



**CHALMERS**  
UNIVERSITY OF TECHNOLOGY

---



# Developing a Dishwasher Splash Guard

for the top basket to avoid splashing of residual liquid

Master's thesis in Product Development

AKHILESH KRISHNA

---

Department of Industrial and Materials Science  
CHALMERS UNIVERSITY OF TECHNOLOGY  
Gothenburg, Sweden 2018

# Abstract

The global market for dishwashing appliances is expanding and the competition is rising. Companies are also trying to add extra features to attract more customers and make life easier for customers. This project was initiated to solve the problem of splashing of residual liquid outside the dishwasher boundary, resulting from the feeding of cups and glasses into the top basket in a dishwasher. The mission of the project was to develop a compact splash guard which can hinder liquid splashes outside the dishwasher boundary without any modification in the existing dishwasher. Further, this project also contributes to ensuring the growth of ASKO within innovation, development and business expansion.

The foundation for the project was based on Lean Product Development, accompanied by a set of tools and methods to find the best result while fulfilling the knowledge gap and saving project time. Clearly stated requirements guided the project to develop concepts. Concepts were generated and tested using a cardboard model and prototyping. At the end, a single concept was selected from the four secondary concepts using a Kesselring Matrix.

Finally, the project resulted in developing a prototype model of dishwasher spillage guard that fulfills all the requirement and desires of the company and users with a compact design as a new accessory to the dishwashing machine. A cost comparison was conducted to identify if the dishwasher spillage guard could generate profits while solving a customer problem. The project concludes with some recommendations for developing the product further for a full-scale production.

# Acknowledgment

I would like to express my sincere gratitude to my supervisor Göran Gustafsson, Ph.D. at Chalmers University of Technology for the assistance and guidance throughout the project. He provided me with the tools and methods with his expertise in lean development for executing the project and steering me to avoid deviation from the project track. I would also like to thank Mikael Johansson, Ph.D. at ASKO Appliances AB for giving a challenging task and for offering valuable feedback at each stage of development.

Finally, I would like to express my profound gratitude towards all my friends who helped me in some of the other way during the project and my family for their support and encouragement.

Thank you.

# Contents

<b>1. Introduction .....</b>	<b>1</b>
1.1 The Company .....	1
1.2 Background .....	2
1.3 Aim .....	2
1.4 Delimitations .....	2
1.5 Out of Scope .....	3
<b>2. Literature and Patent Review .....</b>	<b>4</b>
2.1 Literature Review .....	4
2.2 Patent Search .....	5
<b>3. Methodology .....</b>	<b>7</b>
<b>4. Market Analysis .....</b>	<b>9</b>
4.1 Market Segment .....	9
4.1.1 Benchmarking .....	9
4.1.2 PEST Analysis .....	10
4.1.3 SWOT Analysis .....	10
4.2 Technology Status .....	11
4.3 User .....	11
<b>5. Customer Needs Mapping .....</b>	<b>12</b>
5.1 Survey .....	12
5.2 Observation .....	12
5.3 Goal .....	13
<b>6. Results .....</b>	<b>16</b>
6.1 Problem Definition .....	16
6.2 Concept and Feasibility .....	20
6.2.1 Preliminary Concepts .....	21
6.2.2 Primary Concepts .....	21
6.2.3 Testing Solutions .....	21
6.2.4 Determination of Final Concept .....	22
6.3 Product Design .....	23
6.3.1 Preliminary Cardboard Prototype .....	23
6.3.2 Optimization .....	23
6.3.3 Prototype .....	24

6.3.4 Optimization.....	25
6.4 Testing .....	25
6.5 Product Requirement Fulfilment .....	25
6.6 Further Consideration .....	26
6.6.1 Patent Analysis .....	27
6.6.2 Manufacturing Process .....	27
6.6.3 Choice of Material .....	27
6.6.4 Environmental and Ethical Concerns .....	27
6.6.5 Product and Service .....	29
<b>7. Product Proposal .....</b>	<b>30</b>
7.1 Product Description .....	30
7.1.1 Aesthetics .....	31
7.1.2 Benefits .....	31
7.1.3 Technical Specification .....	32
7.1.4 Cost Comparison .....	33
<b>8. Discussion and Conclusion .....</b>	<b>35</b>
<b>9. Future Outlook .....</b>	<b>37</b>
<b>References .....</b>	<b>38</b>
<b>Appendix A – Patent Search .....</b>	<b>40</b>
<b>Appendix B – PEST and SWOT Analysis .....</b>	<b>52</b>
<b>Appendix C – Survey and Observation .....</b>	<b>54</b>
<b>Appendix D – Morphological Matrix .....</b>	<b>66</b>
<b>Appendix E – Preliminary Concepts .....</b>	<b>68</b>
<b>Appendix F – Elimination Matrix .....</b>	<b>77</b>
<b>Appendix G – Prototype .....</b>	<b>78</b>
<b>Appendix H – Technical Drawings .....</b>	<b>80</b>

# Chapter One

## Introduction

The dishwasher market has seen continuous growth all over the world with the increase in competition. As per Statista's report on Dishwashing product market value in EU (2013-2017), the retail value of automatic dishwashing machine has grown to an approximate value of 2.6 billion EUR in 2017 [1]. Also, in the US the number of unit shipment has bloomed from 5.53 million units in 2011 to 8 million in 2017. The forecast for 2018 and 2019 shows an increase to 8.34 and 8.69 million respectively [2]. ASKO is a Swedish company that produces household appliances and was founded in 1918. ASKO under the parent organization called Gorenje produce the premium products for the Gorenje brand and have been awarded multiple Red dot design awards. Gorenje is a Slovenian white good manufacturing company.

Companies are also trying to add extra features to attract more customers and make life easier for customers. To be on top of market ASKO must search for unexplored customer problems and address it in time. The dishwasher compactness, efficiency, design, and performance have grown throughout the years, but there are few problems like spillage from the dishwasher when feeding it with residual liquid. This spillage leads to stained walls, floors and sometimes the user's clothes. There are a few solutions developed to solve this problem but they are not efficient, user-friendly, or they lack aesthetics.

### 1.1 The Company

Gorenje Group is a leading home product manufacturing company with a global presence in 90 countries worldwide, mainly in Europe, USA, and Australia. It has a consolidated revenue of 1.258 billion Euro and 10,889 employees in 2016. ASKO is an internationally renowned premium global brand of Gorenje Group. ASKO represents 4.8% of the appliances produced by Gorenje Group, but as ASKO produces premium products and are higher priced, so it represents 11.4% of their revenue. Gorenje Group also expects that ASKO group will represent 14.2% of the revenue in 2020 [3].

ASKO is inspired by Scandinavian design and mainly manufactures home appliances like washing machines, dryers, dishwashers, cooking equipment and refrigerators for both professional and private use. It produces products with high performance,

elegant design, added functionality, and user-friendliness. Multiple times it has received Red Dot Design Awards for the product design. It has also received European Product Design Award (EPDA), iF Design Award, IDEA Design Award and a few more [4].

## 1.2 Background

The Gorenje Group with its premium brand ASKO has identified a problem that is causing trouble for most of the dishwasher users. ASKO found that loading the top basket of the dishwasher with cups or glasses containing some left-over liquid in it results in spillage of that liquid on to the bottom basket (if pulled out) or directly on to the front door below it. Which then splashes over to the neighboring walls, floor or on to the user's clothes, resulting in stains. At times the residual liquid directly spills out of the dishwasher basket on to the floor. So, the company now decided to develop a product to avoid the above situation.

## 1.3 Aim

The main aim of the project was to develop a product to avoid the liquid splashing outside the dishwashing area resulting from the spillage of any liquid substance while loading the top basket with cups or glasses containing liquid. The results aimed to be attained was a prototype that could be used in one of the existing premium ASKO dishwashers. A Lean product development process was decided to be carried out throughout the project and all the methods, tools, processes, decisions and its justification to be recorded in this report for future references.

## 1.4 Delimitations

There were few limitations set by ASKO which needed to be considered while developing this product. Each limitation was equally important and served a specific function as explained below;

- It shall be easily integrated/applied in an existing dishwasher

So that customer does not need to buy a new dishwasher to have this new feature. Rather the customer can just buy this product and install or integrate it with their existing dishwasher. Therefore, no modification in the existing dishwasher model was allowed.

- It shall not compromise the function and efficiency of the dishwasher.

The main function of the dishwasher is to clean to the best of its efficiency. So, a customer would not prefer a product that adds an extra feature to their dishwasher but at the cost of cleaning efficiency.

- The material shall be compatible with the dishwashing process.

ASKO dishwashers have a lifespan of 20 years and so should be the case with any new product that will be integrated to it. The dishwashing process includes hot water and washing chemicals, so the material of the product should be able to withstand it.

- It shall not be a “dirt trap”.

No dirt trap where remains from the process are accumulated. If the product traps dirt to avoid splashes, then that would result in accumulated waste which the customer will have to clean over time, creating bacterial growth and extra work.

## 1.5 Out of scope

The processes which need to be addressed after designing a product like a process design, verification testing and start of production is not covered in this report. Therefore, the final product attained in this project is a 3D prototype rather than a plastic injection molded product.



## Chapter Two

### Literature and Patent Search Review

This chapter comprises of the summary of the research conducted through the patent and literature on the development in the field of dishwashers with regards to the spillage problems. It also includes the dependency of current generation on dishwashing machines, the resulting sales and willingness to improve the product for better lifestyle suitability. The available technology that could be helpful in developing the product or could be used as a reference for comparison was also considered.

#### 2.1 Literature Review

In 1886 Josephine Garis Cochran received a patent for the first practical dishwashing machine [5]. With that, the revolution of cleaning dishes started, with initially restaurants using dishwashers on a commercial level and gradually homes started using it on a personal level. As per Statista's report the retail value of automatic dishwashing machine in EU has grown in 2017 [1]. Also, in the US, the number of unit shipment has bloomed in 2017, with a forecast for further increase in the coming two years. [2].

The rising market of dishwasher clearly states that the customers are moving out of the manual washing methods and adopting a more automatic means for washing the dishes. The dependency rate on the dishwashing machine has increased over the years. It also shows that the user does not have time to waste on unproductive and manual work. There is a contradiction between the dishwasher size and the accommodation space per person holds. With the increase in population the accommodation size is decreasing and so the focus is to reduce the dishwasher size with the least possible compromises.

As per the consumer reports currently, dishwashers are available in the market from a starting rate of 500 USD or less to 1000 USD and more [6]. Which clearly states that people are willing to pay to get their dishes cleaned automatically. Any added feature to the existing dishwasher which could provide more convenience to the customer at a cheaper price is appreciated. It is advantageous to both the company to attract more customers and to the users to increase the level of convenience. Throughout the years the dishwashing machine has developed in terms of better space, cleaning efficiency, energy use, comfort and more. These developments have made life easier for a dishwasher user. But still, there are a few unexplored areas of development.

Current dishwashers do not have any facility to avoid any spillage resulting from the dishwasher feeding practice. It is very common to have some residual liquid remains in a cup or glass after use. But when the same cup or glass is fed into the top basket specifically designed for it, it leads to some spillages and splashes of the residual liquid on the floor and surrounding.

Because of spillage and splashing users have developed a habit of dumping the residual liquid in cups and glasses to a sink and sometimes giving it a pre-wash under running water before feeding in the dishwasher. This not only consumes time and effort but also waste water resource. As per ASKO, there is no requirement of manually pre-washing the utensils before feeding into the dishwasher, as the dishwasher is efficient to do that [13]. Users are finding different ways to avoid this situation but there is no such product on the market that could solve the problem for the user.

## 2.2 Patent search

A patent search was conducted to ensure that there is no product available in the market by any other company which addresses the same problem statement as this project or if any, then how a more improved version of the same could be developed. The patent search also helped in getting some inspiration for the product development ideas.

Table 2.1 The Invention Breakdown

<b>Utility:</b>	Dishwasher splash protector that obstruct any liquid to splash outside the dishwasher boundary.
<b>Structure:</b>	guard, cover, screen, protector, wall, curtain, canopy
<b>Function:</b>	Automatic, avoid splash, no dirt trap, easy to install

Online services like Espacenet patent search and Google patent search were used to find any similar inventions [20][21]. A patent search template was used to find the patents on Espacenet. The patent search was categorized into three sections – invention breakdown, search strategy, and relevant inventions. Invention breakdown was a useful way to break down the problem, its context and solution into keywords. A classification search was conducted to find out the different classes that the invention could fall into so that it would be easy to find relevant prior inventions. In the search strategy, the relevant keywords together with their synonyms were used to create search strings. A worldwide database was selected to find inventions on an

international level. These keyword string with the classification class were used to search the database. The search history was recorded for back tracing.

On Espacenet more than 100 patents were found and on Google more than 30,000. Not all of these were entirely relevant to the current project. Therefore, the patent results were investigated to find the most relevant ones. The relevant ones are those inventions from which the technology methods or any inspiration that could be taken for the current project. The relevant inventions were logged in to create a list for idea generation in the later stage of product development, see *Appendix A*.

Some inventions that were relevant were related to the dishwashers, bathtubs, vehicle, sink, urinal bowl, umbrella, window, cooktop and other kitchen equipment's. In some or the other way, these inventions were used to avoid water, oil or slurry material from splashing outside a confined zone. One of the inventions was related to the current project and addresses the similar problem of splashing in a dishwasher. The patent was to avoid residual liquid splashing on to the wall when a dishwasher is placed in the corner of a room, such that other than the back side, the right or the left side of the dishwasher is also in contact with a wall. The product was a 100 to 130-degree angular sector of a circular plate with the radius of door length attached to the door so that it slides open each time the door is opened and protect the wall. This is not what the current project is aiming to do as the product should not be restricted by the location of the dishwasher. Therefore, it proved good for some motivation and idea generation.

## Chapter Three

### Methodology

This chapter covers the basic methodology of product development and why a lean development process was followed and how it proved to be effective throughout the project. Set-based concurrent engineering is another major process which was also utilized in the project to delay freezing on one solution, before eliminating the inferior solutions.

Lean product development principles, methodology, and tools were followed throughout this project. A knowledge-driven product development process gives a better output than a result-oriented product development. As suggested in the book Knowledge-Based Product Development by Bob Melvin, the project was divided into two parts with the first part solely focused on gaining knowledge and filling the gaps and the second half in designing it. All knowledge gaps were closed before the beginning of any formal designing sessions. The required knowledge was gained by conducting multiple testing sessions and then the product prototype was designed [7].

By following the lean development rule of testing and then designing followed by building, the time and resource waste were reduced. This also made the development process faster than the traditional product development process. Other than the development process there are some other factors also which could lead to time wastage, this includes giving a beautiful presentation on monthly basis to keep the organization up to date with the development. This consumes extra time and therefore during the project, there was no pressure from the company to perform any unwanted presentation. Therefore, in this project, there was one main presentation to discuss the concepts and some video calling sessions and emails to discuss the testing results. This saved time and effort.

The knowledge-driven approach focuses on getting to know the customer needs and demands and on the other side what the company can offer to the customers and what changes are required to meet customer needs. To perform the same, customer survey forms were used, and observation sessions were conducted. The survey forms identified the problems of customer and their needs, whereas the observation sessions identified the human behavior that leads to the problem and the way they deal with it.

As explained by Ronald Mascitelli in his book 'Mastering lean product development, about the rapid learning cycle by experimenting with testing models and simple prototypes. Which helps to explore the possible solutions and understanding the challenges to derive an optimal result [8]. The same was applied in the project and the cardboard models were tested before the elimination matrix tool was used to eliminate those solutions that do not fulfil the stated requirements. This lead to the attainment of a solution 'right at the first time'. So, no process was repeated and that increased knowledge and saved time.

Mascitelli also stresses three different design reviews to be considered before freezing a design. The focus is to conduct a review of the concept design, detailed design, and final design. If the design can pass the final design review, then it can be considered for production. During the project, a meeting was conducted with the ASKO design team after getting the first 3D prototype printed. Some valuable feedbacks were collected and was implemented in the design. A major optimization was performed with the design and two parts were combined to be a single part, which solved other problems. This design was approved as a final design with some minor adjustment.

## Chapter Four

### Market Analysis

Benchmarking, PEST and SWOT analysis tools were used to analyze the current market position of the company with possibilities for improvement and to identify the market for the product.

#### 4.1 Market Segment

Analysts from Technavio forecasts a growth of the global market of the dishwasher at a compound annual growth rate of 6.83% for the period of 2017- 2021 (Technavio, 2017) [9]. Gorenje Group now has a strong presence in 90 countries worldwide with a very strong presence of 91% in Europe and the remaining in USA, Australia, Near and the Far East. In 2016 Gorenje Group made an extra 2.7% sales revenue than compared to 2015. It also made an investment of 2.6% of the total Gorenje Group revenue in new appliance development.

The current market focus through this project was Europe as that serves 91% of the company sales and to add an extra feature to the existing dishwasher meant to make a better and more competitive dishwasher in the worldwide market.

##### 4.1.1 Benchmarking

Gorenje Group has a few prominent competitors like Bosch, Haier, Whirlpool, Electrolux, LG, Miele and some other minor competitors on a global level, see *Table 4.1*. The benchmarking data were collected for the year 2016. It can be clearly seen that nearly all major competitors have global presence and are competing to attain the maximum possible share of the market. Comparing Gorenje with its competitor in terms of revenue, Gorenje has the least overall revenue. The reason for this is that the competitors are not just present in the field of home appliances but are also present in many other fields like construction, pharmacy, transportation etc., which generates higher revenue. But the highlight here is that none of these companies have a product to solve the problem that this project has addressed. Therefore, this can be an added feature to increase the sale of Gorenje.

Table 4.1: Benchmarking of Gorenje and its competitors.

Companies	Factors		
	Revenue (In SEK)	Headquarter	Global Presence
Gorenje	12.58 Billion	Slovenia	Europe, North America, South America Australia, Asia
Bosch	731.29 Billion	Germany	Germany, Japan, Switzerland, U.K, U.S, Europe, America, Asia Pacific
LG	434.70 Billion	South Korea	Korea, North America, Asia, Europe, South America, Middle East and Africa, China
Whirlpool	182.09 Billion	U.S.	North America, East Europe, Middle East and South Africa, South America, Asia
Haier	152.90 Billion	China	Europe Middle and Eastern Africa, South Asia, China, East and South East Asia, Australia America
Electrolux	121.09 Billion	Sweden	Africa, Middle East, Eastern Europe, Latin America, Southeast Asia and China
Miele	37.10 Billion	Germany	North America, Asia, Europe Australia, South Africa

#### 4.1.2 PESTAnalysis

PEST Analysis is a tool used to analyze the political, economical, social and technological factors that the organization is dealing with. This gives a better idea of the current position and improvement of the organization in the market. PEST analysis identifies the environment that the organization is working in. The environment of the company can affect the organization's decision making. PEST analysis is performed in four steps. Starting with defining the scope by setting up boundaries. In the second step, the general objectives for every four factors are decided. This is followed by an information research for the four factors with the defined objectives and boundaries, see *Table B.1 in Appendix B*. Finally, the collected information is categorized, and relevant information is extracted.

#### 4.1.3 SWOT Analysis

SWOT analysis is used to analyze the four different aspects of a company or a product. It is useful to analyze the positive aspects which work in favor of the company or product and some weakness which can make it vulnerable and so need to be worked on to change it into strength for future. It also identifies the opportunities that are available which can be made use of in favor of the company or product and threats that need to be addressed or taken care of in time. Similar to

PEST, it is also a four-step process, where initially a scope is defined. Followed by collecting information on the four factors and based on which priorities are established see *Table B.2 and B.3 in Appendix B*. Then based on priorities and issues a strategy is developed to address it. Finally, a set of recommendations are collected for the developed strategy.

## 4.2 Technology Status

There are currently few such solutions in terms of a dishwasher accessory or a product that can help in avoiding the splashes from the spillage while feeding a dishwasher top basket with a glass or cup with left over liquid in it. Customers have to be alert all the time while feeding glasses and cups and have to ensure that their cups or glasses are empty just to avoid the resulting spillage. From the patent search and observations, it was found out that there are many products in the market that are used in daily life to protect human or their valuables from any kind of liquid splashes. These products served as a source of inspiration for idea generation.

## 4.3 User

The user here can be divided into two categories i.e. the customer and the end-user. The customer here is the one who buys the product and end-user is the one that uses the product. In case of a dishwasher at home the customer and the end user are both the same, but in case of a dishwasher at office, the customer and end-users are mostly different people, as the customer will be the one who buys the dishwasher to be installed at the office, but the office worker will be the one who will be using it. The customer will not have much interest or be aware of this problem of spillage as they are not being affected by it. So, the prime focus of the project is the end-user.



## Chapter Five

# Customer Needs Mapping

To map the customer needs surveys and observations were conducted. The online survey form was created using Google form and the same was distributed through social media websites and e-mails. An observation was conducted in one of the staff offices at Chalmers and at ASKO office Lidköping.

### 5.1 Survey

An online survey form was created and was made available for anyone to fill the form, see *Figure C.1 in Appendix C*. The links to the survey was sent out through social media and email to students and office employees. A total of 68 responses were recorded from the survey forms, out of which 30.9% were female and 69.1% were male. Most of the responses were from the 20 to 50 age group, with 11.8% responses from the 51 to 70 age group. 3% responses were from Asia, 1.5% from North America and the rest were from Europe. Of all the respondents 69.1% were employed, 29.4% were students and rest were retired people, see *Figure C.2 in Appendix C*.

Based on the response 77.9% people currently owns a dishwasher at home and 22.1% were planning to buy a new dishwasher. Out of all respondents, 86.8% used dishwasher daily or several times a week. On being asked about if they have experienced a situation of spillage and slashes, the majority of respondent said 'Yes'. To avoid such situation more than half of the people ensured that the cups and glasses are empty before loading and 13.6% people washed their cups and glasses before loading. 10.2% kept a distance from the dishwasher so that even if it spills then it does not land up on their clothes. Whereas 18.6% did not care about it and would clean the mess afterward.

54.2% people were ready to pay a small amount for getting a product that could solve this problem permanently and majority of the people did not want a solution that could hinder the visibility of the lower basket while loading the top basket.

### 5.2 Observation

The user of the dishwasher were Ph.D. students and professors at Chalmers. A total of 17 people was observed during the lunch hours. The dishwasher was sitting on the floor and just next to it was a sink & coffee machine and microwave ovens at the top, see *Figure C.3 in Appendix C*. Only one person washed the glass before placing it

in the dishwasher as the glass was half filled with milk. 3 people reused their glasses as it was used by them and was with them in their office room which gives an assurance that it is good to use again even without washing. None of the other 16 glasses has any liquid left in it, due to which there was no spillage resulting from the loading of glasses or cups. But the front door had some drippings of sauce from the plates of the lower basket. Some people opened the front door half way (nearly a 45-degree angle) and then loaded the glass. In that way neither they had to bend to open and close the door and if there was any spillage then that will just slide into the machine and not splash on them. This will work if the user wants to feed the cup in the front row, but after that, the user needs to open the door completely if the user wants to feed into the back rows of the basket. As the top basket was filled with glasses and cups, people started using the lower basket for loading glasses. This gives us a reason that why would people not prefer a solution that hinders the visibility of lower basket while loading the upper basket.

But the case at the ASKO office at Lidköping was opposite to the situation at Chalmers, as most employees had some coffee or juice in the cups which they thoughtfully spilled inside the sink before feeding into the dishwasher. The reason to do the same were a result of learning through mistake and the awareness that feeding a cup with left over liquid will lead to spillage and splashing. It was confirmed when the user was asked about the reason behind their actions. Similarly, the dishwasher at home is also used by kids other than the elders. Which in turn may increase the chances of spillage to a higher extent. Similarly, the cups or glasses will also may not be empty as opposed to the Chalmers office situation.

