A VILEDA PROFESSIONAL OWNED DESIGN OF A SPRINKLEBOTTLE/DOSING JUG

B.Sc. Graduation Assignment

Martina Schulze

A Vileda Professional owned design of a Sprinklebottle/Dosing Jug

B.Sc. Graduation Assignment 2014

Author: Martina Schulze
s1020897

Supervisors: Harleman, P. (Vileda Professional)
Eggink, W. (University of Twente)
Lutters, D. (University of Twente)

Vileda GmbH
Abt. Professional
Im Technologiepark 19
69469 Weinheim (Germany)

University of Twente
BSc Industrial Design
Postbus 217
7500 Enschede (NL)

Signature

August 11, 2014

Summary

This report is written within the framework if an Industrial Design Bachelor Assignment at the University of Twente, in The Netherlands, in collaboration with the company Vileda Professional, which is providing the assignment. The scope of this project was to design an improved version of a Sprinklebottle, which also includes functions of a dosing jug. Within four months, the complexity of problems has been observed and analyzed. Developed solutions for disadvantages that occurred while using the product were assembled to create a more suitable product-solution. This report is arranged in three chapters. Chapter 1 provides information about the observation and analysis. Chapter 2 introduces partial concepts and describes the process of the development of different concepts. Chapter 3 introduces the final concept and provides a first estimated price indication as well as manufacturing. In addition to this report, a digital and a printed model of the final concept are provided to the company.

Table of Content

CHAPTER 1

Observation and Analysis

This chapter unveils the complete assignment and gives an overview over the Sprinklebottle. It is described how the Sprinklebottle acts in its respective environment. This chapter does also provides an answer to the question on how functions of a dosing jug can be integrated to the product. Additionally, the guidelines that have influence on the future look of the new product are discussed.

1.1 Introduction

This report is written within the framework of an Industrial Design bachelor assignment at the University of Twente in the Netherlands. The company Vileda Professional is providing this assignment. Vileda Professional is a subdivision of Vileda. Vileda is a member of the family-owned Freudenberg Group with its head office located in Weinheim, Germany. The Freudenberg Group consists of 16 business groups, which are globally active. The members, or divisions are active in a broad variety of businesses, including seals and vibration control, non-wovens, chemical specialities and home cleaning solutions.

Vileda Professional provides professional cleaning solutions, cleaning methods and cleaning systems. Their customer groups are companies that provide cleaning services in the fields of the Controlled Environment (CE), Health Care (HC), Speciality Building Cleaning (SBC), General HoReCa (G-HoReCa) and General Building Cleaning (GBC). Besides product solutions and systems, Vileda Professional provides cleaning methods and training to their customers. An extract of their support are one-site test runs, full implementation support, training and laundry service. [1]

An example for a product of a cleaning system is the Sprinklebottle. A Sprinklebottle is a bottle that sprinkles detergent on surfaces to fulfill a cleaning task. The Sprinklebottle that Vileda Professional currently provides to their customers is bought from the company Daloplast, Sweden.
Its original use is to wet textiles while in the process of ironing. However, Vileda Professional is selling the same product to provide the users of their systems a possibility to moisten mops, pre-soaking spots and to clean sanitary facilities.
To provide a first impression of this Sprinklebotte, advantages and disadvantages while using the Sprinklebottle, are listed on page 9.

Advantages:

- The bottle is easy to use
- The bottle is easy to clean

Disadvantages:

- Wrist pain/stress/injuries generated by neglecting ergonomic principles
- Absence of color coding
- Cap drops off too easy
- Too difficult to put on the cap
- Not suitable for applications e.g. moistening mops, pre-soaking spots and sanitary cleaning

Most disadvantages are a result of the fact that the products original aim is to wet textiles while ironing. Vileda Professional decided that this bottle is not longer acceptable for their customers and the end-user of this product. Furthermore, Vileda Professional does not have a dosing jug in their assortment. It is the company's strong whish to combine the functions of a Sprinklebottle and the functions of a dosing jug in one product. Summarized, the company Vileda Professional asked for a company-owned product design that is an improvement of the current Sprinklebotte that simultaneously fulfils on the functions of a dosing jug.

Figure 1.1. Left: The Sprinklebottle[2]; right: VoleoFlex trolley [3]

1.2 General Information

Potential market

According to the company, Vileda Professional is selling the Sprinklebottle in the Benelux countries as well as in the Nordic countries. The to be designed product will be first introduced on the markets in these countries as well. If the sales volume is acceptable and if it turns out that there is a need for the to be designed product in other countries, Vileda Professional can consider the products introduction on these markets as well. Potential sales volume in currently selling countries: Benelux 5.000 pieces and Nordics 25.000 pieces.

Only Vileda Professional has a Sprinklebottle. Competitors are offering trigger spraybottles. Taking this into account, volumes can grow. If a Sprinklebottle/dosing jug combination is developed, one can add up the volume for dosing jugs as well.

Pricing

The product will expand the product range on the market for the benefit of Vileda Professional. A first estimation of the company, of an end-user price, indicates that the products price should be lower than 10 Euro. This price is composed of 20% profit margin for distribution, 40% for manufacturing, material and logistics and 40% profit margin for the company, which leaves roughly 4 EUR for production costs of the new solution. The costs for this project are covered by the profit margin of earlier developed Vileda Professional products.

Customers and consumer

The customers of product series, services and methods, provided by Vileda Professional are companies that offer cleaning services. The consumers of the products, also referred to as the end user are cleaning workforces. The companies that provide cleaning services are selling the products and services, while the end user makes actual use of the products and services provided by Vileda Professional.

Wishes and requirements of both, customer and consumer are important to measure and to take into account while designing new products for the Vileda Professional assortment. The customer requires low price but durable products. Furthermore, the products and systems must be efficient in use. In this case, efficiency can mean to save labor cost. For instance, his can be achieved by for example lowering the

working time the, end user needs to fulfill applications. Therefore, it is important that products with higher pricing can compensate the extra costs through the time saved by work forces during performed applications.

In terms of efficiency, the current Sprinklebottle is not a perfect choice.

A perforated pattern, which is integrated in the cap of the Sprinklebottle enables the user to sprinkle detergent on surfaces. This pattern is arranged in a circle. This is not applicable for the applications and the product does not work well in its environments. The Sprinklebottle assists the end user in three main applications: Moistening mops, pre-soaking spots and sanitary cleaning.

The actions that take place, during the applications will be described later on. Anyhow, it takes too much time to complete the applications because of a non-optimal product that does not support such applications ideally. This can be an indication that using the Sprinklebottle is too time-consuming.

The consumer, who makes use of Vileda Professional products, must be protected against physical and mental stress, as well as health risks during working hours. In order to perform applications such as moistening mops, pre-soaking spots and sanitary cleaning, trigger spraybottles are used frequently. According to the company, such bottles produce pain in the wrist of the user. This is one reason why Sprinklebottles are used for these applications.The main reason for preferring the Sprinklebottles instead of spraybottles is that spraybottles can produce harmful aerosols. In a to be cleaned environment, detergent solutions need to be dispensed by a device on surfaces. Trigger spraybottles are common devices that dispense solutions in an effective manner. The problem that comes along, while using a trigger Spraybottle, is the generation of aerosol. Aerosol is a two-phase system that in this case consists of a liquid phase and the surrounding gas phase. Smoke, dust, fog, or mist can be described as aerosol[4]. The cleaning workforce should be protected against hazardous aerosols at undesirable concentration levels. Changing the design of a dispensing device can lead to a minimization of the creation of aerosols, e.g. by enlarging the liquid exit of the device. In comparison to spraybottles, the Sprinklebottle has an enlarged perforated pattern that does not create aerosols. Additionally, it is of importance that the product can be completely cleaned and disinfected so that it does not transport bacteria and viruses.

One key market of the Sprinklebottle are customer groups that provide cleaning services in Health Care Environments such as e.g. in Hospitals. According to Antoinette Baake, who is a Hygienist of the Bronovo Hospital in Den Haag, already 10 % of the Dutch citizen are carrying multi-resistant germs. The increase in multi-resistant germs in hospitals develops a problem. According to the specialist, bottles, filled with detergent can be bearer for germs because they cannot be cleaned with high temperature, cleaning generally is too difficult and they have a high number of small surfaces where sediments can develop. The Bronovo Hospital in Den Haag is exclusively using disposable detergent bottles. Throwing contaminated devices away only shifts the problem. The germs are not devitalized when the bottles are thrown away and now can come in touch with other environments and develop a higher population until the packaging will be most likely energetically recycled. In addition, cleaning spraybottles is time consuming, which can lead to mental stress and a lack of efficiency. The spray-unit of a trigger spraybottle consists of small and hardly reachable parts, e.g. pipes that nevertheless must be cleaned properly, see figure 1.2. To clean a trigger spraybottle, the cleaning supply must be washed off every part of the device. Solely cleaning of the bottle-unit does not lead to the desired cleanliness. Some particles of the unwanted cleaning supply are still left in the trigger-unit of the bottle. This means that the bottle has to be refilled with water and the trigger should be triggered a few times in order to make sure that the water cleans the unit from unwanted cleaning supplies.

In addition, the bottle must be easy to hold in one hand and if attached on a pocket or belt, it must not be too heavy. Therefore, Vileda Professional decided that the maximum content of the new Sprinklebottle must not exceed 750 ml. Simultaneously, there must be sufficient content available to ensure that the cleaning work force can operate the tasks properly. Due to this, the minimum amount of content is restricted to 500 ml.

The Sprinklebottle

The characteristics of the Sprinklebottle are specified below.

The Sprinklebottle is bought from the supplier, Doroplast in Sweden. In first instance, the aim of this bottle is to wet textiles while ironing but Vileda Professional consumers, use it as device that sprinkles detergent on surfaces.

Figure 1.3 shows the Sprinklebottle that Vileda Professional currently provides to their customers.

The Sprinklebottle has the following attributes

- Two components: cap and bottle
- Bottle is milky transparent
- Blue cap only
- Small holes in the cap in order to be able to sprinkle
- Clip-on cap

Dimensions of the Sprinklebottle

Total height: 179 mm

Max. volume: 470 ml

Figure 1.2. Spray-unit of a trigger spraybottle

Dimensions of the bottle

- Height: 170mm
- Water inlet: 30mm
- Upper top: 45 mm
- Lower top: 30 mm
- Diameter at center of the bottle: 58mm
- Diameter of the bottom: 65 mm

Dimensions of the cap

- Height: 9mm
- Width: bottom: 47mm, top: 45mm

Dimensions of the lip of the cap

- Width: 15 mm - 10mm
- Depth: 3mm

Perforation

- Circular pattern: diameter: 30mm
- Hole diameter: 1mm

Material

- Bottle and cap: PE-HD; resin code 2

Manufacturing

- Bottle: Extrusion blow molding
- Cap: Injection molding

Figure 1.3. The components of the Sprinklebotte

1.3 User-Product Interaction

Standard user-product interactions with respect to the Sprinklebottle demonstrate how the product is used and what tasks are required in order to fulfill an application. The information, needed to create the scenarios is collected by re-enacting the scenes and the information, is given by Vileda Professional [A1]. The main scenario is illustrated on page 17, figure 1.4. The user fills the empty bottle with detergent and will also be able to use it, according to the company for one of the following applications:

1. Moistening Mops
2. Pre-soaking spots
3. Sanitary cleaning

When the bottle is empty, it needs to be refilled or alternatively cleaned, if it must be filled with a different type of detergent. Therefore, the bottle must be disassembled, filled and reassembled again. While cleaning the bottle every disassembled part must be highly visible because of a risk of losing parts. The Sprinklebottle, reducing the risk of losing parts consists of only two parts. In addition, the smallest part, the cap is colored in blue to make it more conspicuous. The Sprinklebottle can be cleaned in a dishwasher or in a sink.

1. Moistening Mops

Vileda Professional provides cleaning solutions and systems. In the area of floor cleaning, such systems are e.g. Swep and ClickSpeed. Both are mopping systems. ClickSpeed makes use of disposable mops, while mops of the Swep system, figure 1.6,can be washed in the washing machine. The two systems of are pre-prepared systems. Pre-prepared systems need to be prepared before usage. To prepare a pre-prepared system, an amount of mops must be pre-wetted before the mops can be used. The mops are pre-wetted by a washing machine, or manually by the work force. After preparing the mops, the required amount of wetted mops is stored in a bucket on a trolley, until the mops are needed. This trolley is equipped with trash bags, buckets with clean and used mops, detergents in Sprinklebottles and/or Spraybottles, cloths and the mopping system, e.g. Swep or ClickSpeed. Vileda Professional trolleys are divided in two parts. The front carries detergents, buckets, clean cloths and clean mops; the back stores the trash bag, used cloths and mops. Sprinklebottles are used when pre-prepared mops are getting too dry, single mops need to be moistened again,

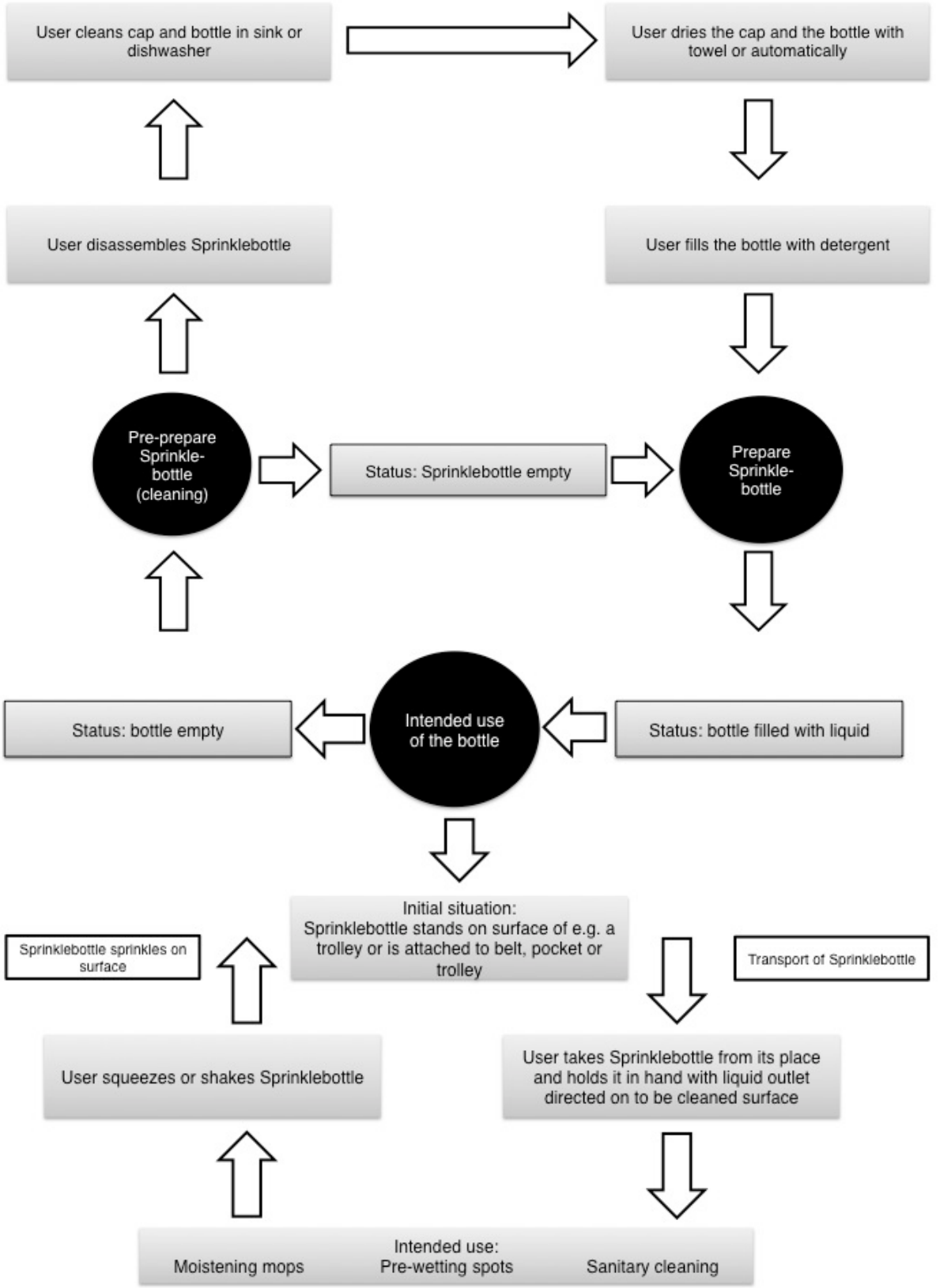


Figure 1.4. The main scenario, while using the Sprinklebottle

or dry mops need to be moistened to absorb dust, figure 1.5.

Sprinkling Shower

To moisten a single mop, the user manually operates the Sprinklebottle by squeezing or shaking. Through the circular perforations in the cap, the liquid pours out. Observation shows, the resulting shower is not optimal to moisten a mop, see figure 1.7. If the perforations would be aligned linear, instead of circular, a higher bandwidth could be accomplished. A mop has a length of 500 mm or 350 mm and a depth of 150 mm. The non-optimal shower induces non-uniform moistening. This results in too many pulls or strokes needed to get a moist mop. Furthermore, it is not possible to control the amount of sprinkled water per pull or stroke.

Movements

As mentioned earlier, Trigger Spraybottles can cause wrist pain. But, can the Sprinklebottle prevent pain and injuries in the wrist or can frequent use lead to pain in the shoulder, elbow, wrist and the fingers? It is important to analyze the movements that can occur in the joints, while fulfilling applications.
To sprinkle detergent, the bottle can be squeezed, shaken or both.
Shaking the bottle lead to the following movements in relevant joints:

Wrist:	Alternating ulnar deviation and radial deviation (1) pronation (2)
Fingers:	Constant flexion (1) (2)
Shoulder:	Alternating abduction and adduction (2)

Squeezing the Sprinklebottle is made possible by flexion and extension of the fingers. Shaking the Sprinklebottle can support squeezing.
Squeezing:

Finger:	Alternating flexion and extension (4) (5)

Squeezing & Shaking:

Wrist:	Alternating ulnar deviation and radial deviation (5)
Fingers:	Flexion and extension (4) (5)
Shoulder:	Alternating abduction and adduction (4)

Visualizations of the movements are displayed on page 21.

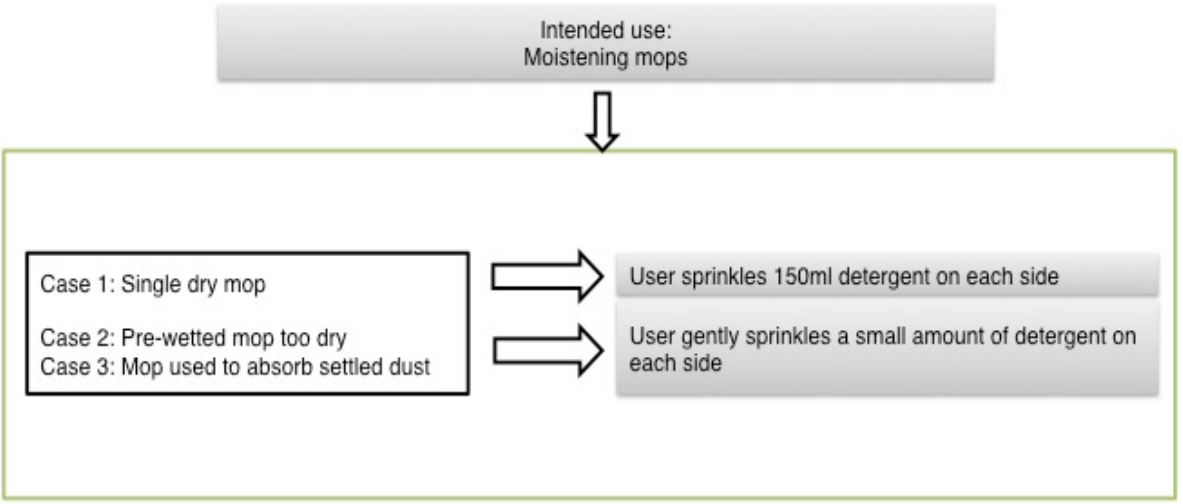


Figure 1.5. Visualization of the scenario for moistening mops

Figure 1.6. Swep Flat Mopping System[5]

Figure 1.7. Sprinkles produced by the Sprinklebottle

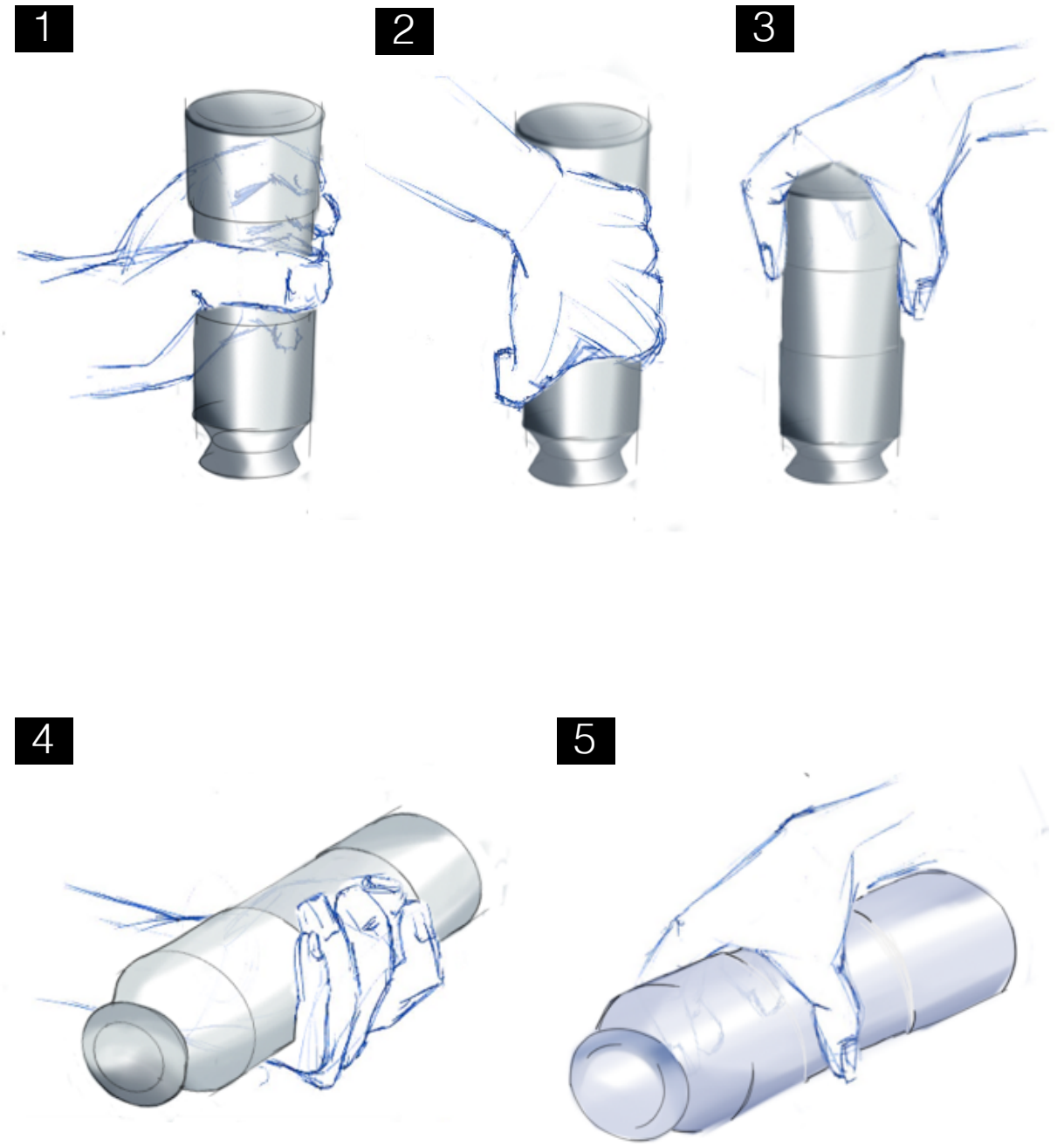


Figure 1.8. Possible movements in wrist and fingers

2. Pre-Soaking Spots

Cleaning work forces make use of the Sprinklebottle if dried dirt or a pool of liquid must be cleaned or disinfected. Therefore, the user sprinkles detergent on a certain spot. Detergent can be sprinkled on a horizontal or vertical surface by a shake or squeeze movement, see figure 1.9.

