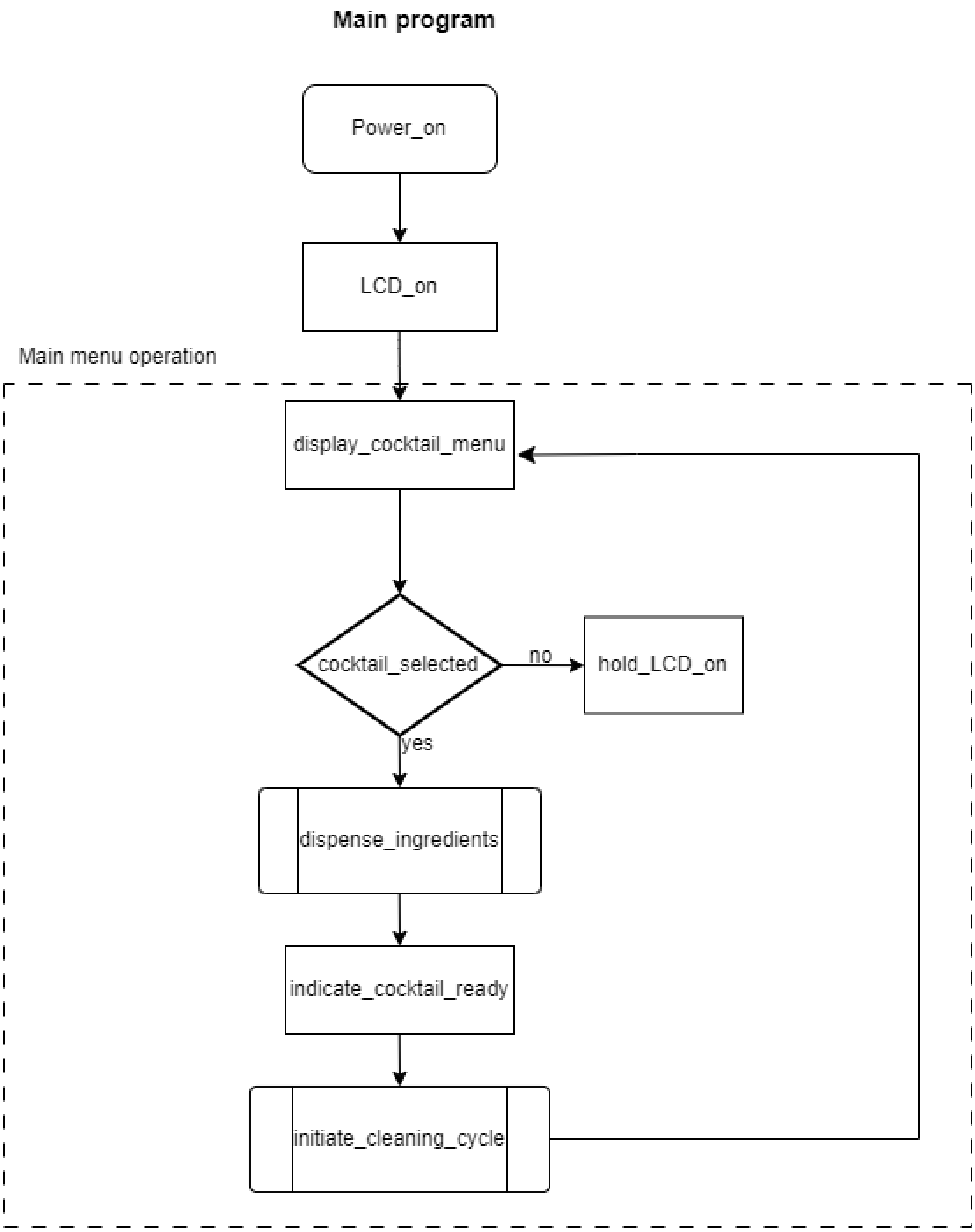


Figure 14.1 - Flowchart representation for main program

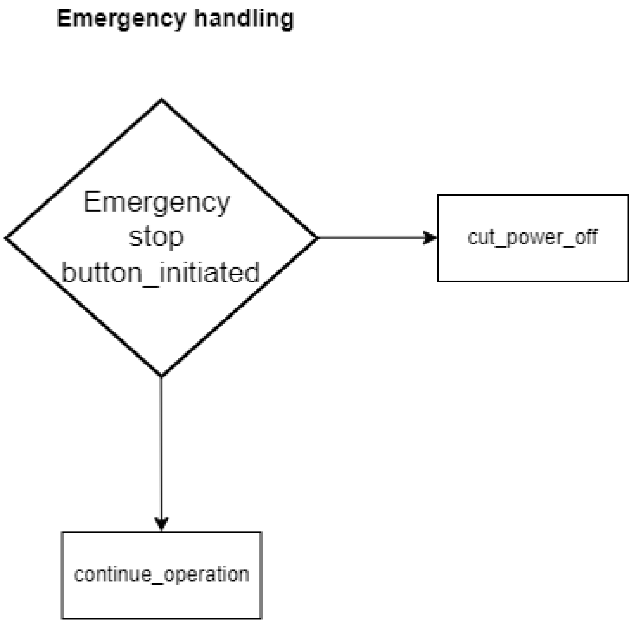


Figure 15.2 - Flowchart representation for emergency handling scenario

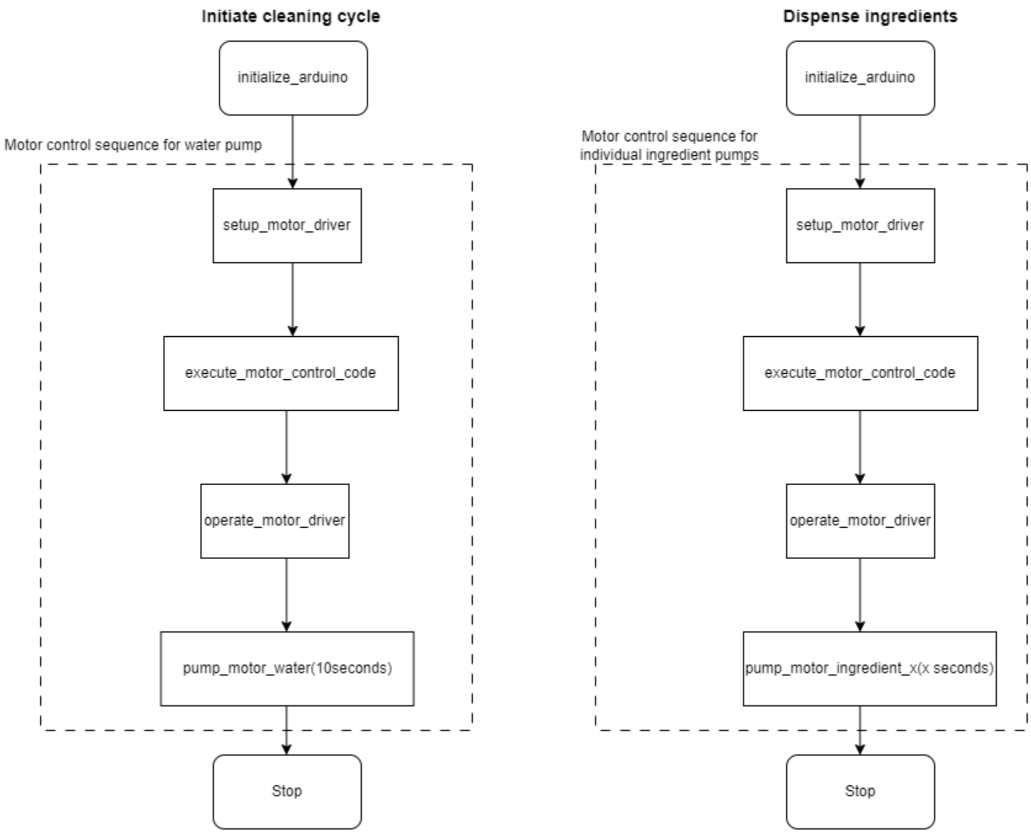


*Figure 15.3 – **Left**: Flowchart representation for cleaning cycle; **Right**: Flowchart representation for dispensing ingredients cycle*

16 Production Planning

Accurate production planning is essential to meet the anticipated demand while maintaining cost efficiency through effective procurement of materials and optimal allocation of machinery.

