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**Research upon ergonomic and ecological-
friendly design of bulk bins for Nada Grocery
market**

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Abstract

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The purpose of the study was to determine ergonomic and ecological friendly solutions for the bulk bins design in the project`s boundaries of Nada Grocery market. This aim was reached by describing the most frequent challenges which both staff and customers face during the exploitation of bins and by closer examination of possible ecological friendly materials for the potential design.

The information was gathered from the literature, articles, corresponding theses, the Internet and knowledge got from the studies. The major part of the research was based on the survey, which has been done among several bulk bins markets in a form of questionnaire.

Based on the findings the suggestions of the environmental friendly materials and recommendations for the ergonomic design were provided, the examples of the possible designs were shown.

Keywords: ecological, design, zero waste

Table of contents

| | | |
|-------|---|----|
| 1 | Introduction | 4 |
| 2 | “Zero waste” movement..... | 5 |
| 2.1 | Nada Grocery | 7 |
| 3 | Markets survey | 8 |
| 3.1 | Scoop and gravity bins..... | 9 |
| 3.2 | Suppliers and materials | 12 |
| 3.3 | Design of Coöperatie de Nieuwe Graanschuur..... | 15 |
| 3.4 | Feedback | 17 |
| 4 | Materials selection..... | 19 |
| 4.1 | Ecological criteria..... | 19 |
| 4.2 | Plastics | 20 |
| 4.2.1 | Handling with plastic waste | 21 |
| 4.2.2 | Plastics recycling..... | 23 |
| 4.2.3 | PET | 24 |
| 4.2.4 | PLA | 24 |
| 4.3 | Alternatives | 25 |
| 4.4 | Materials comparison..... | 27 |
| 5 | Design solutions | 27 |
| 5.1 | Gravity bin..... | 27 |
| 5.2 | Scoop bin..... | 29 |
| 6 | Summary and discussion..... | 30 |
| | Figures..... | 31 |
| | Tables | 31 |
| | List of references | 32 |

Appendices

Appendix 1

List of markets

1 Introduction

Bulk bins stores nowadays are becoming more and more popular. From the perspective of sellers such a business is profitable, because costs are decreased by elimination of packages, which leads to the lower goods prices and higher demand. Many people often prefer bulk bins markets to the ordinary ones due to the possibility of taking the exact amount of the product that they need and not more. In the majority of bulk bins shops customers are asked to bring their own containers or jars to purchase some kind of goods, and this leads to the absence of extra-waste in such business, which makes it much more environmental friendly in comparison with mass productions of packaged goods. The reduction of unnecessary waste is a key concept in “zero waste” movement, the popularity of which is growing now as well. People are starting to look for the options to cut the amount of garbage in their everyday life in order to save the environment, and such stores are able to offer a good possibility to do it. One of such markets, which represents this movement, is the Nada Grocery market, which is located in Canada.

This thesis is the part of the project held by Nada Grocery market, which concentrates on the new design concept of bulk bins. The new concept reviews and corrects the weak parts of modern bins designs in order to improve it. Moreover, one of the main tasks for this project is to find a substitution to the plastics, which are used everywhere in bulk bins production, and make it even more environmental friendly. The objective of the thesis is to find a suitable “green” material in the design of a bulk bin, and make the design itself as much comfortable in operating for both staff and clients as possible.

This research goes through the descriptions of different kinds of existing bulk bins, reviews its typical designs, its advantages and disadvantages. It follows by the review of sustainable materials, which could be used in bins production as a substitute for plastics. And after the data collection, the suggestion about the most optimal design is made. The main questions for the starting point are: Which kinds of materials are usually used and why? Is it possible to get rid of plastics in the new concept of design? What are the challenges in the modern

models of bulk bins if there are any? What are the criteria of the optimal bulk bin “green” design?

To get answers to these questions, the research was done. The survey among bulk bins companies to collect their experience of bulk bins usage was conducted. All information is collected from the Internet, companies themselves and corresponding literature.