Sprinkling shower

The shower of the Sprinklebottle cannot be adjusted which can be a cause of using too much detergent. For some spots it would be handy to be able to adjust the water pressure, e.g. if dried dirt must be removed or if the user must sprinkle on a vertical surface.

Movements

Sprinkling detergent on horizontal surfaces by shaking

Wrist:	Alternating ulnar deviation and radial deviation (1); alternating flexion; and extension (3); pronation (2)
Fingers:	Constant flexion (2) (3) (1)
Elbow:	Alternating flexion and extension (2)
Shoulder:	Alternating abduction and adduction (2)

Sprinkling detergent on vertical surfaces by squeezing

Wrist:	Flexion (5)
Fingers:	Alternating flexion and extension (4) (5)
Elbow:	Alternating flexion and extension (4) (5)

3. Sanitary Cleaning

Sprinklebottles can also be used to clean toilets, sinks or a shower. Sprinkling can take place on vertical, horizontal and bended surfaces, figure 1.10.
Further equipment, such as cloth can be used to disperse the detergent.

Sprinkling shower

Bended, hard to reach surfaces require a device that steers detergent in a desired direction on a spot. The shape of the bottle makes it hard to reach surfaces e.g. bended edges under toilet seat. The current bottle has a short bulky neck. This makes it hard for the user to reach edges. A problem mainly occurring while cleaning toilets.

Movements

Shoulder:	Alternating abduction and adduction (horizontal)(2); alternating flexion and extension (vertical)
Elbow:	Alternating flexion and extension (4) (5)
Wrist:	Flexion (5)
Fingers:	Alternating flexion and extension (4) (5)

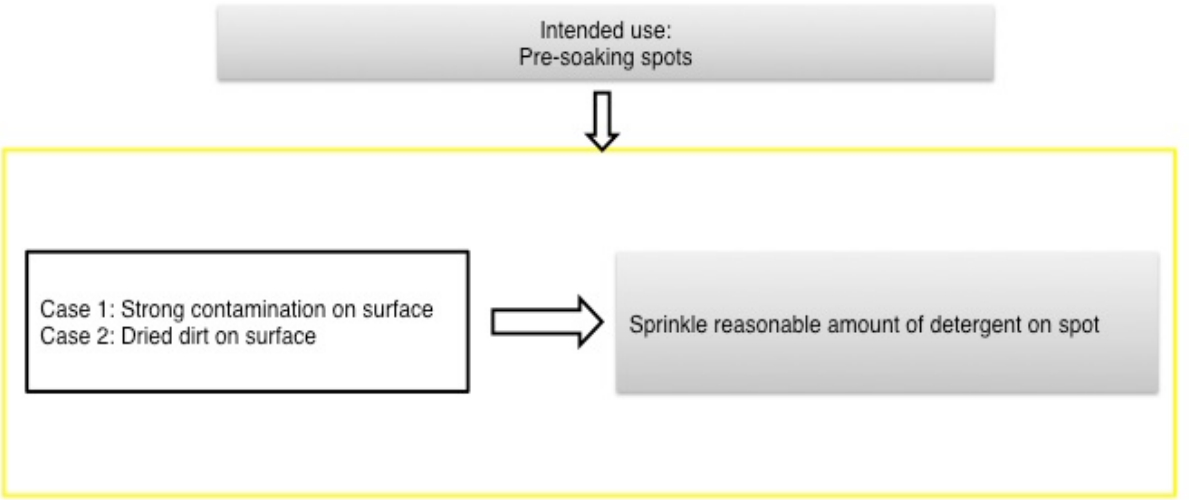


Figure 1.9. Visualization of the scenario for pre-soaking spots

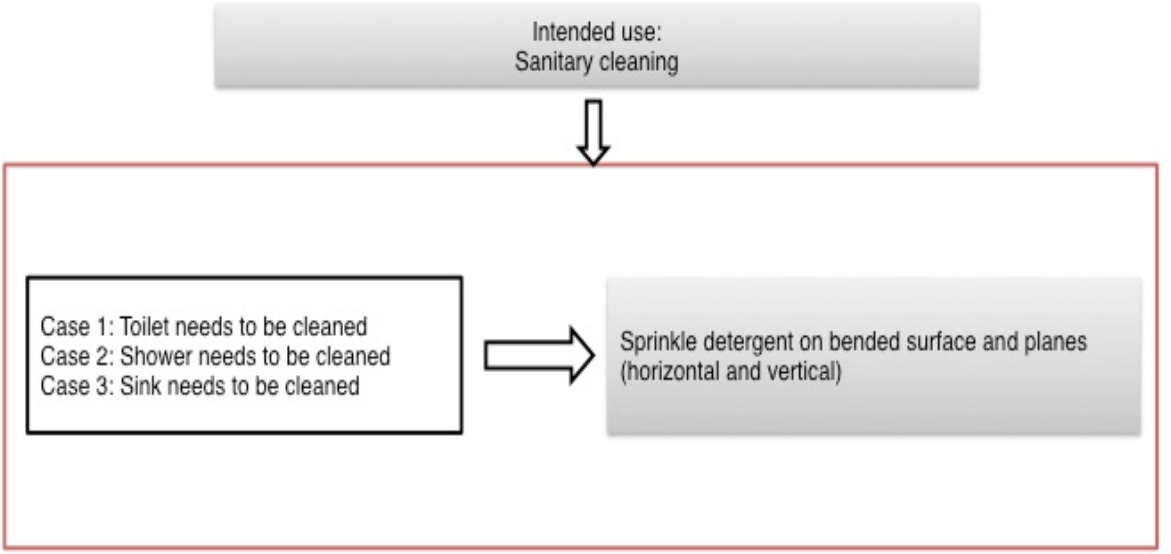


Figure 1.10. Visualization of the scenario for sanitary cleaning

1.4 Evaluation of the Sprinklebottle

The motion analysis shows that the use of a Sprinklebottle for certain applications requires different types of movement in relevant joints. This is beneficial because of more joints that are involved in the movements. This reduces the frequency of the movement per joint, see figure 1.11. However, the amplitude of movements is too high because the shape of the Sprinklebottle does not support the movements that are required in order to reach hardly reachable spots or surfaces. The shape of the Sprinklebottle does not support or reduce movements in the wrist and in the fingers. Using Spraybottles requires the same movements for each application. This implies that handling Spraybottles is more strenuous for the finger, than Sprinklebottles. Nevertheless, flexion and extension happens quite often while using Sprinklebottles. The fact that the Sprinklebottle is too difficult to squeeze exacerbates the problem. Squeezing is possible, but an unflavored combination of the symmetrical round shape of the bottle, the e-modulus and the material thickness makes squeezing too hard. An oval profile would ensure easier squeezing as well as material with a lower E-modulus or a lower thickness of the bottle. The material of the bottle is HD-PE and has an e-modulus of 1.07-1.09 GPa [A4], which is an average value for thermoplastic materials. The redesigned Sprinklebottle should support squeezing in a less strenuous way. Additionally, the overall shape of the bottle should decrease the range of movements in the wrist. In addition, while squeezing with too much force, the cap drops of easily. Moreover, too much force is required to link the cap with the bottle. An optimal scenario would be the other way around.

Sprinklebottle		Shoulder	Elbow	Wrist	Finger
Moistening mops	Shaking	Abduction Adduction		Ulnar deviation Radial deviation	Flexion
	Squeezing				Flexion Extension
	Squeezing, supported by shaking	Abduction Adduction		Ulnar deviation Radial deviation	Flexion Extension
Pre-soaking Spots	Horizontal sprinkling	Abduction Adduction	Flexion Extension	Ulnar deviation Radial deviation; Flexion	Flexion
	Vertical sprinkling		Flexion Extension	Flexion	Flexion Extension
Sanitary cleaning	Bended surfaces (horizontal & vertical)	Abduction Adduction; Flexion Extension	Flexion and Extension	Flexion	Flexion Extension
Action		Positioning		Sprinkling	

Trigger Spraybottle	Shoulder	Elbow	Wrist	Finger
Moisten mops; Pre-soaking spots; Sanitary cleaning	Abduction Adduction; Flexion Extension	Flexion Extension	Ulnar deviation Radial deviation; Flexion	Flexion Extension
Action	Positioning			Triggering

Figure 1.11. Comparison of movements in relevant joints while using the Sprinklebottle and trigger spraybottles

1.5 Market Overview

The most common replacement of a Sprinklebottle is a trigger Spraybottle. In fact, only one competitor has a product in their assortment, which can in some cases replace the Sprinklebottle. The company *TTS* offers a pre-prepared mop system comparable to the Vileda Professional systems. In order to moisten mops they are offering a bottle similar to a shaker for nutritional purposes. It has the shape and all functions of a shaker. Detergent can be poured over the mop.This is the only product found that moistens mops without a spraying. This bottle cannot fulfil applications like pre-wetting spots and sanitary cleaning, because no perforated pattern is added. For such purposes, the company is selling standard trigger spraybottles.

The company *CrispClean* provides a mop preparation system to moisten mops. This system does not require a bottle. For other purposes, they are also offering spraybottles, figure 1.12. In summary, no competitors offer a tool that aid cleaning of spots on surfaces, sanitary facilities and that moistens mops for pre-prepared mopping systems.

Figure 1.12. Selection of currently available bottles. Seen at ISSA/Interclean trade fair in Amsterdam on Mai-08- 2014

Figure 1.13. CrispClean mop preparation system. Seen at ISSA/Interclean trade fair in Amsterdam on Mai-08-2014

Figure 1.14. Selection of bottle-packagings for detergent[6,7,8]

Sanitary Cleaner

To reach small spots and bended surfaces, bottles often are relieved and bended at the top. The packaging of the sanitary cleaner from the brands Domol, Frosch and Sagrotan feature both, a bended neck with a relieved top. See pictures on page 29.

Do It Yourself Options

No fully comparable products to the Sprinklebottle are currently available. An observation in the St. Antonius Hospital in Utrecht, The Netherlands, showed that cleaning work forces reuse old detergent packaging to create a device that sprinkles a controllable amount of detergent through squeezing. Furthermore, they added instructions of how much detergent must be used for applications, see pictures on the right, see figure 1.15.

This points to the fact that there is a need for instructions referring to how much detergent must be used for applications. In addition, Vileda Professional mentioned the wish to combine the functions of a dosing jug in the product. According to them, this wish is of the highest priority.Due to these circumstances, the next part of this report gives information and a characterization of dosing jugs.

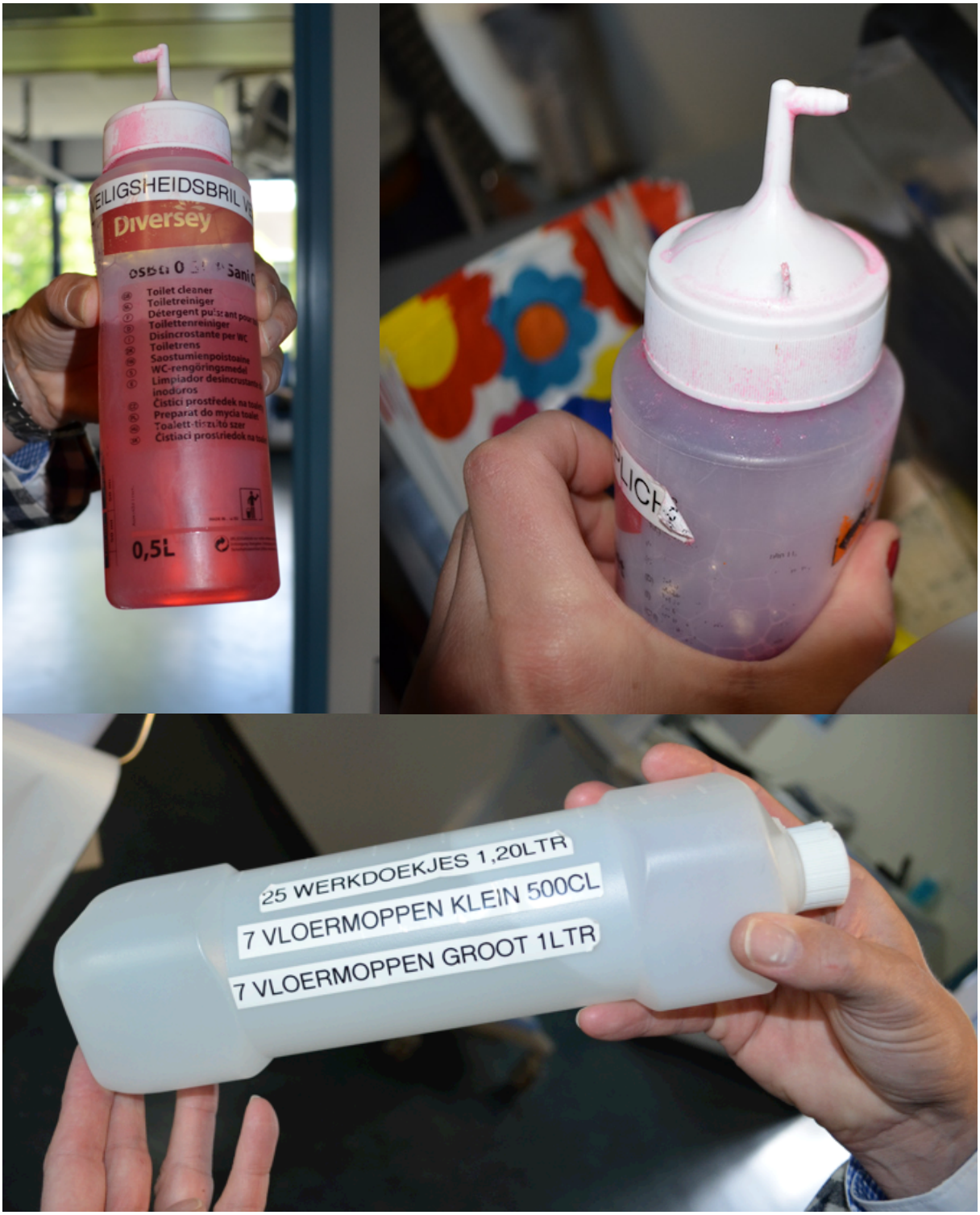


Figure 1.15. Re-used detergent packaging, seen in the S. Antonius Hospital in Utrecht, The Netherlands on Mai-15-2014

1.6 Integration of the Functions of a Dosing Jug

A dosing jug is used to measure and dispense an amount of content. See figure 1.16 for impressions.

A dosing jug has the following functions:

- Measure and dispense an amount of the reservoir capacity
- Refillable

To fulfil those functions, the following components are needed:

- Jug
- Dispense unit
- Measure unit

The main scenario is displayed on the right, figure 1.17.

It is also possible to measure and mix contents. A dosing jug indicates the amount of content in units for example in liter or milliliter, kilogram or gram. The amount of content should be easily recognizable. Furthermore, the user must be able to dispense a specific amount of content. Therefore, different considerations are possible. See figure 1.18 for impressions. Vileda Professional does not have a dosing jug in their assortment. Consumers need a dosing device to pre-prepare the mopping system. To pre-prepare such a system, 3-liter detergent must be poured over mops in a bucket.

Moisten Multiple Mops:

A bunch of mops need to be pre-prepared before starting with the application. Therefore, 3-liter detergent is needed and must be dispensed over the mops. Mops are in a bucket. In addition, while sprinkling on mops, spots or sanitary facilities, consumers need a device to measure and to control the amount of detergent.

It is of equal importance to be able to prohibit dispensation if not needed. Otherwise the product will leak in unwanted situations. Unwanted situations could be:

- Bottle is placed on trolley and tilts over
- Bottle is hanged on trolley, pocket or belt; through movements, bottle tilts until liquid pours out

On page 35 is illustrated how the functions of a dosing device are integrated in the scenarios of the main applications: Moistening mops, pre-soaking spots and sanitary cleaning.

Figure 1.16. Visualization of the functions of a dosing jug[9, 10, 11, 12, 13]

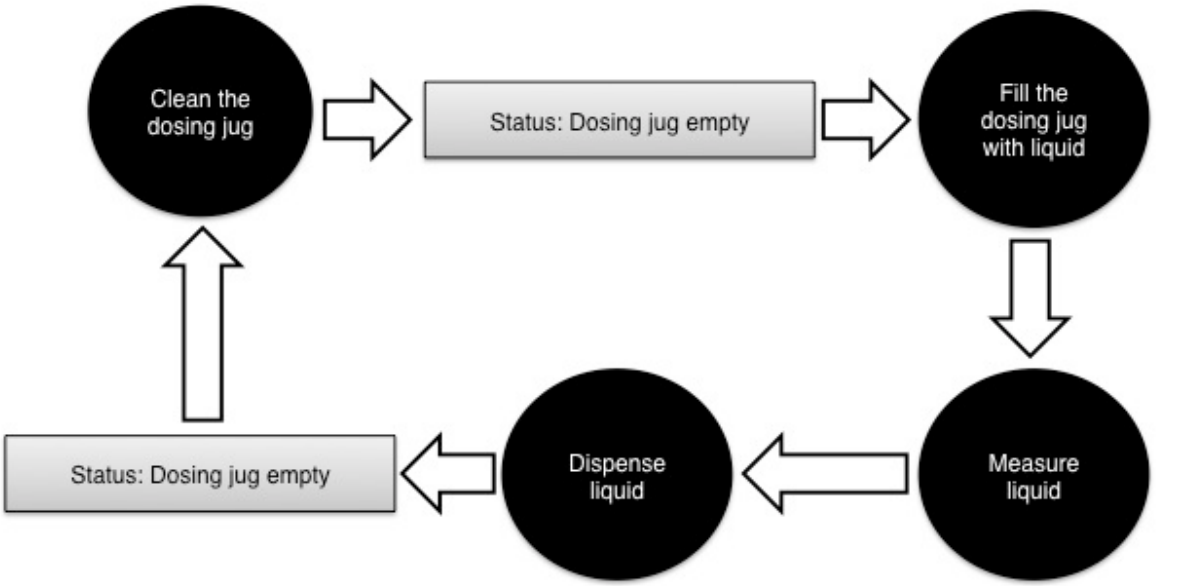


Figure 1.17. Basic scenario for using dosing jugs

Moisten single mop

For some systems, mops can be used with both sides. To moisten a single mop, each side of the mop should be moistened with 150 ml detergent. This is the amount needed for wet-mopping floors. Mops are also needed to clean floors from dust. In this case, the mops must be wetted with less detergent. Equivalently, a smaller amount of detergent is required.

The Sprinklebottle does not give feedback about the amount of dispensed content. A dosing jug could represent a system that enables the user to control the amount of sprinkled fluid.