16.1 Equipment Specification

Supplier: Anycubic
Price estimation: 520 €
Raw material: ABS Plastic

*Figure 16.1 - Anycubic 3D printer used for manufacturing purposes (*Anycubic Kobra 2 Max*, n.d.)*

*Table 16.1 - Technical Data for AnyCubic 3D Printer(*Anycubic Kobra 2 Max*, n.d.)*

Machine Weight	21kg
Printing Volume	23.2gal./88.2L
Nozzle	*≤500F/260°C* ø 0.4mm (replaceable)
Printing Speed	500mm/s(Max.) 300mm/s(Typ.)
X/Y-axis	Double Metal Spindle
Printing Platform	PEI Magnetic Spring Steel 16.5x16.5in./420x420mm
Cooling Fan RPM	7000rpm/min
Printing Material	PLA/ABS/PETG/TPU
Machine Dimensions	29.1x28.9x25.1in./ 740*735*640 mm(HWD)

Printing Dimensions	19.7x16.5x16.5in./ 500x420x420 mm(HWD)
Hotbed temperature	*≤194F/90°C*
Z axis	Double Motor Double Z-axis
Machine Leveling	New Anycubic LeviQ 2.0 Automatic Leveling System (49-point)
Control Panel	4.3" LCD Touch-Control Screen
Extruder	Anycubic Self-Developed Direct Extruder + Double Gears
Data Input	USB ports x 3

16.2 Capacity Calculation

Shift Model and Available Production Time

Table 16.2 - Capacity Calculation Analysis

Capacity Analysis	VALUE	UNIT
No. of days per year	365	days
Weekends and public holidays	115	days
Working days annually	250	days
Working time per shift	7.5	hrs
shifts per day	3	
Price per piece	990	€
Annual Sales target	1000	
Downtime Ratio	0.85	
Required time for one unit	5.6	hrs

Note: We work 5 days a week.

The main goal of the company is to achieve the annual revenue sales of 990,*000 € set by the CEO and the board members of the company. To translate* this target to a production plan, the calculation for the number of finished goods is done, which will be produced in the factory each year.

$$No.\ of\ units\ produced\ annually = \frac{Target\ annual\ revenue}{product\ price}$$

$$= \frac{990000€}{990€}$$

= 1000 units

Consumer Takt Time

The Takt time is the required production duration to meet the customer demand. The aim here is to produce 1000 units in the first year. This is based on the market research done in Milestone 1, which were 200 units in the initial launch phase.

$$\text{No. of units produced per day } = \frac{No.of\ units\ produced\ daily}{annual\ working\ days}$$
$$= \frac{1000}{250}$$

$$\boxed{= \textbf{\textit{4 units per day}}}$$

$$Takt\ time = \frac{total\ production\ time}{total\ units} = \frac{250\ days\ x\ 3\ shifts\ x\ 7.5\ hrs}{1000} = 5.6\ hrs$$

Actual Takt time = 5.6 x 0.85 (downtime ratio) = 4.76 hrs

We assume that some units will be discarded during the quality assurance cycle and the production and sales targets will not be achieved; therefore, some safety buffers will be kept which will increase our annual production to 1000 units.

Factory Working hours

The make parts are manufactured and transported between the machines on a lot size basis. The factory will be active for 24 hours per day, in three 8-hours shifts. Out of those 24 hours, 1.5 hours will be break time (30 minutes per shift) and daily 10 minutes will be taken for short staff meetings and briefings. Hence, the overall productive working hours will be 22 hours each day.
There are many advantages of 8-hour shift schedules, for both the employee *and the employer. There's a likelihood of a reduction in staff accidents and/or* errors due to the amount of rest time in between shifts. The disadvantage of this shift model is it requires up-front planning, but it pays eventually. Down times for each machine is specified as a general 5 -10% margin for maintenance, the planned production considers available time to allow for the margin. Daily production volume considers an extra of 10% from each part to be stored as spare parts.

Table 16.3 – Capacity calculation *for make parts*

Item #	Part Name	Manufacturing Technology	Production time per piece(min)	Daily No of units	Daily time of production(min)	Qty	Lot Size	Factory working time per day(min)	Total time per product (hrs)
1	Front Housing	3D Printing	1800	4	7200	1	1	1320	30.00
2	Front cover	3D Printing	1500	4	6000	1	1	1320	25.00
3	Back Housing	3D Printing	960	4	3840	1	1	1320	16.00
4	Back cover	3D Printing	1740	4	6960	1	1	1320	29.00