### 5.3 Goal

The project should focus on a common goal to be successful. The goal of a project is determined based on the end users' requirements and demands. So, the voice of the user determines the goal statement. The customer needs were mapped through online survey forms and observations. The collected data was analyzed to frame the customer needs list, see *Table 5.1*.

A dishwashing machine is mainly used to clean the cutlery, plates, cups and glasses. Removing leftover food from the plates before feeding into the dishwasher looks reasonable as some foods are sticks and can cause hindrance in the way of water jets in the dishwasher. In case of a cup or glass removing liquid from it before feeding into a dishwasher is not required as the water jets can clean it. But still users must do that as while feeding the cups or glasses with the leftover liquid into the top basket in a dishwasher can result in spillage and splashing of residual liquid on the floor and nearby surfaces.

So, the goal was to develop a solution by which the mess resulting from the splashes could be avoided. In other words, a residual splash protection product that keeps splashes inside the dishwasher when feeding a cup or glass with the residual liquid directly into the top basket. It was highly important that the product should not reduce the cleaning efficiency and should not act as a dirt trap. The product should be able to withstand the air and water temperature inside the dishwasher. The product should be cheap in price and easy to install, best if it can be installed without

Table 5.1 Customer Requirements

Features	Avoids any residual liquid to move outside the dishwasher boundary Assembles and disassembles on its own when dishwasher open or close Do not reduce the efficiency of the dishwasher Visibility of the baskets with the installed solution Easy to remove baskets with an installed solution Do not act as a dirt trap Have a long-life span Is a reliable solution
Safety	No sharp edges Kids and animal-friendly
Maintenance	Easy to install and save installation time Easy to replace Easy to remove in case of emergency
Purchase	Affordable pricing Do not use any energy

the use of any tools. Further for user convenience the visibility and accessibility of top basket or any other basket should not be hampered by the solution. It should also not hinder the process of removal of the basket from the dishwasher whenever needed.

From the energy use point of view, it was required that the solution does not use any energy as an insignificant increase in energy use could lower the energy rating of the dishwasher. Due to safety concerns, it was important to have no sharp edges and to make a solution that is both animal and kid friendly. To give a tough competition, the solution should be easy to install such that the user can buy it as an added accessory and install by themselves. A mission statement was created with the benefit, goal, market, constraints and stakeholders, see *Table 5.2*.

Table 5.2 Mission Statement

Mission Statement	
Product Description	<ul style="list-style-type: none"> <li>• Anti-splash attachment for existing ASKO Dishwasher</li> </ul>
Benefit Proposition	<ul style="list-style-type: none"> <li>• Avoiding mess resulting from splash</li> <li>• Save water consumed by manual rinsing</li> <li>• Simplicity and peace of mind</li> </ul>
Key Business Goal	<ul style="list-style-type: none"> <li>• Environmentally friendly</li> <li>• After sales upgrade</li> <li>• Market expansion</li> <li>• Customer satisfaction</li> </ul>
Primary Market	<ul style="list-style-type: none"> <li>• Home and office department with existing ASKO Dishwasher</li> </ul>
Secondary Market	<ul style="list-style-type: none"> <li>• New customer worldwide</li> </ul>
Assumption and Constraints	<ul style="list-style-type: none"> <li>• User-mounted accessory</li> <li>• No compromise with dishwasher function and efficiency</li> <li>• Dishwasher compatible material</li> <li>• No dirt traps</li> <li>• Lifespan of 20 years</li> <li>• Transparent material (based on solution)</li> </ul>
Stakeholders	<ul style="list-style-type: none"> <li>• Buyer and user</li> <li>• Manufacturing and Production</li> <li>• Service</li> <li>• Sales and Distribution</li> </ul>

*A dishwasher splash guard for the top basket to avoid splashing of residual liquids.*

## Chapter Six

### Results

A lean development process was followed from start to finish. It was necessary to define the problem that needs to be addressed in the development process before the requirement list was created. Therefore, a detailed requirement list was created after the mission statement. Based on detailed requirement list, the process of concept generation was initiated. Both concept development process and feasibility testing process were carried out hand in hand to obtain the best solution. Once all the unsuitable concepts were eliminated such that only one concept remained. Further the final concept was developed with designing software, keeping in mind the limitations, safety and manufacturability. With this, the product was ready for multiple prototyping and iteration with each prototyping to obtain the best results. Each prototype was tested, and the final prototype was installed at ASKO office at Lidköping for user feedback on a long term.

#### 6.1 Problem Definition

Any product development process can only be carried out after a clarified problem statement is defined. Initially, a requirement list was created with focusing on all the needs and desires of the user and stakeholders, using survey forms for users and discussion with stakeholders. The user requirements were the prime focus followed by the stakeholders. In case of any conflict between the user and stakeholder's requirement, a balance was maintained to satisfy both the groups.

#### Requirements

The customer requirements were combined with the requirement stated by ASKO project. Requirements are marked as 'R' and desires as 'D' in the table. A detailed requirement list can be found in *Table 6.1*. The major product requirements were to stop residual liquid splash outside the dishwasher zone, without reducing the cleaning efficiency or creating a dirt trap. Further the product should be safe to use and easy to install and uninstall. It is preferred if no tools are required to install and uninstall the product, so that the user could buy the product as an accessory and could install themselves with a bit of guidance. The product should have a lifespan of minimum 20yrs and a reliability of 120 thousand cycles as per the company standards. It should be able to withstand the temperature and moisture condition inside the dishwasher. As compact as possible and causing no hindrance to the user

in terms of basket visibility or reachability. The product should have the recyclability percentage of 85%.

Table 6.1 Requirement List

No.	Requirement	R/D	Target Value	Justification	Evaluation
1	Function				
1.1	Avoid discomfort from splash	R	Yes	ASKO	Binary
2	Performance				
2.1	Life	R	20Yrs	ASKO	Engineering Assessment
2.2	Reliability	R	120000 Cycles	ASKO	Engineering Assessment
2.3	Operating Temperature	R	-20°C to +70°C	ASKO	Engineering Assessment
3	Usability				
3.1	Interaction required	R	1	Market Requirement	Binary
3.2	Interaction required	D	0	Market Requirement	Binary
3.3	Easy to operate	R	Yes	Market Requirement	Binary
3.4	Visibility of racks	R	Yes	Market Requirement	Binary
4	Product Dimension				
4.1	Mass	R	<4kg	ASKO Design and Manufacturing	Engineering Assessment
4.2	Mass	D	<1kg	ASKO Design and Manufacturing	Engineering Assessment
4.3	Volume	R	700x550x500 (mm)	ASKO Design and Manufacturing	CAD
4.4	Volume	D	100x550x500 (mm)	ASKO Design and Manufacturing	CAD
5	Installation and Maintenance				
5.1	Easy Installation	D	Yes	ASKO Assembly and Service	Binary
5.2	Easy replacement	D	Yes	ASKO Service	Binary
5.3	DIY	D	Yes	ASKO	Binary
5.4	Only ASKO brand compatible	D	Yes	ASKO	Binary
5.5	No power consumption	R	Yes	ASKO	Binary
6	Design				
6.1	Asko Design guidelines	R	Yes	ASKO	ASKO Designer
6.2	Asesthetical appearance	D	Yes	ASKO, Market need	ASKO Designer
7	Material				
7.1	Non Porous	D	Yes	ASKO	Binary
7.2	Nickel & Cadmium free	R	Yes	ASKO	Binary
7.3	Food grade material	R	Yes	ASKO	Engineering Assessment
8	Installation and Maintenance				
8.1	Cost/piece for 28,000 pieces	D	18 EUR	ASKO, Market need	Engineering Assessment
9	Environmental				
9.1	Recyclability	D	85% (mass)	Environmental Law	Engineering Assessment
10	Safety				
10	Safe for all age user	R	Yes	Safety Regulations	Binary
10	No sharp edges	D	Yes	Safety Regulations	Binary

## Function Breakdown

Before any brainstorming of ideas for the concept generation could be carried out, it was necessary to define the main function of the product. Therefore, the problem functionality was broken down using a Black Box model to find out the major function that needs to be focused in concept generation. The main function obtained from the Black Box model can be further broken down into sub-functions using a Flow

Chart model. But in this case, it was not required as the main function could not be further decomposed.

The Black Box model is the foundation of a functional structure, which projected the main function of the product and to understand if the function can be further broken down into sub-functions. The Black Box can have one or more inputs and outputs categorized in terms of material, energy, and information. As shown in *Figure 6.2* the input here is only a material and no other information or energy is considered. The main function of the system is to stop residual liquid splash outside the dishwasher zone. So, the input here is residual liquid into the dishwasher which is processed by the main function to give an output as a splash-free dishwasher surrounding. In early stage of Black Box model creation an input in form of information was also considered, i.e. dishwasher door opening/closing and an output as device assembling/disassembling. This was initially considered as it was not sure if the product will have a moving part and will be engaged only when the dishwasher door is open and disengaged when the door closes.

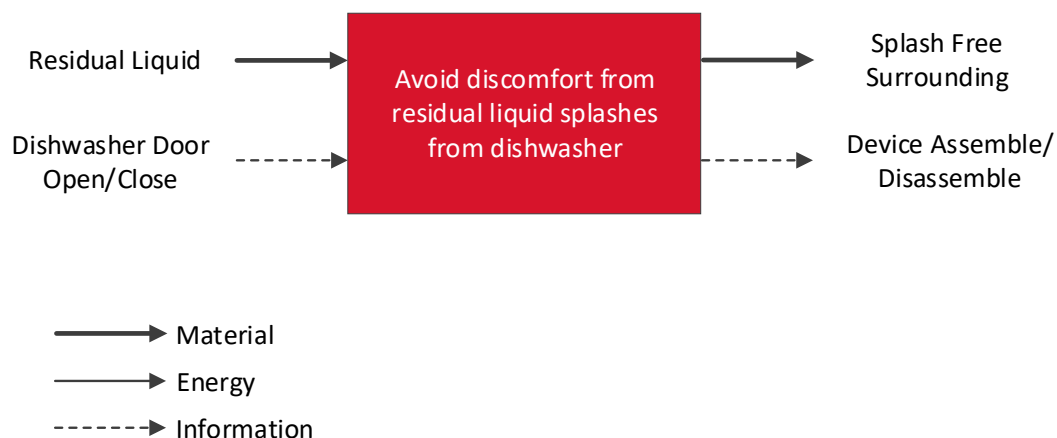


Figure 6.2 Black Box Model

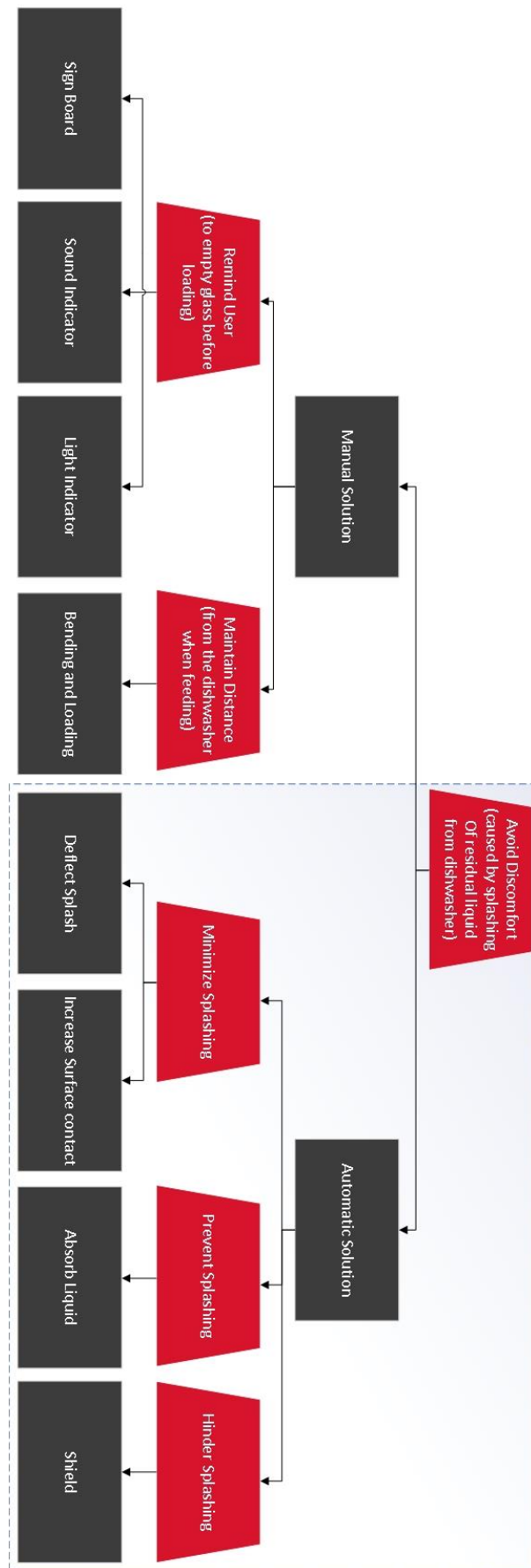


Figure 6.3 Function Means Tree



Function Means model was used to have a broader understanding of the function and the different means by which it can be attained. Therefore, the main function is further decomposed at different levels. In *Figure 6.3* the box colored red is the functions and the ones colored in grey are the means. The area marked in dash lines is the scope of the project. In this model, the main function to stop residual liquid splash outside the dishwasher zone can be attained by two means at the first level i.e. by manual and automatic. In manual solution, the user can be reminded of the problem and the user can take care to avoid it. It can be attained by reminding the user using a signboard, sound or light indicators. Else the user can be taught to bring a behavioral change in the process of feeding the dishwasher. But as with the project, the aim is to find an automatic solution to the problem and to not bother the user in any intended way.

In automatic solution there are three ways in which the splashing can be avoided outside the dishwasher. The occurrence of splash can be prevented by absorbing the liquid spillage. It can also be minimized by deflecting the splash or increasing the surface contact to reduce the impact of spillage. The spillage can also be hindered by a shield.

## 6.2 Concept and Feasibility

In a Lean Product Development process, the concept development and feasibility testing are conducted in parallel to save time in the process of evaluation and to eliminate the impractical concepts. The process of concept development started with a brainstorming session to generate as many concepts as possible without considering any limitations. The impractical concepts were eliminated before the feasibility testing. Elimination process was a three-stage process to find the best solution of all by eliminating the solutions that don't meet the set standards, see *Figure 6.4*



Figure 6.4 The Concept Elimination Process

### 6.2.1 Preliminary concept

For preliminary concept generation, multiple brainstorming sessions were conducted. Some sessions were conducted within the project group and some were conducted with people outside the project group for some wider solution possibilities as the one working on the project tends to limit their thinking because of being aware of the limitations of the project. Initially, a morphological matrix was created and all possible ways to tackle the problem were recorded in a matrix format.

The results were 18 preliminary concepts altogether, see *Appendix E*. After the primary concept generation, it was considered important to involve the development team at ASKO to ensure a better result from the considered approach. Therefore, the concepts were presented at ASKO and feedback was received.

### 6.2.2 Primary concepts

After the session conducted at ASKO and getting a broader view of the framed solution, it was time to consider some of the basic requirements that the project needs to fulfill. It was necessary to check out which of the 18 ideas could withstand the defined criteria. Therefore, a concept elimination process was performed using an elimination matrix with the 18 concepts, see *Table F.1* in *Appendix F*. The category of criteria considered was: solves the main problem, compatible, cost, easy installation, user-friendly, safety and energy use. The elimination matrix resulted in eliminating 10 concepts out of 18 and leaving 8 concepts to be further tested and developed.

### 6.2.3 Testing solutions

Now it was necessary to get a better understanding if the 8 proposed technology will serve the purpose. So, a few models were created for basic testing of the functionality. In the process of testing, a few of the concepts proved out to be not so good to be carried up any further in the development process. String curtain concept was unable to stop the residual liquid from escaping out completely. As the Rain curtain and String curtain concepts were somewhat similar, so both the concepts were not considered good enough to be further investigated. The Venetian curtain concept had more moving parts and the horizontal slits it allows water to escape out of it, so it was rejected. The Slider curtain concept required more space as it had overlapping parts which increase the thickness and space required. Since the available space inside the dishwasher was minimum so the Slider curtain concept was discarded. The remaining four concepts proved out to hinder spillage to some extent. So, it was decided to continue further with those concepts.

## 6.2.4 Determination of Final Concept

Now 4 concepts namely, Side Wall S, Rail Curtain, Folded Curtain and Strip Curtain were remaining after the process of elimination based on testing. Kesselring Matrix was used to determine the best and the final concept that could be investigated and developed further to solve the problem, see *Table 6.1 given below*.

Pugh matrix could also be used over Kesselring matrix as a lot of companies prefer to use it. But in Pugh matrix, the concepts are graded with "+", "s" or "-" with respect to datum concept, which does not show to what extent one concept is better than the other. Thus, there can be multiple concept with the same ranking, which makes it harder to eliminate the concepts. Pugh matrix would be preferable in case of a design evaluation selection rather than concept elimination process. As a lean development approach is followed, therefore A Kesselring matrix was preferred over Pugh matrix [10].

Table 6.1 Kesselring Matrix

Criteria	Alternative Solutions										
	Weightage(1-5)	Ideal		Rail Curtain		Strip Curtain		Folded Curtain		Side Wall S	
		v	t	v	t	v	t	v	t	v	t
Avoid the spillage to escape out	5	5	25	5	25	5	25	5	25	5	25
Easy installation	3	5	15	3	9	3	9	3	9	4	12
No tool required	1	5	5	2	2	2	2	2	2	4	4
Lower rack accessibility	4	5	20	5	20	5	20	5	20	5	20
Lower rack visibility	4	5	20	5	20	5	20	5	20	5	20
Less movable parts	2	5	10	3	6	2	4	3	6	5	10
Compact solution	3	5	15	1	3	1	3	1	3	5	15
Less user interaction	2	5	10	3	6	2	4	3	6	5	10
Reliable	3	5	15	3	9	3	9	3	9	4	12
Durable	3	5	15	4	12	3	9	4	12	4	12
Low cost	2	5	10	4	8	2	4	3	6	4	8
	T = Sum t	160		120		109		118		148	
	T/Tmax	1		0.75		0.68125		0.7375		0.925	
	Ranking			2		4		3		1	

In Kesselring matrix, the 4 concepts were compared in parallel to each other. 11 criteria with each having a weightage of 1-5 based on the severity of the criteria were selected, with 1 being least important and 5 the most important. The severity of each criterion was decided based on the main requirements set by the company and user needs from survey and observation. The 4 concepts were now given scoring and were ranked according to the scoring. The Strip curtain and Folded Curtain concepts were rated 4<sup>th</sup> and 3<sup>rd</sup> ranking respectively. The Rail Curtain concept proved to be better and was ranked 2<sup>nd</sup> with a 0.75 rating. The Side Wall S concept received a rating of 0.92 and was top on ranking. The rating difference between the 1<sup>st</sup> and 2<sup>nd</sup> ranking is of 0.17, which is a significant difference. Considering a confidence of 95% on the rating of the different concepts in the Kesselring Matrix, it was decided to further develop the Side Wall S concept.

## 6.3 Product Design

### 6.3.1 Preliminary cardboard prototype

Now the Side Wall S concept was selected as the final concept and a preliminary cardboard model already created for the testing session was available to proceed further with it. The preliminary cardboard model was not completely able to avoid the spillage because of the angle of attack of the residual liquid. Therefore, a closer look was given over the testing session results. It was observed that the lower part of the cardboard model was not able to hinder the spillage because of the angle at which the residual liquid was striking the model. Therefore, the lower part of the cardboard model was bent at an angle of 135 degrees with the upper part, see *Figure 6.5*. This modified cardboard model was tested and proved out to be better in hindering the residual liquid, compared to the previous model.



Figure 6.5 Cardboard Prototype

### 6.3.2 Optimization

The second cardboard model was considered better because of changing the angle of the lower part of the cardboard. With this, the question that was raised was what the optimum angle and the heights of the lower and upper part of the cardboard model that could deliver the most effective result with the minimum material used. To find an appropriate answer to this question an optimization test was conducted.

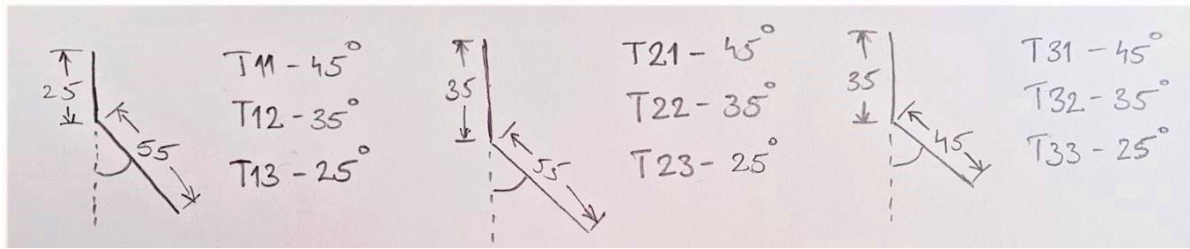


Figure 6.6 Optimization Test Specifications

A total of 3 cardboard prototype were created as per the selected specification, see *Figure 6.6*. Model A had a top height of 25mm and bottom height of 55mm. Model B had top height of 35mm and bottom height of 55mm. Model C with a top height of 35mm and bottom height of 45mm. All the 3 models were tested with three different angles of 45°, 35° and 25° of the flap part with the vertical axis. After observing all the tests and the obtained results, it was identified that the Model A with an angle of 45° with vertical axis was the best suited as it led to the least amount of liquid splashing outside the dishwasher boundary.

### 6.3.3 Prototype

The cardboard model gave a fair idea about the design of the product, but the cardboard model was just plain in shape. Also, during testing sessions, it was attached to the top basket with the help of duct tapes. Now there was a need for a prototype model that could easily fit in the desired space inside the dishwasher without causing any hindrance in opening and closing mechanism of the dishwasher door and the baskets. Therefore, the cad files of the dishwasher and the top basket were collected from ASKO and a cad model of the new product was developed. The cad model had 4 parts i.e. Backside cover, Front side cover, Flap and Front cover, see *Figure G.1, G.2 and G.3 in Appendix G*. Due to two height adjustment setting for the top basket, the side cover was divided into two parts as the Front side cover and the Back-side cover. The Flap part was attached to the Front side cover with a hook over hinge design.

The developed prototype was tested for its fitting with the basket and interaction with the dishwasher and it was observed that some minor modifications were required, see *Figure G.4 in Appendix G*. The idea was to make a mechanism to fold the Flap part as the top basket moves inside the dishwasher and vice versa. This was to avoid any decrease in cleaning efficiency resulting from the flap obstructing water jets from the rotating spray arm under the top basket or hitting the rotating arm. So, some more idea generation was carried out regarding the same.

#### 6.3.4 Optimization

While developing some ideas for the folding and unfolding mechanism, it was observed that when the Flap part is in folded position then the rotating arm was not encountering it, when in motion and the water jets from the rotating arm could easily reach the cups and glasses without any hindrance. It was also observed that there was no resulting decrease in efficiency if the Flap part was in folding position while operating the dishwasher. Therefore, the Frontside cover and the Flap was merged together to be a single part as Frontside cover. This optimization simplified the cad design. The simplified cad model was 3D printed as the second prototype for further testing.