Figure 1.18. Collection of dispense mechanism [14, 15, 16, 17]

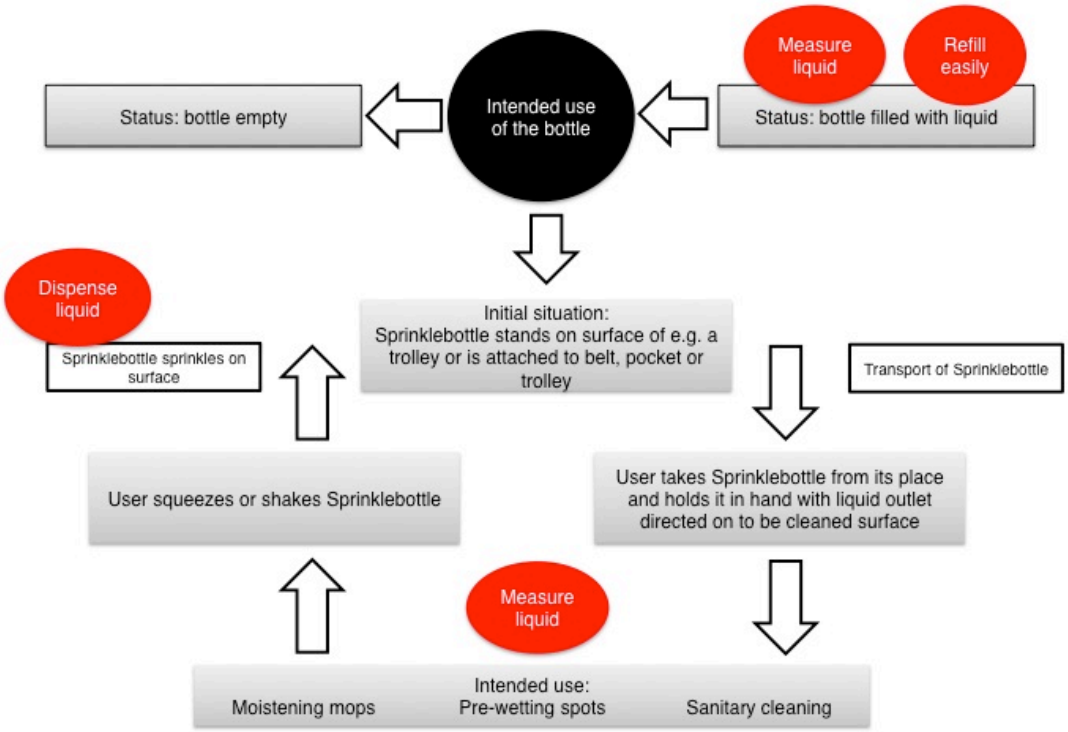


Figure 1.19. Dosing Jug mechanism integated in cleaning scenario

1.7 Design and Styling of the Product

The desired design and styling of the product evolves by involving functional requirements as well as Vileda Professionals aesthetic design guidelines.
On the one hand, the new product must have no surfaces that cannot be cleaned through rinse thoroughly with warm water, eventually mixed with disinfectant.
Therefore, the design of the product must not contain small surfaces with edges being hard to reach. Thus, surfaces and edges where layers of sediments can develop are not suitable. Those sediments remain after cleaning in dishwasher or after cleaning by hand. In addition to the shape of the product it must be possible to reach small and bended surfaces that are hard to reach. Such surfaces or edges require more movements by the user or a thin or powerful device that is able to reach them.
Furthermore, the new Sprinklebottle with the functions of a dosing jug will be a part of a complete series of Vileda Professional products. Therefore, the product must be recognizable as a product of Vileda Professional. Vileda Professionals specific design guidelines that must be taken into account while designing the product are:

Universal Guidelines

- Ergonomics lead to user-friendly design
- Aesthetics lead to high attraction
- Functionality leads to the best performance

- Lines must meet in a radius
- Handles must have smooth transitions and waist
- Walls end with a radius

- Proportion of shapes, see figure 1.20
- Color system
- Color and Surface
- Brand

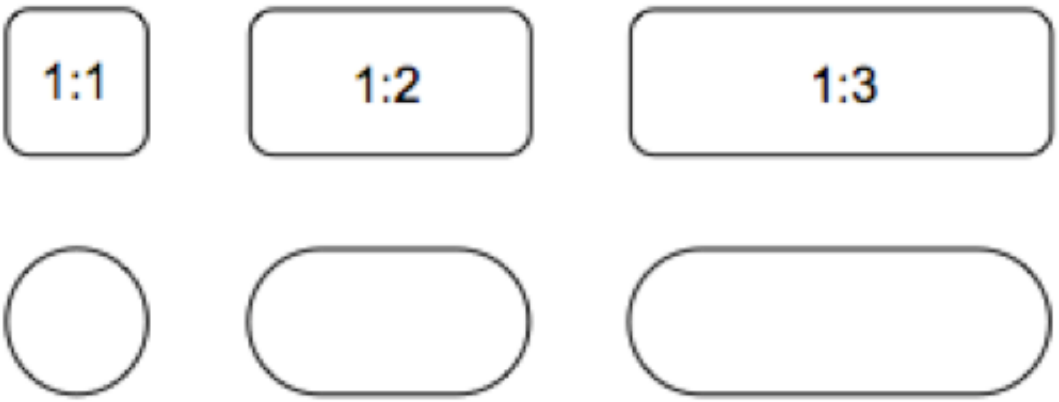


Figure 1.20. Proportion of shapes Vileda Professionals products must have

Figure 1.21. Top of a trolley after a work shift. Seen at St. Antonius Hospital in Utrecht, The Netherlands May-15-2014

The new Sprinkebottle must fit to the cleaning systems and product series of Vileda Professional. The Sprinkebottle is used within the environment of trolley cleaning systems. Trolleys carry products such as cloths, mopping systems, buckets, dirt bags and different types of detergent. Detergent can be stored in a Sprinklebottle.
In a busy work environment, it is conceivable that the need arises to manage and store recently used products quickly. The picture on page 37, figure 1.21., shows an equipped trolley after a half day of work. It can be imagined that the Sprinklebottle is not always placed on a constant, designated position. Many positions a bottle can stand or hang on are
feasible. Sprinklebottle does not include a device that enables the user to attach the bottle on a pocket or a belt or to hang it up on a trolley. Trigger Spraybottles do have this advantage, see figure 1.22 for an example of an attached Spraybottle. It makes it a lot easier to operate and to stop operation with the bottle in a fast manner. The trigger allows the user to attach the bottle on almost every tube or profile.
The profiles of Vileda Professional trolleys have a rounded oval shape with a maximum diameter of 30 mm.

Figure 1.22. Trigger spraybottle attached on trolley. Seen at St. Antonius Hospital in Utrecht, The Netherlands May-15-2014

Color system

Color-coding is an essential and intuitive way to explain the work force within which background a product can be used or which detergent is located in which bottle.
In relation to the to be designed product, four basic colors can be used to indicate which content is suited for the applications. The Sprinklebottle does not provide color-coding yet. Vileda Professional products often include the following four signal colors, figure 1.23, that can be used with respect to their scope of applications:

Red:	Sanitary
Blue:	Interior
Green:	Floor
Yellow:	Others

In conjunction with the beforehand analyzed applications, it is advisable to make use of the red, green and yellow coding to distinguish sanitary cleaner from e.g. water and disinfectants.
Color-codes must not be used twice on one product. Furthermore, the color-coding must be always visible. Independently from where and how the bottle is placed.

Color and surface

All figures on page 41 and 43 are an extraction of the *Vileda Professional design world – smart balances product architecture*.
It is important to assign the material quality and color with respect to the parts place and function.

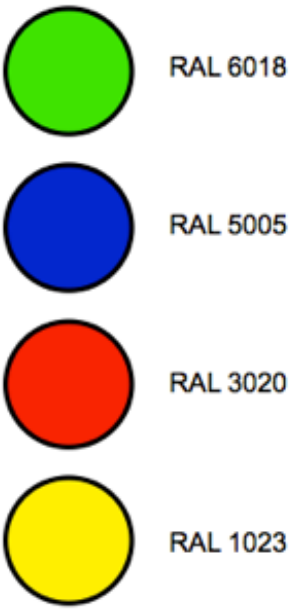


Figure 1.23. Color-coding with signal colors. Extraction of the *Vileda Professional design world – smart balances product architecture, p.20* [18]

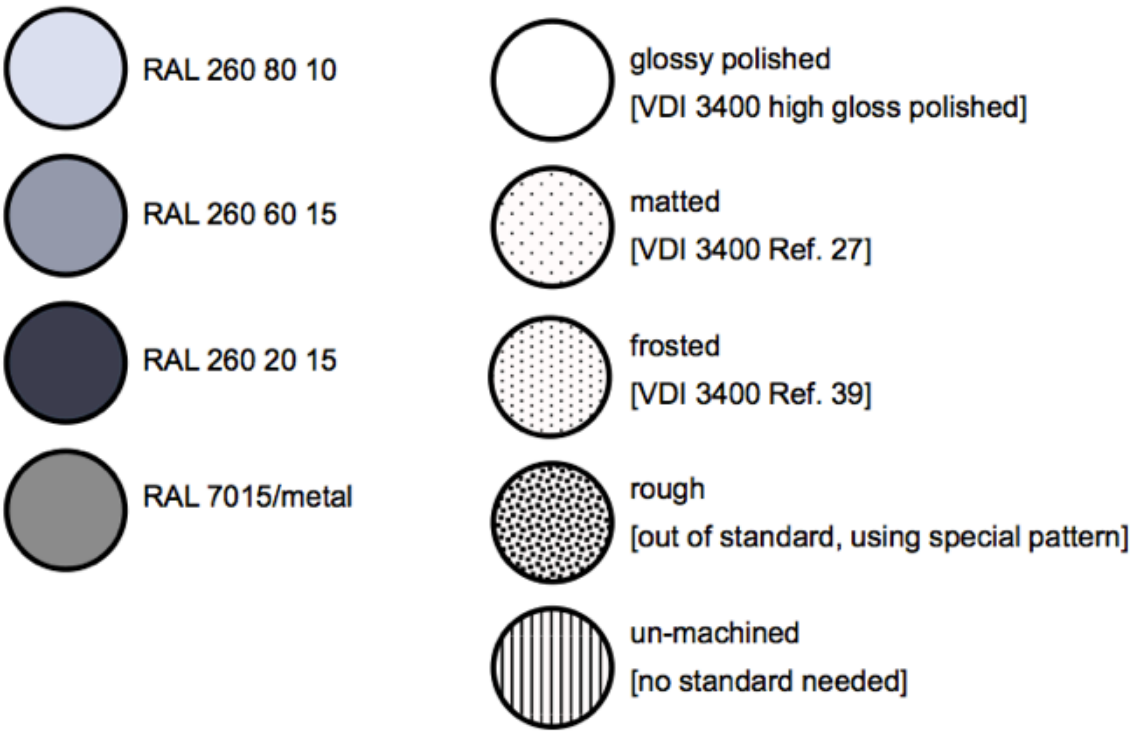


Figure 1.24. Color-coding and surface quality. Extraction of the *Vileda Professional design world – smart balances product architecture, p.42* [18]

The importance of content declaration

Besides declaration of the type of detergent by signal colors such as red, yellow, green and blue, the product has to offer space for a detailed declaration of the detergent. The most common way to declare the content of a bottle is by adding a sticker, which includes additional information about the content of this bottle.

According to the Classification, Labeling and Packaging (CLP) regulation, it is prescribed to label substances and its classification on a packaging. Even though the Sprinklebottle is not a disposable product, it may or may not carry hazardous content. In this case it is even more important to transfer this information through a label. On the label, the following information should be given[19]:

- Hazard pictograms
- Product identifiers
- Signal word
- Supplier identity
- Hazard statement
- Precautionary statements

Placement and dimensions of the logo

The bands logo can be printed or embossed on Vileda Professional products.

The printed red logo is used for first communication of the brand and can be found on trolleys, buckets, mop boxes and tubes.

The embossed logo can be found on frames, trays, lids and sieves and is used to sign the products. Depth of embossment: 0.2mm.

The logo must be placed very prominently on the product and is always positioned at the upper right. On 2D surfaces, as well as on 3D surfaces, e.g. tubes.

The embossed logo is not suitable for the to be designed product. Development of sediments at the embossed surfaces and edges is most likely. In this case, a product must be developed that must be easy and fast to clean. It is advisable to make use of the printed, red logo.

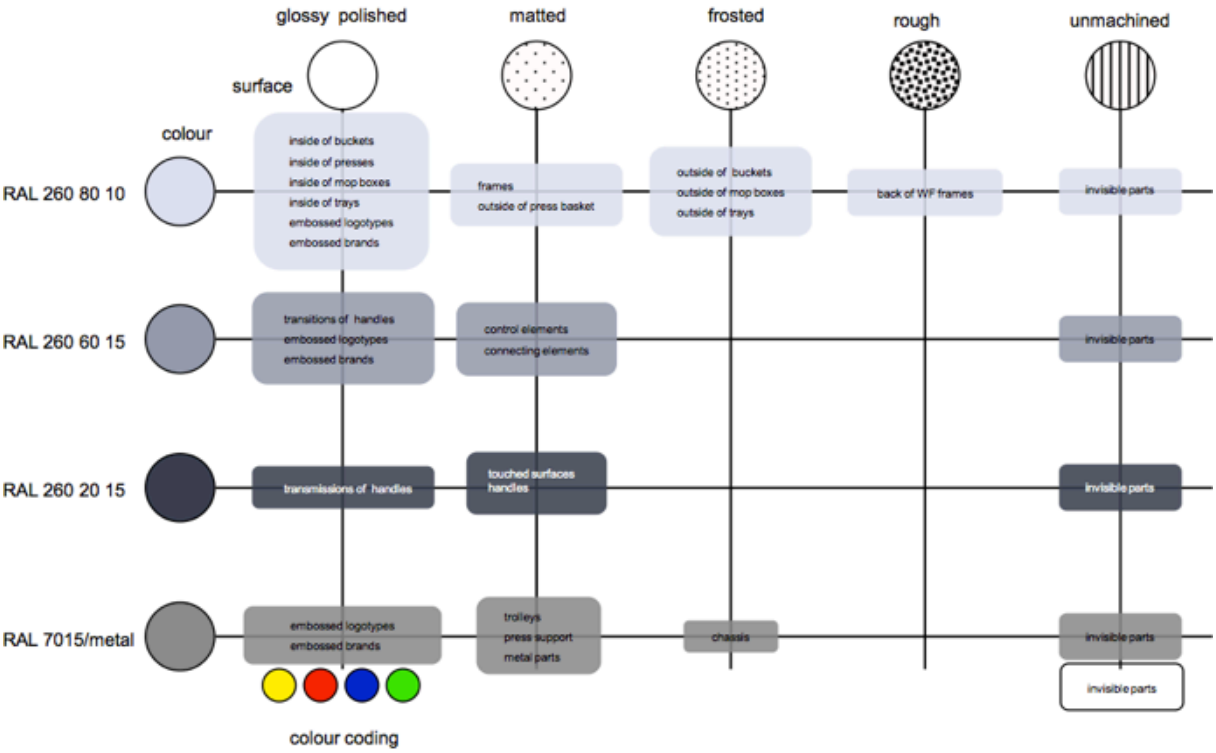


Figure 125. Color-coding, surface quality and location. Extraction of the *Vileda Professional design world – smart balances product architecture, p.43* [18]

Figure 1.26. Dimensions of the logo. Extraction of the *Vileda Professional design world – smart balances product architecture, p.45* [18]

1.8 Material Properties

The Sprinklebottle, which is currently provided by Vileda Professional is made of the material PE-HD. In the following, properties and critical values are determined which the material of the new Sprinklebottle must fulfill.

material of the redesigned Sprinklebottle must fulfill. The Sprinklebottle must be made of thermoplastic plastic in order to be able to avoid long production times and higher tooling cost. Production processes that can come into consideration are injection molding, injection blow molding and extrusion molding. Furthermore, the material must be squeezable. Flexibility can be achieved by modifying the shape of the products bottle, the material thickness and by proper material attributes such as a low e-modulus. In addition, the material must resist high temperatures. Microorganisms increase at temperatures between 5 and 65 degrees Celsius[20]. To disinfect the Sprinklebottle, detergents and high temperatures are required. The material must be stable at temperatures between -10 and 70 degrees.

To clean the Sprinklebottle as to use the Sprinklebottle as a cleaning device, detergents are needed. It is not possible to give a reliable assertion on what detergents will be used for the applications. The material must be resistant against possible detergents. One has to calculate with strong acid because strong acids as chlorine have the most effects on the material properties. Even if strong acids shall be used less often, the material must be imperishable against strong acids such as chlorine.

The bottle-unit of at least one division of this unit must be semi-crystalline to ensure that the current amount of fluid is always visible.

Materials that must not be used for production

According to the company it is not appropriate to use PVC because of its poor ecological profile. In addition, the precursor, vinyl chloride as well as compounds that are used during PVC production can cause cancer and transformation of genetic material[21]. The Sustainability plan “We all take care” of the Freudenberg group provides amongst others protection of employees that are involved in manufacturing processes[22].

1.9 List Of Requirements And Wishes

As a summary of the previously described observation and analysis, a list with requirements and wishes is compiled. This list represents the framework for developing the concepts.

Requirements

1. The product must be able to store liquids
2. The product must be able to sprinkle liquids
3. Every surface of the product that can come in touch with fluid must be able to be cleaned in a sink or a dishwasher
4. The product must be able to be produced by mass production
5. The product must not produce aerosols
6. The end user price must be lower than 10 Euro
7. The product must be cleaned faster than a trigger spraybottle
8. The product must assist a work force while moistening mops, pre-soaking spots and sanitary cleaning
9. The product must not leak liquids while tilting
10. The user must be able to hold the bottle in one hand
11. The maximum content must not exceed 750 ml and must not be less than 500ml
12. Using the product must not cause pain/stress injuries in relevant joints of the end-user
13. The product should decrease the performed range of movements in the wrist
14. The product must not contain small, easy to lose parts
15. It must be easier to put on the cap, than to put off the cap
16. The cap must not drop off if not wanted
17. The current amount of content must be always visible
18. The product must enable the user to pour liquids on desired spots or surfaces
19. The product must sprinkle fluid through squeezing and/or shaking
20. The product must be squeezed easier than the current Sprinklebottle

21. The top of the product must be bended and relieved
22. The product must give instruction on how much fluid is needed for an application
23. The product must mirror the current amount of liquid by a unit
24. The product must enable the user to pour a desired amount of content over a surface
25. The product must be able to stand independently on a flat horizontal surface (filled and empty)
26. The lines of the product must meet in a radius
27. Walls of the product must meet in a radius
28. The products dimensions must meet the following proportions: 1:1, 1:2, 1:3
29. Same color-codes with respect to an identification of content must only be used once
30. Color coding with respect to the identification of content must be visible at all times
31. Shadings and textures of material of parts must be assigned to specific functions and location of the part
32. The product must offer space to place a sticker with additional Information about the current content
33. The logo must be placed prominently with a minimum width of 30mm
34. The logo must be printed on the product
35. The material must be printable
36. The product must be made of a thermoplastic material
37. The Material must be at a minimum of one part transparent
38. The Material must be imperishable against strong acids
39. At least one part of the product must be squeezable
40. The material of the product must not be PVC

Wishes

1. The product shall be able to attach the product on pocket, belt or tubes or profiles of a trolley
    a. The attachment device shall be able to attach the product on a profile with a maximum diameter of 30mm
    b. The attachment device shall be able to attach product with second device and can preserve while movements of the second device or the product itself
    c. Handles must have smooth transitions and waist
2. The product shall provide a cap closure-system
    a. The closure system must not contain hard to reach and/or small parts and surfaces

CHAPTER 2

Designing the Concepts

This chapter gives insight about the design process from collecting ideas to combining them into concepts. Evaluation of the concepts leads us to subsystems, which then are combined to create the final concept.

2.1 Concept Development

Introduction

The previous section of this report provided information about the background of the product and thought-provoking impulses to support the design decisions that must be taken and ended with an extensive list of requirements for the to be designed product solution. This section guides through the process of concept development and at last discloses the final concept. Because of the complexity of requirements, the concept development started from the most important requirements for the desired solution, which are listed below:

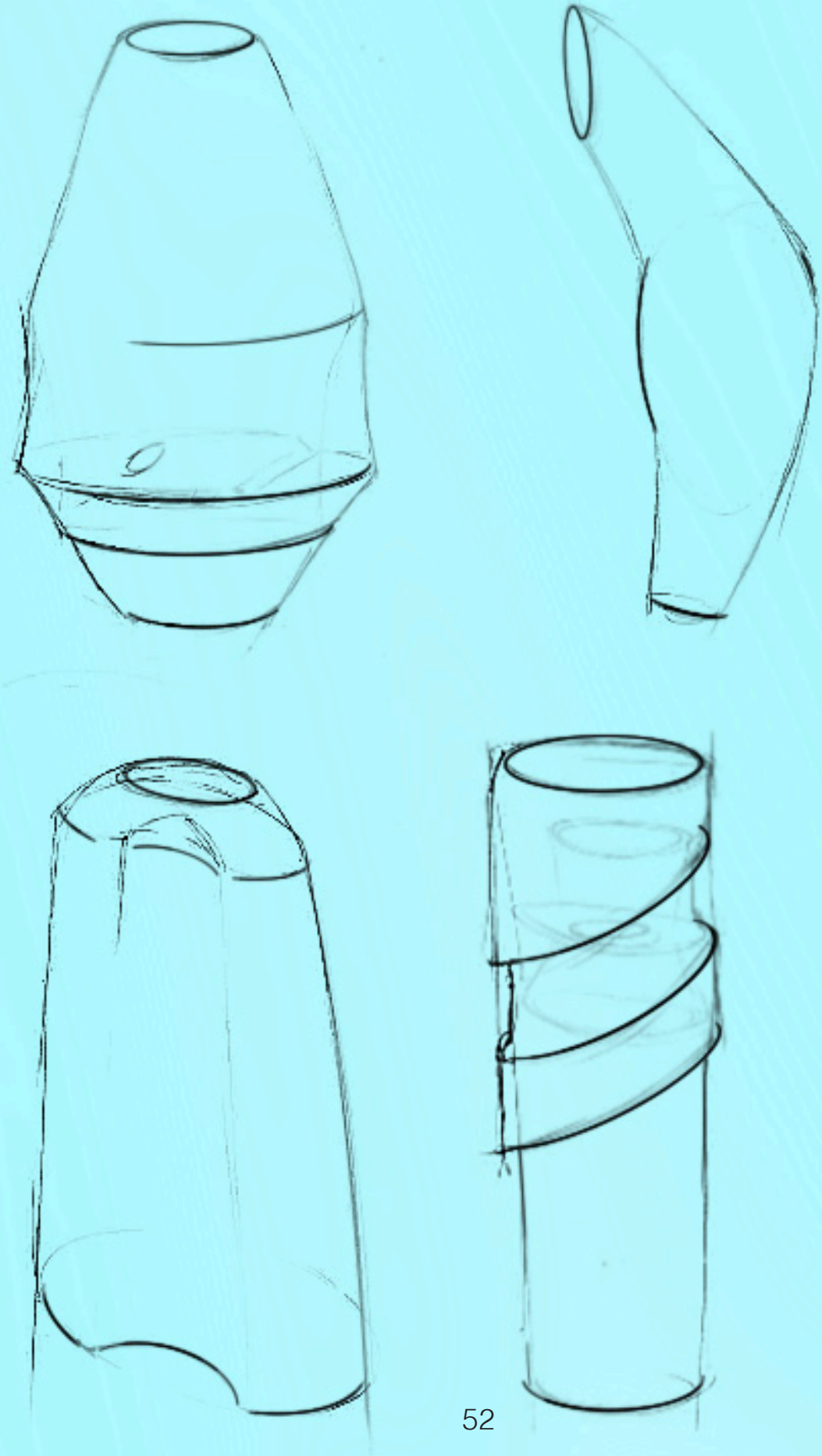
1. The design solution must include a bottle with a squeezable and shakable part, showing how much content is currently available and that can be refilled and cleaned fast and easily
2. The design solution must include a removable cap alike part with a perforated pattern to enable sprinkling. Additionally, it must be cleaned fast and easily
3. The design solution must include a possibility to link both parts together without leaking
4. The current amount of liquid must be translated in a unit-language

The following features should be included:

a. The design solution should include an attachment-system
b. The design solution should include a closure-system

The market overview points out that there are no comparable products currently available that combine all these features in one product. Possible design solutions are not predetermined. To develop concepts that can achieve these functions, they will be examined separately. Hereby, a pool of ideas is generated that offers separated solutions for feature 1, 2, 3 and 4, as well as for possible features a and b. Out of this pool of generated ideas, three concepts can be developed that in first instance can achieve the functions and can in first instance be compared with each other, by making use of the list of requirements and wishes. A selection of the pool of ideas is unveiled on the following pages.