5	Top holder	3D Printing	1680	4	6720	1	1	1320	28.00
6	Bottle adapter	3D Printing	75	4	300	1	1	1320	1.25
7	Funnel	3D Printing	120	4	480	1	1	1320	2.00
8	Drip tray Housing	3D Printing	125	4	500	1	1	1320	2.08
9	Drip tray part	3D Printing	45	4	180	1	1	1320	0.75
10	Drip Tray cover	3D Printing	240	4	960	1	1	1320	4.00
14	Pump holder	3D Printing	300	4	1200	1	1	1320	5.00
1,2,3,4, 5	Housing	Painting	0.33	4	1.32	1	10	1320	0.01
Total					**34341.32**				

The time needed for 3D printing for the various parts is taken from a slicing software called Bambu lab which is compatible with our printer.

Number of Machines Needed

In reality, production processes do not have a 100% utilization of the production time, so a downtime ratio of 85% is used as seen on the capacity table above.

Actual time (hrs) = 5.6 x 0.85 = 4.76 hrs

$$\text{No. of machines} = \frac{\text{Production time per day(min)}}{\text{Factory working time per day(min)}}$$

Table 16.4 - Number of machines needed for production

Process	Machine	Tact time for a setup(hrs)	Processing time(hrs)	No of machines	Employees per machine
Part No. 1	3D Printer	4.76	30.00	6.0	1
Part No. 2	3D Printer	4.76	25.00	5.0	1
Part No. 3	3D Printer	4.76	16.00	4.0	1
Part No. 4	3D Printer	4.76	29.00	6.0	1
Part No. 5	3D Printer	4.76	28.00	6.0	1
Part No. 6,7,8,9,10,14	3D Printer	4.76	15.08	1.0	1
total				**28.0**	**6**

So we use 28 (3D Printers) + 1 setup (painting) = 29 machines.
Total Staff = *6* + *1(painter)* = *7* employees

Daily Production staff = Total no. Of employees x Total no. Of shifts
= 7 employees x 3 shifts = 21 daily production staff

Assembly Time Per Unit

Total units produced = 4 units

Total man-hours = 22 hours

Units per man-hour = $\frac{4\ units}{22\ hours} = 0.1818$ units/man-hour

Time taken per unit = $\frac{60\ mins}{0.1818\ units/man{-}hour} = 330.03$ mins/unit

Overall Equipment Effectiveness (OEE)

Overall equipment efficiency (OEE) is a critical metric used to measure the effectiveness of manufacturing equipment or assets. It provides insights into how well machines are being utilized and identifies areas for improvement. OEE considers three key factors; Availability, Performance, Quality;

Relevant information for understanding the required capacity and efficiency achievement is further explained with the use of the following calculations.

OEE = Availability x Performance x Quality

a. Availability: A = Available time, B = Scheduled time
b. Performance: C= Ideal production rate ,D= Actual production time
c. Quality: E= Total units, F= Good units

$$OEE = \frac{B}{A}\ x\ \frac{D}{C}\ x\ \frac{F}{E}$$

Scheduled production time = 24 hrs

Downtime(planned/unplanned) = 2 hrs.

Up time (available time) = (24-2hrs) = 22hrs

$$\text{Availability} = \frac{B}{A} = \frac{22\ hours}{24\ hours}\ \text{x}\ 100 = 91.67\ \%$$

$$\text{Actual production Rate} = \frac{4\ units}{22\ hours} = 0.1818\,\frac{\text{unit}}{hr}$$

Ideal production rate = 0.2

$$\text{Performance} = \frac{D}{C} = \frac{0.1818}{0.2}\ x\ 100 = 90.9\ \%$$

Total number of units = 4 units

Number of good units = 3.8

$$\text{Quality} = \frac{F}{E} = \frac{3.8\,units}{4\,units} \text{x } 100 \quad = 95\%$$

$$OEEE = 91.67\ \%\ x\ 90.9\%\ x\ 95\ \% = 79.1\ \%$$

16.3 List of employees

Table 16.5 - Overall Employee Requirements

Position	Qualification	Number of employees	Salary per year(EUR)	Total amount per year(EUR)
Financial Manager	Accountant	1	31,000	31,000
IT Manager	Technicians in Field	1	40,000	40,000
Logistics Manager	Industrial Engineer	1	35,000	35,000
Maintenance manager	Mechanical Engineer	1	35,000	35,000
Plant Manager	Industrial Engineer	1	45,000	45,000
Production & Logistic Employees	Company training	21	27,000	189,000
Production Manager	Mechanical Engineer	1	45,000	45,000
Quality Assurance	Industrial Engineer	1	40,000	40,000
Cleaning Staff	Company training	2	25,000	50,000
Total (EUR)				**846,000**