### 6.4 Testing

The simplified prototype was tested at the ASKO office at Lidköping for its fitting, usage and performance, see *Figure G.7 in Appendix G*. In terms of fitting the prototype was properly attached to the top basket and the installation was easy. As it was a 3D printed prototype model, so the strength of the parts was not satisfactory, which was acceptable as the original product will be printed in a different material and with an injection molding process. The movement of the top basket with the installed parts was smooth but with a slight grinding sound.

To test the performance of the product, initially some cups and glasses were filled with 15 ml of water and was fed into the dishwasher top basket and there was rarely any spillage outside the dishwasher zone. The quantity was set at 15ml by ASKO, considering the residual amount of liquid left in a cup on an average. To further check the performance, some of the users (ASKO employees) were asked to feed their cups and glasses with the residual liquid into the top basket after their lunch breaks. The users were surprised and satisfied with its performance.

### 6.5 Product Requirement Fulfilment

Initially, an overall requirement list was created to map all the requirements from the user, company, environment and safety point of view. As the final product proved to be satisfactory in performing its main function of stopping the residual liquid splash outside the dishwasher zone, it was now necessary to check whether the final product could satisfy all other requirements. So, the current product specification was compared with the previous requirement specification, see *Table 6.2*. In the table letter, 'R' and 'D' represents requirements and desires respectively for the product. The evaluation process for various requirement criteria was carried out using cad files, engineering assessment, designer review and visual inspection.

All the requirements and desires were fulfilled, except for one requirement of a single action of the user as an interaction to operate the product. Rather the desire of no user interaction was fulfilled, so it was a better option. Most of the verification process for the 3D prototype was fast due to the availability of the immediate testing facility.

Table 6.2 Requirement Fulfilment

No.	Requirement	R/D	Target Value	Justification	Evaluation	Fulfillment
1	Function					
1.1	Avoid discomfort from splash	R	Yes	ASKO	Binary	Yes
2	Performance					
2.1	Life	R	20Yrs	ASKO	Engineering Assessment	Yes
2.2	Reliability	R	120000 Cycles	ASKO	Engineering Assessment	Yes
2.3	Operating Temperature	R	-20°C to +70°C	ASKO	Engineering Assessment	Yes
3	Usability					
3.1	Interaction required	R	1	Market Requirement	Binary	No
3.2	Interaction required	D	0	Market Requirement	Binary	Yes
3.3	Easy to operate	R	Yes	Market Requirement	Binary	Yes
3.4	Visibility of racks	R	Yes	Market Requirement	Binary	Yes
4	Product Dimension					
4.1	Mass	R	<4kg	ASKO Design and Manufacturing	Engineering Assessment	Yes
4.2	Mass	D	<1kg	ASKO Design and Manufacturing	Engineering Assessment	Yes
4.3	Volume	R	700x550x500 (mm)	ASKO Design and Manufacturing	CAD	Yes
4.4	Volume	D	100x550x500 (mm)	ASKO Design and Manufacturing	CAD	Yes
5	Installation and Maintenance					
5.1	Easy Installation	D	Yes	ASKO Assembly and Service	Binary	Yes
5.2	Easy replacement	D	Yes	ASKO Service	Binary	Yes
5.3	DIY	D	Yes	ASKO	Binary	Yes
5.4	Only ASKO brand compatible	D	Yes	ASKO	Binary	Yes
5.5	No power consumption	R	Yes	ASKO	Binary	Yes
6	Design					
6.1	Ask Design guidelines	R	Yes	ASKO	ASKO Designer	Yes
6.2	Aesthetical appearance	D	Yes	ASKO, Market need	ASKO Designer	Yes
7	Material					
7.1	Non Porous	D	Yes	ASKO	Binary	Yes
7.2	Nickel & Cadmium free	R	Yes	ASKO	Binary	Yes
7.3	Food grade material	R	Yes	ASKO	Engineering Assessment	Yes
8	Installation and Maintenance					
8.1	Cost/piece for 28,000 pieces	D	18 EUR	ASKO, Market need	Engineering Assessment	Yes
9	Environmental					
9.1	Recyclability	D	85% (mass)	Environmental Law	Engineering Assessment	Yes
10	Safety					
10	Safe for all age user	R	Yes	Safety Regulations	Binary	Yes
10	No sharp edges	D	Yes	Safety Regulations	Binary	Yes

## 6.6 Further Consideration

Apart from requirement fulfillment product feasibility other aspects also need to be considered to develop a successful product. A second patent search process was conducted to check for any infringement with existing patents. The material for the product and the manufacturing techniques for its full-scale production was investigated. Environmental and safety aspects were also investigated to ensure an overall product safety.

### 6.6.1 Patent Analysis

A patent search was conducted after the product was developed to check if there existed any filed patents that could still match with the developed product, as the initial patent search was to find if there existed any product in the market and to get some inspiration for the development. But further detailed level patent search needs to be conducted by ASKO.

### 6.6.2 Manufacturing process

The final prototype was made with ABS plastic using Fused Deposition Modelling process of 3D printing due to limited time and cost. But it lacks strength, texture and other important qualities so the final company product will differ in its way of manufacturing. The original product will be manufactured on an industrial level using the process of injection molding to produce large quantity.

As the product is only made of a single material, therefore it does not involve multiple manufacturing or integration process. It also depends on only one supplier for material. Which in turn reduces the cost and workforce required to manufacture the product. Currently, the parts were 3D printed but the original company product will be injection molded with Polypropylene (PP). Due to the complex design of the parts, multiple pick-outs will be required for the mold.

### 6.6.3 Choice of material

Not much effort was made to search for a material to be used for making the product. The reason for that being, all the parts inside the dishwasher washing zone is made up of different materials like metal, PP, ABS, PEEK, and PA. All the material has been proven to withstand the temperature, chemical and physical conditions inside the dishwasher. There was no requirement of high strength material and rather a cheaper priced product, so the best option was to choose PP as the material for manufacturing purpose. ASKO has a long relationship with the supplier for material for dishwasher parts which also further adds to be useful in controlling the product cost.

### 6.6.4 Environmental and ethical concerns

The environmental impact of the product begins from the time the material for the product is extracted and ends with the way it is discarded. It can be divided into three phrases: manufacture, use and dispose. So, the choice of material, product size, life, recyclability, and disposal need to be considered in parallel to the product development. All essential aspects of the life cycle are presented by Jönbrink et al., 2011 as the Eco Strategy Wheel. *Figure 6.7* depicts the Eco Strategy Wheel with three defined categories. In the manufacturing phase, the focus is on optimizing production and distribution of the product, choosing the right material and attaining minimum material usage. The use phase focuses on minimizing the environmental impact



resulting from product usage, optimizing life and function of the product. During the disposal phase the aim to optimize disposal by maximizing recyclability and reducing waste.

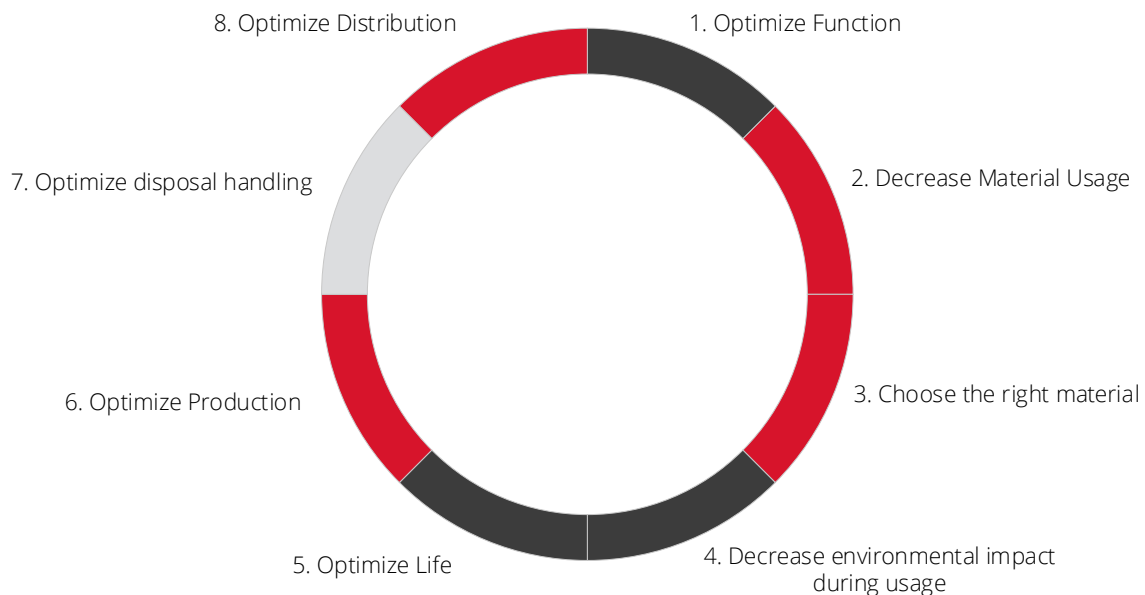


Figure 6.7 The Eco Strategy Wheel adapted from Jönbrink et al. (2011) [11]

Considering the manufacturing phase, the product was initially in four parts in first prototype which was later reduced into three parts. DFE process also helped in decreasing the size of the product by optimizing the required product length, which in turn reduced the material used. For prototyping, ABS material was used which minimized the material wastage. For the production process, PP material will be used. ASKO attains a minimum 85% recyclability of the dishwasher parts. The product will be manufactured using an injection molding process, which will result in minimizing waste and material efficient production.

For the usage phase, the product was optimized to its function in the initial phase of development by identifying the major areas in which the spillage was prominent and avoiding other area. The product was designed accordingly, thus avoiding the need of any shielding in the middle part of the front side of the top basket. The material used for manufacturing the product has a lifespan of 20 years or 120000 cycles.

Considering the disposal phase of the product, the product has an 85% recyclability with a long-life span, which reduces the amount of disposal waste. The waste disposal can only give the best result only if the user discards the product in a proper way or by returning the used product back to the company after its lifespan.

#### 6.6.5 Product and Service

The product can be sold to the customer as an upgrade accessory to their existing ASKO dishwasher. This improves better relationship between the company and existing consumers. The product can be installed by the customer themselves, which triggers a feeling of accomplishment in the user mind. Else the installation team from ASKO can install the product at the customer's site. The product can be sold as a complete part of the new dishwashers, which can attract more user because of the feature that the product provides, which no other brand dishwashers provide.

## Chapter Seven

### Product Proposal

In this chapter, the product is presented with the product description, technical details, specification, and business perspective. It also provides a complete overview of the final product.

#### 7.1 Product Description

The product has been named as 'Dishwasher Splash Guard' based on its function. As mentioned in the mission statement, Dishwasher splash guard is an anti-splash protection system that prevents any residual liquid from splashing outside the dishwasher zone, while feeding the top basket. This section describes the final product with focusing on the design aesthetics, technical specification, and benefits.

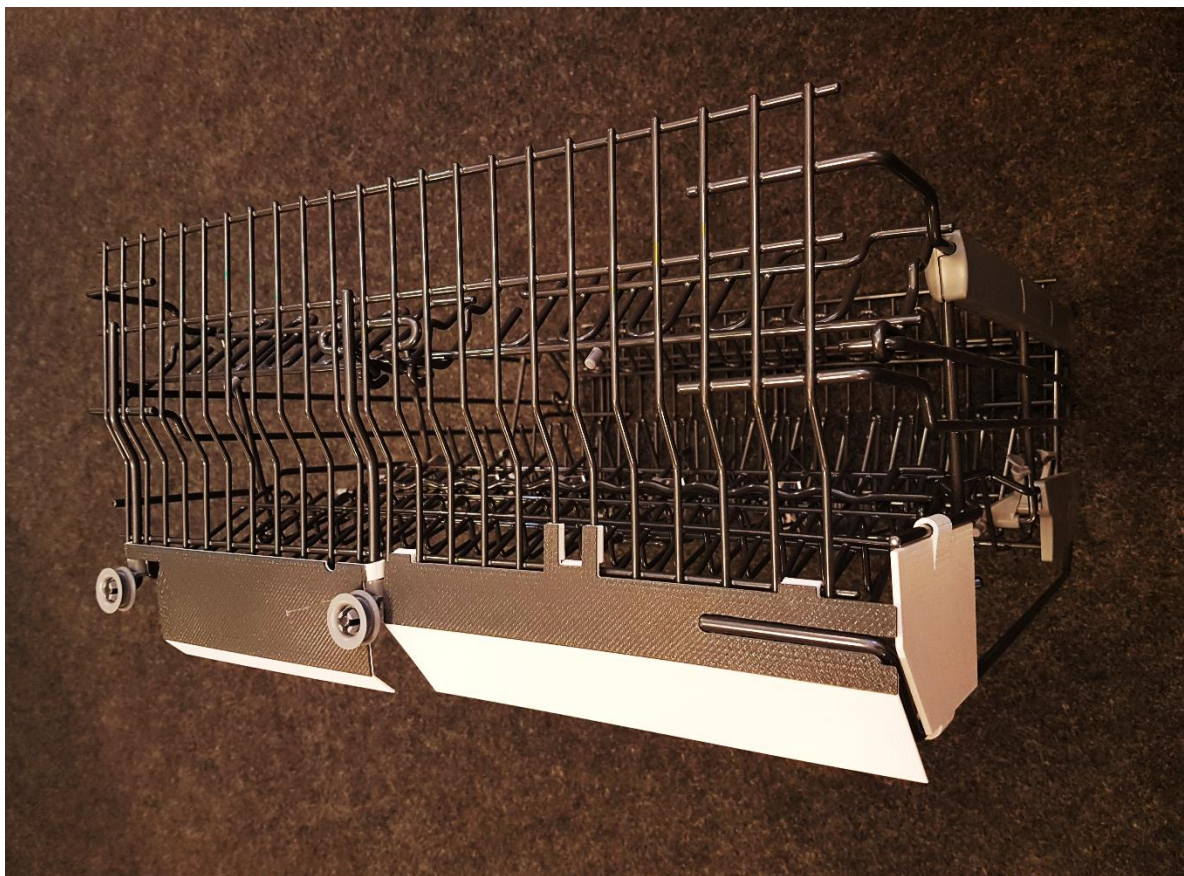


Figure 7.1 Final Product



Figure 7.2 Back Side Cover

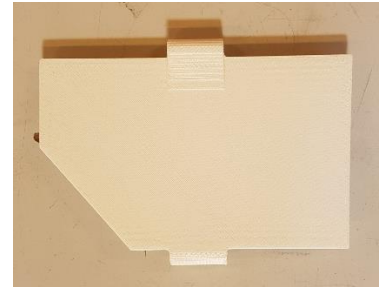


Figure 7.3 Front Cover

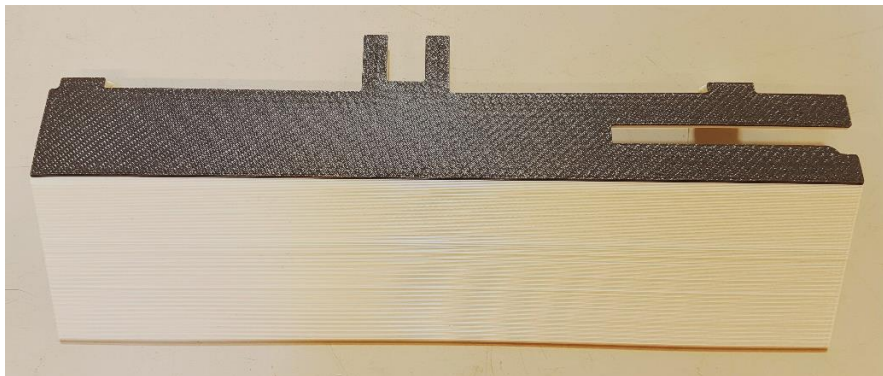


Figure 7.4 Front Side Cover

### 7.1.1 Aesthetics

The Dishwasher Splash Guard is designed according to Scandinavian design, which means elegance and simplicity in product design. The product will rarely be visible to user or anyone as it is inside the dishwasher. It will only be visible when the dishwasher door is opened, and the user pulls out the top basket for feeding used cups and glasses. As the product is not in direct sight of the user, the aesthetics of the product is also lower on the priority list. All the inner parts of the dishwasher are currently in dark color and the product needs no user interaction or attention, so the product will also be in that same color to camouflage with other parts. *Figure 7.1* shows the aesthetic design of the final prototype product. But as discussed, the final product will be in grey color (NCS S5502-B).

### 7.1.2 Benefits

The Dishwasher Splash Guard has numerous benefits for both the user and ASKO. The product can be compared with other product as there is only few products that were invented to solve the addressed problem but were not efficient and therefore are not available currently in the market.

#### User Benefits

Avoiding spillage – User was fed up with cleaning the floor and the dishwasher surrounding because of the spillage of residual liquid from feeding glasses or cups.

With time user try to consciously remember to be careful and check for any residual liquid before feeding. But with Dishwasher Spillage Guard user need not to remember to pour out the residual liquid from the cup or glasses before feeding as it avoids spillage of any residual liquid. Some user pre-wash cups or glasses before feeding to be sure of no dirt splashing, which will also be eliminated.

Basket Visibility or accessibility – The product does its function and does not hinder the visibility or the accessibility of any basket. This helps the user to feed and receive any utensils without any problem

DIY – There is no tool required to install the product, which makes the installation process super easy. The user can just buy the product and install it by themselves, this will provide a sense of satisfaction and accomplishment.

### **ASKO benefits**

No power consumption – The product is purely mechanical and thus the product does not use any energy. If this product uses any energy, then there is a risk that the overall energy rating of the dishwasher could go down, which is not acceptable.

Tools free installation – There is no need for any tool to install the product, just the product, and the installation guide is enough. This feature helps to easily install and uninstall in case of emergency.

Upgrade accessory – The product can also be sold to existing customer as an upgrade accessory, which keeps the Image of ASKO as a customer oriented and after-sales service company.

First in market- There is no such product in market which solves the spillage problem in a dishwasher, so this product will add an extra feature to ASKO dishwashers which no other brand offers.

No modification – The product installation does not require any kind of modification in the existing dishwasher, which makes it easy to sell to the existing and new customer, without any extra effort.

### **7.1.3 Technical Specification**

The Dishwasher Splash Guard consists of two mirrored sets of three part. The technical specification explains the mounting and function of each part. More details of the parts can be found in the technical drawing in *Appendix H*.

#### **Back Side Cover**

The back side cover is attached to a stainless steel part in the back side of the dishwasher top basket. The part is mounted by inserting one hook part of the product on the metal part of the basket and snapping the other hook part to the

other side. The part only moves horizontally with the action of pulling the basket in and out.

### Front Side Cover

The front side cover is attached to the coated metal part on the front side of the top basket. The part is mounted just by using the snap function, with three snapping parts to hold the part in the horizontal direction and two snaps to hold the part in the vertical direction. The part moves vertically with the basket when the height adjustment mechanism is used. It also moves horizontally with the action of pulling the basket in and out.

### Front Cover

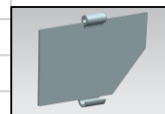
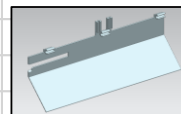
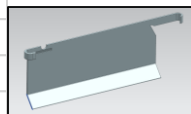
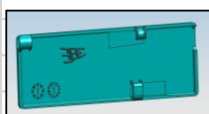
The front cover is attached to the front part of the top basket on the coated metal part. It has a sliding lock at the top portion and a hook design at the bottom to hold on to the China guard. It also moves horizontally with the action of pulling the basket in and out.

## 7.1.4 Cost Comparison

In this section, the currently developed product is compared with other existing parts of ASKO dishwasher to attain a rough idea about the cost of the product and to check if the product is under the set requirement of product cost, see *Table 7.1*.

Table 7.1 Cost Comparison

Other ASKO part	Factors	Dishwasher Spillage Guard		
		Back Side Cover	Front Side Cover	Front Cover
Medium	Complexity	Low	Medium	Medium
PP-T20	Material	PP-T20	PP-T20	PP-T20
2pcs/Injection	Tool Cavity	2pcs/Injection	2pcs/Injection	2pcs/Injection
20.1cm <sup>3</sup>	Product Volume	22.5cm <sup>3</sup>	31.8cm <sup>3</sup>	15.3cm <sup>3</sup>
16,500 EUR	Tool Cost	16,500 EUR	20,000 EUR	18,000 EUR
0.3 EUR/pcs	Installation Cost	1EUR/set		
2.6 EUR	One side product	2.526 EUR	2.634 EUR	2.548 EUR
	Cost	7.71 EUR		
	Total product cost	17.42 EUR		
NOTE: The product cost is for 28,000 parts produced. The values have been modified due to company confidentiality.				



The product cost is considered for 28,000 products produced as Gorenje group produces 280,000 dishwashers each year and 10% of that is ASKO dishwashers. The products are made of a PP-T20 material with 2 pcs/injection mould. The mould for different parts will cost different based on the complexity and volume of the parts. There is no assemble cost for the product as each part are ready for installation or mounting on to the dishwasher directly. Therefore, the installation will only cost 2€ for the pair. There is no maintenance cost as if the product fails, then it will be replaced with new one and not repaired. The total cost to the company for the product from manufacturing to installation will cost 17.42 EUR for the whole set, which is below the set value of 18 EUR. The values mentioned in the able have been modified due to company confidentiality, but the relation between the different parts and cost factors are constant.

## Chapter Eight

### Discussion and Conclusion

In this chapter, the process followed to complete the project with the attained results are summarized. A thorough review of the various process followed in the development process, followed by the results derived from it and the business development it offers is considered. A conclusion regarding the same is summarized for the company to decide to make further decisions.

Lean product development process is the foundation of this project. Lean development was preferred over the traditional product development process because of its logical order of various actions to be performed to eliminate waste and save time. Therefore, only two 3D prototypes were printed, and the resource wastage was avoided. Because of following a lean approach, the final selected concept was not changed at any point of time and repetitive work and time wastage was avoided. Lean development together with set based concurrent engineering provided knowledge and learning throughout the project. This was crucial as there was no other similar category product in the market with which the current developed product could be compared for reference. The result was a fast process with a precise product.

While following a lean product development process, multiple tools were also used to converge the project to attain a productive result. Some tools were more focused on expanding the problem for a better understanding and idea generation. Whereas some tools were focused on eliminating ideas that does not meet the set criteria's and eliminating waste. With a lean development process, the time consumed between the different stages were greater, but it also ensured to give better results with zero repetitive work.

The Dishwasher Spillage Guard proved to be the best solution while considering the set limitations and requirements. It not only fulfilled both the company and user requirement but also the desires. The final prototype was tested at ASKO and it was able to withstand all condition and deliver the desired output. The product can prove to be a good feature to compete with other brand dishwashers.

Few of the topics were not consider during the project like the mould preparation, production testing and start of production as it was out of scope. The developed product needs further approval from the company to be considered for production. The product needs to be further developed to ensure that it is suitable for the production process. The product is subjected to any changes in terms of its design to ease the moulding process or production in general, which will lead to changes in production.



The feasibility testing for the final selected concept using a cardboard model was to ensure a full proof solution. The results of the testing were evident after the first prototyping and followed by some minor modifications to obtain the final product. The final product performed well on the tests in real life situation and was fully functional.

The product pricing is mainly based on some assumptions as the actual cost for the mould, required number of labours, labour costs, and energy use cannot be precisely calculated. Installation cost is the same even if the product is sold as an upgrade accessory to the existing user. With the product cost calculated from the available data, the product seems to be viable for commercial production.

## Chapter Nine

### Future Outlook

The Dishwasher Spillage Guard has opened a new door of possibilities and an added feature to ASKO dishwashers. This product can be used to have some competition with the existing brands on the market. This product can address a problem that no other brands have addressed currently in this best possible way, which will make ASKO the first in the market with spillage protection feature for the top basket.