Figure 2.1. Inspirational approach: Product experience inspired by nature[23]



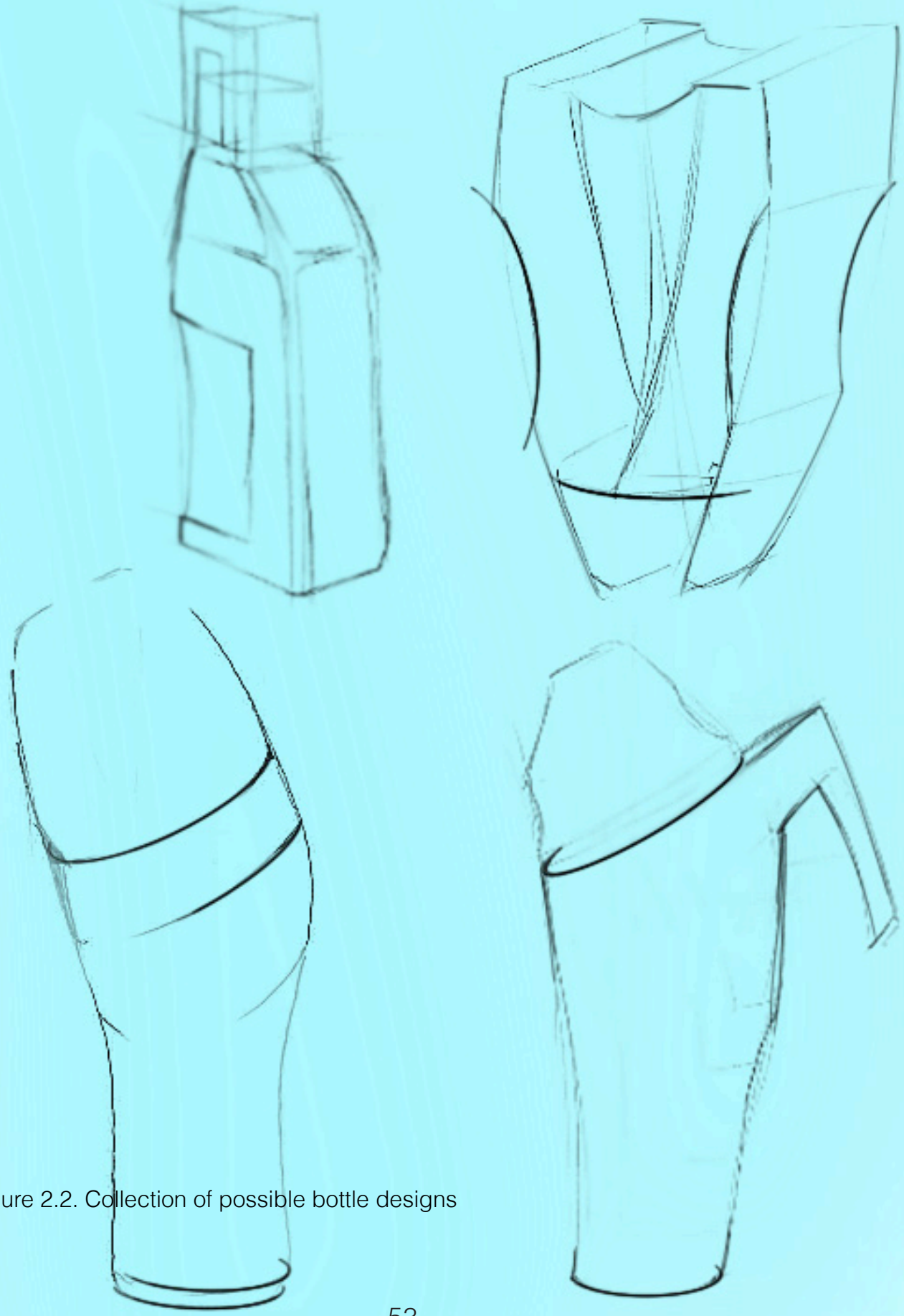
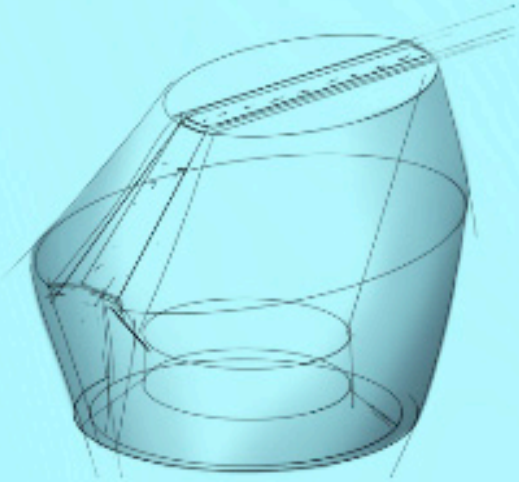
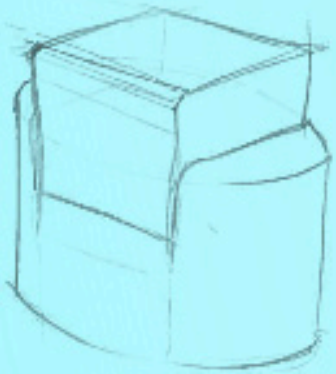


Figure 2.2. Collection of possible bottle designs





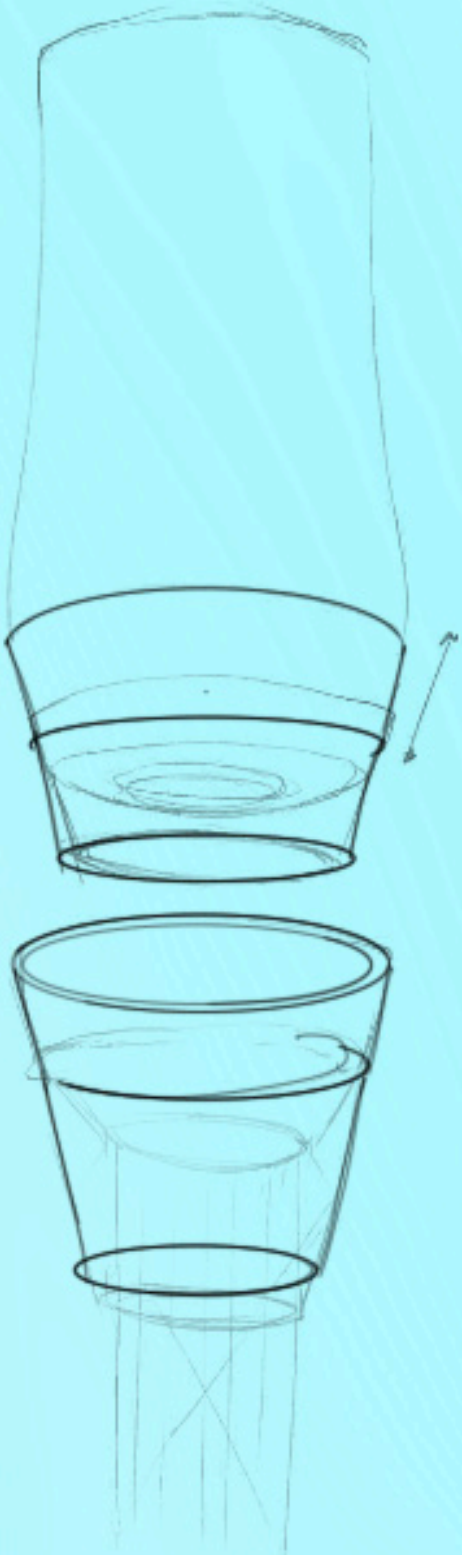


Figure 2.3. Collection of possible cap designs


150

Figure 2.4. Collection of possible measurement systems

2.2 Introduction Of The Concepts

Out of the partial solutions, three concepts are generated and will now be discussed on the following pages. They do all approach the as preferential contemplated requirements in a different manner. The first concept approaches the current Sprinklebottle the most, while concept 2 is designed without taking the current usage and shape of the Sprinklebottle into account. The third concept is a more visual and functional approach of a dosing jug. The concept can be placed between concept 1 and 2 pertaining to the functional and visual distance to the current Sprinklebottle.

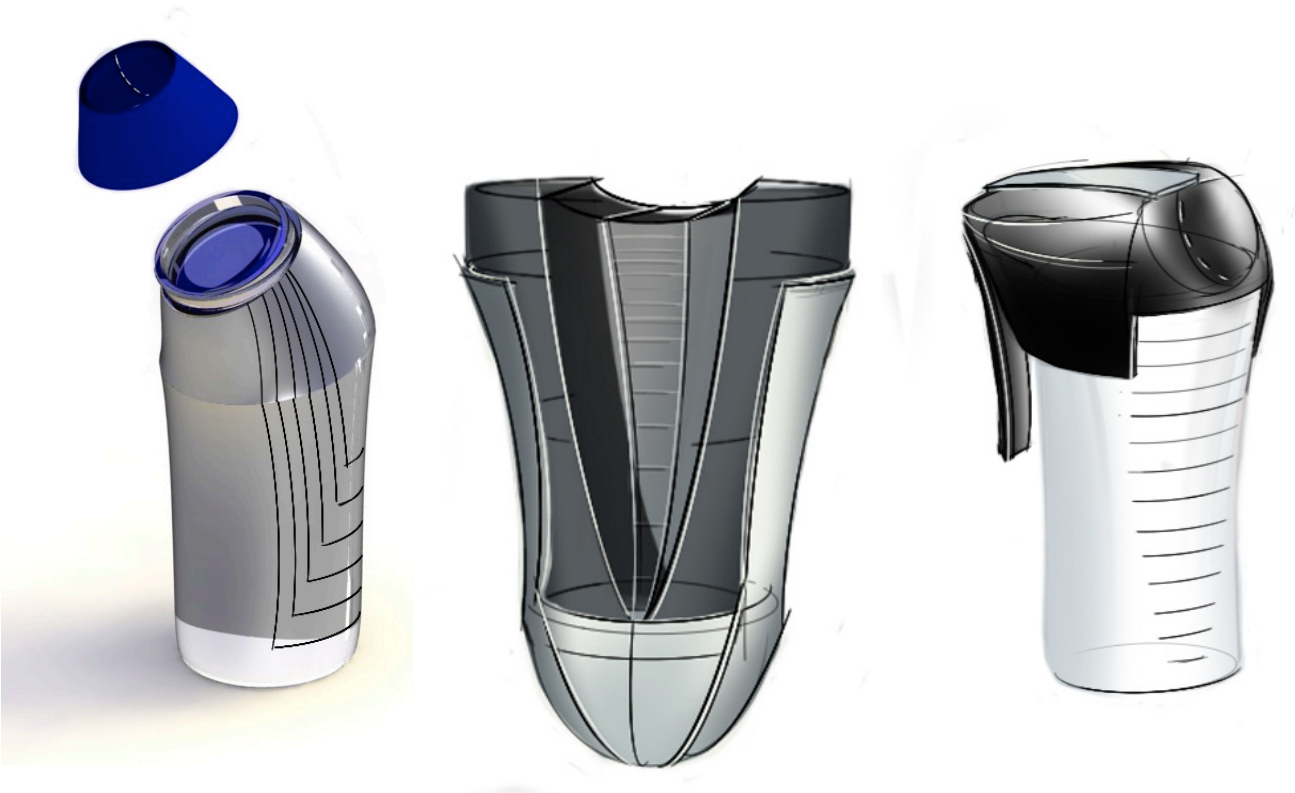


Figure 2.5. From left to right: Concept1, concept 2 and concept 3

Concept 1

The first concept is composed of two parts, a cap and a bottle. It is the concept that approaches the current Sprinklebottle the most.

The bottle features the following functions:

- The transparency of the material allows the user to constantly check the current amount of detergent in the bottle
- The horizontal stripes allow the user to translate the current amount of detergent in milliliters while holding the bottle vertical or while bottle stands on even, horizontal surface
- The vertical stripes allow the user to translate the current amount of detergent in milliliters while holding the bottle horizontal or while operating applications
- The big opening at the top enables the user to refill the bottle easily
- The round shape of the opening allows putting the cap on by screwing

The cap supports the following features:

- The top of the cap is made of flexible material to support switching between two different kinds of showering
- Adjustment of the size of the shower through pressing the upper surface in or out
- Wide spread of sprinkles when top of the cap is not pressed in
- When top of the cap is pressed in, the width of the spread is reduced
- On the bottom, the cap has a round shape, ensuring that the cap can be screwed on the bottle

Figure 2.6. Visualization of concept 1

Concept 2

As the first concept, concept 2 is composed of two parts, a bottle-unit and a cap. The second concept is the one that differs the most from the current Sprinklebotte with respect to shape and the functionality.

The bottle-unit features the following:

- Unit is squeezable
- The horizontal stripes allow the user to translate the current amount of detergent in milliliters while holding the bottle vertical or while the bottle stands on even, horizontal surfaces
- Two extensions on the bottle-unit disable leaking, while the device is not used.
- This unique cap-closure system activates sprinkling when bottle-unit is squeezed in. The two extensions will digress from the concepts cap. If the bottle is squeezed, the fluid content sprinkles out through the cap

The cap features the following functions:

- Through the perforated pattern, fluid content is able to sprinkle out of the device
- Cap and bottle can be connected through a screw-connection

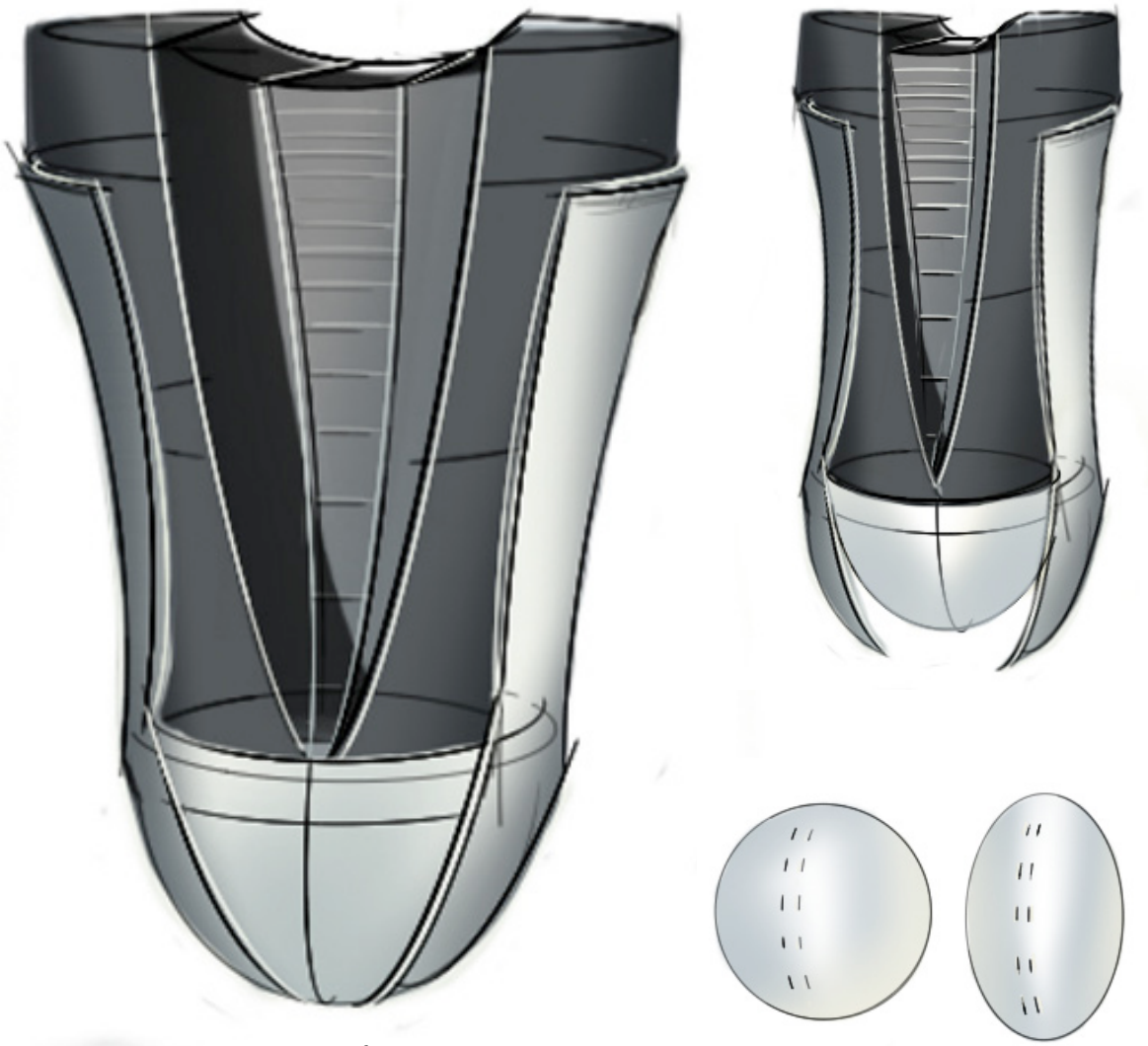


Figure 2.7. Visualization of concept 2

Concept 3

This concept, which consists of two parts, a jug-unit and a cap is a more visual and functional approach of a dosing jug. It also supports necessary functions of the Sprinklebottle.

Features of the jug-unit:

- The jug can be attached on trolley, pocket or belt
- The horizontal stripes allow the user to translate the current amount of detergent in milliliters while holding the bottle vertical or while bottle stands on even, horizontal surface
- Through shaking of the device, detergent sprinkles out

The cap features the following functions:

- Two different shower options are available
- The not needed shower option can be blocked through a locking-device
- The cap and the jug can be connected by a slide connection

Figure 2.8. Visualization of concept 3

2.3 Evaluation

Evaluation of the concepts according to the list of requirements and wishes

To evaluate, which concept is the most convenient, all of them are compared with each other by a comparison with the list of requirements and wishes. If a concept achieves a requirement, it gets the value 2, if it is at the moment not possible to evaluate whether a concept can achieve a requirement or not, it gets the value 1. If a concept does not achieve a requirement, it gets the value 0.

The results of the comparison of concept leads to the following results:

Value	**2**	**1**	**0**	**Total**
Concept 1:	24	15	1	63
Concept 2:	18	16	6	52
Concept 3:	14	20	6	48
Wishes:				
Concept 1:	0	2	0	2
Concept2:	0	2	3	2
Concept 3:	2	3	0	7

The complete comparison can be found in the appendix A1.

Evaluation according to the list of requirements is a very useful tool to control whether the concepts fulfill on the functions as well and whether the concepts can integrate in their environment or not. Additionally, the potential risks must be evaluated as well. After a discussion with the project supervisors of the company and the university, it turned out that evaluation based on the list of requirements can indicate which concept achieves most of the requirements, but it cannot evaluate possible risks that can occur. For this reason, an additional evaluation, based advantages and disadvantages of the concepts is made with the goal to reduce the risk of product and project failure. Therefore, advantages and disadvantages with respect to the concepts are summarized. To evaluate the concepts by possible disadvantages, the negative points must be categorized and organized. Value (–) indicates that a disadvantage cannot get solved within the scope of this project.

The value (+) describes that the problem is present but there are several options that can be developed to solve the issue within the scope of this project. In addition, the number of advantages will be taken into account during evaluation as well.

Concept	Disadvantage		Value
1.	-	No cap-closure	+
	-	No attachment-system	+
	-	Shower-adjustment system not tested, yet	+
	-	Durability of shower-adjustment system unknown	-
	-	Stability of shower-adjustment system unknown	-
	-	If top of the cap is pressed in, one has to disconnect cap with bottle to switch back to wide spread-shower	+
	-	While squeezing the bottle, it can be possible that pressed-in cap switches back to wide spread shower automatically	+
2.	-	Sprinkling only possible if bottle is squeezed	-
	-	Cap-closure mechanism not tested	-
	-	Insufficient space to place a sticker on bottle-unit	+
	-	Difficult to put on the cap	+
	-	Cleaning time of the product increased through hard to reach edges between extensions and rest of the bottle-unit	-
	-	No attachment-system added	-
	-	The shower cannot be adjusted	-
3.	-	Closure per shower option require an additional small locking device that can become lost easily	+
	-	The jug is less squeezable than the bottle-units of concept one and two	-

Concept	Advantage		Value
1.	-	Possibility to adjust the shower	2
	-	Squeezable bottle	
2.	-	Probably no leaking, if bottle is not in use	1
3.	-	The styling of the product and a dosing jug resemble each other in appearance.	2
	-	The functions of a Spinklebottle are added to the product, which can lead to an increased end-user price and a higher profit margin for Vileda Professional	

It seems that at this stage of development, concept 1 and concept 3 are most suited for further development. This statement is based on the evaluation of the concepts by comparing them with the list of requirements, the classification of disadvantages and the number of advantages.
Concept 2 has a new look and an innovative functionality but within the scope of this project, it is less likely to turn this concept into a fully functional product. Concept 1 and concept 3 are currently no perfect solutions as well. But both have a higher probability that developing into fully functional products within the scope of this project is possible. For this reason, both concepts will be further developed. The aim of the further development is to reduce disadvantages and to generate more advantages, as well as reducing the risks of failure. Furthermore, concept 1 and concept 3 will no longer be treated as individual concepts but the parts of the concepts will be treated as sub-concepts. This enables combining sub-concepts and makes the generation of hybrids possible. A hybrid is a concept that combines features of both concepts that can but must not be a better solution.

2.4 Testing

For further development, both sprinkling mechanisms are tested for their respective functionality. Therefore, simplified shapes of both options are printed in 3D. The models feature a screw connection and can be connected with a 0.5 liter PET-bottle.

Flexible surface mechanism:	Two models represent the two types of showers. It is tested whether the sprinkling focus mechanism and the wide spread mechanism are functional.
Locking sprinkling mechanism:	One model represents this mechanism. It is tested whether one sprinkling pattern works, while the other is locked. Furthermore the intensity of the sprinkles has to be observed.
Installation:	Respectively, one model is screwed on a bottle, which is filled with water.
Observation:	The sprinkling range is observed by taking pictures.
Observation medium:	Camera
Results:	Both mechanisms work, adjustments on sprinkle range and focus point will be necessary. Focus point must be shifted. Reasonable intensity of sprinkles.

Pictures of the observation can be seen in Appendix A3.

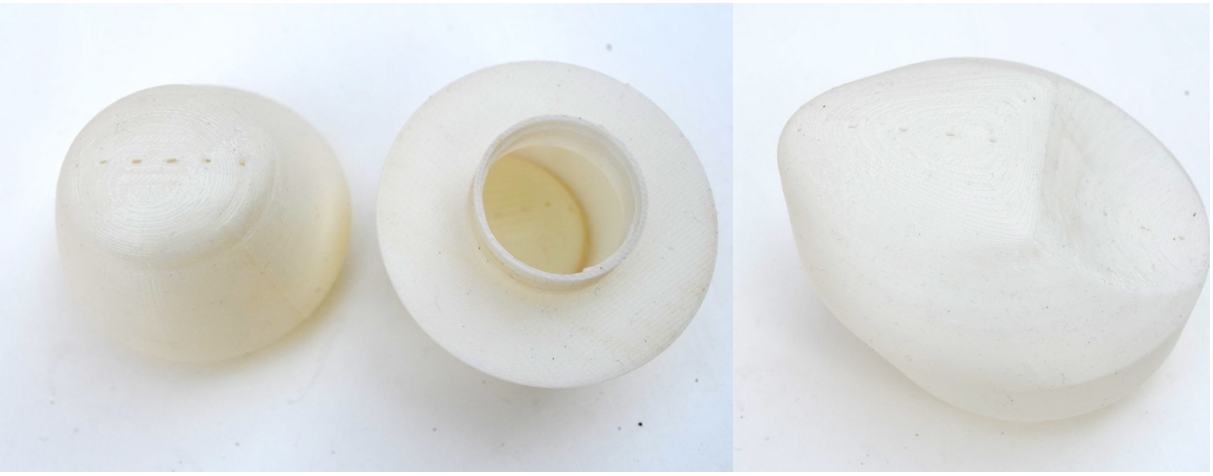


Figure 2.9. 3D printed test models: Left: flexible surface mechanism, right: Locking sprinkling mechanism

2.5 Adding Functions

To improve the usability of the product, an attachment –system can be added in the device. This attachment-system must be able to attach the new Sprinklebottle on a trolley, a pocket or belt of the user.