16.4 Factory Layout

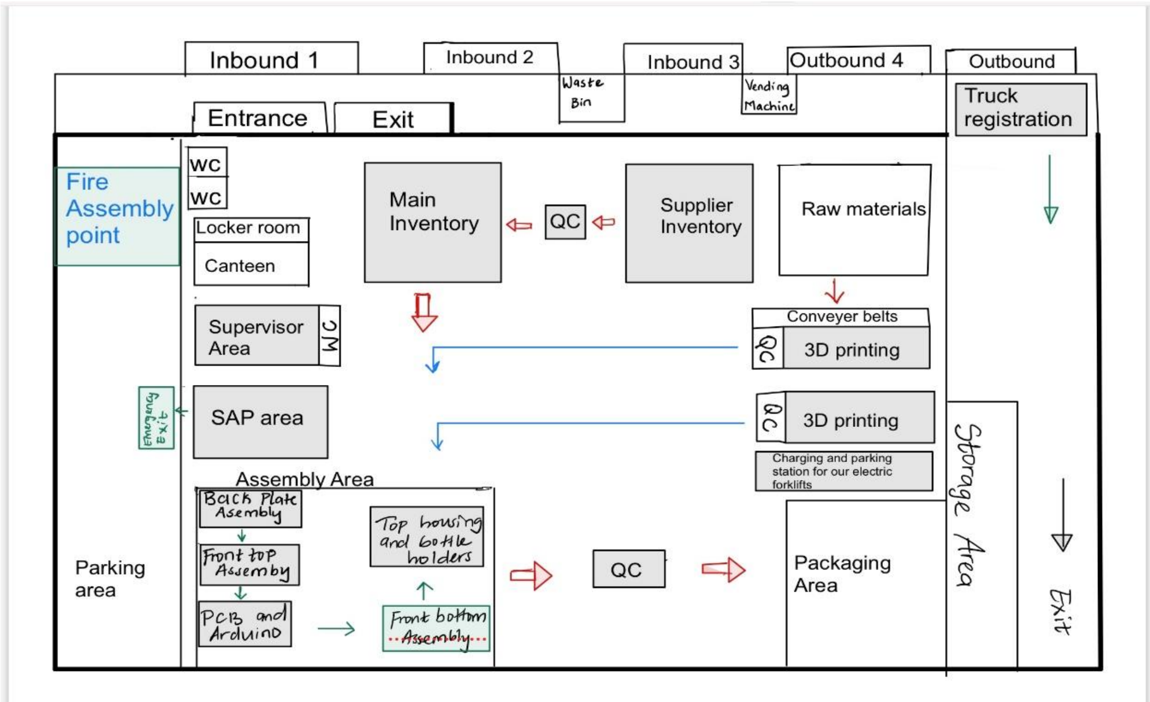


Figure 16.2 - Complete Factory layout

16.5 Assembly Lines

Assembly Lines maintaining lean manufacturing principles in mind leads to the division of the entire assembly process to 4 different subassemblies, and a final assembly.

Subassembly 1-Back Housing

The Back sub assembly consist of the following steps;

Table 16.6 - Steps to assemble Back Subassembly

Operation sequence	Time to assemble (s)
1)Pumps(8) are mounted on pump holders and screwed to the back base.	360
2)Stepper Motor drivers(8) screwed to the back housing and connected to the pumps.	180
3)Arduino Mega Board is connected to power supply, stepper motors and screwed to back housing (later connected to LCD screen in final assembly)	30
4) Install the ON/OFF button	15

5) Power Supply holders are glued to the back housing base so that the Power supply can be placed and held firmly.	60
6)Screw the back cover	30
Total Time to Complete (TTC)	675

Subassembly 2 - Front housing

Table 16.7 - Steps to assemble Front Subassembly

Operation sequence	**Time to assemble (s)**
1)Screen is screwed to the front housing	60
2)Emergency Stop button is mounted	30
3)Funnel is mounted on the funnel holder in the housing	60
Total Time to Complete (TTC)	150