The final prototype installed at ASKO office was working smoothly but was creating a grinding sound each time the dishwasher basket was moving in and out. There is a further need to investigate the reason for the grinding sound and how it can be avoided. Other than that, the parts were only developed for the left side of the dishwasher. A mirrored version of the back-side cover and the front side cover will be suitable for the right side, but the front cover will not be because the front grill of the top basket is not symmetric in design. Therefore, the front cover design for the right side needs to be further designed.

There are few more process and activities which need to be considered before starting the process of production and launching the product in the market like in-depth patent analysis, process design, verification testing and start for production. As this was not included in the project, it needs to be considered for the future.

## References

- [1] Statista Report. *Dishwashing product market value in the EU 2013-2017*. June 2018.
- [2] Statista report. *Dishwashers: unit shipments in the U.S. 2005-2019*. March 2018
- [3] *Annual Report Gorenje Group*. 2016
- [4] ASKO website – [www.asko.se/om-asko/designpriser](http://www.asko.se/om-asko/designpriser). 07 October 2018
- [5] USPTO. *Patent for first practical dish washing machine issued*. December 28, 1886
- [6] Consumer Reports. *Dishwasher buying guide*. April 2018
- [7] Bob Melvin. *Knowledge based product development*. 29 September 2013
- [8] Ronald Mascitelli. *Mastering lean product development*. 2011. ISBN- 13:978-0-9662697-4-1
- [9] *Global Dishwasher Market 2017-2021*. May 2017
- [10] D. Raudberget. *The decision process in Set-Based Concurrent Engineering- An Industrial case study*. International design conference – Design 2010 Dubrovnik - Croatia, May 17 - 20, 2010.
- [11] A.K Jönbrink, H.L Norrblom, and M. Zackrisson. *Ekodesign – praktisk vägledning*. SWEREA / IVF, 2011. ISBN 9789186401078.
- [12] K.T. Ulrich and S.D. Eppinger. *Product Design and Development*. McGraw-Hill/Irwin, 2012. ISBN 9780071086950.
- [13] ASKO website - <http://www.askona.com/dishwashers/why-asko-dishwashers> - 07 October 2018
- [14] Gorenje annual report 2016 from the website - [https://static14.gorenje.com/files/default/corporate/investor-relations/annual-reports/GORENJE\\_AR2016\\_i.pdf](https://static14.gorenje.com/files/default/corporate/investor-relations/annual-reports/GORENJE_AR2016_i.pdf)
- [15] Bosch annual report 2016 from website - [http://media.bosch.com/media/ro\\_master\\_remote/publications\\_documents/bosch-annual-report-2016.pdf](http://media.bosch.com/media/ro_master_remote/publications_documents/bosch-annual-report-2016.pdf)
- [16] Haier annual report 2016 from the website- [http://www.haier.net/en/investor\\_relations/haier/gsgg/gsgg/201806/P020180621607393722823.pdf](http://www.haier.net/en/investor_relations/haier/gsgg/gsgg/201806/P020180621607393722823.pdf)
- [17] Whirlpool annual report 2016 from the website - <http://www.whirlpoolcorp.com/2016Annual/chairmans-message.html>

- [18] Electrolux annual report 2016 from the website-  
<https://www.electroluxgroup.com/annualreports/2016/en/financial-reporting/report-by-the-board-of-directors/2016-in-summary/>
- [19] Miele annual report 2016 from website -  
<https://www.miele.com/en/com/business-development-2094.htm>
- [20] Espacenet website - [https://worldwide.espacenet.com/?locale=en\\_EP](https://worldwide.espacenet.com/?locale=en_EP) -  
20 February 2018
- [21] Google Patent website - <https://patents.google.com/> - 20 February 2018

## Appendix A

### Patent Search

Table A.1 Keyword Generation

Area	Description	Keyword	Synonyms for each keyword
Utility	Dishwasher splash protector that obstruct any liquid to splash outside the dishwasher boundary.	Avoid Splash Spillage Residual Liquid Dishwasher Boundary	avert, bypass, escape, protect, guard dash, splatter, spatter leak, scatter, squirt, discharge silt, debris, slag, remains solvent, fluid Dishwasher zone, area, perimeter, border,
Structure	Device, basket mounted, dishwasher mounted	Automatic Device Basket mounted Dishwasher mounted	automated, electric, mechanical, electronic gadget, gear, equipment, machine tray mounted, box mounted dishwasher mounted
Function	Automatic, avoid splash, no dirt trap, easy to install	Easy installation Automatic Avoid splash No dirt trap	effortless installation, simple installation automated, electric, mechanical, electronic avoid dash, avoid splatter, avoid spatter No dirt collection

Table A.2 Relevant Patent Class

Class code	Explanation
A45B25	Details of umbrella
A47B77	Kitchen cabinets
A47J43	Miscellaneous implements for preparing or holding food

A47K3	Baths; Douches; Appurtenances
A47L	Kitchen equipment
A47L4/00	Cleaning window shades, window screens, venetian blinds
A47L15/00	Washing or rinsing machines for crockery or tableware
A45B25/006	Automatic opening and closing devices
A45B2023/0018	With a canopy in form of an inverted cone
A47H23/05	Of chain or chain mail; of free-hanging strips or lamellae
A47H2023/025	Panel type curtains
A47H15/02	Runners
B60J1/00	Windows and Windscreens
B60J9/04	Air curtains instead of windows
B60R21/12	Glass partitions inside vehicles to protect occupants against personal attack
B60J1/20	Wind deflectors, blinds
E03D13	Splashing shields for urinal
E04H15/003	Bathing or beach cabins
E04H15/44	Collapsible, e.g. breakdown type having connecting nodes
E06B9/00	Screening or protective devices for wall or similar openings
Y02A30/277	Absorption based systems

Table A.3 Search Strategy

Keywords used	Classes used	Search query/string	Hits	Comments on search
Splash, spill, guard, screen, block, prevent, proof, cover	A45B25	(splash OR spill*) AND (guard* OR screen* OR block* OR prevent* OR proof* OR cover*)	5	Related to dishwasher, bath tubs, vehicle, sink, urinal bowl, umbrella, window, cooktop and other kitchen equipment's
	A47B77		8	
	A47J43		19	
	A47K3		47	
	E03D13		18	
	E06B9		2	
	A47L15		4	
	A45B25		5	

Table A.4 Relevant Prior Art

Title	DRIBBLE DRAIN INHIBITOR ADAPTOR FOR URINALS
Patent Number	US2018163386 (A1)
Applicant	STOREY BRYANT [US]
Priority Date	20161213
Sections of relevance in prior art	
<p>A dribble drain inhibitor adaptor for use with a urinal includes a basin adapted to readily drain urine or other liquids directed at the adaptor into the urinal, a splash guard approximately at the periphery of the basin and largely co-terminus with or extending outwardly a predetermined distance from the outer rim of the urinal to inhibit the urine or other liquids from spilling or splashing out of the urinal, means for maintaining the height and angle of the basin in a desired manner, and means for secure placement in or attachment of the adaptor to the urinal</p>	
Subject features fulfilled	
Hinder liquid splashing	

Title	Splash Guard
Patent Number	US2018184852 (A1)
Applicant	THE SPLASH BABY LLC [US]
Priority Date	20180302
Sections of relevance in prior art	
<p>An article for use in a water receiving structure is disclosed. The article is directed to keeping water inside a water receiving member and preventing water splash and water damage to adjacent surfaces</p>	
Subject features fulfilled	
Hinder liquid splashing	

Title	Splash Protector for a Spindle Mixer or Similar Machine
Patent Number	WO2015126873 (A1)
Applicant	VITA MIX MAN CORPORATION
Priority Date	20150218
Sections of relevance in prior art	

<p>A splash protector for a spindle mixer or similar machine is provided in order to minimize or eliminate unwanted splashing or spraying of foodstuff out of the mixing vessel during operation of the machine. The splash protector includes a splash guard mount part configured to be attached to the spindle mixer and a splash guard body removably attachable to the splash guard mount part such as by a user's hand, wherein the splash guard body is configured to be removed and attached to the splash guard mount part without the use of tools. Consequently, the splash protector can be readily removed for cleaning and readily reattached for additional use.</p>
<p>Subject features fulfilled</p>
<p>Hinder liquid splashing</p>

Title	SPLASH PREVENTION GUARD
Patent Number	JP2018062840 (A)
Applicant	KIMATA MITSUKO
Priority Date	20161012
Sections of relevance in prior art	
<p>A splash prevention guard includes a material having elasticity. The splash guard is configured such that a notch (lateral side) is provided at a center in parallel with each of long sides of an edge of an upper side of a rising side face, the rising side face being perpendicular to a long side of a plane on a rear side part where plural suction cups are arranged all across. The splash prevention guard is further configured such that, when applying, to a face of an installation base, the plural suction cups of the plane that are arranged all across on the rear side part of the plane, a protrusion height of a skirt of each of the long sides is equal to a height dimension by which the skirt reaches the face of the installation base not having a gap vertically in a state in which the suction cups are pressed against the installation base so that a gap on a side of the long sides does not open. Thus, a splash is prevented from entering from the skirt of each of the long sides when the suction cups are applied.</p>	
Subject features fulfilled	
Hinder water splashing	

Title	UMBRELLA
Patent Number	US2017303649 (A1)
Applicant	BRAND DEV LTD [NZ]
Priority Date	20150918
Sections of relevance in prior art	



Disclosed is an umbrella that can be used as a canopy to protect a user against rain or sunlight. The umbrella may comprise an elongate member having proximal and distal end portions, a support structure that is connectable to a canopy able to be disposed about the distal end portion of the elongate member, the support structure being adjustable between an erect position, whereby the canopy is able to be tensioned by the support structure, and a collapsed position, whereby the tension in the canopy is able to be released. The umbrella may also include a plurality of biasing means configured to inhibit the support structure from inverting.

**Subject features fulfilled**

**Protects against liquid**

<b>Title</b>	Device for preventing mosquitos and flies gets into indoorly
<b>Patent Number</b>	CN206071421 (U)
<b>Applicant</b>	CAO JINJIANG
<b>Priority Date</b>	20160922

**Sections of relevance in prior art**

The utility model relates to a device for preventing mosquitos and flies gets into indoorly, device for preventing mosquitos and flies gets into indoorly bloies including setting up to be used for providing concentrating to one side in door frame or window frame top or both sides, can form the blast apparatus of air curtain, still including setting up at the open and shut touch switch of department of door leaf, touch switch passes through the relay and sets up the motor series in blast apparatus, is provided with screen door that opens and shuts or the screen window that is used for shielding the door frame entry outside the door frame, is provided with the door leaf that opens and shuts or the casement that are used for shielding the door frame entry in the door frame, touch switch has the head of touching, touch switch installs in the door frame outside, it stops with opening of screen door cooperation control motor towards the outside to touch the head.

**Subject features fulfilled**

**Repels out foreign material**

<b>Title</b>	Venetian blind blade
<b>Patent Number</b>	CN205063764 (U)
<b>Applicant</b>	XU KEI
<b>Priority Date</b>	20151024

**Sections of relevance in prior art**

The utility model discloses a venetian blind blade, weaving the yarn fabric drum who forms including an organic whole, some axial symmetry's in the yarn fabric drum section of thick bamboo wall is followed yarn fabric drum axial looks fixed connection and is formed (window) curtain blade main part, the part that (window) curtain blade main part both sides are open form forms the fine excellent passageway of glass, the utility model discloses beautifully, simple structure, low in manufacturing cost are honest and clean.

**Subject features fulfilled**

**Hinders water splash**

<b>Title</b>	Sinkmat
<b>Patent Number</b>	USD581120 (S)
<b>Applicant</b>	HMS MFG COMPANY
<b>Priority Date</b>	20080404
<b>Sections of relevance in prior art</b>	
A mat that can layed down inside a sink and will avoid water from splashing after hiting the mat.	
<b>Subject features fulfilled</b>	
<b>Avoids water splashing</b>	

<b>Title</b>	Splash-Proof Umbrella Structure
<b>Patent Number</b>	US2012006367 (A1)
<b>Applicant</b>	CHANG TZU-CHENG [TW]; HSIEH CHIN-SEN [TW]; CHOU CHIH-CHI [TW]
<b>Priority Date</b>	20100706
<b>Sections of relevance in prior art</b>	
<p>A splash-proof umbrella structure comprises a rod passing through a slide sleeve sliding up and down along the rod. The slide sleeve is coupled to support sticks. A piece of umbrella cloth is arranged on the support sticks. The upper side of the rod has a first rod sleeve and a second rod sleeve. The first rod sleeve has first link rods coupled to the support sticks. The second rod sleeve has second link rods coupled to the first link rods. The bottom of the rod has a handle. When getting off a vehicle in rain, the user can open the umbrella in a confined space to prevent from being wetted by rainwater via sliding the slide sleeve upward to stretch the umbrella cloth bottom-up. When not in use, the umbrella cloth can be collapsed via sliding the slide sleeve toward the handle. Further, the handle can collect rainwater.</p>	
<b>Subject features fulfilled</b>	
<b>Avoids water splashing</b>	

Title	MEMBERS FOR SPLASH PREVENTION OF WATER OF SINK
Patent Number	USD581120 (S)
Applicant	DAEJE CO LTD [KR]
Priority Date	20080404
Sections of relevance in prior art	
<p>A member for preventing the water from splattering in a sink is provided to prevent the water from splattering around a cleaning unit of the sink, to be moved in the sink according to needs, and to be separated from the sink. CONSTITUTION: A member (100) for preventing the water from splattering in a sink comprises a main body in a cylindrical shape, a latching groove, and a fastening unit. The main body is inserted into the sink and is formed in a cylindrical shape in which upper and lower sides are punched. The latching groove is formed to insert a faucet into the rear wall of the main body. The fastening unit is extended to maintain a predetermined gap to each lateral wall facing the lower part from the upper end of the rear wall and the front wall of the main body and is equipped on left and right sides of each lateral wall. When the main body inserted into the sink is raised, the main body is not separated from the sink by the fastening unit.</p>	
Subject features fulfilled	
Avoids watersplashing	

Title	Electrically retractable splash guard for protection against greasy spills in cooking region in kitchen, has switch for electrically extending or retracting guard, where guard is constructed in colorless or colored manner
Patent Number	DE102011101305 (A1)
Applicant	PREUS THORSTEN [DE]
Priority Date	20110512
Sections of relevance in prior art	
<p>The guard has a manual switch that is utilized for electrically extending or retracting the guard, where the guard is able to be constructed in colorless or colored manner with different light transmission levels. A set of LEDs is provided as an additional light source for illuminating a cooking region. A set of different translucent plates is provided in the guard, where the guard is provided with a gap for allowing the switch to be passed. A film is glued on surface of the guard.</p>	
Subject features fulfilled	
Avoids oil splashing	

Title	APPARATUS FOR PREVENTING SPLASH OF WATER
-------	--

Patent Number	KR20110087816 (A)
Applicant	KIM DONG HYUN [KR]
Priority Date	20100127
Sections of relevance in prior art	
An apparatus for preventing the splash of water in a drinking water stand is provided to improve the convenience in use of a drinking water stand by effectively preventing the water discharged from a faucet from splashing.	
Subject features fulfilled	
Avoids water splashing	

Title	Splash Prevention Curtain
Patent Number	KR20090002517 (U)
Applicant	
Priority Date	20070908
Sections of relevance in prior art	
A spring loaded curtain that has two circular opening for inserting hand and then washing the dishes, so that no water falls over the user.	
Subject features fulfilled	
Avoids water splashing	

Title	Cooking work station with splash guard
Patent Number	US6053164 (A)
Applicant	DELAWARE CAPITAL FROMATION INC [US]
Priority Date	19971101
Sections of relevance in prior art	
A work station has a cooking kettle mounted for movement between an upright cooking position and a tilted pouring position. The work station includes a support structure defining a work surface above which the cooking kettle is mounted. A splash guard is mounted on the support structure for movement between a first position whereat the splash guard forms a portion of the work surface and a second position whereat the splash guard forms a barrier against splashing substances poured from the kettle when in its pouring position.	
Subject features fulfilled	
Avoids water splashing	

Title	Faucet splash guard and storage unit
Patent Number	US6212708 (B1)
Applicant	MULAW AZANAW [US]
Priority Date	19991221
Sections of relevance in prior art	

A member for preventing the water from splattering in a sink is provided to prevent the water from splattering around a cleaning unit of the sink, to be moved in the sink according to needs, and to be separated from the sink. CONSTITUTION: A member (100) for preventing the water from splattering in a sink comprises a main body in a cylindrical shape, a latching groove, and a fastening unit. The main body is inserted into the sink and is formed in a cylindrical shape in which upper and lower sides are punched. The latching groove is formed to insert a faucet into the rear wall of the main body. The fastening unit is extended to maintain a predetermined gap to each lateral wall facing the lower part from the upper end of the rear wall and the front wall of the main body and is equipped on left and right sides of each lateral wall. When the main body inserted into the sink is raised, the main body is not separated from the sink by the fastening unit.

**Subject features fulfilled**

**Avoids water splashing**

<b>Title</b>	KITCHEN MACHINE WITH SPLASH GUARD
<b>Patent Number</b>	CN105592762 (A)
<b>Applicant</b>	KENWOOD LTD
<b>Priority Date</b>	20141020

**Sections of relevance in prior art**

A kitchen machine (10) comprises a hand/stand mixer consisting of a hand mixer body (12) having at least one drive socket for a shanked mixing tool, and a stand arrangement including a cradle (22) configured to support said body (12) for use as a stand mixer. The machine has a support for a mixing bowl (24) in a position such that the mixing tool can depend into the (bowl 24), and means for rotating the bowl (24) about an axis offset from that of the shank of the tool, and a splash guard (26) with attachment means (28) for temporarily attaching the splash guard (26) to said cradle (22), thereby to substantially cover said bowl (24) with said splash guard (26) during a mixing operation.

**Subject features fulfilled**

**Avoids slurry material splashing**

<b>Title</b>	Retractable splash guard
<b>Patent Number</b>	US7328466 (B1)
<b>Applicant</b>	KIDKUSION INC [US
<b>Priority Date</b>	20051019

**Sections of relevance in prior art**

A splash guard includes a shield that deploys in one direction, such as horizontally, but that also can be moved in a transverse direction, such as vertically, relative to a housing upon deployment. The retractable shield is used in a bathtub environment to help form a short retractable vertical wall across the open side of the bathtub to help return splashed water to the bathtub. Methods of using a retractable splash guard are also disclosed.

**Subject features fulfilled**

**Avoids water splashing**

**Title**

System of four swivel mounted transparent screens, serving as splash protection of area surrounding shower unit

**Patent Number**

DE10135145 (A1)

**Applicant**

SCHOLPP WERNER [DE]

**Priority Date**

20010719

**Sections of relevance in prior art**

A carrying element (4) is positioned with its lower end in one corner of the shower tray (3), fixed to the adjacent walls (1, 2) and holding two transparent screens (6) joined with hinges (10) to the element (4). Two more screens (17) are swivel mounted to the front edges of the first screens (6) and serve as doors. A long rectangular metal sheet (5) is attached diagonally to the front of the carrying element (4), serving as a cover and an armature holding element.

**Subject features fulfilled**

**Avoids water splashing**

**Title**

Automatic dishwasher for rinsing of tableware, has rinsing container, which provides rinsing space and has feeding opening for feeding rinsing space with dishes, where splash guard is formed on side of edge of feeding opening

**Patent Number**

DE102012103476 (A1)

**Applicant**

MIELE & CIE [DE]

**Priority Date**

20120420

**Sections of relevance in prior art**

The automatic dishwasher (1) has a rinsing container (2), which provides a rinsing space (3) and has a feeding opening (17) for feeding the rinsing space with dishes. A splash guard (4) is formed on the side of an edge of the feeding opening and has multiple pulling sheets that are arranged in layers on top of each other. The pulling sheets are coated with an anti-bacterial material. The individual pulling sheets are connected with each other by an adhesive, particularly acrylate- or silicone adhesive. The pulling sheets are formed of polyester or polyimide.

**Subject features fulfilled**

**Avoids residual material splashing**

<b>Title</b>	APPARATUS FOR PREVENTION SPLASH IN DISHWASHER
--------------	---

<b>Patent Number</b>	KR20070037171 (A)
----------------------	-------------------

<b>Applicant</b>	DAEWOO ELECTRONICS CORP [KR
------------------	-----------------------------

<b>Priority Date</b>	20050930
----------------------	----------

**Sections of relevance in prior art**

The washing water prevention device of the dishwasher according to the present invention is configured such that the blocking plate provided on the upper surface of the opening of the main body is supported by the spring, and when the door is opened, the blocking plate protrudes, Thereby preventing contamination of the periphery of the dishwasher by discharging the washing water, thereby improving the reliability of the product. In addition, when washing with hot water, the washing water is protruded to the outside to prevent the user from being injured, thereby improving the reliability of the product.

**Subject features fulfilled**

**Avoids residual material splashing**

<b>Title</b>	Combined shower splash guard and shower curtain holder
--------------	--

<b>Patent Number</b>	US07357125 US (1)
----------------------	-------------------

<b>Applicant</b>	MELARD ACQUISITION Inc
------------------	------------------------

<b>Priority Date</b>	31-07-1990
----------------------	------------

**Sections of relevance in prior art**

A combined shower splash guard member with a shower curtain holder is provided by a molded, generally triangularly-shaped, and modified, one piece body having two straight legs that intersect at a vertex of the triangle, and a third, web-like leg that extends between the free ends of said first two legs of the splash guard. Means for holding the one piece body to a mounting for the body is provided by an adhesive strip of a length to be secured to the entire outer surface of the two straight legs of the splash guard. To accommodate the departure from the desired perpendicularity of the legs of the splash guard, a gusset means is provided in the web of the splash guard which permits the web of the one-piece body to be varied from its normally intended size and shape.

**Subject features fulfilled**

**Avoids water splashing**

**Title** Splash guard for vehicles

**Patent Number** US2605119A

**Applicant** Maxwell L Earnest

**Priority Date** 29-07-1952

**Sections of relevance in prior art**

A flat flexible covering behind the wheels of the vehicle to avoid the splashing of slurry or liquid.

**Subject features fulfilled**

**Avoids slurry splashing**

**Title** Splashguard for corner-positioned dishwashers

**Patent Number** US5282547A

**Applicant** Murray Joseph A

**Priority Date** 28-09-1992

**Sections of relevance in prior art**

A splashguard device for a dishwasher includes an angular sector of a circular plate. A sector angle of the angular sector has an angle of from about 100 to 130 degrees. The radius of the circular plate substantially equals the radial length of a dishwasher door determined from the hinge axis of the dishwasher door. A plurality of fastening devices permanently secures the angular sector at a radially extending edge to a radially directed side face of the dishwasher door. Spacer devices are provided for spacing the angular sector at a distance of approximately 0.5 inch from the radially extending side face of the dishwasher door in a vertical plane parallel to an outer face of a dishwasher outside wall. A guide is attached to the dishwasher outside wall to ensure a free movement of the splashguard.