Secondly, usability would be improved if a cap-closure system would be added to the device. A first approach of a cap-closure system can be integrated in the caps push in/out surface, see figure 2.10. In this case, one shower type must be neglected. The perforations in the surface close when the surface is pushed in. This is a non-suitable solution, when one shower option must be neglected. This system enables the user to only be able to fulfill on a selection of the application that was discussed in the previous section of this report. Fulfilling on all applications has the highest priority. Another option can be a third part that creates a complete device together with the bottle-unit and the cap-unit. In this case, the chance of losing parts must be reduced to a minimum.

To analyze, which factors can lead to a higher chance of lost parts, the main scenario is observed again, see figure 2.11.

It is responsible to add a third part to the product if this part is conforming with the following:

Requirements

- While usage, third part must be a fixed part of the product
- Must be removed while/for cleaning
- Must be highly visible

Adding a third part can ensure cap-closure. Due to the fact that the added part must be highly visible, a solution can be a not too small part. In order to increase the size of this part and to make it more visible, an attachment-system can be added to this part. Simultaneously, the usability and the functionality of the complete device increases.

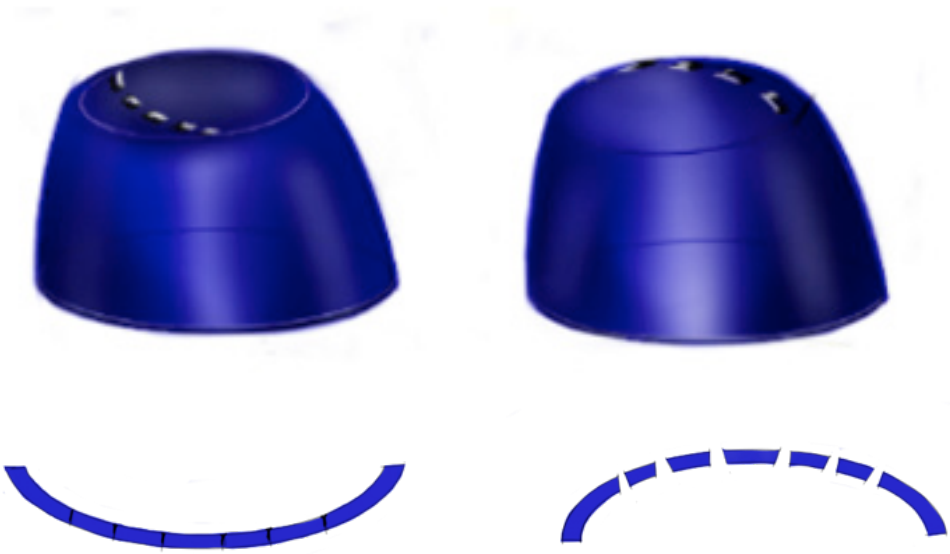


Figure 2.10. Cap-closure system: Left: closed; right: open

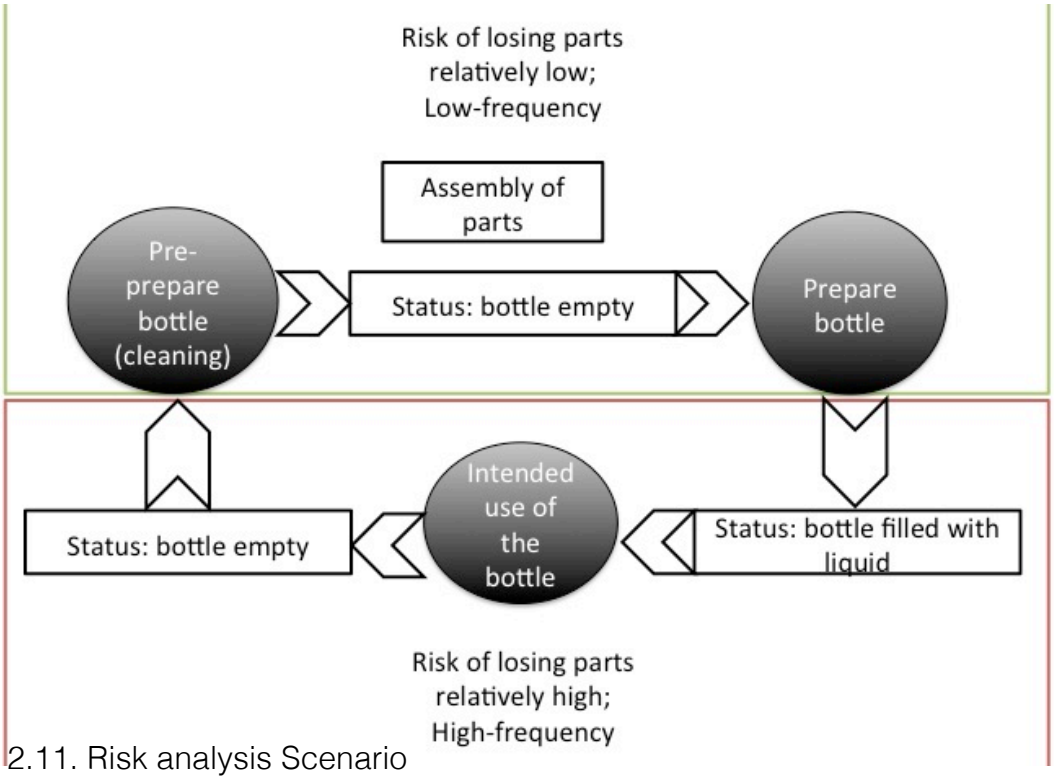


Figure 2.11. Risk analysis Scenario

Development of Sub Concepts

The additional system can be located between cap and bottle-unit. The advantage of this is that this part is only removed when the complete device must be cleaned. When bottle-unit needs to be refilled, cap and the new system can be demounted as one piece.

Two sub concepts are designed. The first sub concept is related to the primary concept 1. The basic structure is similar to the previously described option. The closure and attachment unit can be connected with each other by a click-connection. The bottle-unit can be connected with the attachment-unit by a screw connection. The cap provides two types of showers. One can switch between the two shower types by pressing the upper surface of the cap in or out. This flexible surface is extended. Switching between the two shower options is now possible without disconnecting the cap with the other parts of the device. Closure can be achieved by rotating the cap 180 degrees around the y-axis. Figure 2.12.

A second sub concept is related to the primary concept 3. The Jug and the attachment-closure unit can be connected through a slide-connection. The cap can rotate around the y-axis, this enables switching between the shower types as well as closure. Figure 2.13.

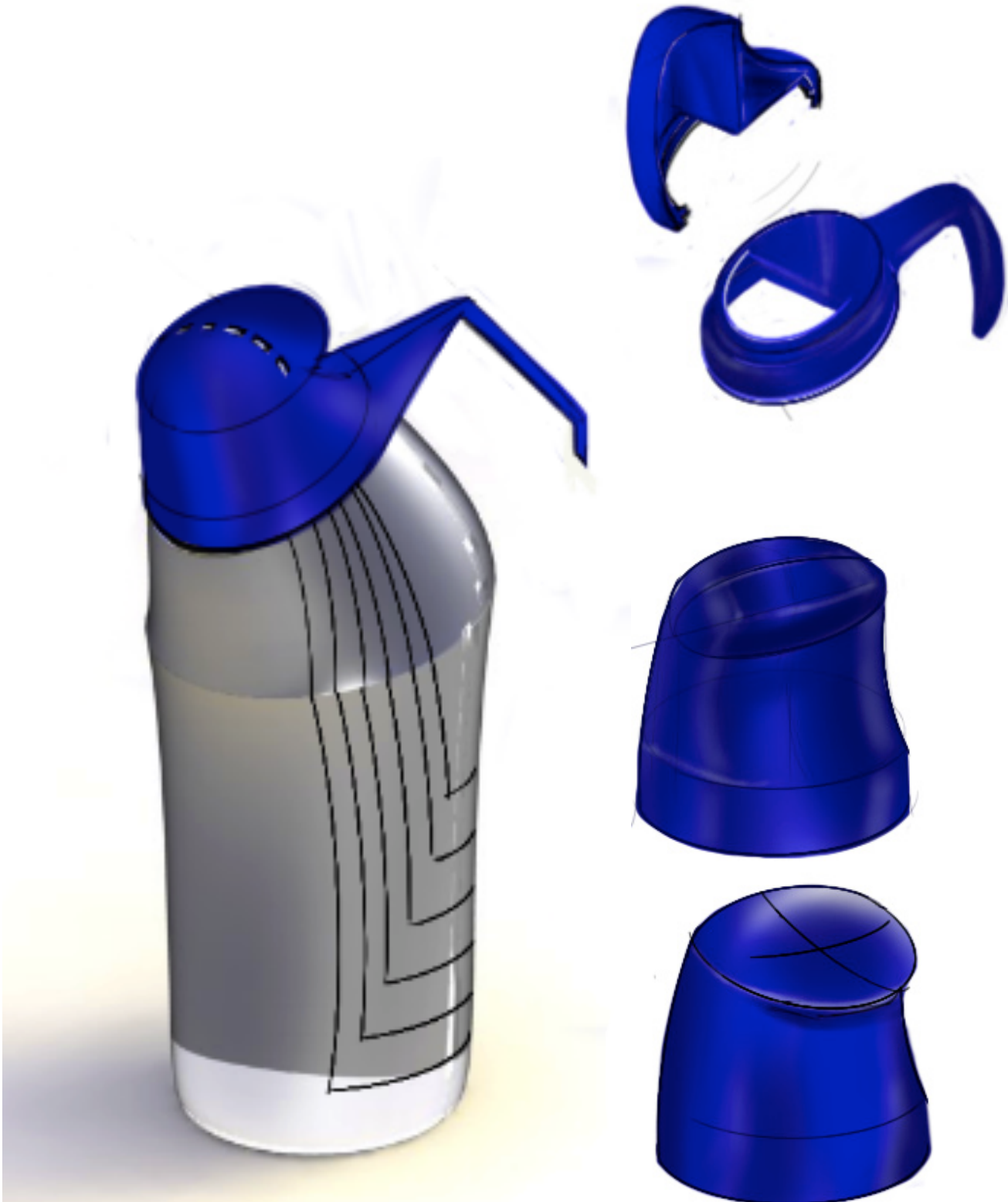


Figure 2.12. Sub concept, related to the former concept 1

2.6 Examination and Evaluation with Respect to Intuitive and Foolproof Design

List of sub concepts:

1. Bottle-unit
2. Jug-unit
3. Vertical and horizontal fluid measurement system
4. Horizontal fluid measurement system
5. Attachment system
6. Closure system
7. Rotatable shower adjustment system
8. Push down/up shower adjustment system

The bottle-unit is easier to squeeze than the jug-unit, while the jug-unit suggests that a complete device with this unit can also be used as a dosing jug. However, easy squeezing has a higher priority, as the complete device must allow the user to sprinkle detergent efficiently and controllable.
A vertical and horizontal fluid measurement system allows the user to control how much detergent is sprinkled while fulfilling an application. This is preferable to a horizontal fluid measurement system. Nevertheless, it must be distinctive when to use the horizontal identification stripes and when to use the vertical identification stripes.
An attachment and closure system increases the functionality of the product, but can also affect intuitive decision making of the user in a negative way. This must be avoided.

The complete device will include a squeezable bottle with horizontal and vertical stripes. The top of the bottle has a round shape. A screw connection provides a possibility to connect the attachment system with the bottle-unit. The attachment-unit is equipped with an attachment appliance and assists the cap closure function.
Now, it must be assessed which shower adjustment system is more suitable for this combination of sub concept.

Figure 2.13. Sub concept, related to the former concept 3

Choosing the rotatable shower adjustment system leads to two types rotational movements that are possible.

- Screwing the middle piece on the bottle
- Rotating the cap around y-axis to close the device or to adjust showers

The push in/out shower adjustment system will lead to three movements.

- Screwing the middle piece on the bottle
- Screwing the cap around the y-axis to close the device
- Pressing the upper surface of the cap in or out

The advantage of two rotational movements is that the user performs the same movement for closing and activating shower options. But it must be communicated explicitly which status is currently active and which options are available. Otherwise, the user is not in charge to operate with the device correctly. The push in/out option gives feedback about the current type of shower through the change of the shape of the upper surface of the cap. But, the possibility that the user forgets to close the cap by rotating it is higher. Mainly because a rotational movement with this cap will be performed less often than with the first mentioned sub concept.
Furthermore, it is more likely that this shower adjustment system has a lower durability than the other parts because its frequent use and the resulting stress in the intersection between the flexible surface and the less flexible outer surface.
The rotational movement is more durable and it is less likely that the user forgets to close the cap because rotating the cap is the standard task the user performs with this device.

The concept that will be designed in detail includes the sub concepts 1, 3, 5, 6 and 7. A fist impression of the design is shown on page 77 and 78. The following chapter of this report refers to the final concept and its specifications and final design.

Figure 2.14. First impression of the final concept: Bottle and cap

Figure2.15. First impression of the final concept: Cap and attachment-system

CHAPTER 3

Introduction of the Final Concept

The last chapter unveils the final concept with all its functions. Additionally, manufacturing and material advice is given to proof that the design is developed with attention towards mass production. A first price indication completes this chapter.

3.1 The Final Concept

This section introduces a concept of the new Sprinklebottle. Following, all details of the Sprinklebottle will be described. A preliminary price calculation as well as a manufacturing advice is provided to enable the company to estimate whether the product can be introduced on the market or not.

Description

The previous version of the Sprinklebottles came with advantages as well as disadvantages that appeared while using the product. The assignment was to design a new improved version of this bottle that meets the wishes and requirements of the brand, the customer and the consumer. The result is an ergonomically shaped bottle with a high-performance cap. The product allows the user to achieve the following tasks:

- Sprinkling detergents on vertical and horizontal surfaces
- Sprinklling water on hard to reach surfaces
- Adjust the shower size
- Close the cap
- Hang- up the bottle on trolley, pocket or connect to a belt
- Clean the bottle easily
- Assemble and disassemble the bottle easily
- Translate the current amount of liquid into a unit (even during applications and handling the Sprinklebottle)
- Correct preparation of Vileda Professional pre-prepared mop systems
- Easy identification of the type currently used detergent

Overall shape of the product

The bended shape of the bottle ensures ergonomically interaction between user and product. It is necessary to avoid too much movement in the wrist because the product is used frequently. The bended top steers the water flow in its desired direction. This reduces movement in the relevant joints. Besides the screwable top of the bottle, the bottle is oval shaped with diverging diameter.

Figure 3.1. The look of the new Sprinklebottle

This makes the bottle easily squeezable. Furthermore, the shape of the bottle allows squeezing in two directions that can depend on the sprinkling direction. For toilet cleaning, the bottle will be hold with the thumb on one side, and the remaining finger on the opposing side of the bottle. To moisten single mops, the bottle can also be hold in the hand with the thumb on the back of the bottle and the remaining finger on the front.
The attachment system is reduced on its basic function to avoid retractions. It enables attachment of the product on trolley, pocket or belt. The shape even allows to hang-up the product on a heel.
When cap and attachment-unit are connected, five degrees of freedom are fixated. Only rotation along the y-axis is still possible. Through rotation of the cap, the shower size can be adjusted. In addition, this mechanism makes closure of the cap possible without parts that can get lost easily. Illustrations of the parts and descriptions of the functionality of the Sprinklebottle is given on the following pages.

Figure 3.2. The bottle, side and front view

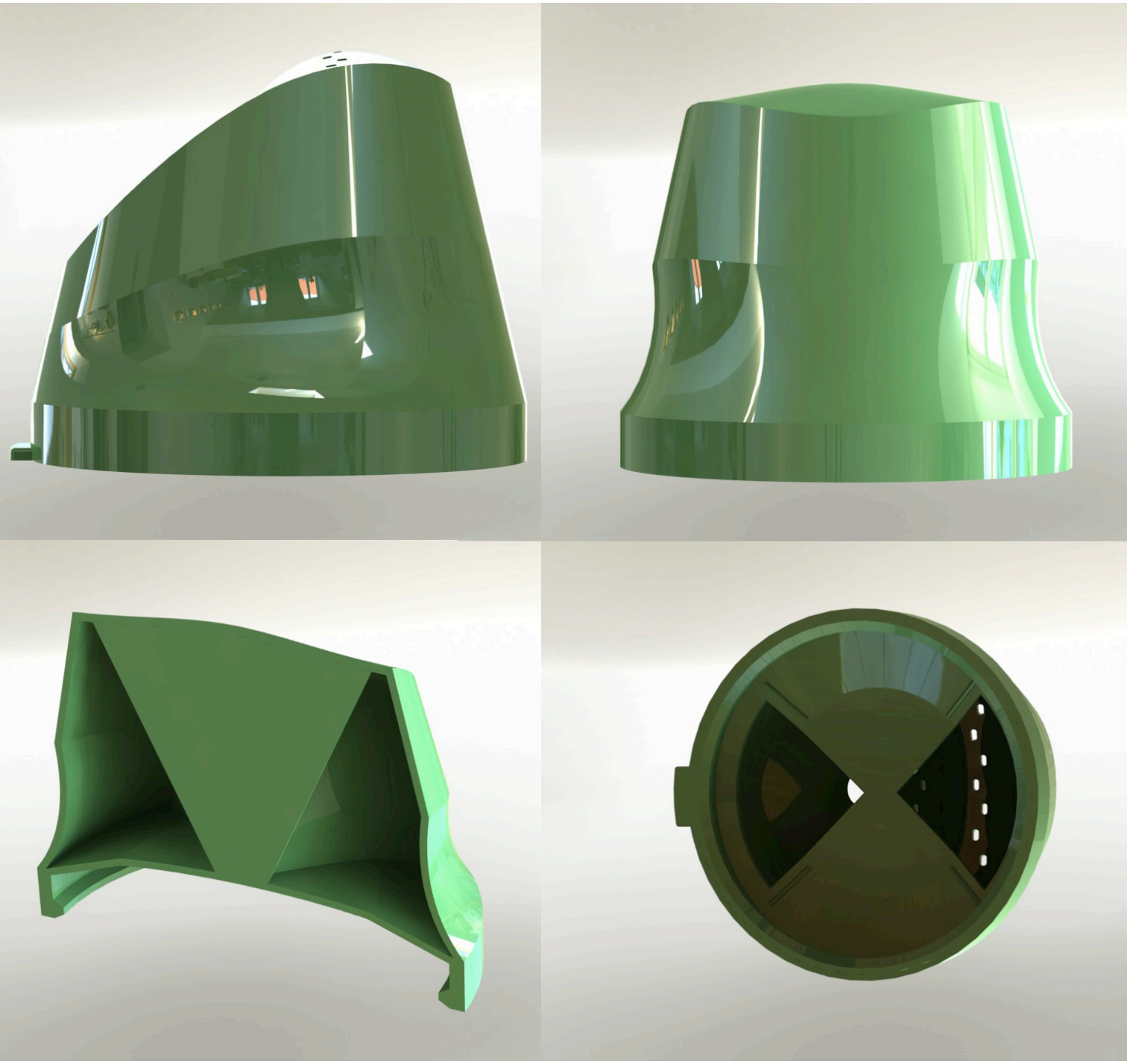


Figure 3.3. The cap, side, back, section and bottom view.

Figure 3.4. The attachment and closure system

Figure 3.5. Assembled Sprinklebottle

Figure 3.6. Assembled Sprinklebottle: Cap and attachment-system connection

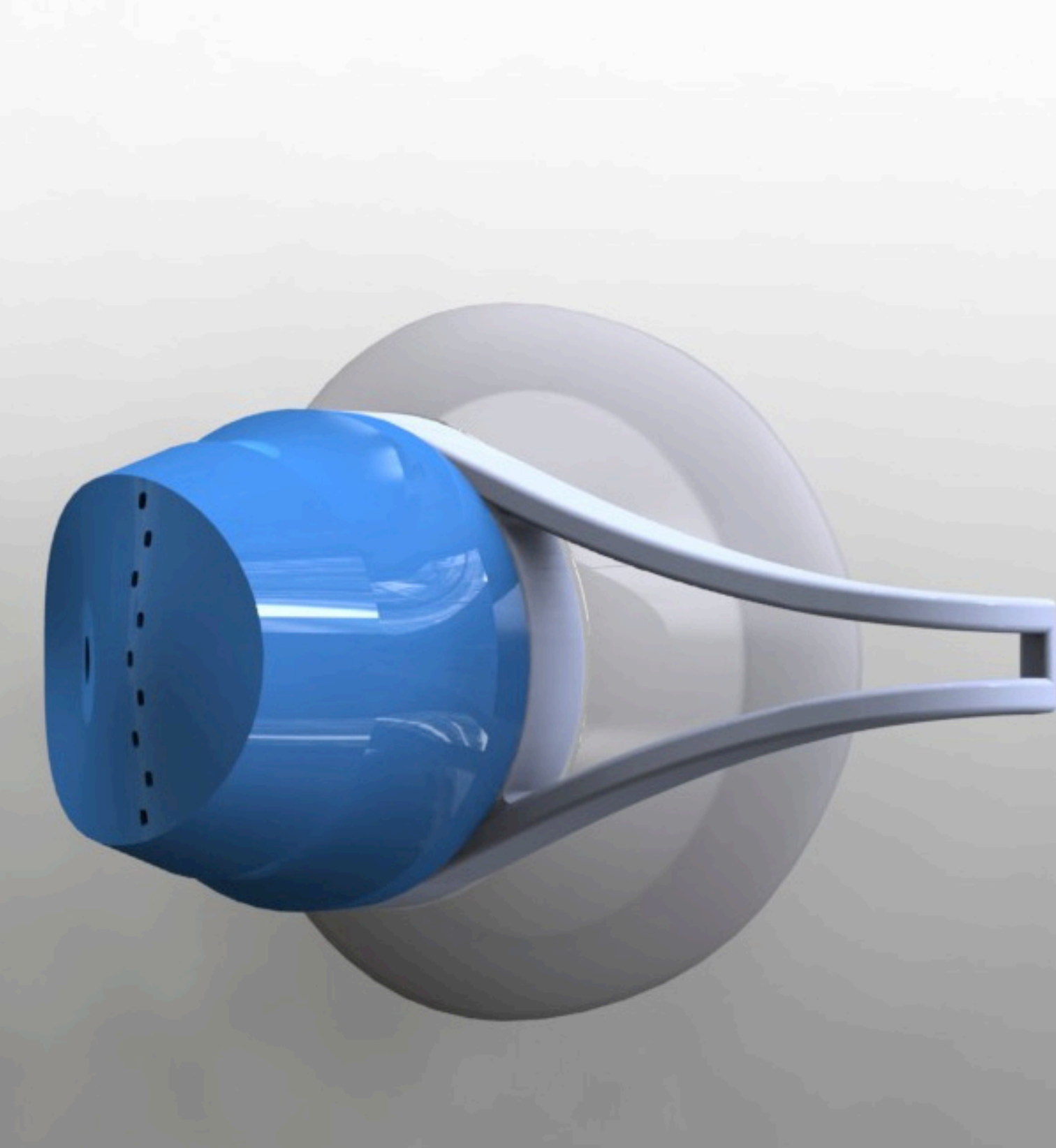


Figure 3.7. Assembled Sprinklebottle: Top view

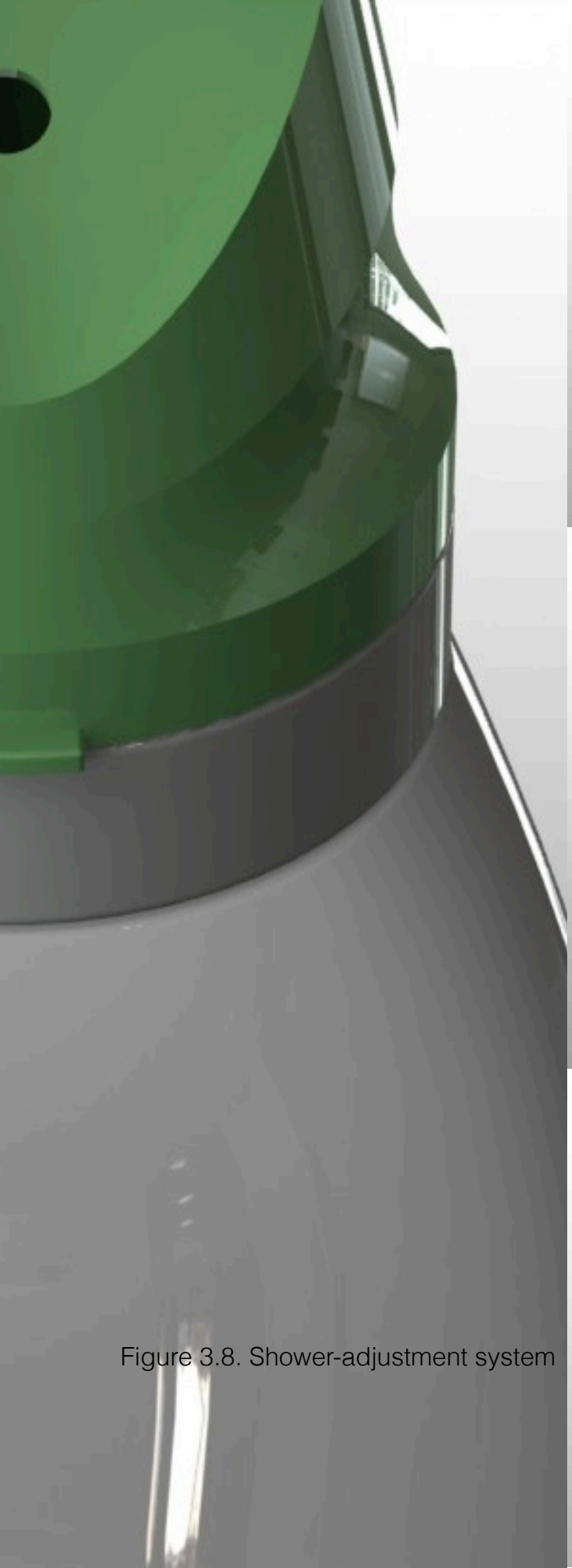
3.2 The Sprinklebottle and its Functions