Subassembly 3 – Front Cover

Table 16.8 - Steps to assemble Front Cover and Drip tray

Operation sequence	**Time to assemble (s)**
1) Drip Tray Housing is mounted on the Front Cover using screws.	30
2)Drip Tray slides into the Drip tray housing.	30
Total Time to Complete (TTC)	60s

Subassembly 4 -Top Holder

Table 16.9 - Steps to assemble Top Holder and Bottle Adapter

Operation sequence	**Time to assemble (s)**
1)Bottle adapters(8) are partially screwed on the top holder and tubes pass through them into the bottles	60

16.6 Final assembly

The final assembly consist of connecting the 4 subassemblies (Back Housing, Front housing, Front Cover, Top Holder) together along with tubes that run from funnel to pumps to the bottle adapters mounted on top holder. The electronic connection for LCD Touchscreen and Emergency Stop button is also done to the Arduino Mega Board and power supply. In the end the Top Holder partial screws are tightened when all subcomponents are properly connected. This subassembly runs on a standard rolling production line.

TTC

Back housing + Front Housing + Front Cover + Top Holder + transport + final assembly = 675s + 150s + 60s +40 s + 240s + 245s = 1410 s

Required assembly time = $\frac{1000\ pieces}{5500\ hours}$ =18.2pcs/hour

The assembly time is reasonable and can be managed with the different subassemblies and workers. 4 Workers will be used for assembly out of the 6 workers, while the remaining 2 will change the 3D printed parts when we are done from the machine.

16.7 Value Chain

The value chain is a series of steps that a company takes to create, deliver, and support its products or services.

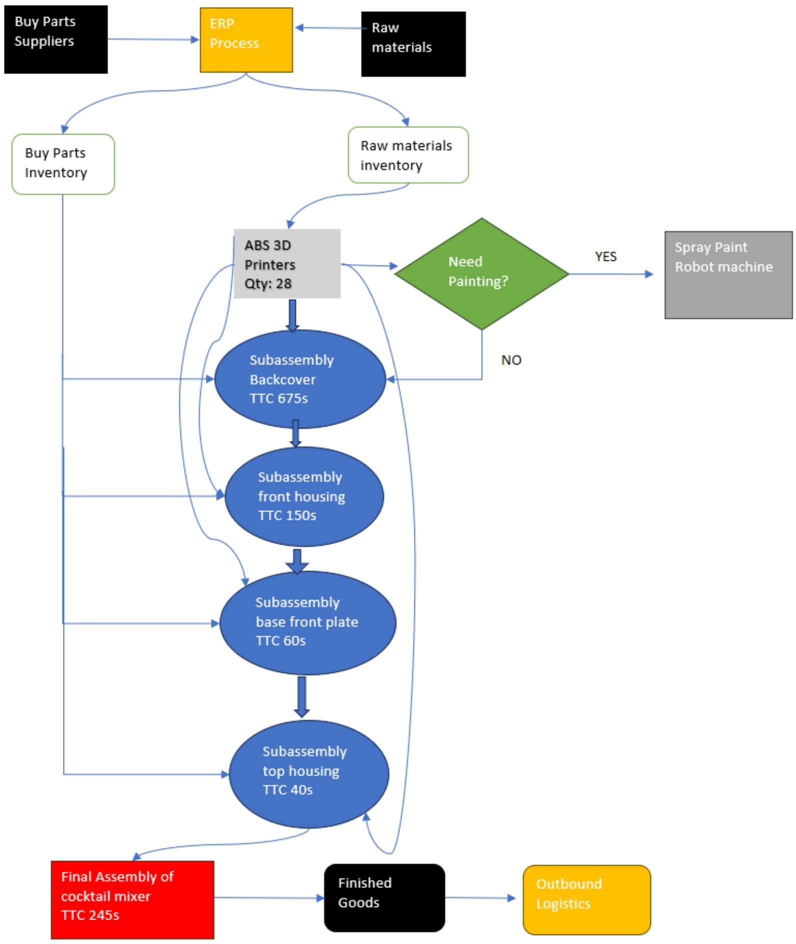


Figure 16.3 - Value chain flow chart

17 Cost Calculation

The manufacturing cost is the sum of costs of all resources, which is consumed during the process generation of a product.

17.1 Labour Cost

The direct labor cost of our product per year will be 846000€ *per year according* to Table16.5 above.