**Subject features fulfilled**

**Avoids liquid splashing**



## Appendix B

### PEST and SWOT Analysis

Table B.1 PEST Analysis

Political	Economic
<ul style="list-style-type: none"> <li>• Environmental laws and recyclability</li> <li>• Conformity law</li> <li>• Safety design guidelines</li> <li>• Hygiene standards</li> <li>• Material used</li> </ul>	<ul style="list-style-type: none"> <li>• Increase in value of EUR currency against USD.</li> <li>• A continuous increase in sales of dishwasher machines in US with 7.74 million pieces in 2016 and 8.1 million pieces in 2017.</li> </ul>
Social	Technological
<ul style="list-style-type: none"> <li>• Employee training and education</li> <li>• Reducing work accidents</li> <li>• After sales service</li> <li>• Employee rights and gender equality.</li> </ul>	<ul style="list-style-type: none"> <li>• Currently, no major brand has a solution for this problem.</li> <li>• There are few technologies available from other products that share similar context, which can be used for reference.</li> </ul>

Table B.2 SWOT Analysis (Company)

Strength	Weakness
<ul style="list-style-type: none"> <li>• Gorenje Group's global presence in 90 countries.</li> <li>• ASKO as a premium brand product of the Gorenje Group.</li> <li>• Expertise in home appliances.</li> <li>• Share price growth by 30%</li> <li>• 60% foreign shareholders.</li> <li>• 2.6% share investment in product development.</li> <li>• Reduction in financial debt.</li> </ul>	<ul style="list-style-type: none"> <li>• Material Import and export</li> <li>• New material research</li> <li>• Distributors</li> </ul>
Opportunity	Threat
<ul style="list-style-type: none"> <li>• Simplifying life</li> <li>• Product advancement</li> <li>• New accessories</li> <li>• New design</li> <li>• Newmarket and customer</li> </ul>	<ul style="list-style-type: none"> <li>• Increasing competition</li> <li>• Environmental law</li> <li>• Import and export regulations</li> </ul>

Table B.2 SWOT Analysis (Product)

Strength	Weakness
<ul style="list-style-type: none"> <li>• User-mounted accessory</li> <li>• Easy Installation</li> <li>• Automatic</li> <li>• No dirt traps</li> <li>• No residual liquid splashes</li> <li>• Compatible with existing ASKO dishwasher.</li> </ul>	<ul style="list-style-type: none"> <li>• Unidentified product life</li> <li>• Unknown material</li> <li>• Unknown product cost</li> <li>• Undetermined reliability and efficiency</li> </ul>
Opportunity	Threat
<ul style="list-style-type: none"> <li>• Easy product demonstration at home or office.</li> <li>• Added feature over competitor product.</li> </ul>	<ul style="list-style-type: none"> <li>• May be compatible with other brand dishwashers.</li> <li>• Time to market</li> <li>• Intense competition</li> <li>• Environmental laws</li> </ul>

## Appendix C

### Survey and Observation

#### Avoiding spillage while loading home/office dishwasher.

Currently, a thesis addressing the development of a spillage protection product for dishwashers is conducted at Chalmers University of Technology in cooperation with ASKO Appliances AB. In order to create the best, most suitable solution, a customer needs mapping is necessary.

To give a better understanding of the problem images are attached.

If you have any questions regarding this survey or the project in general do not hesitate to contact me at [akhilesh@student.chalmers.se](mailto:akhilesh@student.chalmers.se)

Thank you for your participation in creating the dishwasher of tomorrow.

\* Required

1. **Gender \***

*Mark only one oval.*

- ☐ Male
- ☐ Female
- ☐ Others
- ☐ Prefer not to say

2. **Age \***

*Mark only one oval.*

- ☐ <20
- ☐ 20 - 30
- ☐ 31 - 40
- ☐ 41-50
- ☐ 51 - 60
- ☐ 61 - 70
- ☐ >70

3. **Location \***

*Mark only one oval.*

- ☐ Asia
- ☐ Africa
- ☐ Europe
- ☐ North America
- ☐ South America
- ☐ Australia
- ☐ Antarctica

9. **Sometimes while loading the dishwasher, the remains from coffee cups or juice glass spill from the rack on to the open front door just below it. In some cases, it then also splashes onto the users clothes, floor or walls nearby. Have you ever experienced such a situation? \***

*Mark only one oval.*

- ☐ Yes      *Skip to question 10.*
- ☐ No      *Skip to question 12.*

## Spillage situation

10. **How do you usually deal with such a spillage situation? \***

*Mark only one oval.*

- ☐ I wash juice/coffee cup before placing it in dishwasher.
- ☐ I ensure there is no juice/coffee left in the cup.
- ☐ I try to keep a sufficient distance from the dishwasher while loading cups and glasses into it, just in case it spills
- ☐ I just clean up the mess afterwards.
- ☐ Other: \_\_\_\_\_

11. **Would you be willing to pay some small amount to add an attachment to avoid the spillage situation in your existing dishwasher? \***

*Mark only one oval.*

- ☐ Yes
- ☐ No
- ☐ Other: \_\_\_\_\_

## Dishwasher problems

12. **At the moment it's possible to see the lower tray even when the upper tray is pulled out and being filled. How much would it bother you if this was not possible anymore? \***

Mark only one oval.

	1	2	3	4	5	6	
It wont be a problem at all	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	It will be a big problem

13. What other problems do you face while using a dishwasher?

---

---

---

---

---

<https://docs.google.com/forms/d/1RDPjuVCpPbe2nA7LFTU74JCCWUci0EihNByk8G8ek/edit>

4/5

8/19/2018

Avoiding spillage while loading home/office dishwasher.

14. Any other comments?

---

---

---

---

---

Powered by  
 Google Forms

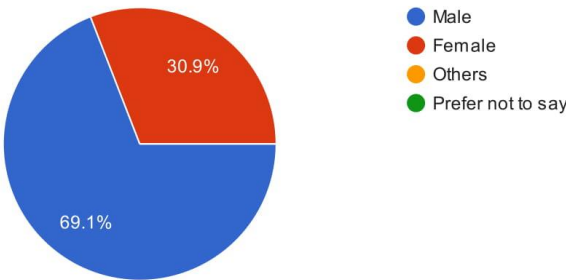
Figure C.1 Google Survey Form

# Avoiding spillage while loading home/office dishwasher.

68 responses

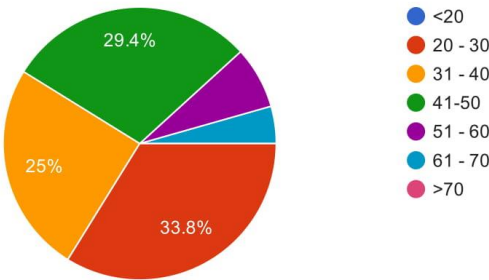
## Gender

68 responses



## Age

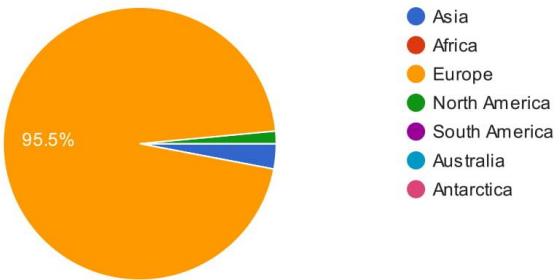
68 responses



## Location

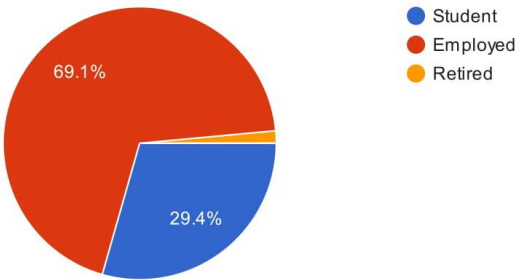
<https://docs.google.com/forms/d/1RDPjuVCpPbe2nA7LFTU74JCCWUci0EihNBxk8G8ek/viewanalytics>

67 responses



Occupation

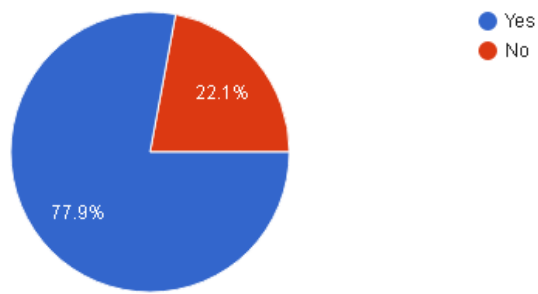
68 responses



Dishwasher usage

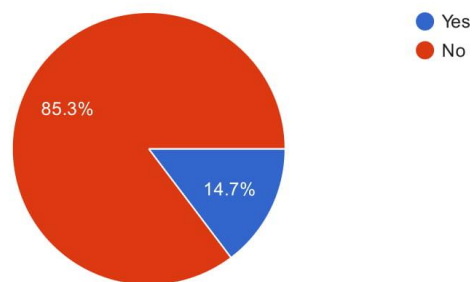
Do you have a dishwasher at home?

68 responses



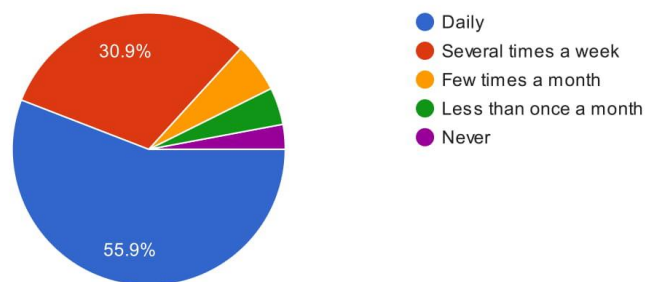
Are you planning to buy a new dishwasher any time soon?

68 responses



How often do you use a dishwasher at home, office or at educational institutions?

68 responses





To find space for all my load

To fit the bigger items (pots, trays and bowls)

When loading wine-glasses they are in the way for putting ordinary glasses under the shelf. Have to take away glasses and put them back again

Lack of organization leads to less dishes in each cycle

To much cutlery in the cutlery basket.

Bulky items as pots steel a lot of Place from plates etc. Also placing odd size items can be a problem

It's that I've to do it..... besides that it is the space and accuracy needed to load the upper tray with cuttleries etc.

Nothing

Light plastic objects that fall over and collect water.

Items not fitting well

Lätt att få för högt gods, mest köksredskap typ stekspadar och div slevar, i underkorgen som stoppar övre spolarm.

Lack of space in upper basket (top basket interference)

-Se till att inte lasta fel vid diskmedelsluckan, att den ska kunna öppnas. -Placera besticken rätt i takkorgen så det diskas rent. - Får ofta plats över för glas i underkorgen och dessa kan vara svåra att placera så de inte välter. - kan sällan använda den extra kopphyllan i överkorgen för även de lägre glasen vi har är för höga så hyllan går inte att fälla ned.

Good space for long wine glasses.

Space Management

Constantly moving the baskets in and out to put in the cutlery and plates

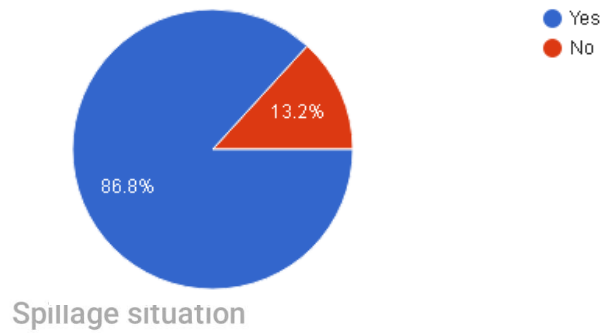
not enough space for flat plastic boxes

Sometimes while loading the dishwasher, the remains from coffee cups or juice glass spill from the rack on to the open front door just below it. In some cases, it then also splashes onto the users clothes, floor or walls nearby. Have you ever experienced such a situation?

68 responses

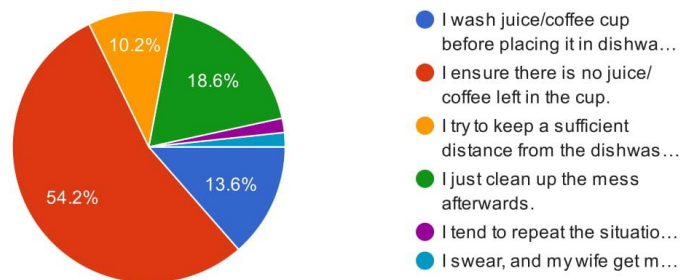
8/19/2018

Avoiding spillage while loading home/office dishwasher.



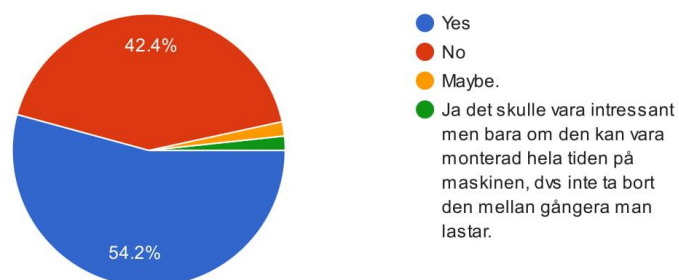
How do you usually deal with such a spillage situation?

59 responses



Would you be willing to pay some small amount to add an attachment to avoid the spillage situation in your existing dishwasher?

59 responses



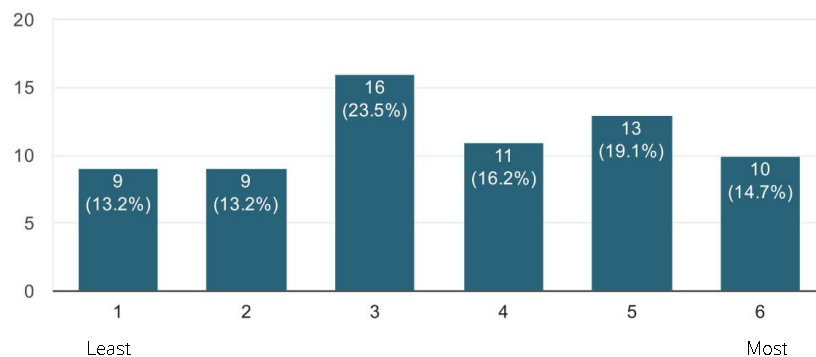
<https://docs.google.com/forms/d/1RDPjuVCpPbe2nA7LFTU74JCCWUci0EihNBykBz8G8ek/viewanalytics>

6/9

## Dishwasher problems

At the moment it's possible to see the lower tray even when the upper tray is pulled out and being filled. How much would it bother you if this was not possible anymore?

68 responses



## What other problems do you face while using a dishwasher?

31 responses

None, really, mine works very well

It's perfect

Some bowls occasionally turn and they fill up with water and soap. When that happens I wash these again by hand, to get rid of the concentrated soap.

Sometimes when the lower tray is full, it requires a bit more energy to push in. Considering the position of a human bending and pushing it in, there could be solution to somehow make it easier.

Possibility to display remaining time n status (clean or dirty) on the outside.

Steam coming outside of dishwasher

Sometimes water remains on top of mildly shallow vessels.

1)for big spoon no vertical space2)all the time need to bend down to keep the utensils.3)tray can be modify wrt regular use of items.4)vertical height height is less should be interchangability with usage.

Problems with odd sized dishes

The dishwasher is small

The architecture is not optimal, especially at the office

Spilling detergent

Too long programs.

Plast som ej torkar. Vatten som kommer på golvet när korgarna dras ut (främst mellankorgen).

vassaknivar man sticker sig på när man plockar ur bestickskorgen

Unloading is not popular among the family members

The one I have cleans poorly. Very annoying.

Plastic boxes, mugs and sometimes glasses that turn during dish cycle and therefor fills with water.

ugly

Programs take to long time

I want to know how to fill the dishwasher in the best way

Door pop up during cycle

I usually choose a 1h30min program and dishes doesnt dry during this time

Drying performance of plastic trays and plastic items.

Nothing

Too long time in the programs.

-

Den föreslagna lösningen på bild löser nedsmutsning av golv men det jag tycker är svårast att städa är den smuts som hamnar på skåpsvägen, på luck-kant samt på lådor närmast diskmaskinen.

1. Good drying of plastic item's. 2. load items of odd shape, whispers etc.

Sometimes the dishes aren't washed properly

Lower basket is so low

## Any other comments?

8 responses

No

8/19/2018

Avoiding spillage while loading home/office dishwasher.

All the best :)

No comments

Hood luck

My dishwasher is currently leaking water on one side during operation, ruining the wooden frame around it. This is a bit frustrating and i dont know why

När vi lastar maskinen hemma lastas ibland ett kuvert i taget, dvs man drar in och ut korgarna ganska ofta.

When I'm loading the baskets, I'm loading all of them at the same time depending on the items I have. Lower basket fully pulled out, Upper basket half pulled out. This gives me a flexible loading procedure.

No, Thank you

This content is neither created nor endorsed by Google. Report Abuse - Terms of Service - Additional Terms

Google Forms

<https://docs.google.com/forms/d/1RDPjuVCpPbe2nA7LFTU74JCCWUci0EihNBykBz8G8ek/viewanalytics>

9/9

Figure C.2 Survey Responses






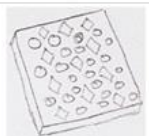






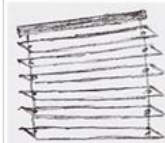







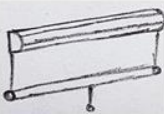

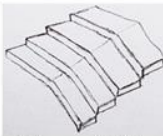

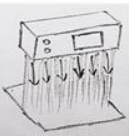
Figure C.3 Dishwasher Observed at Chalmers

## Appendix D

### Morphological Matrix

Table D.1 Morphological Matrix

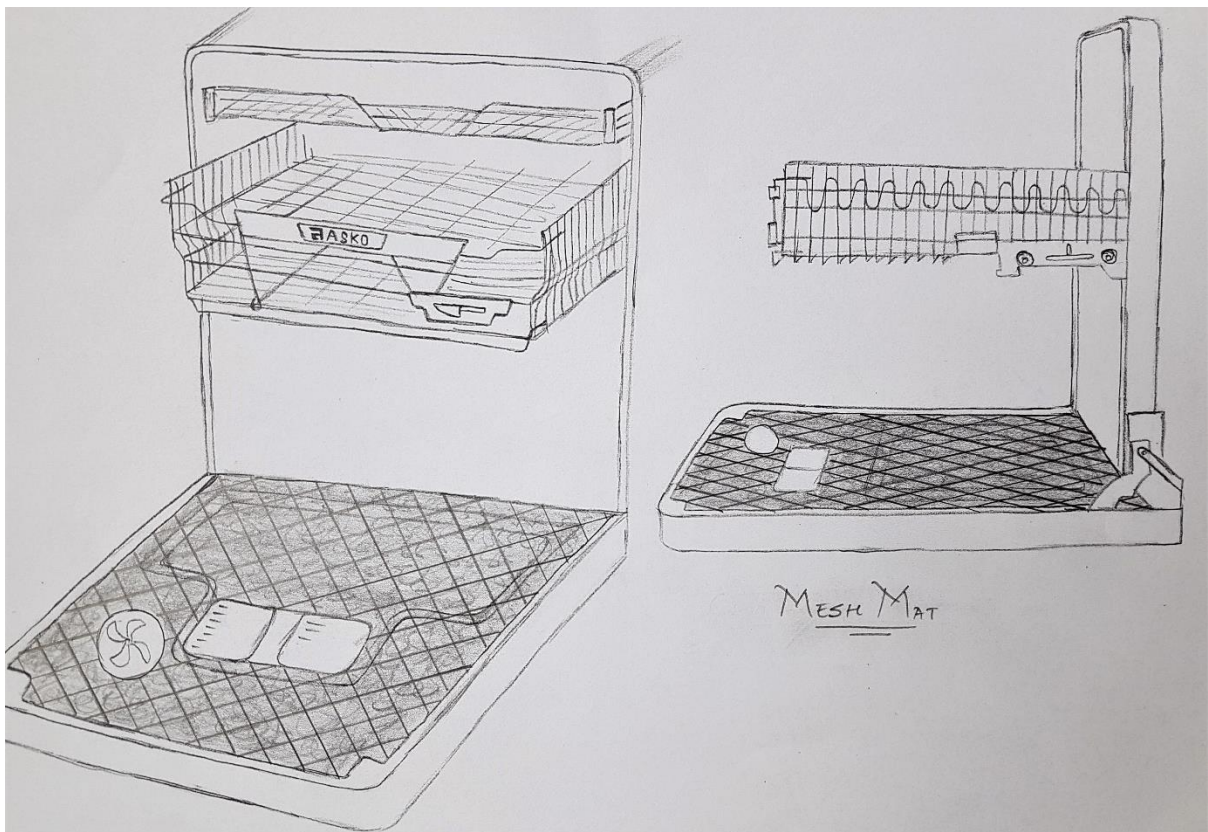
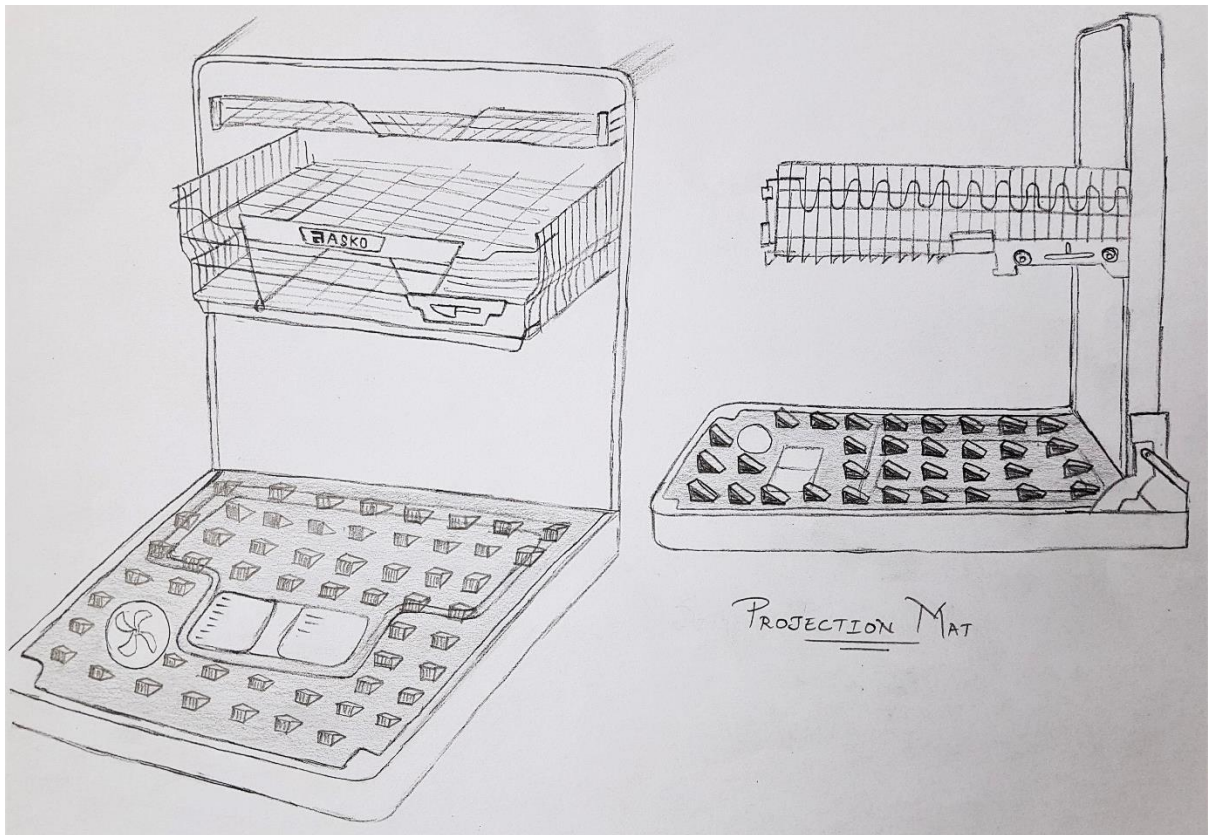
Function		1	2	3	4	5
Minimize Splash	Deflect Splash	 Slider	 Angled Projections			
	Increase Surface Contact	 Rain Chain	 Wire Mesh			
Prevent Splash	Absorb/Collect Liquid	Mat				
		 Cloth	 Rubber Mat	 Silicone Mould	 Sink Mat	 Urinal Mat
Hinder Splash	Shield	Curtain				
		 Hand Fan	 Umbrella	 Folded Blinds	 Venetian Blinds	 Rail Curtain