Color-coding and surface quality

The colors red, green and yellow indicate which type of detergent is located in the Sprinklebottle. This indication must always be visible. The cap is the part of the Sprinklebottle that should include this type of color-coding, because this part is even visible if the trolley is fully packed with bottles and other devices. If the Sprinklebottle is attached on the trolleys profile or on a belt, the cap is the part, which will be recognized at first. This part of the Sprinklebottle has a glossy polished surface quality.
The attachment system is a control element that also connects the cap and the bottle. According to *Vileda Professional design world - smart balanced product architecture*, this part must have a matted surface and the color RAL 260 60 15.
The bottle is made of a semi-crystalized polymer, which makes the bottle transparent. The transparency ensures that content within the bottle is always visible. This part has a glossy polished surface quality.

Shower adjustment

The sprinkling shower can be adjusted. Two shower types are available. One shower type is specially designed to sprinkle on mops; the second type is designed to sprinkle on hard to reach surfaces and spots. Switching between the two shower types can be achieved by rotating the cap 180 degrees around the y-axis.
Rotating the cap 90 degrees around y-axis, activates the closure system, regardless of the current type of shower, see figure 3.8.



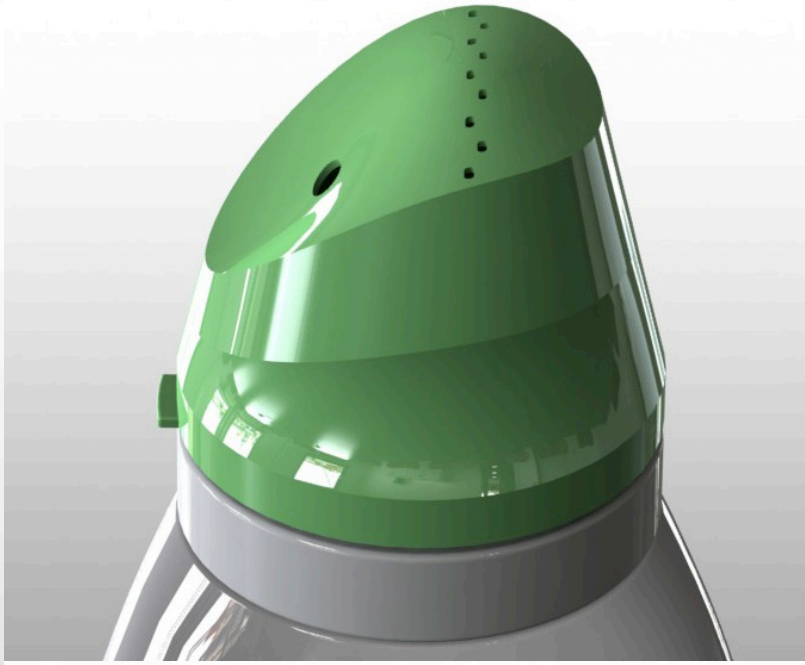


Figure 3.8. Shower-adjustment system

Dosing jug

The final concept integrates improved functions of a Sprinklebotte and functions of a dosing jug. The dosing jug functions are specific for wetting multiple mops and to allow the user to control the amount of sprinkled detergent. It features the following:

- Measuring stripes
- Vertical & horizontal indication
- Refilling the bottle easily by disconnecting bottle and attachment-system

Placement of the logo

The red logo can be printed on the upper back of the bottle. It has a prominent place and a width of minimal 30 mm.

Placement of the sticker

A sticker can be placed on the front of the bottle. At this place, it does not inhibit the indication of the current amount of detergent.

Stripes and shower indications

The stripes allow the user to read the current amount of detergent whether the Sprinklebottle is in use or not. To wet one side of a single mop, 150 ml detergent is required. Each stripe indicates the amount of 150 ml detergent. This makes it easy for the user to moisten the mops properly. While moistening mops the bottle is hold horizontally. Therefore, the horizontal stripes end in vertical stripes. This reduces one step, namely rotating the bottle back in its vertical position to see how much detergent is already sprinkled. The vertical stripes allow the user to read the amount of content while sprinkling detergent on a mop. Furthermore, the product gives instructions on how often the bottle must be refilled to moisten multiple mops. A horizontal stripe which is placed on the front of the bottle, in order to prevent misunderstanding, indicates that until this stripe the bottle must be filled with water and that this task must be repeated four times, see figure 3.9.

The symbols indicate which type of shower is activated or whether the closure function is active or not. The symbols are divided in two parts. The lower part of the symbol is always the same, and can be found on the same place.

Figure 3.9. Sprinklebottle with measuring stripes

It is located at the front of the attachment-unit. The upper part is available in three versions. One indicates the shower option for moistening mops, one indicates the shower option for sprinkling on spots or small surfaces and the last one indicates whether the closure-system is activated or not. The symbol for closure can be found two times as there are two surfaces that ensure closure (figure 3.10).

Feedback mechanism

The user must be aware of which shower type or closure is currently active. The Sprinklebottle features feedback systems on different levels.

Haptic feedback

Excrescences on the inner part of the cap and analog, inversions on the upper surface of the attachment system provide feedback by offering resistance while switching between the types.

Visual feedback

Symbols that indicate which type is currently active are added to the cap and the attachment system. The symbol consists of two parts. One half of the symbol is placed on the attachment system, one half that comes in three different types. By rotation of the cap, the two types can form one symbol. This composed symbol provides indication of the current type of shower or closure, see figure 3.10.
In addition, the perforated pattern on the cap is visible and gives also information about the current type of shower.

Assembly of parts

The bottle and attachment-unit can be connected by a screw connection. The screw connection must be at one point self-locking to prevent that the attachment-system disconnects while the user rotates the cap. When the acting force, which results in a moment, overshoots the drag, bottle and attachment-unit can be disconnected. For further development, the acting force must be higher than the drag and low enough to allow the user disconnect to the parts easily. The attachment-unit and cap are connected by a click- or put-over connection. To clean the bottle, it is advisable to

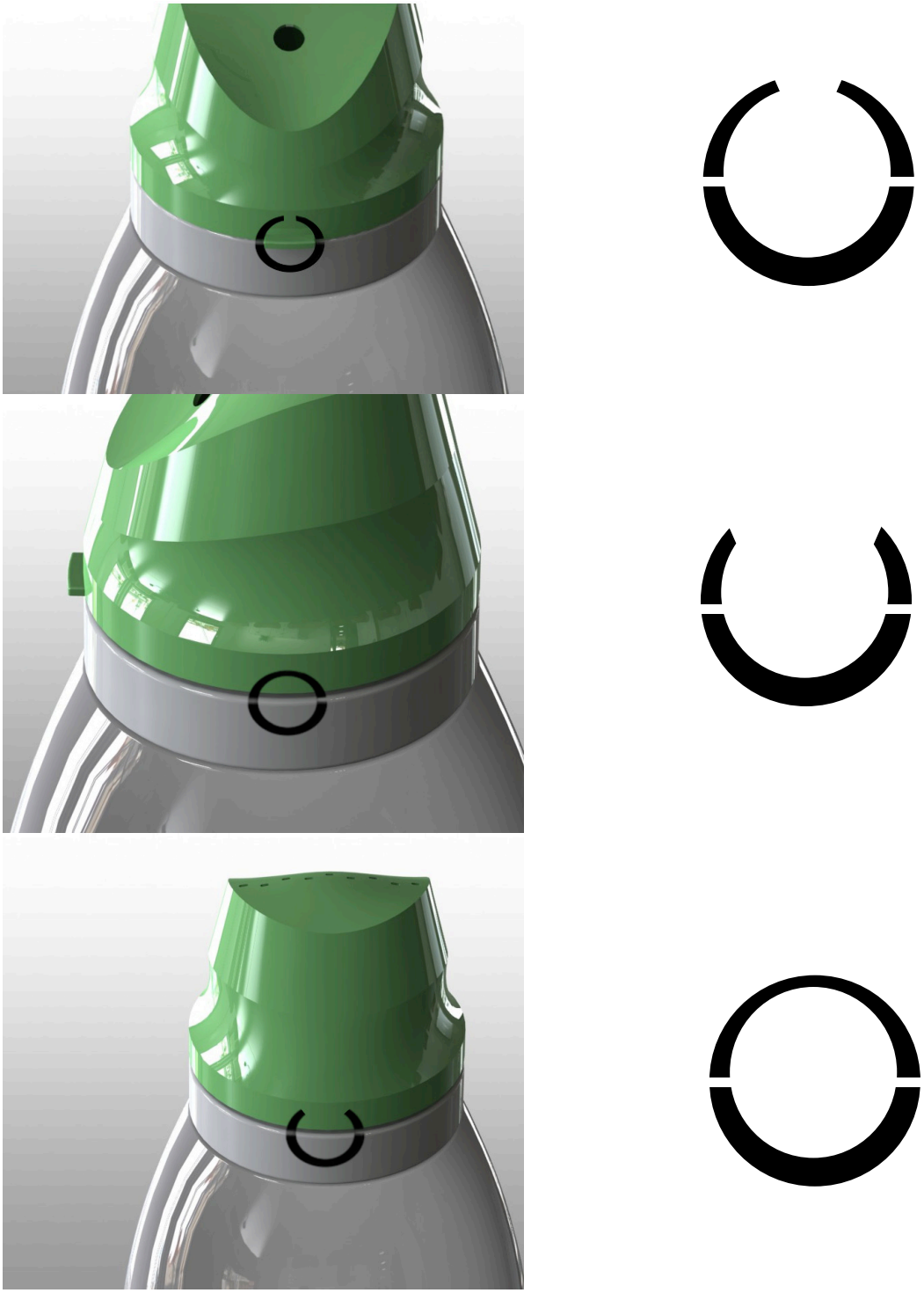


Figure 3.10. Shower indication through symbols

disconnect each part. When the Sprinklebottle needs to be refilled, one can screw the attachment system off the cap.

Optimal volume of the bottle

The desired amount of content needed for pre-preparing mops is 3000 ml. For wetting single mops, 150ml detergent for each side is needed.
1000 ml would be to heavy to carry- not desired. The company's wish: 500ml - 750ml)
Taking this into account, the optimum max. volume of content is 750 ml.

- 750 ml: refill bottle 4 times to pre-prepare mops
- 5 sides of single mops can be wetted with one fill

Thus: 280 ml should be added to the current 470 ml: total: 750 ml
This amount allows easy refill instructions while according to the company, the Sprinklebottle will not be too heavy. However, refilling bottle 4 times is relatively time consuming, but an optimized perforated pattern compensates for this loss of time.

Sprinkling quality

The perforated pattern is adjusted to improve the sprinkling quality respective to the applications. The first option can sprinkle detergent on a relatively large surface. Adjusting the width of the sprinkles is possible by changing the distance between the bottle and the surface. A distance of 350 mm between the Sprinklebottle and a mop is optimal for moistening mops as fast as possible.
The second shower options allows sprinkling on spots or hardly reachable surfaces. To facilitate these applications, only two holes are active while this type of shower is activated. The holes steer the water flow in the desired direction. The holes are generally bigger, ensuring that when pressure is applied on the bottle, the device sprinkles with more power. This eases steering the water flow on vertical or upper surfaces, see figure 3.11.

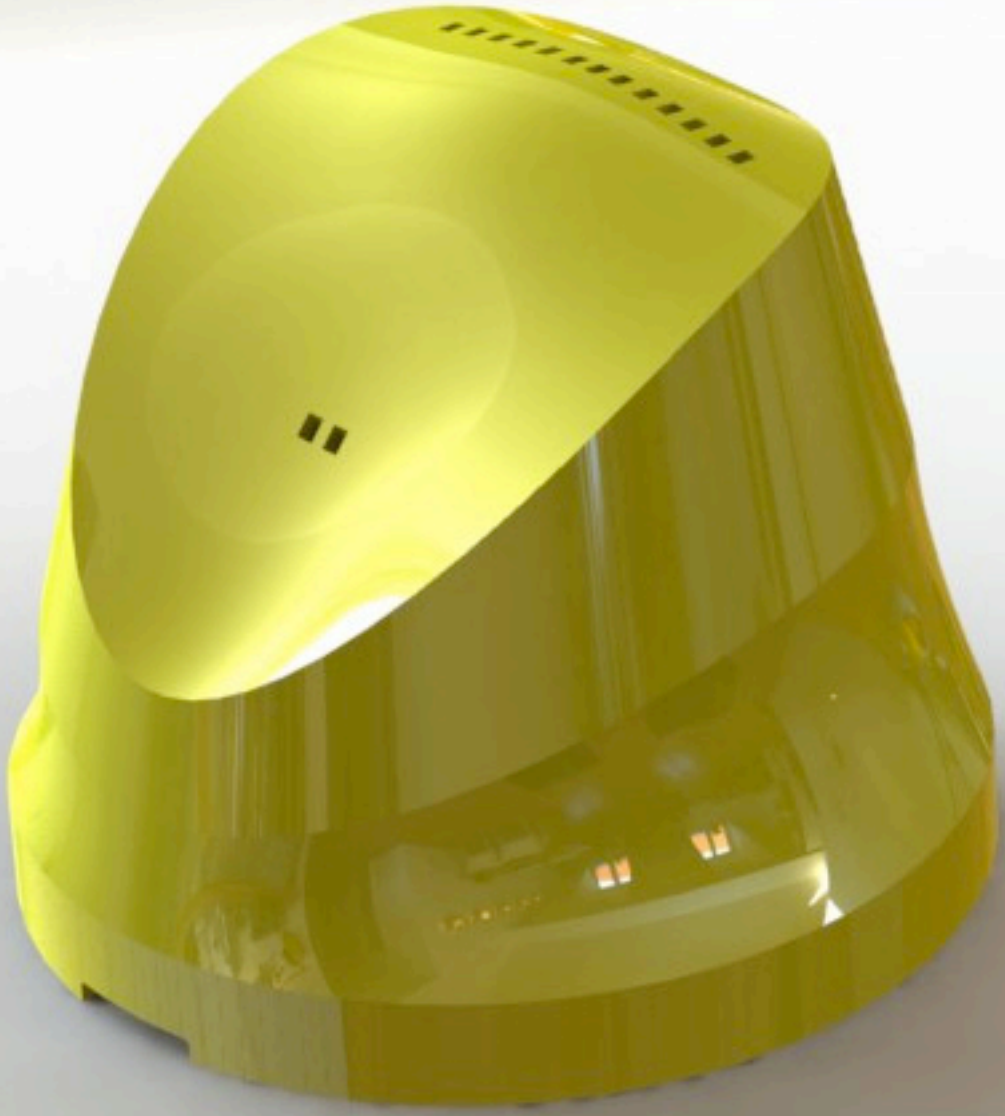


Figure 3.11. Perforated pattern of the redesigned cap

Dimensions of the new product

Total height:	**211**	**mm**
Maximum content possible:	**800**	**ml**

1. Bottle

Average height:	180	mm
Slope at the top:	34	Degrees
Front: Width bottom:	80	mm
Width center:	90	mm
Side: Width bottom:	60	mm
Width center:	80.5	mm
Outer diameter of screw extension at the top:	58	mm
Material thickness:	1	mm

2. Attachment-Unit

Total height:	24	mm
Visible height when assembled:	13	mm
Total length:	115	mm
Triangle shaped opening: Radius:	15.9	mm
Length of the edges:	22.4	mm
Diameter of heel:	30	mm
Material thickness:	2	mm

3. Cap

Height: Minimum height:	15.3	mm
Maximum height:	42	mm
Outer diameter at the bottom:	60	mm
Material thickness:	2	mm
Lid: Width:	10	mm
Depth:	5	mm
Height:	1	mm
Material thickness:	1	mm

Figure 3.12. Final design, exploded view

3.3 The Sprinklebottle as a Vileda Professional Owned Product

The new improved Sprinklebottle/ Dosing jug fits to Vileda Professionals products that are used within the scope of the product. On a functional level it fits to its product environment through its functions that are specifically designed to fulfill the desired applications. On a visual level, it fits to Vileda Professionals product portfolio because of the integration of the brands design guidelines, e.g. color-coding, see figure 3.13.

Figure 3.13. Visual approach: color-coding[24]

Figure 3.14. Sprinklebottle in its product environment[25, 26]

3.4 Material Selection

The material of the product must meet the following evaluation criteria:

- Must be transparent
- Must be flexible
- Must be suitable for pad printing
- Beneficial: no pretreatment processes necessary
- Maximum price per kilogram: 2 Euro
- Suitable for diverse molding and extrusion processes
- Must have good barrier properties towards water
- Must resist strong and weak acids
- Must have a maximum service temperature of at least 70 degree Celsius
- Must have a minimum service temperature of at least 0 degree Celsius
- Must have a maximum glass temperature of -10 degrees Celsius

Note: PVC not suitable

It is essential that all parts of the product achieve these criteria besides the flexibility. The bottle must be flexible, the attachment part as well as the cap must be stable enough and are not allowed to deform massively when a force acts on them. By adjusting the wall thickness, differences in flexibility can be achieved. This ensures that parts of the product can be made of the same material.

The critreria are used to give advice on which material suits best. The analysis is made with the Cambridge Engineering Selector (CES)[27]. According to this analysis, two types of thermoplastics can be considered. PE-HD meets most of the targets. This material is easy to manufacture and is mainly used for containers that can come in touch with different detergents. It also has good barrier properties. The biggest advantage is that is approved for devices such as the new Sprinklebottle. Especially because the current Sprinklebottle is made of PE-HD.

However, the material does not have sufficient optical properties, being translucent. PE-HD would strongly affect the visibility of the current amount of content in a negative way. PP is a transparent material and has the advantage of special pad printing tools being available, dismissing the requirement of pretreatment processes[28].

Furthermore, it meets the important criteria but is more expensice in comparison to PE-HD.

PE-HD has a price per kg between 1.4 Euro and 1.54 Euro.
PP costs 1.68 – 1.94 EUR/kg. The price varies because distributors offer the material for different prices and it depends on the sales volume in kg.

Amount of material needed:
Mass of all parts respective of the material

Needed amount of PP for the new Sprinklebotte/ Dosing jug: 79.4 gram
Needed amount of PE for the new Sprinklebottle/ Dosing jug: 81.02 gram

Mean values of the given prices are used for further calculations.
PP_mean: 1.81 EUR/kg
PE_mean: 1.47 EUR/kg

The material price per product will be approximately 0.144 EUR/piece for PP and 0.119 EUR/piece for PE. This makes a difference of 0.025 EUR/piece. Taking into account that the logo, stripes and symbols must be printed on the product through pat printing the difference of 2.5 Cents per piece will be regulated because of the pretreatment processes that are necessary for pat printing, when using the material PE-HD.

On basis of these values, PP will be considered as the basic raw material for further development of the product.
The complete list with characteristics of the materials PE and PP can be found in appendix (A3 and A4).

3.5 Manufacturing

In first instance, 30.000 pieces must be produced to supply the customers in the Benelux and the Nordic countries with the new Sprinklebottle.
Therefore, the bottle, the attachment-system and the cap must be produced by processes, which are suitable for mass production.
The bottle of the Sprinklebottle has a hollow shape. It must be squeezed easily, which requires a good control over the wall thickness by the producing machines.
Furthermore, production of the neck with a screw thread requires a machine that is capable of high tolerances. In order to save material costs, it is desirable that the production process produces limited or no waste material.
The most suitable production process for this part is injection blow molding. In comparison to extrusion blow molding, it requires higher tooling costs but can simultaneously handle higher tolerances[A6/a].
The machine that produces the attachment-unit of the product must be capable of producing screw threads and the relative complex shape. Injection molding is a common production process for solid polymer parts. The material is injected under pressure in molds. After a cooling period, the molds opens and the part ejects. To produce a large number of pieces, multicavity molds are often used. A cheaper option for prototyping or lower production rates is a single cavity mold made of cheaper materials. With respect to a first production rate of 30.000 pieces, this can be an option that in first instance reduces risks and tooling costs in comparison to multicavity molds of durable material. However, production time is reduced when using multicavity molds[A6/b].The cap is the most complex part of the new Sprinklebotte. The inner construction makes production through injection molding difficult. It can be produced when the cap is split in two parts, an inner and an outer part. This claims further production processes, such as gluing or welding the parts on each other.
Disadvantages of these production processes are a longer production time, higher tooling costs that are a result of the two parts that must be produced by injection molding and higher personnel costs. Furthermore, when splitting the cap in two parts, the glued or welded seam must be dense. If detergent can pour in the hollow forms, it cannot be ensured that the cap can be cleaned properly.