Table 17.1 - Material cost

Factors	**Cost**
Wages	*14€ per hour*
Interest	5%
Depreciation	Fully depreciated over 10 years
Space costs	*5€*/m^2 per month
Electricity cost	
Maintenance and repairs	5% of the machine value
Tools and supplies	Varies as per machine
Marketing and Sales Overhead	15%
Remaining production overheads	8%
Administration Overheads	10%
Material Overheads	5%

17.2 Annual Operating Time

For the 3D Printers;
22 hours (3 shift) x 5 days a week x 49 weeks a year = 5390 hours per year

For the Painting machine;
2 hours x 5 days a week x 49 weeks a year = 490 hours per year

Note:2 week has been reserved for vacation and 1 week makes up for public holidays when the production process will be completely shut down.

17.3 Machine Hourly Rate

3D Printers = 28 x 520€ = 14,560€
Painting Set up = 30,*000€*

Table 17.2 – Electricity consumption for complete Machine setup

Machine	**Power Consumption per year**	**€/kWh**	**Cost**
3D Printer (28 printer)	0.4kW x 5390= 2156kWh	0.40	*862.4€ x 28= 24147.2€*

Painting Robot sprayer setup	15kW x 490hrs =7350kWh	0.40	*2940€*

Table 17.3 - Space costing of every machine

Machine	**Area in m²**	**Cost per m² per year**	**Total cost**
3D Printer(x28 printer)	28 x 2m² = 56	*5 € x 12= 60€*	*3360€*
Painting Robot sprayer setup	15	*5€ x 12= 60€*	*900€*

Table 17.4 - Labour cost of every machine

Machine	**Average annual wage per person**	**% of time Assistance**	**Total Cost**
3D Printer(x28 printer)	*27000€*	10	*2700€*
Painting Robot sprayer setup	*27000€*	15	*4050€*

Machine Hourly Rate = Machine Dependent Overheads/ Annual Operating hours

Table 17.5 - Machine Hourly rate for all machines

	3D Printer	**Robot paint sprayer**
Space cost	*3360€*	*900€*
Electricity cost	*24147.2€*	*2940€*
Maintenance cost (5%)	*728€*	1500
Tool cost	*1064€*	*1500€*
Annual Depreciation(10%)	*1456€*	*3000€*
Interest(5%)	*728€*	*1500€*
Labor Cost	*2700€*	*4050€*
Machine dependent overheads	**34183.2€**	**15390**
Annual operating hours	5390 hours	490 hours
Machine Hourly Rate	**6.34€**	**31.4€**

17.4 Material Cost

Table 17.6 - Material Costing for raw materials used

	ABS Plastic	**Paint**
Price per unit	*0.40€/kg*	*51€/kg*
Weight of the product	5 kg	1kg
Material overhead(5%)	*0.1€*	*2.55€*
Total cost	*2.1€*	*53.55€*

17.5 Production Cost

As calculated previously, the manufacturing time of 1complete unit of the cocktail machine is 5.6hours.

- Direct production cost of 1 unit

  5.6 hours x14€ = 78.4€
- Machine Dependent Overhead cost:

  Production time in hours x (Sum of hourly rate of all machines)

  5.6 hours x (6.34€ + 31.4€) = 211.3€
- Remaining Production Overhead cost:

  8 % of the (Direct production Cost + Machine dependent cost)

  = 0.08 x (78.4€ + 211.3) =23.1€
- Total Production cost

  Direct production Cost + Machine dependent cost + Remaining Overhead

  78.4€ + € + 211.3€ + 23.1€ = 312.8 €

17.6 Prime Cost

Price for all the buy parts per unit of the product = 392 €

Manufacturing cost per unit:
Manufacturing cost = Total Material Cost per unit + Production Cost + Buy Parts price

= 55.65€ + 312.8€ + 392€ = 760.45€

Administrative cost per unit:
Administrative Cost = 10 % of the Manufacturing *cost=0.10 x 760.45€ = 76.04€*

Marketing and Sales cost per unit:
Manufacturing Cost = 15 % of the Manufacturing cost = 0.15 x 760.45€ = 114.07€

Total Prime cost of unit of Shade Pro:
Prime cost = Marketing Cost + Manufacturing Cost per unit + Administrative Cost

= 114.07€ + 760.45€ + 76.04€ = 950.56€

Therefore, the cost to make produce one unit of cocktail mixer is 950.56€

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