6	7	8	9	10	11	12
						
Steel Wool	Tray					
						
String Curtain	Slider Door	Retractable Screen	Canopy	Telescopic Plate	Sink Splash Guard	Air Curtain

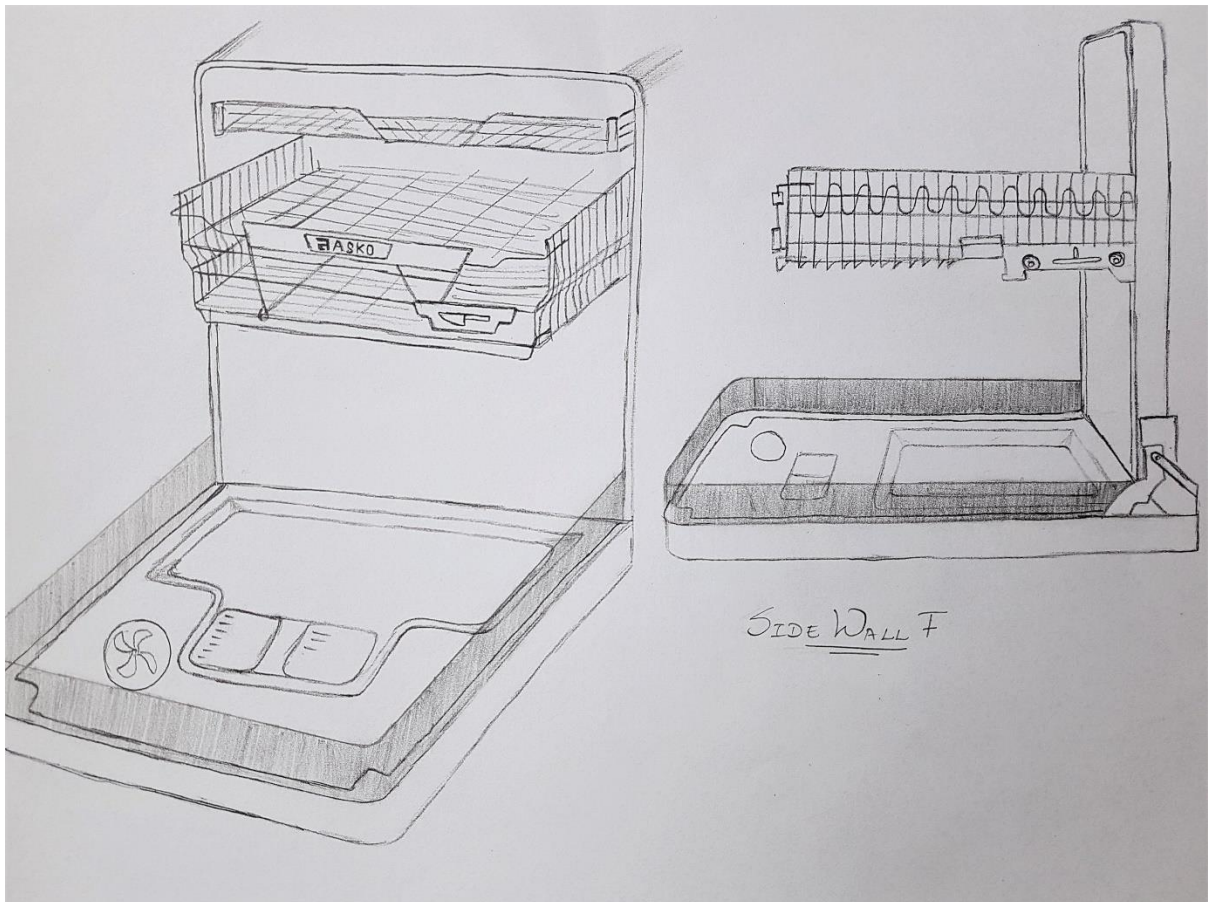
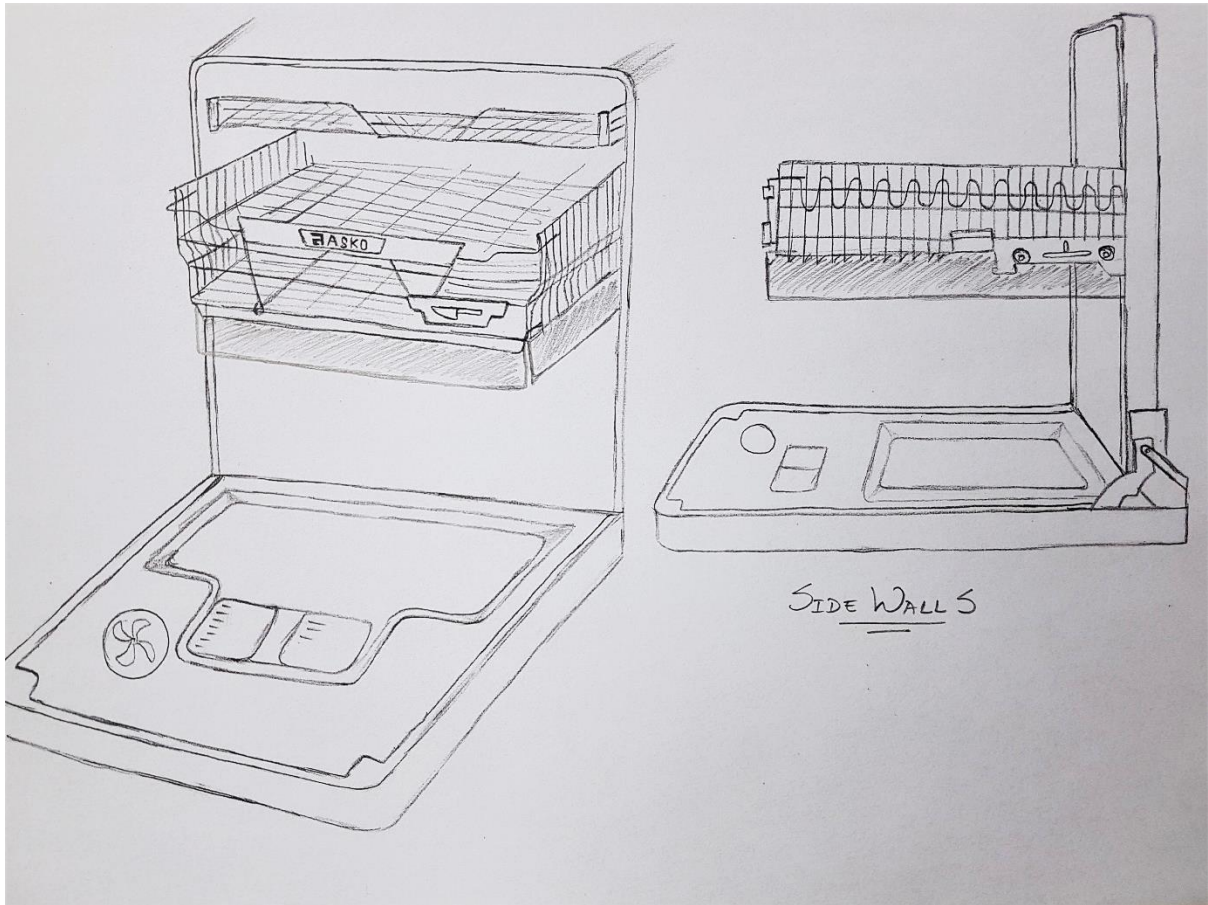


## Appendix E

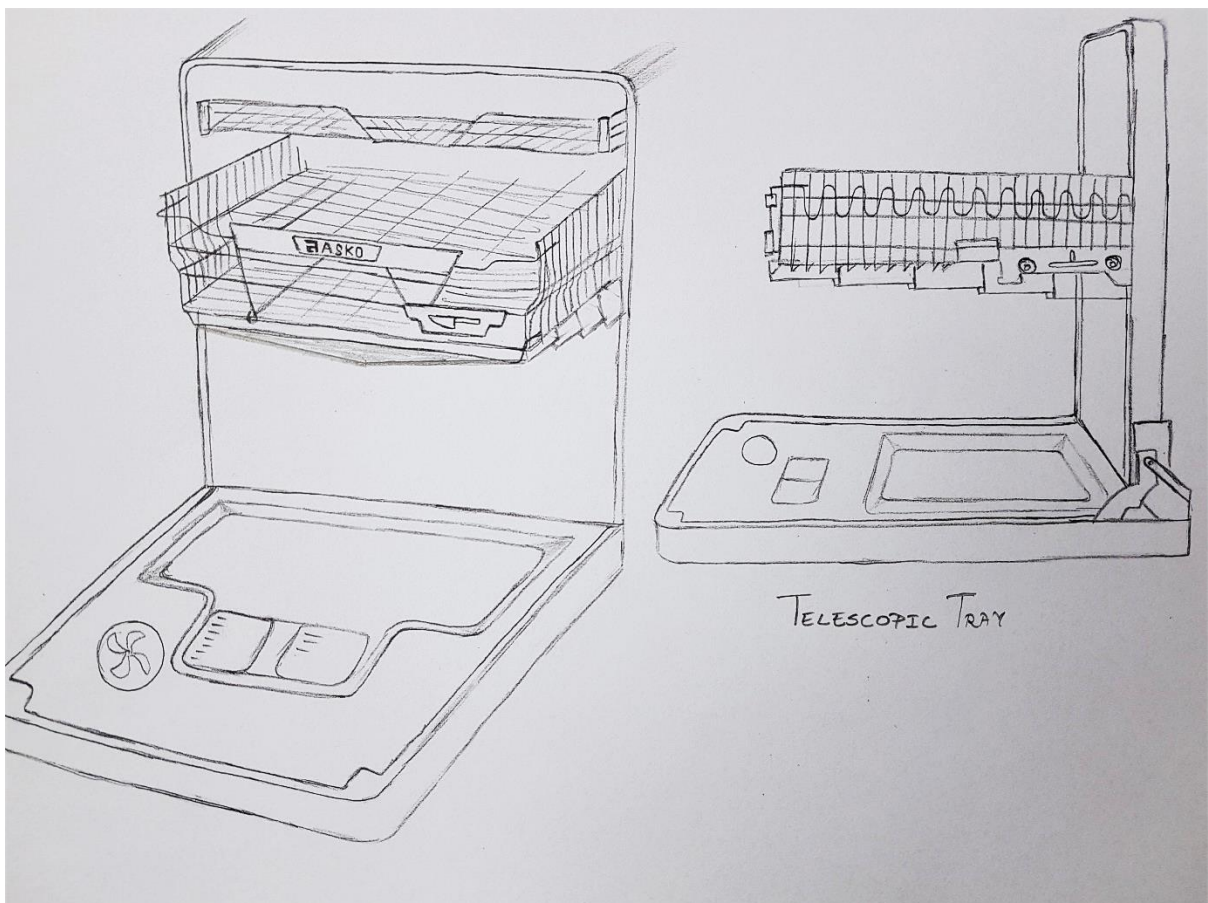
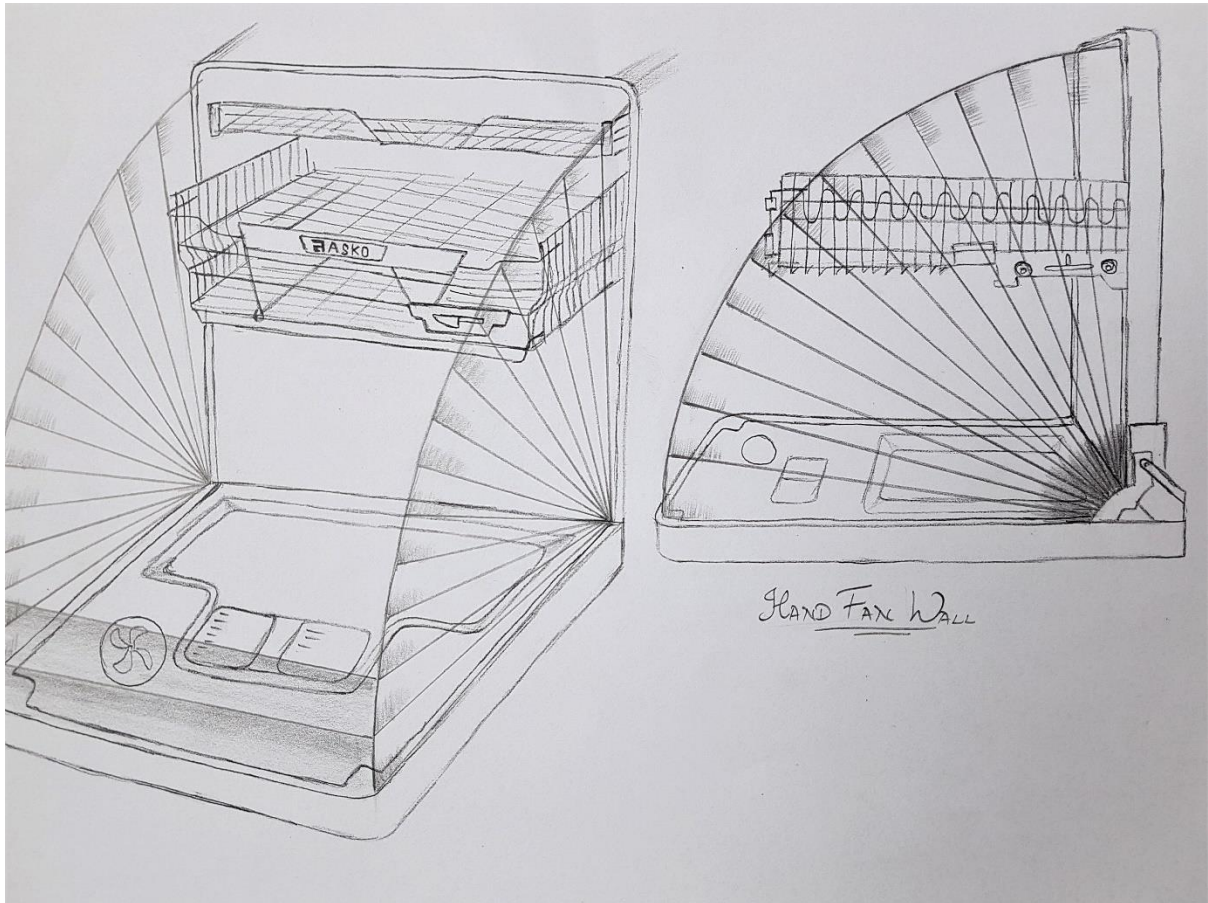
### Preliminary Concepts

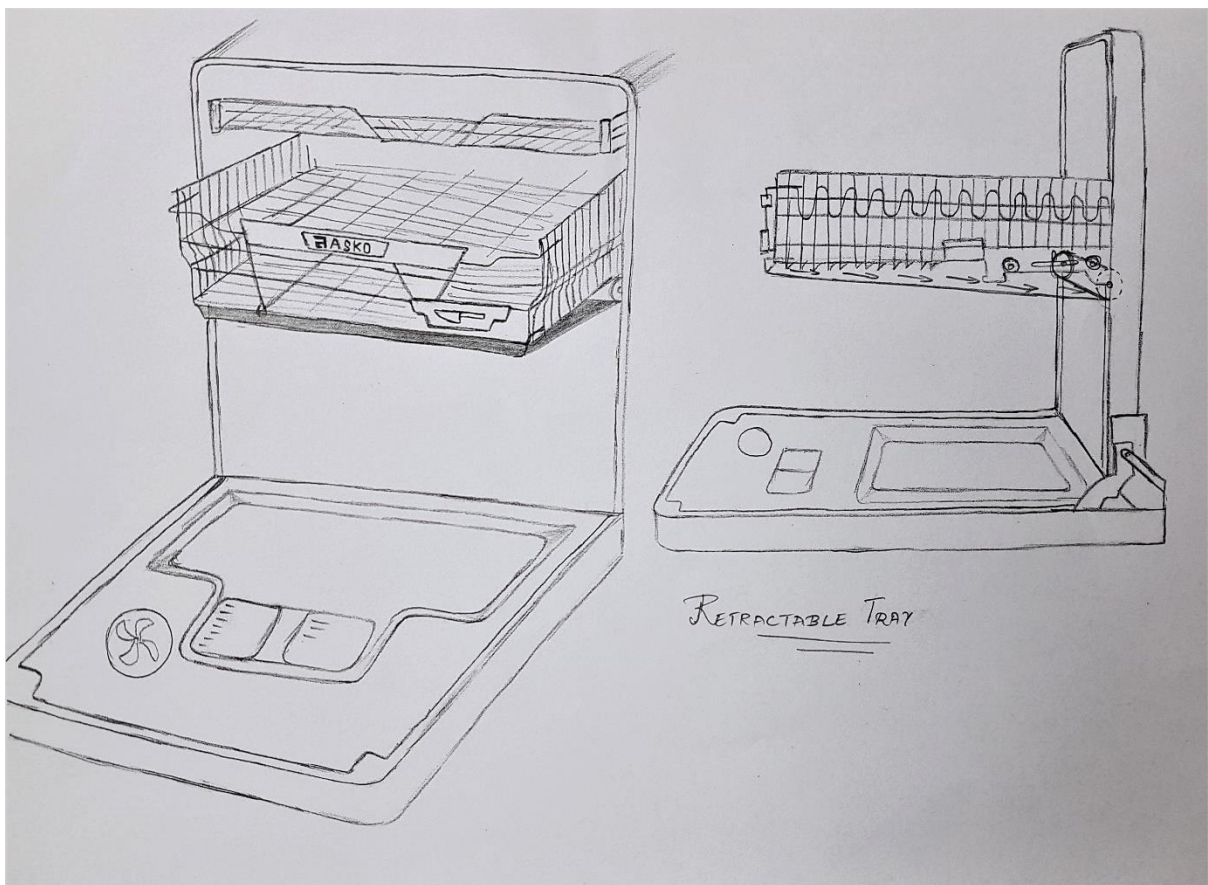
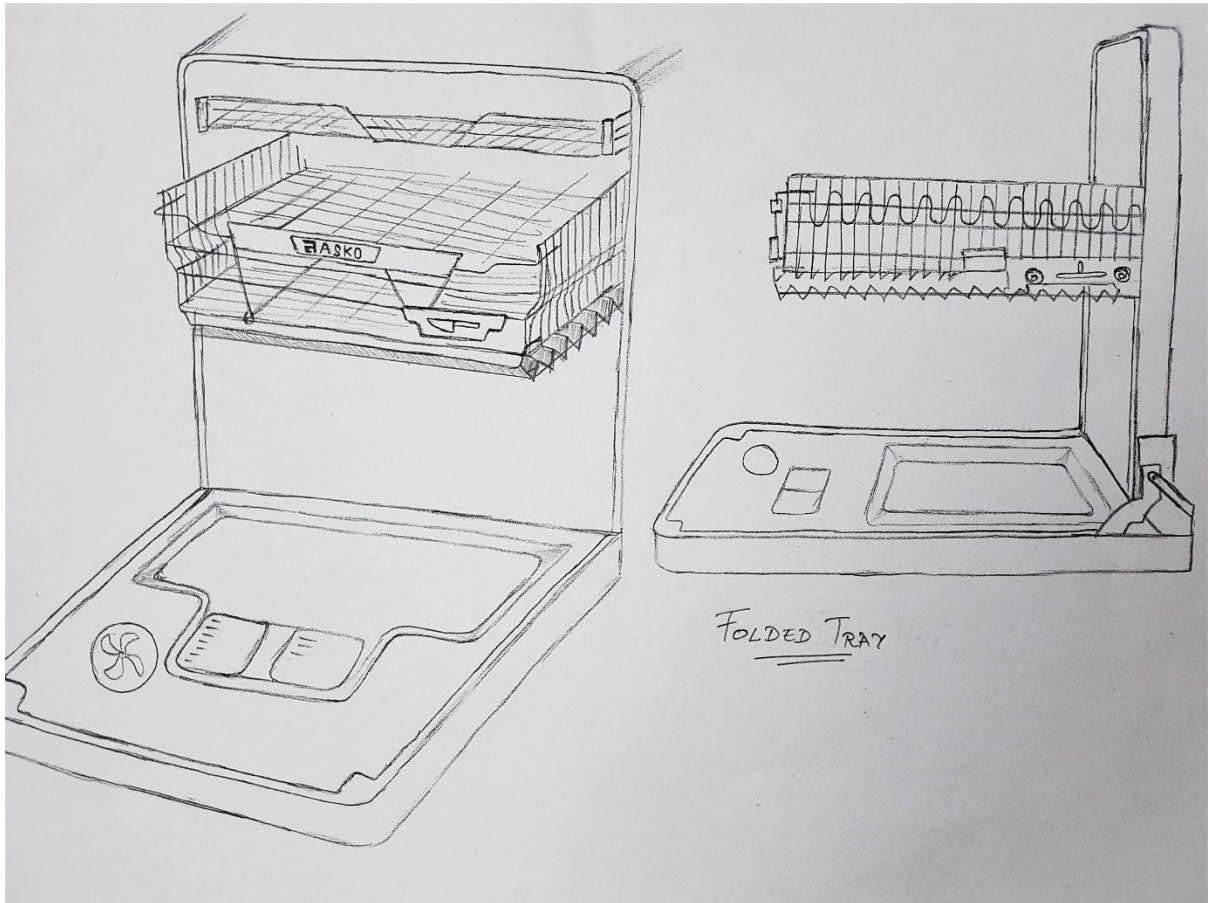