Gas injection molding is a process, related to injection molding. The machines are almost typical injection molding machines with further equipment to inject gas. The most common gas is Nitrogen, which is injected to create an inner hollow shape.
Tooling costs for gas injection molding are higher than for injection molding[29]. Taking into account that when producing the part with injection molding, two pieces must be produced and that personnel costs and production time increases and further production processes are required, such as gluing or welding the pieces on each other, it is most likely that the production costs when injection molding, will increase significantly. Higher tooling costs for gas-injected molding are then even to injection molding, or more probable lower than during the first described process. It is advisable to choose gas injection molding over injection molding.
However, gas injection molding in some cases requires simple further manufacturing processes since the hole where gas was injected must be sealed and filled with material through welding. Whether this is required or not depends on the type and the location of the gas injection needle or nozzle[29].

Finishing

Measuring stripes, the logo of the brand and symbols that indicate, which type of shower is active must be printed on the parts. Because of the round shaped parts, pad printing is a suitable method to print on thermoplastic 3D shapes[28].

3.6 First Price Indication

Injection blow molding is mainly used for production of relative small parts with a volume of less than 500ml. However, bigger parts with wide mouth are also possible but increase the tooling costs. For production of 30.000 pieces, a cheaper material can be used for the molds. The price increases when a more stable material must be used.

Capital costs for injection blow molding [A6/a]

Option 1: Lower tooling life, lower tooling cost, average production rate.
Estimated price: 7.000 EUR

Option 2: Higher tooling life, higher tooling cost, average production rate.
Estimated price: 15.000 EUR

Average material utilization fraction: 0.945

Injection molding is used for the production of small and large complex shapes. Through the relatively complex shape of the attachment-unit, tooling costs increase.

Capital costs for injection molding [A6/b]

Option 1: Lower tooling life, lower tooling cost, lower production rate.
Estimated price: 30.000 EUR

Option 2: Higher tooling life, higher tooling cost, higher production rate and fast production cycle (multicavity molds).
Estimated price: 70.000 EUR

Average material utilization fraction: 0.75

Gas injection molding is in comparison to injection molding more expensive because of an added production step. A fist estimation of capital costs is as follows:

Capital costs for gas injection molding

Option 1: Lower tooling life, lower tooling cost, lower production rate.
Estimated price: 40.000 EUR

Option 2: Higher tooling life, higher tooling cost, higher production rate and fast production cycle (multicavity molds).
Estimated price: 75.000 EUR

Average material utilization fraction: 0.75

Total average material utilization fraction

0.945 * 0.589 + 0.75 * 0.239 + 0.75 *0.176 = 0.861

In average, 13.9 % material waste is produced.

The pad-printing device must be capable of printing with two different colors. The logo must be printed in red. It is advisable to print the stripes and the symbols in black to increase visibility. Furthermore, the cap will be offered in the colors yellow, green and red. A red printed symbol would not be visible on a red colored cap.

To print the logo and the stripes, the machine must be able to print on a round surface and must be capable to print on a printing area of 150x200mm.

Estimated price per print and piece: 0.10 Euro, including 2-component ink and tooling cost for cliché and pad.

Calculation:

Production quantity:	30.000 Sprinklebottles
Price for injection blow molding per piece:	0.23 EUR
Price for injection molding per piece:	1 EUR
Price for gas injection molding per piece:	1.33 EUR
Price for material, including waste per piece: 90.44 gram:	0.16 EUR
Price for finishing per piece:	0.1 EUR

Total: 2.82 EUR per Sprinklebottle

This preliminary estimation is only made to give a first indication of the manufacturing price. When quantity increases, the costs to manufacture the product will decrease although tooling costs increase.

Production quantity:	150.000 Sprinklebottles:
Price for injection blow molding per piece:	0.1 EUR
Price for injection molding per piece:	0.467 EUR
Price for gas injection molding per piece:	0.5 EUR
Price for material, including waste per piece: 90.44 gram:	0.16 EUR
Price for finishing per piece:	0.1 EUR

Total: 1.33 EUR per Sprinklebottle

It is most likely that the company can decrease the price through contracts with manufacturing companies or company –owned manufacturing facilities.

3.7 Conclusion

The aim of this project was to create an improvement of the currently available Sprinklebottle. Furthermore, the functions of a dosing jug must be added to the product as well. The observation of the usage of the Sprinklebottle disclosed features that needed improvement. The current Sprinklebottle is an improvement of the original on different levels. The bottle is shaped ergonomically and allows squeezing with less required force. The design has changed significantly. The styling of the new product fits in an active environment and invites the user to make use of the product in a fast and efficient way. Through the bended shape of the Sprinklebottle, it is now possible to reach the surfaces under a toilet seat. The shape cooperates with the user and can reduce movements in the wrist, elbow and shoulder. Furthermore, it relieves the fingers through the shape of the bottle and through easy squeezing. In comparison to trigger spraybottles, the new Sprinklebottle can be cleaned faster because of a reduction of surfaces that are time–consuming when cleaning the bottle. All wishes and requirements of Vileda Professional are achieved. The dosing jug functions offer an added value to the product. The new Sprinklebottles allows the user to control the amount of dispensed detergent even when the product is in use. The print on the bottle is especially designed to support the user to complete tasks that are within the scope of applications that can be fulfilled with a Vileda Professional system. The new Sprinklebottle cooperates with Vileda Professional products and is a useful addition to their systems. With its first estimated manufacturing costs of 2.82 EUR, it would have an estimated end-user price of approximately 7.05 EUR. If the sales volume grows up to 150.000, a first estimation of the end-user price would be 3.30 EUR. Both values are under the from the company-given indication of an estimated maximum end-user price of 10 EUR.

It is up to the company to decide if the new Sprinklebottle can be considered for further development. Before launching the product, further investment costs are necessary to create a marketable product. Up to now, ideas are generated and a design solution is provided. Before the concept can be launched on the market, further steps and evaluations must be made. The material thickness of the product is not fully determined, yet.

Within the scope of this project it was only possible to preliminary determine the thickness of the parts. The optimum thickness allows easy squeezing, while the bottle automatically returns in its initial shape when no force acts on this part. The final wall thicknesses remains to be calculated and tested. Further development should also include final determination of the connections between bottle and attachment-unit and attachment-unit and cap. Until now, it is not proven that the haptic feedback is working well and whether the conncetion between cap and attachment-unit still can be leak-proof. Additionally, it is necessary to test the product on durability and efficiency and to prepare the concept for manufacturing.

References

1. Eisenhut, A. Vileda Professional Training Center, Retrieved April, 08, 2014 from Vileda Professional RTC Introduction
2. [Untitled photograph of the Sprinklebottle] Vileda Professional, Retrieved August 08, 2014 from: http://vileda-professional.com/fi-FI/products/03-floor-cleaning/03-accessories/02-sprinkle-bottle/
3. [Untitled photograph of the VoleoFlex trolley] Vileda Professional, Retrieved August 08, 2014 from: http://vileda-professional.com/en-GB/products/05-trolleys/03-voleoflex/04-voleoflex-3boxes/index.shtml
4. Kulkarni, P., Baron, P., Willeke, K. (2011) Aerosol Measurement: Principles, Techniques and Applications, Third Edition, Jon Wiley &Sons Inc. Retrieved August 08, 2014 from: http://books.google.de/books?hl=de&lr=&id=ETvXooNW4-EC&oi=fnd&pg=PA1&dq=health+care+cleaning+inhaling+aerosol&ots=Gl6wEFNSLu&sig=TMMf8zbuNuDQxv_EuZrP_vZKh2c#v=onepage&q&f=false
5. [Untitled photograph of the Swep System] Vileda Professional, Retrieved August 08, 2014 from: http://vileda-professional.com/en-CA/products/systems/swep/swep-blackboxCA.jpg
6. [Untitled photograph of Sagrotan disinfectant packaging] Sagrotan, Retrieved August 08,2014 from: http://www.bueromarkt-ag.de/bilder/wc-reiniger_sagrotan_alles-in-1,p-270002,s-700.jpg
7. [Untitled photograph of Domol detergent packaging] Domol, Retrieved August 08,2014 from: http://www.rossmannversand.de/DesktopModules/WebShop/images/full/666688_1.jpg
8. [Untitled photograph of Frosch detergent packaging] Frosch, Retrieved August 08,2014 from: https://frosch.de/uploads/tx_n98frogprods/Frosch_D_Essig_WC-Reiniger_750ml_201ds.png
9. [Untitled photograph of dosing jugs] Buerkle, Retrieved August 08, 2014 from: http://www.buerkle.de/files/pim/lightbox/volumenmessung_00013474.jpg
10. [Untitled photograph of a syringe] Spar-Helferchen, Retrieved August 08, 2014 from: http://www.spar-helferchen.de/images/product_images/popup_images/738_0_spritze_nachfuelltinte.jpg
11. [lillholmen-soap-dispenser] Ikea, Retrieved August 08, 2014 from: http://www.ikea.com/us/en/images/products/lillholmen-soap-dispenser__35061_PE125582_S4.jpg
12. [Untitled photograph of a sauce dispenser] Retrieved August 08, 2014 from: http://www.pubshop.co.uk/catalog/images/CF948.jpg
13. [HDPE Dispensing Bottles] United States Plastic Shop, Retrieved August 08, 2014 from: http://www.usplastic.com/catalog/item.aspx?itemid=22892
14. [Untitled photograph of pasta measuring device] Retrieved August 08, 2014 from: http://3.bp.blogspot.com/-_3RwaeBKP7I/To8oRAIVP9I/AAAAAAAA-S4/GrVpboMJDL4/s1600/75.jpg
15. [Untitled photograph of a dispense and measuring device for small amounts of liquid] Retrieved August 08, 2014 from: http://2.bp.blogspot.com/-ZE0mK7iT6W4/To8nU7XReNI/AAAAAAAA-SQ/VU0fTnZcwL8/s1600/80.jpg
16. [Untitled photograph of dispense and measuring device for non-liquids] Retrieved August 08, 2-14 from: http://2.bp.blogspot.com/-XZPoKkzlxxY/To8uw7k9tcI/AAAAAAAA-jg/iE3zzFwRSQY/s1600/1.jpg
17. [Untitled photograph of a packaging design vor baby foods] Mamaot, Retrieved August 08, 2014 from: http://mamaot.com/wp-content/uploads/2012/06/plum-organics-pouch-with-food.jpg
18. [The Vileda Professional design world – smart banaced product architecture] Vileda Professional, Retrieved April 06, 2014 from Paul Harleman
19. [Guidance on Labelling and Packaging in accordance with Regulation (EC) No 1272/2008] ECHA, retrieved August 08, 2014 from: http://echa.europa.eu/documents/10162/13562/clp_labelling_en.pdf
20. [Microorganismen und die Wachstumsfaktoren] Radiosuedtirol, Retrieved August 08, 2014 from: http://www.radiosuedtirol.eu/index2.php?option=com_content&do_pdf=1&id=405

21. Gromicko, N. PVC Health Hazards, International association for certified home inspectors, Retrieved August 08, 2014 from: http://www.nachi.org/pvc-health-hazards.htm
22. [We All Take Care] Freudenberg Group, Retrieved August 08, 2014 from: http://www.freudenberg.com/de/Verantwortung/Seiten/We-all-take-care.aspx
23. [Unknown picture of a squeezed lemon] Retrieved August 08, 2014 from: http://i1.ytimg.com/vi/fAEoBe-kYvQ/0.jpg
24. [Unknown photograph of dustbins] Vileda Professional, Retrieved August 08, 2014 from: http://vileda-professional.com/nl-NL/products/10-waste-management/05-iris-range/portrait.gif
25. [Unknown photograph of trolley] Vileda Professional, Retrieved August 08, 2014 from: http://vileda-professional.com/nl-NL/products/04-trolleys/12-voleopro/portrait.gif
26. [Unknown photograph of trolley] Vileda Professional, Retrieved August 08, 2014 from: http://vileda-professional.com/nl-NL/products/04-trolleys/12-voleopro/voleopro_closeup2.gif
27. CES Selector software, Granta Design Limited, Cambridge, UK, 2013 Retrieved Juli 09, 2014 from: www.grantadesign.com
28. [Pad printing – list of Accessories] Siebdruck-Service Eikmeyer GmbH, Retrieved August 08, 2014 from: http://www.siebdruckservice.com/pdf/Tampondruck-Seite_01_bis_75.pdf
29. [Gas-Injection Moulding with DuPont engineering polymers] DuPont, Technical Report, Retrieved August 08, 2014 from: http://plastics.dupont.com/plastics/pdflit/europe/markets/GasInj_e.pdf

APPENDIX

Additional information

A1 An Extraction of the Sprinklebottle/ Dosing Jug Briefing

A2 List with Requirements Compared with the Concepts

A3 Testing the 3D Printed Models

A4 Material Properties: PE-HD

A5 Material Properties: PP (copolymer, clarified/nucleated)

A6 a Injection Blow Molding

b Injection Molding

c Extrusion Blow Molding

A1

An Extraction of the Sprinklebottle/Dosing Jug Briefing

Sprinklebottle/dosing jug

An intermediate alternative

Sprinklebottle

Instead of a spraybottle Vileda Professional Nordics and BNL use a "Sprinklebottle" instead of a standard spraybottle.

Characteristics:

- Standard bottle from a Nordic supplier
- Original use: to wet textile while ironing
- Milky transparant
- Blue cap only
- Small holes in the cap in order to be able to spray

PHA/221012 Vileda Professional presentation 3

Sprinklebottle/dosing jug

Strong wish: Two in One

+

Combined Sprinkle bottle & dosing jug

Vileda Professional does not have a dosing jug in the assortment.
There is a strong wish to have a sprinklebottle and dosing jug combined in 1 product

The sprinklebottle/dosing jug can be used for:

- Sprinkling detergent solutions on surfaces or cloths
- Pre-wetting a single mop (Swep, ClickSpeed etc.)
- Sprinkling water on spots in order to soak them
- Measuring a amount of fluid

PHA/221012 Vileda Professional presentation 5

Sprinklebottle/dosing jug
Application 1: moistering mops

Sprinklebottle/dosing jug
Application 2: pre-soaking spots

Sprinklebottle/dosing jug
Application 3: toiletcleaning

Sprinklebottle/dosing jug

Why interesting to develop

Potential

Sales in currently selling countries

- Benelux: est. 5.000 pieces
- Nordics: est. 25.000 pieces

Competition

Only Vileda Professional has a Sprinkle bottle. Competitors are Offering trigger spraybottles.
Taking this in account, volumes can grow. If we develop a Sprinkle bottle/dosing jug combined in one product, you can add up the volume for dosing jugs as well.

Pricing

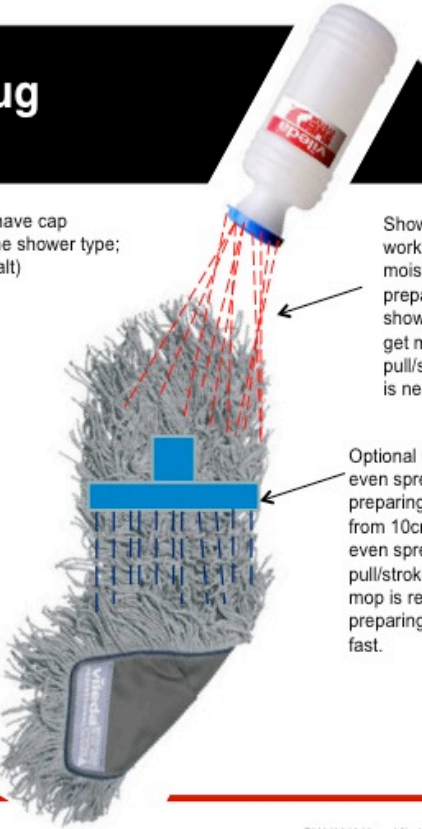
Estimated end-user price: first indication **max.** € 10,=
Distrubutor price:
Out of factory price:

Sprinklebottle/dosing jug

Specific input Nordics

Would it be possible to have cap
Where you can adjust the shower type;
like in cruet(pepper or salt)

Bottle shape: Bottle on the right picture is more practical keep in pocket than round one.
But is it ergonomically worse to squeeze?
Oval shape could be best – but diffucult find ready product from the market…



Shower/water spread is working well for adding moisture onto floor. But preparing mops the shower is not optimal. To get moist mop too many pull/stroke over the mops is needed.

Optional Cap type: even spread when preparing mop. Benefit from 10cm distance even spread. 1 or 2 pull/stroke over and mop is ready. For preparing 1-3 mops fast.

A2

List with Requirements Compared with the Concepts

	Requirements	**Concept:**	**1 2 3**
1.	The product must be able to store liquids		2 2 2
2.	The product must be able to sprinkle liquids		2 2 2
3.	Every surface of the product that can come in touch with fluid must be able to be cleaned in a sink or a dishwasher		2 0 2
4.	The product must be able to be produced by mass production		2 2 2
5.	The product must not produce aerosols		2 2 2
6.	The end user price must be lower than 10 Euro		1 1 1
7.	The product must be cleaned faster than a trigger spraybottle		2 0 2
8.	The product must assist a work force while moistening mops, pre-soaking spots and sanitary cleaning		2 2 2
9.	The product must not leak liquids while tilting		0 2 0
10.	The user must be able to hold the bottle in one hand		2 2 2
11.	The maximum content must not exceed 750 ml and must not be less than 500ml		1 1 1
12.	Using the product must not cause pain/stress injuries in relevant joints of the end-user		2 0 0
13.	The product should decrease the performed range of movements in the wrist		2 1 1
14.	The product must not contain small, easy to lose parts		2 2 0
15.	It must be easier to put on the cap, than to put off the cap		2 0 1
16.	The cap must not drop off if not wanted		2 2 1
17.	The current amount of content must be always visible		2 2 2
18.	The product must enable the user to pour liquids on desired spots or surfaces		2 2 2
19.	The product must sprinkle fluid through squeezing and/or shaking		2 0 0
20.	The product must be squeezed easier than the current Sprinklebottle		2 2 0
21.	The top of the product must be bended and relieved		2 2 1
22.	The product must give instruction on how much fluid is needed for an application		1 1 1

Figure XX

23.	The product must mirror the current amount of liquid by a unit	2 2 2
24.	The product must enable the user to pour a desired amount of content over a surface	2 2 2
25.	The product must be able to stand independently on a flat horizontal surface (filled and empty)	2 2 2
26.	The lines of the product must meet in a radius	1 1 1
27.	Walls of the product must meet in a radius	1 1 1
28.	The products dimensions must meet the following proportions: 1:1, 1:2, 1:3	1 1 1
29.	Same color-codes with respect to an identification of content must only be used once	1 1 1
30.	Color coding with respect to the identification of content must be visible at all time	1 1 1
31.	Shadings and textures of material of parts must be assigned to specific functions and location of the part	1 1 1
32.	The product must offer space to place a sticker with additional Information about the current content	2 0 1
33.	The logo must be placed prominently with a minimum width of 30mm	1 1 1
34.	The logo must be printed on the product	1 1 1
35.	The material must be printable	1 1 1
36.	The product must be made of a thermoplastic material	1 1 1
37.	The Material must be at a minimum of one part transparent	2 2 2
38.	The Material must be imperishable against strong acids	1 1 1
39.	At least one part of the product must be squeezable	2 2 0
40.	The material of the product must not be PVC	1 1 1

Total:

c1: 2:24; 1:15; 0:1

c2: 2:18; 1:16; 0: 6

c3: 2: 14; 1: 20; 0:6

Wishes

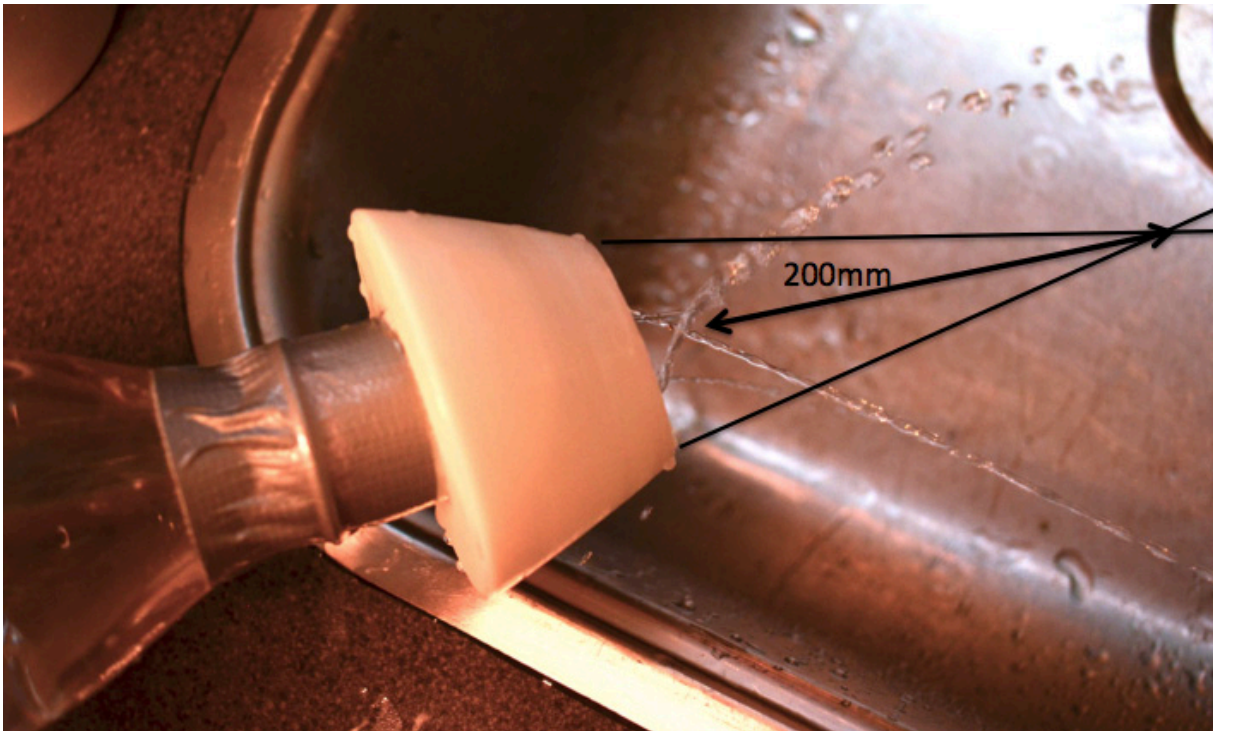
1.	The product shall be able to attach the product on pocket, belt or tubes or profiles of a trolley	0 0 2
	a. The attachment device shall be able to attach the product on a profile with a maximum diameter of 30mm	0 0 1
	b. The attachment device shall be able to attach product with second device and can preserve while movements of the second device or the product itself	0 0 2
	c. Handles must have smooth transitions and waist	1 1 1
2.	The product shall provide a cap closure-system	
	a. The closure system must not contain hard to reach and/or small parts and surfaces	1 1 1

Total:
c1: 2:0; 1:2; 0:3
c2: 2:0; 1:2; 0: 3
c3: 2: 2; 1: 3; 0:0

Figure XX.

A3

Testing the 3d printed models



A4

Material Properties: PE-HD (general purpose, molding & extrusion)

Identification

Designation:High density polyethylene / HDPE (homopolymer)

Tradenames:

Alathon; Alkathene; Alkatuff; Alphacan; Alpolic; Appryl; Argentina-I; Argetena-J; Aspun; Asrene; Bapolene; Borstar; Bralen; Bynel; Cestidur; Cestilene; Cestilite; ChampLine; Clearflex; Cogefill; Cogegum; Compotene; Cosmothene; Cotene; CPGSeaboard; DaelimPoly; Dafnelen; Daisolac; Densetec; Dinalen; Dowlex; DPE; Dunalon; Dynex; Elenac; Elite; EL-Lene; Eltex; Eraclene; Ethafoam; Etilinas; Evatane; Evolue; Exxco; Farralloy; Ferrene; Finathane; Flexet; Flexirene; Forlink; Formolene; Fortiflex; Funecon; Getilan; G-Lene; G-Lex; Halene; Harmorex; HiD; Hipersite; Hitec; HiVal; Hivorex; HiWax; HI-ZEX; Hostalen; Illen; Indothene; Innovex; Ipethene; J-Rex; Kemcor; Lacqtene; Lagomix; Lagotene; Lamdex; LinTech; Liten; Lubotene; Lucofin; Luflexen; Lumitac; Lupolen; Lupolex; Malen-E; Marflex; Marlex; Maxbatch; Maxlen; Microlen; Microthene; Mirason; Mirathen; mPact; Nevilen; Nipolon; Nissen; Nortuff; Novapol; Novatec; Novex; Okiten; Osstyrol; Padmex; Paxon; Perlene; Petilen; Petromont; Petrothene; Plastazote; Polidan; Polinter; Polyfort; Polystone; Pre-Elec; Pro-Fax; Purell; Reclair; Relene; Repolen; Rexell; Riblene; Rigidex; Rotoflame; Sanalite; Sanatec; Sanren; Schulink; Scolefin; S-Com; Seetec; Spherilin; Stamylan; Stamylex; Sumikathene; Sunfine; Suntec; Suplex; Syncure; Tecafine; Thai-Zex; Thermolen; Tipilen; Tipolen; Total Petrochemicals PE; Tracel; Tracolen; Tuflin; Tyvek; Ultzex; Umerit; Unival; Venelene; Vstolen; VulTracell; Vyon; Vytek; Yuhwa; Yukalon; Zemid

General Properties

Density	952	-	965	kg/m^3
Price *	1.4	-	1.54	EUR/kg
Composition overview				
Composition (summary)	(CH2CH2)n, typical n=10,000-20,000			
Base:	Polymer			

Polymer class:	Thermoplastic : semi-crystalline				
Polymer type	PE-HD				
Polymer type full name:	Polyethylene, high density				
Filler type:	Unfilled				
Composition detail (polymers and natural materials)					
Polymer	100%				
Mechanical properties					
Young's modulus	1.07	-	1.09	GPa	
Compressive modulus*	1.07	-	1.09	GPa	
Flexural modulus	0.997	-	1.55	GPa	
Shear modulus*	0.377	-	0.384	GPa	
Bulk modulus*	2.15	-	2.26	GPa	
Poisson's ratio*	0.41	-	0.427		
Shape factor	4.6				
Yield strength (elastic limit)	26.2	-	31	MPa	
Tensile strength	22.1	-	31	MPa	
Compressive strength*	18.6	-	24.8	MPa	
Flexural strength (modulus of rupture)*	30.9	-	43.4	MPa	
Elongation	1.12e3		-	1.29e3	% strain
Hardness - Vickers *	7.9	-	9.9	HV	
Hardness - Rockwell M*	31	-	35		
Hardness - Rockwell R*	45	-	55		
Fatigue strength at 10^7 cycles*	8.84	-	12.4	MPa	
Fracture toughness *	1.52	-	1.82	MPa.m^0.5	
Mechanical loss coefficient (tan delta)*	0.0367		-	0.0374	
Impact properties					
Impact strength, notched 23 °C	6.14	-	18.6	kJ/m^2	
Impact strength, notched -30 °C	3.33	-	16.3	kJ/m^2	
Impact strength, unnotched 23 °C	590	-	600	kJ/m^2	
Impact strength, unnotched -30 °C	590	-	600	kJ/m^2	
Thermal properties					
Melting point	130	-	137	°C	
Glass temperature	-125	-	-90	°C	

Heat deflection temperature 0.45MPa	79	-	91	°C
Heat deflection temperature 1.8MPa*	44	-	77	°C
Maximum service temperature	113	-	129	°C
Minimum service temperature	-82	-	-72	°C
Thermal conductivity	0.461	-	0.502	W/m.°C
Specific heat capacity	1.75e3		-	1.81e3J/kg.°C
Thermal expansion coefficient	106	-	198	μstrain/°C
Processing properties				
Linear mold shrinkage	1.5	-	4	%
Melt temperature	177	-	274	°C
Mold temperature	30	-	50	°C
Molding pressure range	82.5	-	103	MPa
Electrical properties				
Electrical resistivity	3.3e24		-	3e25 μohm.cm
Dielectric constant (relative permittivity)	2.2	-	2.4	
Dissipation factor (dielectric loss tangent)	4e-4	-	6e-4	
Dielectric strength (dielectric breakdown)	17.7	-	19.7	MV/m
Comparative tracking index	600			V
Optical properties				
Refractive index	1.53	-	1.55	
Transparency	Translucent			
Absorption, permeability				
Water absorption @ 24 hrs	0.005	-	0.01	%
Water vapor transmission	0.0283	-	0.0425	g.mm/m².day
Permeability (O2)	49.8	-	69.4	cm³.mm/m².day.atm
Durability:	flammability			
Flammability	Highly flammable			
Durability:	fluids and sunlight			
Water (fresh)	Excellent			
Water (salt)	Excellent			
Weak acids	Excellent			
Strong acids	Acceptable			
Weak alkalis	Excellent			

Strong alkalis	Excellent			
Organic solvents	Limited use			
UV radiation (sunlight)	Fair			
Oxidation at 500C	Unacceptable			
Primary material production:	energy, CO2 and water			
Embodied energy, primary production*	77	-	85.1	MJ/kg
CO2 footprint, primary production *	2.64	-	2.92	kg/kg
Water usage *	55.3	-	61.1	l/kg
Material processing:	energy			
Polymer extrusion energy *	5.9	-	6.52	MJ/kg
Polymer molding energy *	20.8	-	23	MJ/kg
Coarse machining energy * (per unit wt removed)	0.688	-	0.76	MJ/kg
Fine machining energy * (per unit wt removed)	2.6	-	2.88	MJ/kg
Grinding energy * (per unit wt removed)	4.73	-	5.23	MJ/kg
Material processing:	**CO2 footprint**			
Polymer extrusion CO2*	0.442	-	0.489	kg/kg
Polymer molding CO2*	1.56	-	1.73	kg/kg
Coarse machining CO2* (per unit wt removed)	0.0516	-	0.057	kg/kg
Fine machining CO2 * (per unit wt removed)	0.195	-	0.216	kg/kg
Grinding CO2 (per unit wt removed)	0.355	-	0.392	kg/kg
Material recycling: energy,	**CO2 and recycle fraction**			
Recycle	True			
Embodied energy, recycling*	26.1	-	28.9	MJ/kg
CO2 footprint, recycling*	0.897	-	0.991	kg/kg
Recycle fraction in current supply	8.02	-	8.86	%
Downcycle	True			
Combust for energy recovery	True			

Heat of combustion (net)*	44	-	46.2	MJ/kg
Combustion CO2*	3.06	-	3.22	kg/kg
Landfill	True			
Biodegrade	False			
A renewable resource?	False			

Notes

Typical uses: Pipes; toys; bowls; buckets; milk bottles; crates; tanks; containers; film for packaging; blown bottles for food.

Data from CES Selector 2013, Granta Design Limited, Cambridge, UK, 2013, (Grantadesign.com)

A5

Material properties: PP (copolymer, clarified/nucleated)

Identification

Designation: Polypropylene (Copolymer, clarified/nucleated/nucleated)

Tradenames

A. Schulman PP; ACCPRO; Amoco PP; Bormed; Capilene; CERTENE; Cosmoplene; DOMOLEN; DOW Polypropylene; El-Pro; ELTEX P; ExxonMobil PP; FHR Polypropylene; Formolene; Globalene; Global PP; Halene P; Huntsman PP; Hypro; Innovene PP; M. Holland; Marlex PP; Moplen; Mytex; Network Polymers PP; Petrothene; Polifin PP; Pro-fax; Propilco PP; Purell; REPOL; SABIC PP; Sunoco PP; TIPPLEN; TITANPRO; TOTAL PETROCHEMICALS Polypropylene; Trilene; YUPLENE

General Properties

Density	897	-	906	kg/m^3
Price *	1.68	-	1.94	EUR/kg

Composition overview

Composition (summary)	copolymer of propylene (CH2-CH(CH3))n and up to 7% ethylene (CH2CH2)m or other comonomer
Base	Polymer
Polymer class	Thermoplastic : semi-crystalline
Polymer type	PP-copolymer
Polymer type full name	Polypropylene copolymer
Filler type	Unfilled

Composition detail (polymers and natural materials)

Polymer	100	%

Mechanical properties

Young's modulus	1.18	-	1.41	GPa
Compressive modulus*	1.18	-	1.41	GPa
Flexural modulus	1.12	-	1.36	GPa
Shear modulus*	0.454	-	0.465	GPa
Bulk modulus*	2.27	-	2.32	GPa
Poisson's ratio*	0.402	-	0.41	

Shape factor	11.9			
Yield strength (elastic limit)	24.6	-	30	MPa
Tensile strength	18.4	-	19.8	MPa
Compressive strength*	31.8	-	33.4	MPa
Flexural strength (modulus of rupture)*	31.3	-	35.9	MPa
Elongation	62	-	524	% strain
Elongation at yield	5.41	-	9.52	% strain
Hardness - Vickers *	7.94	-	8.34	HV
Hardness - Rockwell M	55.4	-	62.3	
Hardness - Rockwell R	84	-	93.2	
Hardness - Shore D	59.9	-	65.2	
Hardness - Shore A *	93.6	-	98.4	
Fatigue strength at 10^7 cycles*	7.45	-	7.82	MPa
Fracture toughness *	1.26	-	1.33	MPa.m^0.5
Mechanical loss coefficient (tan delta)*	0.0302		-	0.0317
Impact properties				
Impact strength, notched 23 °C	5.02	-	9.09	kJ/m^2
Impact strength, notched -30 °C	4.1	-	5.24	kJ/m^2
Impact strength, unnotched 23 °C	102	-	200	kJ/m^2
Impact strength, unnotched -30 °C	31.9	-	69.3	kJ/m^2
Thermal properties				
Melting point	151	-	167	°C
Glass temperature	-24	-	-16	°C
Heat deflection temperature 0.45MPa	87	-	105	°C
Heat deflection temperature 1.8MPa	44.4	-	60.5	°C
Maximum service temperature*	69.4	-	86.8	°C
Minimum service temperature*	-25	-	-10	°C
Thermal conductivity	0.225	-	0.234	W/m.°C
Specific heat capacity*	1.88e3		-	1.92e3J/kg.°C
Thermal expansion coefficient	58.2	-	59.7	μstrain/°C
Vicat softening point	131	-	151	°C
Processing properties				
Linear mold shrinkage	1.15	-	2.12	%

Melt temperature	209	-	238	°C
Mold temperature	16.5	-	46.8	°C
Molding pressure range	7.27	-	78.1	MPa
Electrical properties				
Electrical resistivity	9.9e22	-	1.01e23	μohm.cm
Dielectric constant (relative permittivity)	2.06	-	2.14	
Dissipation factor (dielectric loss tangent)	2.94e-4	-	3.06e-4	
Dielectric strength (dielectric breakdown)	21.3	-	22.1	MV/m
Comparative tracking index	600			V
Optical properties				
Refractive index	1.48	-	1.5	
Transparency	Transparent			
Absorption, permeability				
Water absorption @ 24 hrs	0.0195	-	0.0205	%
Water vapor transmission	0.224	-	0.308	g.mm/m².day
Permeability (O2)	61.2	-144	cm³.mm/m².day.atm	
Durability:	flammability			
Flammability	Highly flammable			
Notes				
Currently NOT UL tested but expected to pass the HB test				
Durability:	fluids and sunlight			
Water (fresh)	Excellent			
Water (salt)	Excellent			
Weak acids	Excellent			
Strong acids	Excellent			
Weak alkalis	Excellent			
Strong alkalis	Excellent			
Organic solvents	Excellent			
UV radiation (sunlight)	Poor			
Oxidation at 500C	Unacceptable			
Primary material production:	energy, CO2 and water			
Embodied energy, primary production*	75.7	-	83.7	MJ/kg
CO2 footprint, primary production *	2.96	-	3.27	kg/kg

Water usage*	37.2	-	41.2	l/kg
Material processing:	energy			
Polymer extrusion energy*	5.94	-	6.56	MJ/kg
Polymer molding energy*	21.9	-	24.3	MJ/kg
Coarse machining energy* (per unit wt removed)	0.818	-	0.905	MJ/kg
Fine machining energy* (per unit wt removed)	3.91	-	4.32	MJ/kg
Grinding energy (per unit wt removed)*	7.34	-	8.12	MJ/kg
Material processing:	**CO2 footprint**			
Polymer extrusion CO2*	0.445	-	0.492	kg/kg
Polymer molding CO2*	1.65	-	1.82	kg/kg
Coarse machining CO2 (per unit wt removed)*	0.0614		-	0.0678kg/kg
Fine machining CO2 (per unit wt removed)*	0.293	-	0.324	kg/kg
Grinding CO2 (per unit wt removed)*	0.551	-	0.609	kg/kg
Material recycling:	**energy, CO2 and recycle fraction**			
Recycle	True			
Embodied energy, recycling*	25.7	-	28.4	MJ/kg
CO2 footprint, recycling*	1	-	1.11	kg/kg
Recycle fraction in current supply	5.26	-	5.81	%
Downcycle	True			
Combust for energy recovery	True			
Heat of combustion (net) *	44	-	46.2	MJ/kg
Combustion CO2 *	3.06	-	3.22	kg/kg
Landfill	True			
Biodegrade	False			
A renewable resource?	False			

Notes

Typical uses

Household Goods; Closures; Toys; Containers, Thermoformed; Sheet; Consumer Applications; Lids; Containers, Thin-Walled; Cups; Media; Parts, Thin-walled; Food Applications, Non-specific;Automotive Exterior Parts; Automotive Interior Parts; Furniture; General Purpose; Industrial Applications; Appliance Components;

Industrial; Automotive Interior Trim; Washer; Luggage; Fittings; Pipe, Corrugated; Packaging, Rigid; Compounding; Seats; Coverings, Protective; Tools, Power/Others; Filaments; Profiles; Lawn and Garden Equipment; Agricultural Applications; Blow Molding Applications; Vials; Connectors; Tool/Tote Box; Kitchenware; Labware; Containers, Blown; Sheet, Clear; Bottles, Fruit Juice; Cosmetics; Drinkware, Disposable; Packaging, Cosmetic; Packaging, Pharmaceutical; Audio Tapes; Buckets; bowls; general mechanical parts; bottle crates; medical components; washing machine drums; pipes; battery cases; bottle caps; bumpers; films for packaging; fibers for carpeting and artificial sports surfaces.

Other notes

Clarified polypropylene resins are ‘nucleated’, meaning that a crystal nucleation additive has been mixed into the resin. These additives clarify the material by increasing the number and reducing the size of crystallites in the material. Crystallites become so small that they no longer scatter visible light, thereby lowering haze in the material from >50% to <20%.

Data from CES Selector 2013, Granta Design Limited, Cambridge, UK, 2013, (Grantadesign.com)

A6

A6/a Injection blow molding

General

Designation

Molding: Injection Blow Molding

The process

In INJECTION BLOW MOLDING, a hollow preform is injection-molded over a mandrel which provides the hollow shape. The mandrel transfers the hot preform to the blow molding die and also functions as the blow nozzle.

Air is injected under pressure through the mandrel blowing the polymer radially against the mold walls where it cools and freezes. The mold is opened and the part ejected. The process produces no waste material.

Injection blow molding offers better control over finished part weight and wall thickness (than extrusion blow molding) and is capable of high tolerances in the unblown, injection-molded neck area, hence is it useful for screw closures, etc.

Handles may be molded in (solid only). The process is most competitive for production of small bottle sizes (< 360mL), for rigid thermoplastics (e.g. PS, PC, PET, etc.), and for wide mouth containers.

Tooling costs are much higher than for extrusion blow molding, hence process is only used for volume production.

Stretch Blow Molding is an important variant. It is most commonly used for the production of oriented PET drinks bottles.

Process schematic

Shape				
Hollow 3-D	True			
Physical attributes				
Mass range	0.001	-	0.25	kg
Range of section thickness	0.4	-	3	mm
Tolerance	0.25	-	1	mm
Roughness	0.2	-	1.6	μm
Process characteristics				
Primary shaping processes	True			

Secondary shaping processes	False			
Machining processes	False			
Prototyping	False			
Discrete	True			
Continuous	False			
Economic attributes				
Economic batch size (units)	1e5	-	1e7	
Labor intensity	low			
Cost modeling				
Relative cost index (per unit)	11.9	-	22.5	EUR

Parameters: Material Cost = 6.37EUR/kg, Component Mass = 1kg, Batch Size = 1e3, Overhead Rate = 119EUR/hr, Capital Write-off Time = 5yrs, Load Factor = 0.5

Capital cost	4.5e3	-	4.5e4	EUR
Material utilization fraction	0.9	-	0.99	
Production rate (units)	100	-	2.5e3	/hr
Tool life (units)	1e5	-	1e7	
Tooling cost	4.5e3	-	1.5e4	EUR
Supporting information				

Design guidelines

Used for thin-walled hollow or tubular articles with small openings (e.g. bottles). Suitable for fairly regular shapes.

Technical notes

Thermoplastics commonly used include PET, PC, HDPE, LDPE, PP, ABS and uPVC. Limited level of reinforcement possible for composite materials (i.e. particulate and short fibers).

The wall thickness should be as uniform as possible to ensure more rapid molding cycles and to avoid distortion.

Typical uses

Primarily bottles and containers - largely small bottles (< 0.5L), wide mouth containers, and simple shapes.

The economics

Tooling cost range covers small, simple to large, complex molds.

The environment

Waste material is recyclable. Significant dust exposures may occur in the formulation of the resins. Thermostatic controller malfunctions can be extremely hazardous.

A6/b Injection molding (thermoplastics)

General

Designation

Molding: Injection (thermoplastics)

The process

INJECTION MOLDING of thermoplastics is the equivalent of pressure die casting of metals. Molten polymer is injected under high pressure into a cold steel mold. The polymer solidifies under pressure and the molding is then ejected.

Various types of injection molding machines exist, but the most common in use today is the reciprocating screw machine (shown schematically). Capital and tooling costs are very high.

Production rate can be high particularly for small moldings. Multicavity molds are often used. The process is used almost exclusively for large volume production.

Prototype moldings can be made using cheaper single cavity molds of cheaper materials. Quality can be high but may be traded off against production rate. Process may also be used with thermosets and rubbers.

Some modifications are required - this is dealt with separately (see Injection Molding - thermosets). Complex shapes are possible, though some features (e.g. undercuts, screw threads, inserts) may result in increased tooling costs.

STRETCH BLOW MOLDING (SBM) is an important variant of the extrusion and injection blow molding processes. It is most commonly used as injection stretch blow molding for the production of oriented PET drinks bottles.

In injection SBM a preform is injection molded (as for injection blow molding). This is then transferred hot to the blow mold where it is stretched longitudinally by plunger before being blow radially.

The biaxial stretching significantly improves the mechanical properties (strength and toughness) of the finished part. In extrusion SBM the cut parison is mechanically

stretched longitudinally before being blown.

Capital and tooling costs are very high as is production rate. Hence process is used exclusively for high volume production.

Process schematic

Shape				
Circular prismatic	True			
Non-circular prismatic	True			
Solid 3-D	True			
Hollow 3-D	True			
Physical attributes				
Mass range	0.01	-	25	kg
Range of section thickness	0.4	-	6.3	mm
Tolerance	0.1	-	1	mm
Roughness	0.2	-	1.6	μm
Process characteristics				
Primary shaping processes	True			
Secondary shaping processes	False			
Machining processes	False			
Prototyping	False			
Discrete	True			
Continuous	False			
Economic attributes				
Economic batch size (units)	1e4	-	1e6	
Labor intensity	low			
Cost modeling				
Relative cost index (per unit)	13.1	-	88.8	EUR

Parameters: Material Cost = 6.37EUR/kg, Component Mass = 1kg, Batch Size = 1e3, Overhead Rate = 119EUR/hr, Capital Write-off Time = 5yrs, Load Factor = 0.5

Capital cost	3e4	-	6.75e5	EUR
Material utilization fraction	0.6	-	0.9	
Production rate (units)	60	-	3e3	/hr
Tool life (units)	1e4	-	1e6	
Tooling cost	3e3	-	7.5e4	EUR

Supporting information

Design guidelines

Complex shapes are possible. Thick sections or large changes in section are not recommended. Small reentrant angles are possible.

Technical notes

Most thermoplastics can be injection molded. Some high melting point polymers (e.g. PTFE) are not suitable. Thermoplastic based composites (short fiber and particulate filled) are also processed.

Injection-molded parts are generally thin-walled.

Typical uses

Extremely varied. Housings, containers, covers, knobs, tool handles, plumbing fittings, lenses, etc.

The economics

Tooling cost range covers small, simple to large, complex molds. Production rate depends on complexity of component and number of mold cavities.

The environment

Thermoplastic sprues can be recycled. Extraction may be required for volatile fumes. Significant dust exposures may occur in the formulation of the resins. Thermostatic controller malfunctions can be extremely hazardous.

A6/c Extrusion blow molding

General

Designation

Molding: Extrusion Blow Molding

The process

In EXTRUSION BLOW MOLDING, a tube (or parison) is extruded and clamped in a split mold. Air is then injected under pressure inside the parison, blowing the polymer against the mold walls where it cools and freezes.

The mold is opened and the part ejected. Surplus material at both ends of the part is then removed. The process uses thermoplastics of high melt viscosity and high molecular weight. It is most widely used with PE (especially HDPE), PP and PVC.

Other thermoplastics are also used. The process is capable of producing irregular shaped containers and blown handles. Mold cost is lower than for injection blow molding.

It is generally most competitive for larger containers (capacity > 0.5 L) and high batch sizes.

Data from CES Selector 2013, Granta Design Limited, Cambridge, UK, 2013, (Grantadesign.com)