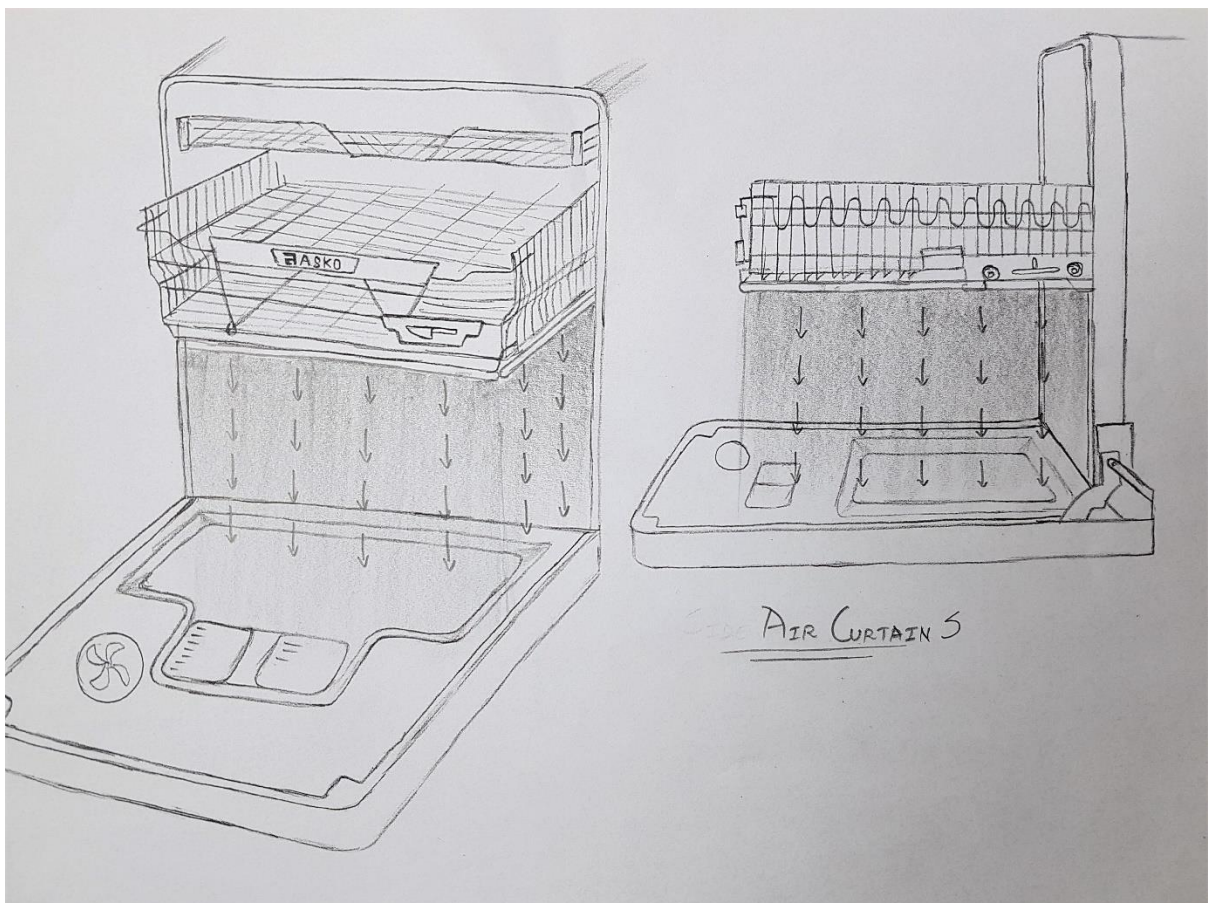
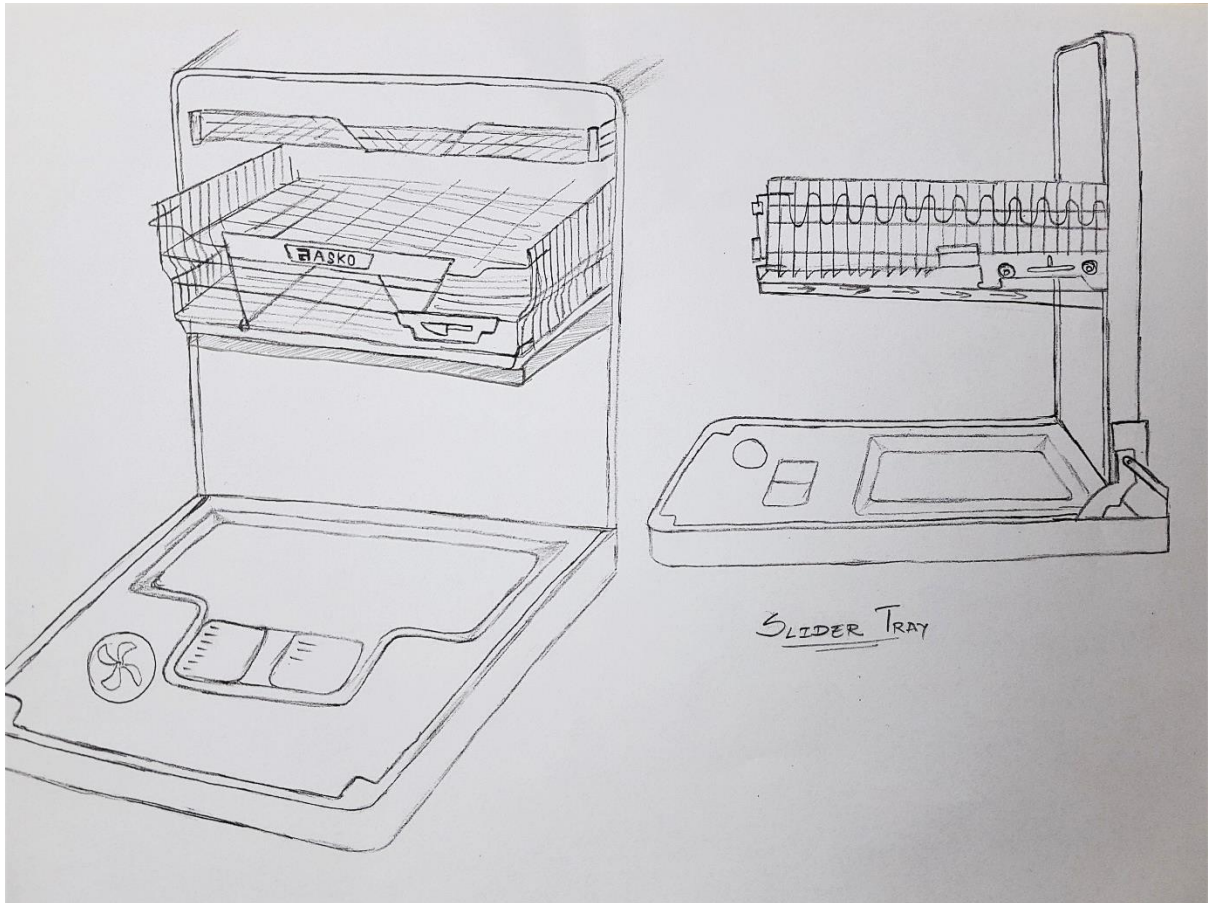




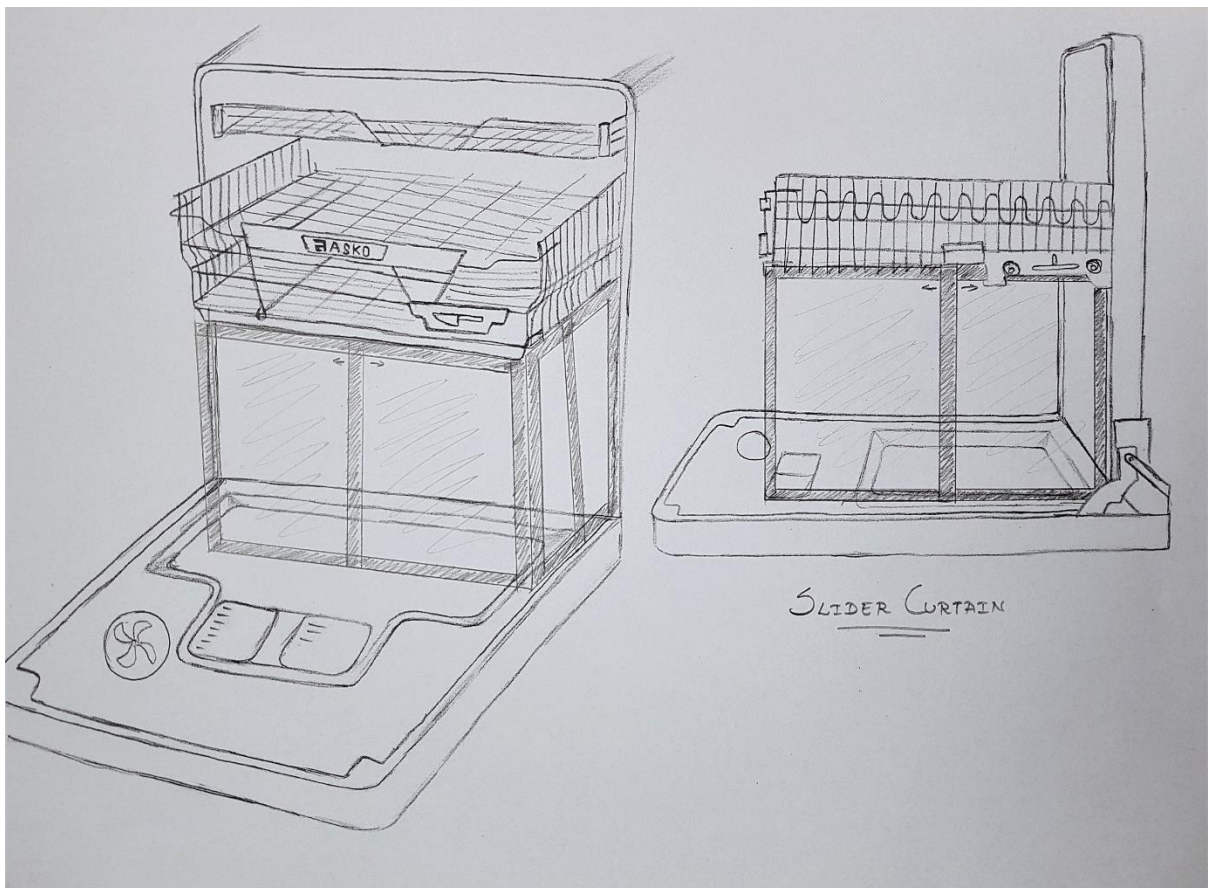
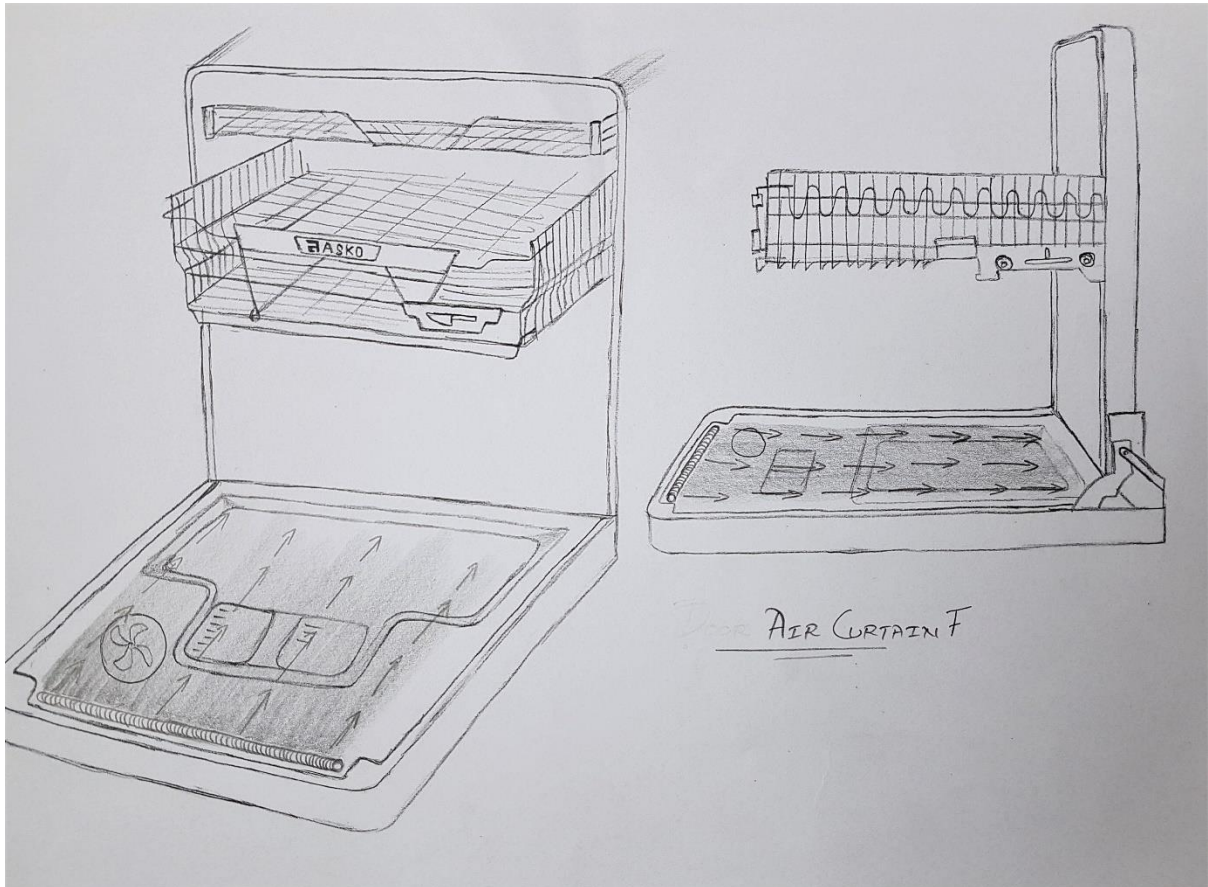


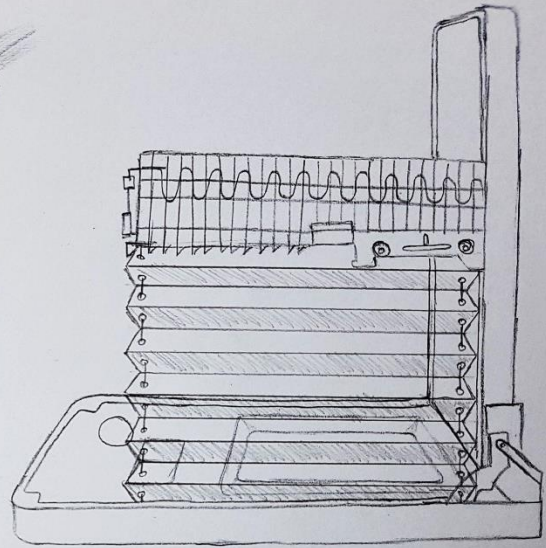
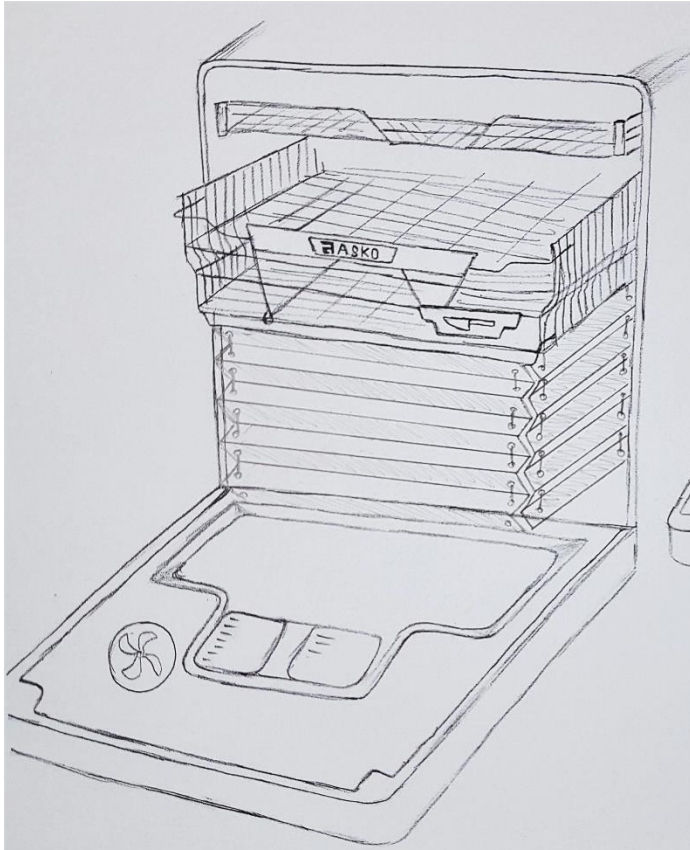




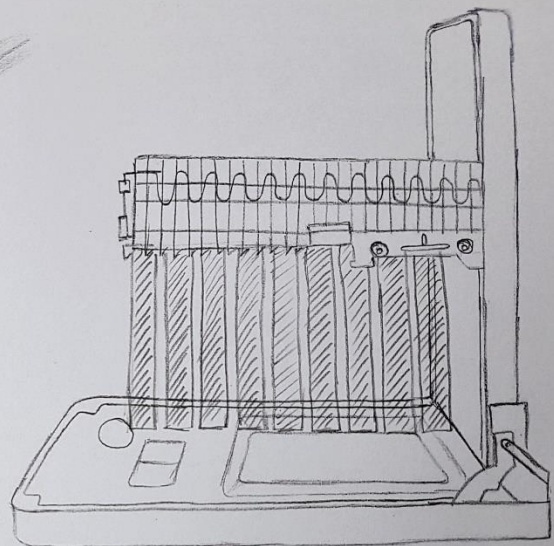
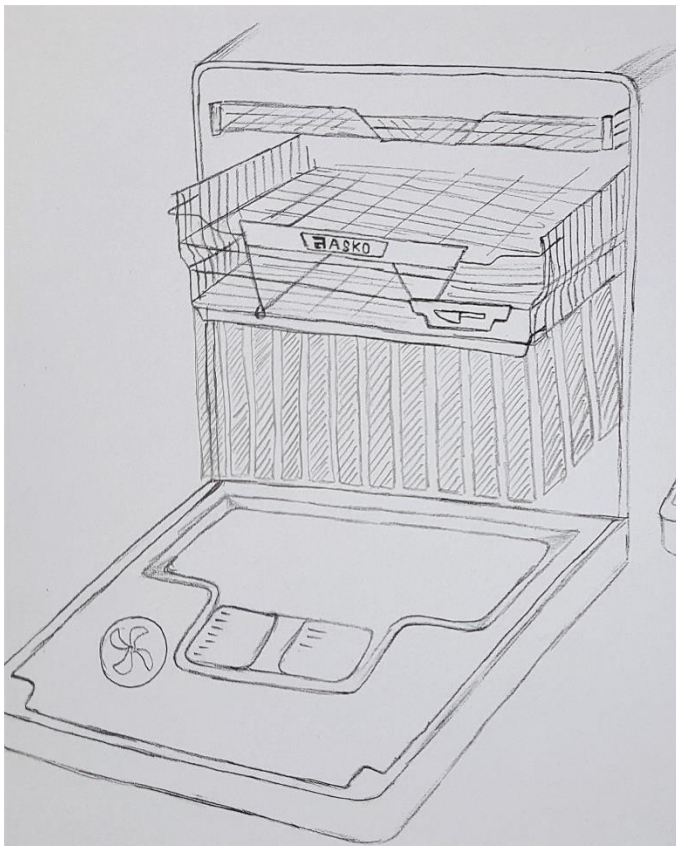






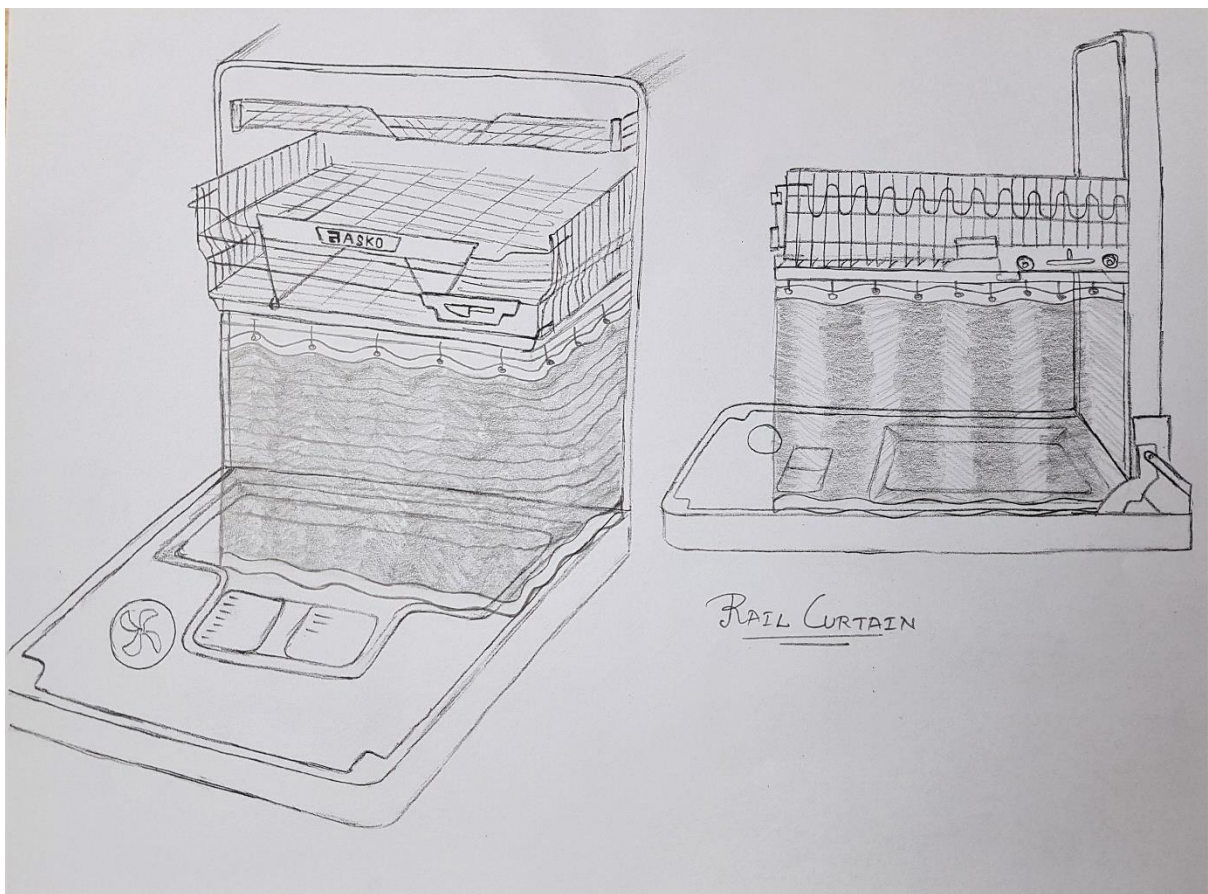
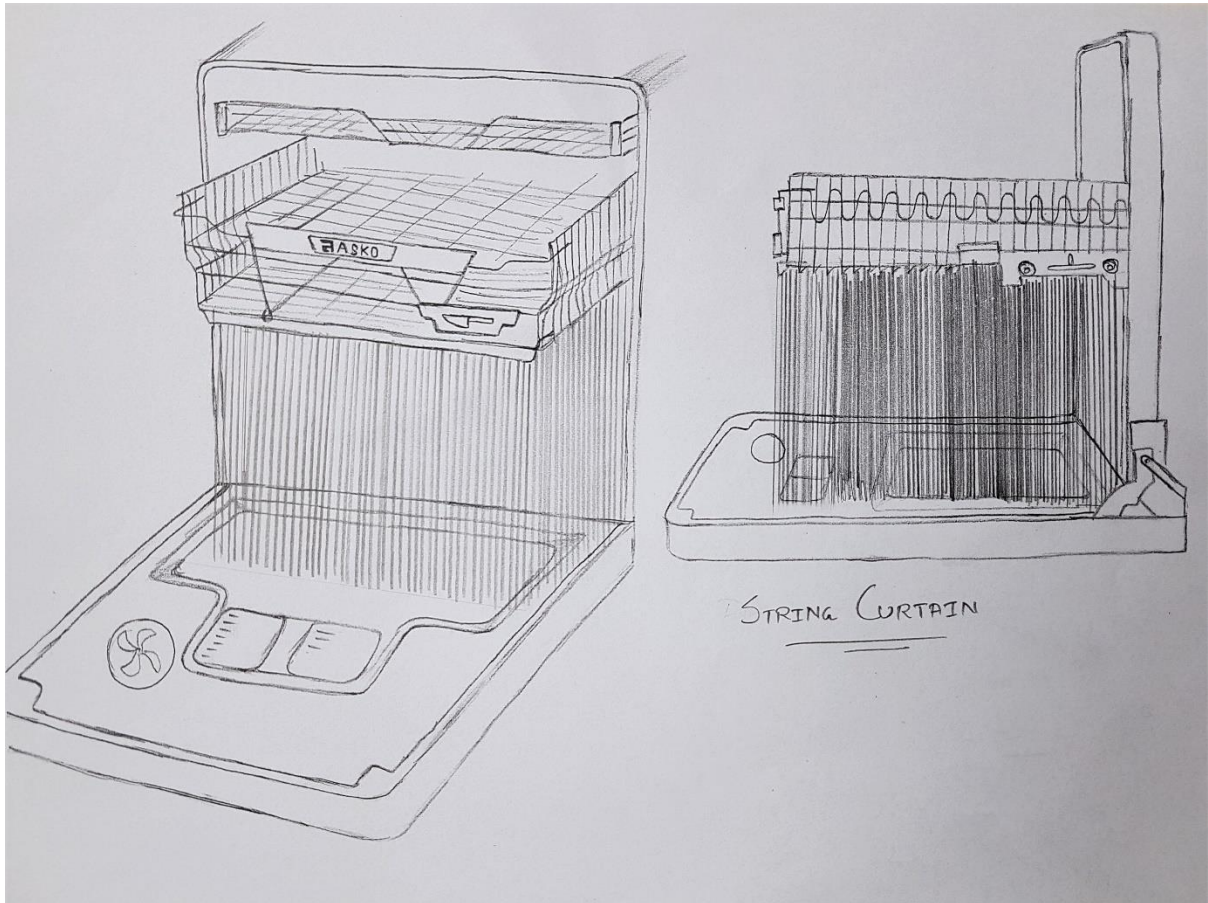


FOLDED CURTAIN

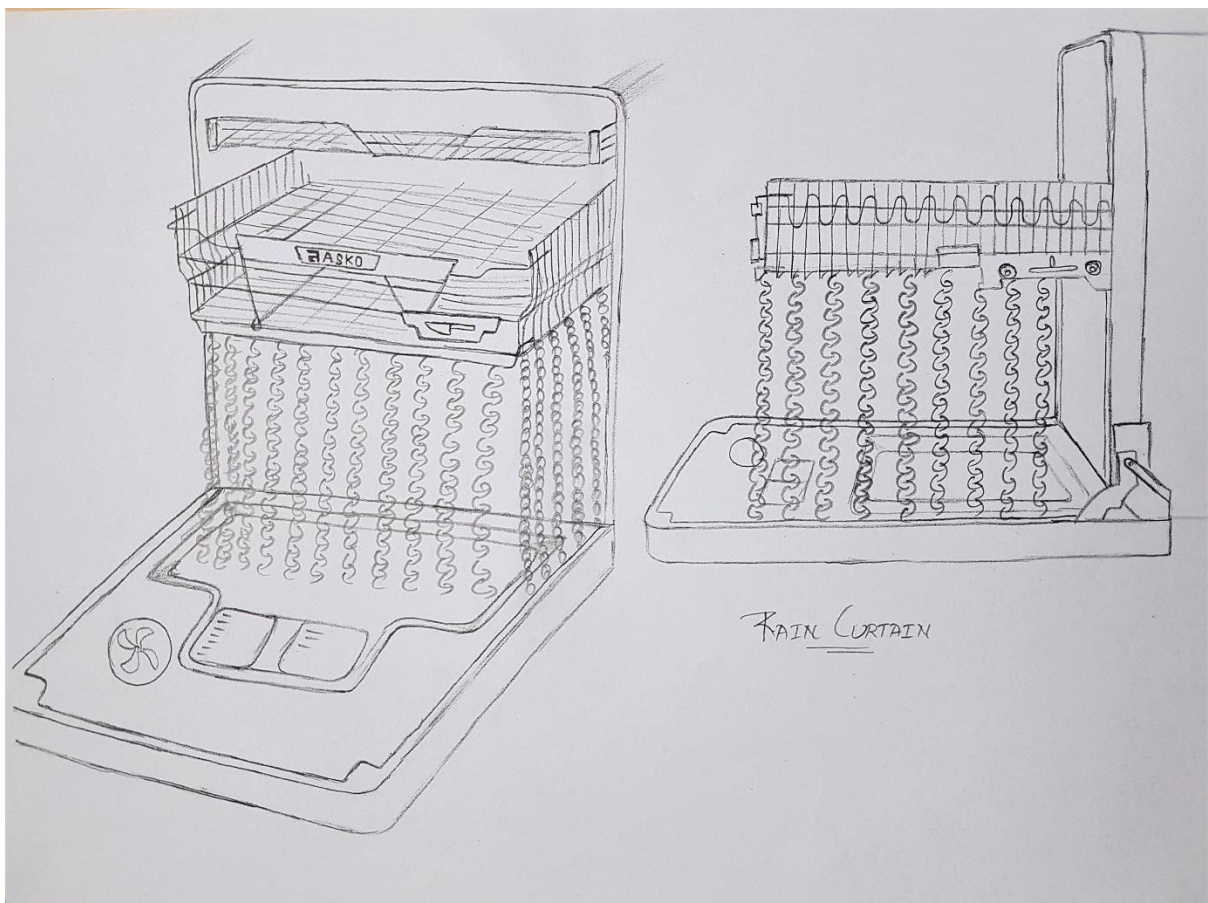
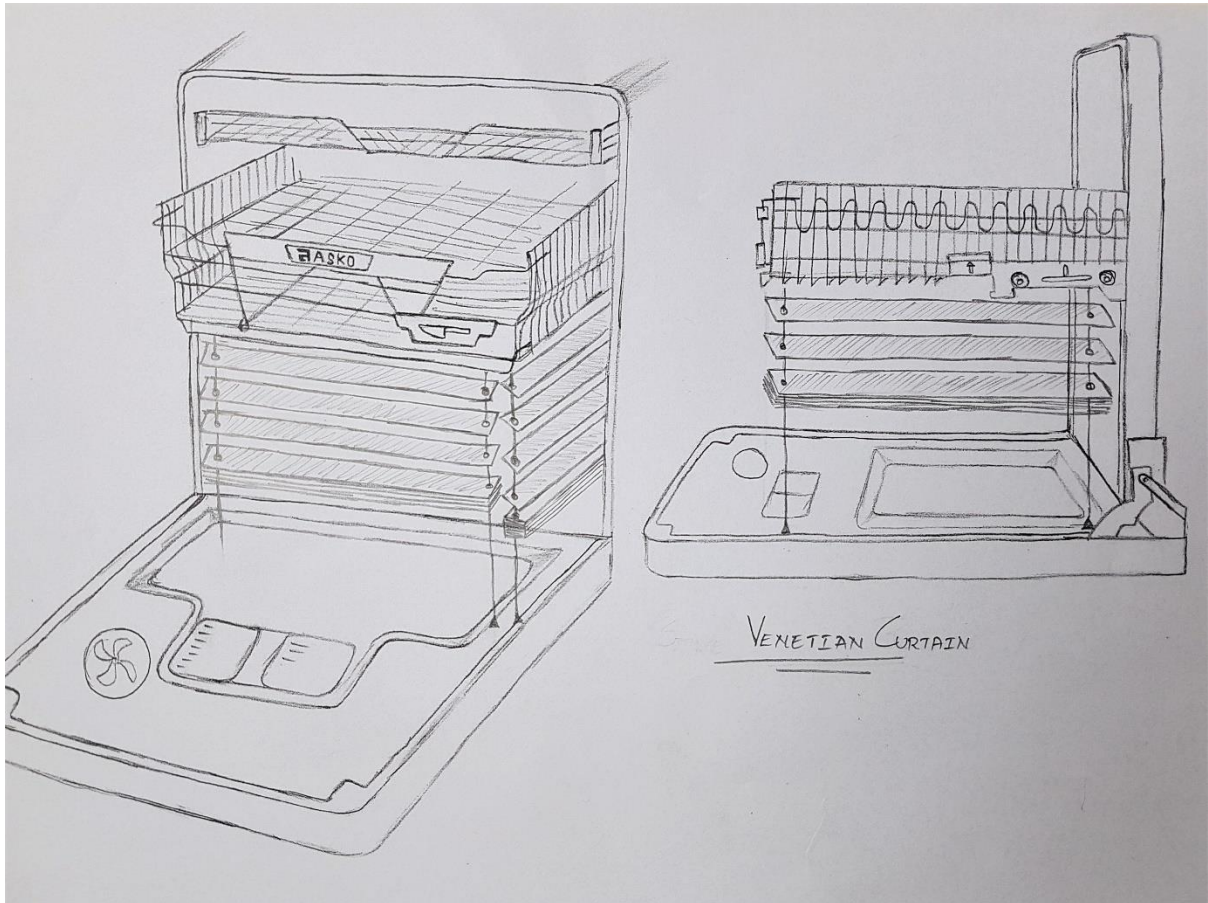


STRIP CURTAIN









## Appendix F

### Elimination Matrix

Criteria										
Category	Name	Concept	Solve main problem	Compatible/Realizable	Reasonable cost	Safe	User Friendly	Easy Installation	Energy consumption	Comment
Curtain System	Rain Curtain	Rain chain hanging around the 3 sides of the basket	+	+	+	+	+	+	+	
	Venetian Curtain	Venetian Blinds hanging around the 3 sides of the basket	+	+	+	+	+	+	+	
	Rail Curtain	Polyester screen hanging around the 3 sides of the basket	+	+	+	+	+	+	+	
	String Curtain	Strings hanging around the 3 sides of the basket	+	+	+	+	+	+	+	
	Strip Curtain	PVC strips hanging around the 3 sides of the basket	+	+	+	+	+	+	+	
Tray System	Folded Curtain	Folding curtain hanging around the 3 sides of the basket	+	+	+	+	+	+	+	
	Slider Curtain	Sliding door attached to 3 sides of basket	+	+	+	+	+	+	+	
	Air Curtain F	High speed air blown on the front door	?	?	-	?	+	-	-	
	Air Curtain S	High speed air blown on the 3 sides of the basket	?	?	-	?	+	-	-	
	Slider Tray	Sliding tray below the basket	-	+	+	+	+	+	+	Obstruct the spraying arm
Wall System	Retractable Tray	Rolling screen below the basket	-	+	+	+	+	+	+	
	Folded Tray	Folded Blind below the basket	-	+	+	+	+	+	+	
	Telescopic Tray	Telescopic expanding and contracting tray below the basket	-	+	+	+	+	+	+	Overlapping means more thick
	Hand Fan Wall	Foldable hand fan on both sides of basket	+	+	+	+	-	+	+	Obstruct the feeding from sideways
	Side Wall F	3 sided wall of certain height on the front door	-	+	+	+	+	+	+	
Mat System	Side Wall S	3 sided wall of certain height on the basket side	+	+	+	+	+	+	+	
	Mesh Mat	Cloth and wire mesh mat on the front door	-	+	+	+	+	+	+	
	Projection Mat	Mat with some projections like urinal mat, sink mat, etc.	-	+	+	+	+	+	+	

Table F.1 Elimination Matrix

## Appendix G

### Prototype



Figure G.1 Back Side Cover



Figure G.2 Front Cover



Figure G.3 Front Side Cover and Flap Part



Figure G.4 First Prototype Mounting





Figure G.5 Splash with Guard

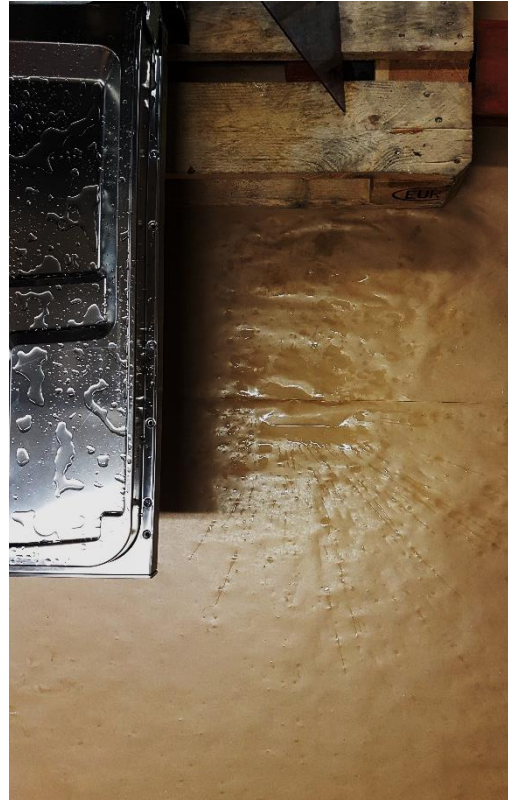


Figure G.6 Splash without Guard



Figure G.7 Final Prototype installed at ASKO Office at Lidköping

# Appendix H

## Technical Drawings

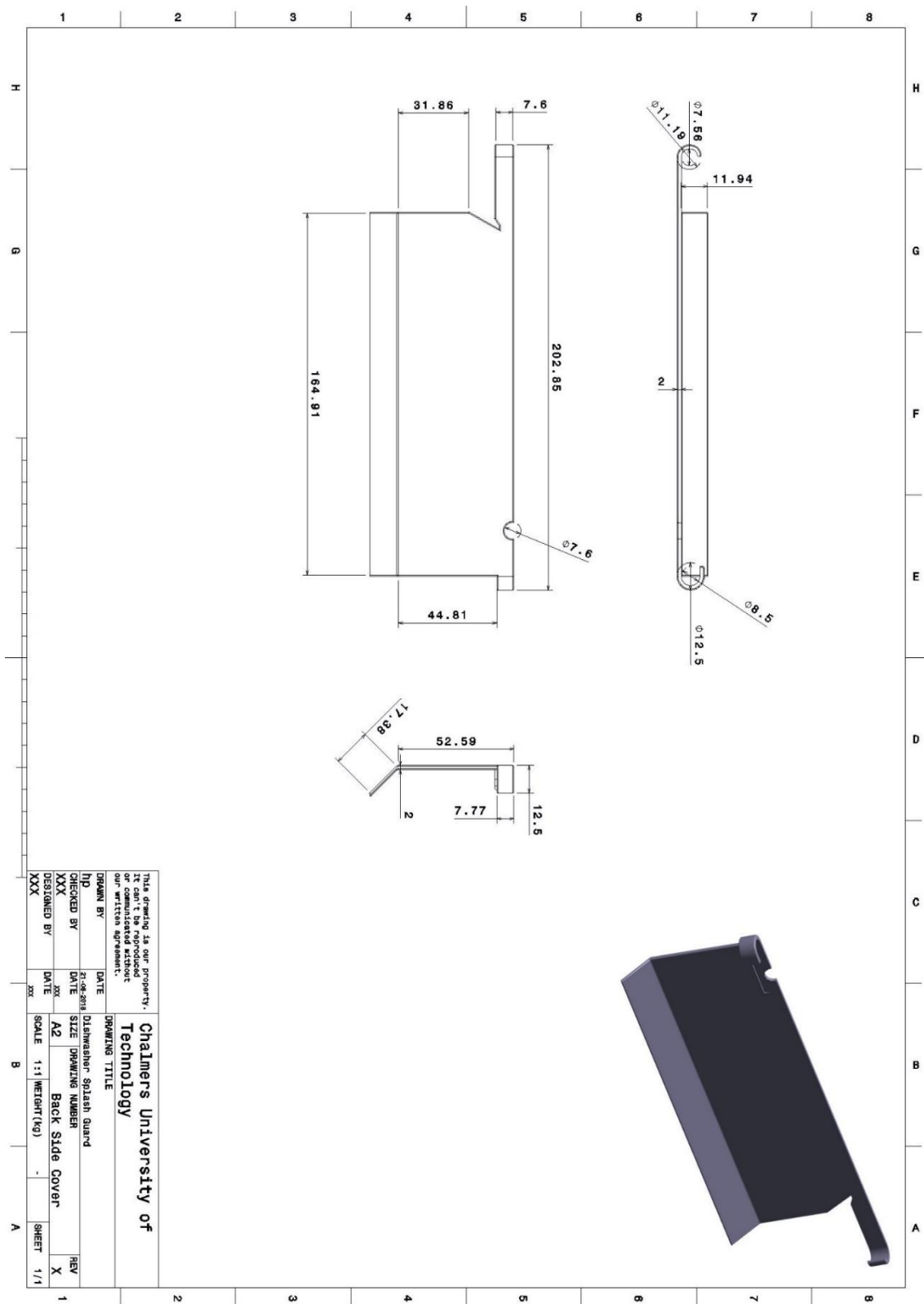


Figure H.1 Back Side Cover

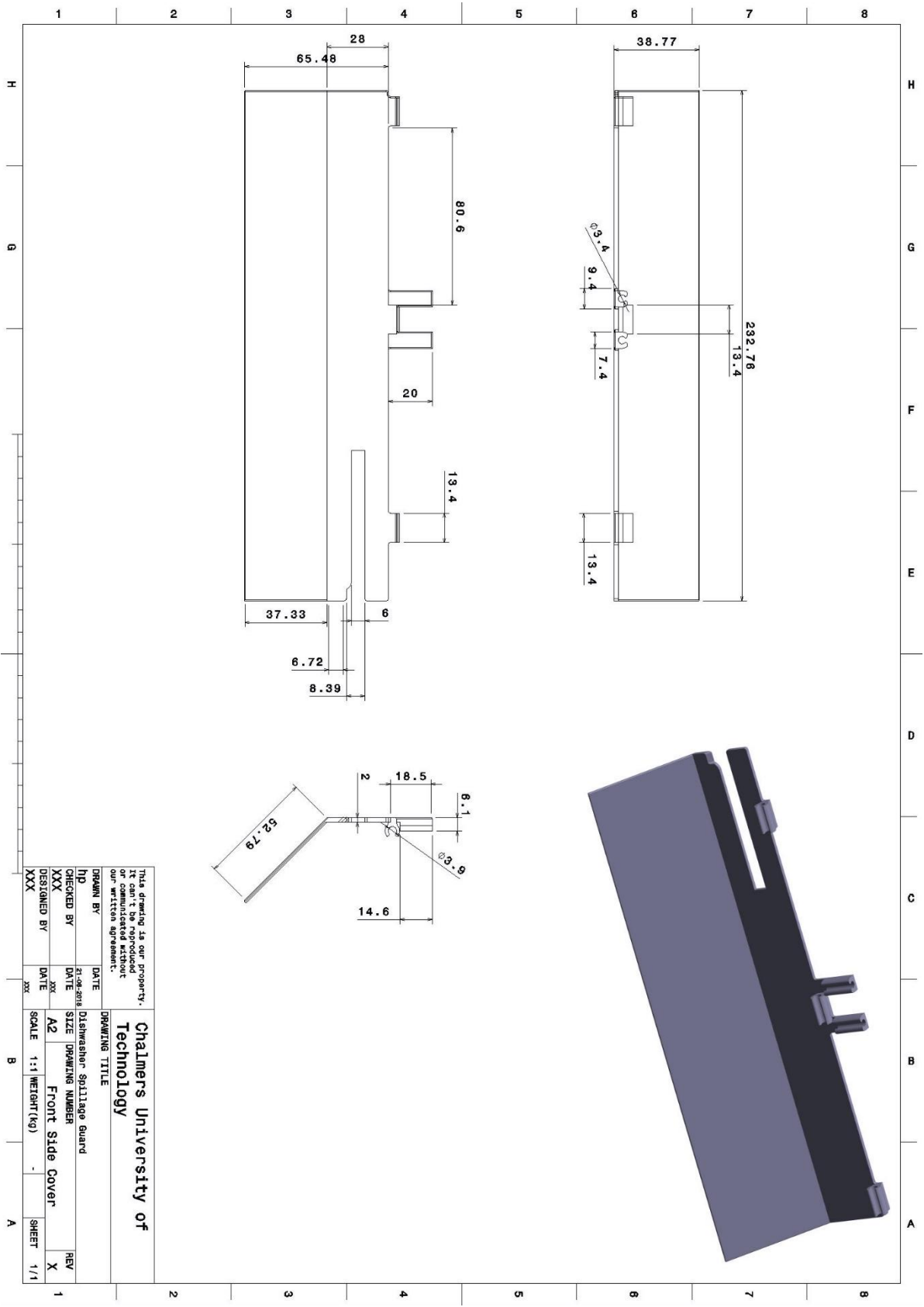


Figure H.2 Front Side Cover

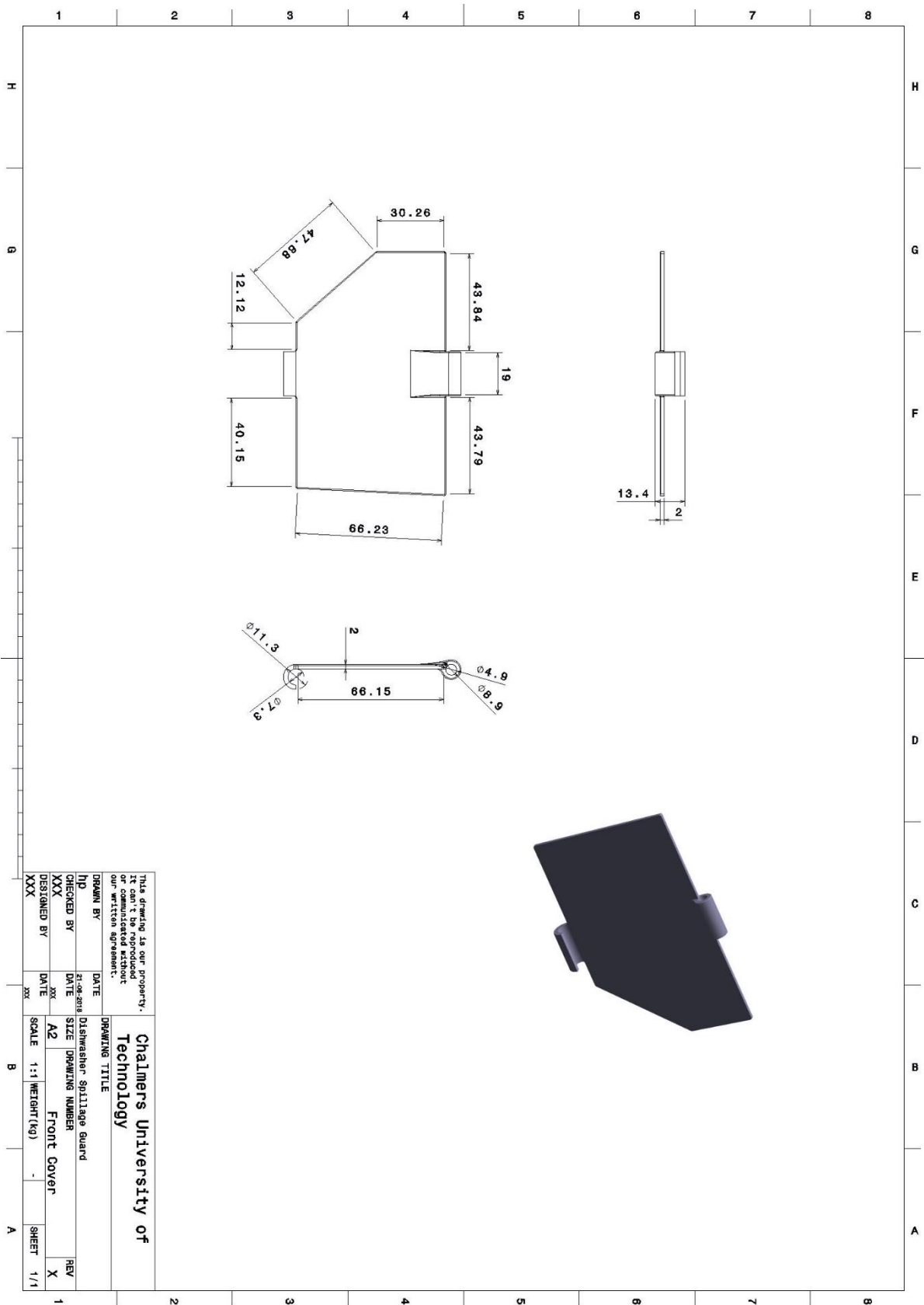


Figure H.1 Front Cover