In the first chapter a brief introduction into the “zero waste” movement is made, the concept of Nada Grocery market is described. It follows by the bulk bins design research and the survey of companies and clients. The conception of ecological design and overview of the possible plastic substitutions are provided afterwards. In the end the new concept of possible designs, based on the combination of all collected data, is presented.

2 “Zero waste” movement

In this chapter a brief background of the “zero waste” movement is introduced in order to answer the questions of how and where it has appeared, which ideas it develops and which role it plays in the modern society.

The first mention of “zero waste” comes from the early 1970s, when the company Zero Waste Systems was founded by American chemist Paul Palmer in San Francisco. This company was engaged in industrial chemicals recycling and its main task was to purchase chemicals from the factories where they were considered as production waste. Due to the fact that the factories did not have any use of these chemicals, the prices for them were incommensurable low in comparison to the prices of the same chemicals in the market. In its turn the factories had no need to care about the utilizing these chemicals, as long as the Zero Waste Systems were in charge of transporting them to other places, where they were sold as raw materials. The company stopped functioning in 1990s, but the idea of the concept has not vanished. Paul Palmer has realized that the “zero waste” model could be adopted by many other fields, not only chemical industry. In 2005 he wrote a book *Getting to Zero Waste*, where he described the possible methods of reusing and recycling of so-called garbage, which included

not only industrial excesses but also the ones, produced by consumers. (Upadhyaya 2013, Palmer n.d.)

The idea of “zero waste” has developed through time and nowadays can be described as philosophy of waste reducing, reusing and recycling in order to reach its minimum possible level. In “zero waste” philosophy waste is considered as a potential resource, which is simply needed to be transferred in another chain of production. This vision also can be interpreted as a way of maximizing the efficiency of the resources. From the perspective of mass production saving resources means saving money, so the “zero waste” approach is the one where both ecological and economical interests meet. (Upadhyaya 2013.)

To get rid of waste completely seems like an unreachable target in the modern age, but the first steps in moving toward this goal are already being undertaken. One of the possible ways of waste reduction in a production process is designing it out of the system. The example of such a type of waste that can be eliminated on the first production stages is food packaging.

Food packaging is playing a role of a disposable food storage which after a short period of usage ends its life on a dump. The idea that the food can be kept and transported in long-lasting jars and containers has developed into bulk bins stores – goods markets where the packaging is fully avoided. Such types of stores require customers to bring their own tare and fill it with the right amount of everything they need. There are several advantages for customers to shop in such types of stores. First of all they are able to choose the exact amount of the product they need. Plus, due to the absence of the package prices in such stores are relatively lower. Moreover as a rule such stores prefer to purchase the products from the local farms, supporting small business. So the goods, which are offered to the customers, are fresh and have a high quality.

Nada Grocery is a representative of bulk bins markets, located in Canada, which aims to follow the philosophy of “zero waste” in each aspect of their functioning. A more precise look on it is given in the next section.

2.1 Nada Grocery

Nada Grocery is a bulk bin market, located in Vancouver, Canada. It has been existing as a pop-up store since 2013 under the name of Zero Waste Market until 2018 when it changed its name to Nada Grocery. In June of the same year it got the constant location and started to function as a regular market. (Nada Grocery 2018.)

Nada Grocery store has its official website, where the brief history of its origin is described. The founder of the market is a Canadian marine biologist Brianne Miller. The idea of the package-free market came to her back in 2013, when Brianne noticed that the major part of the ocean pollution consists of the food packaging. She started to brainstorm possible solutions of how to cut down the amount of waste, produced by consumption, and came up with the idea which lately developed into the bulk bins market. (Nada Grocery 2018.)

Nada Grocery takes part in the Canadian “zero waste” movement. The founders put their effort into donation to the relative ecological organizations, such as “1% to the planet” movement. They are aiming to follow the holistic approach upon every undertaken decision, starting from the product sourcing, ending up on the decisions concerning the fate of a surplus. The values of Nada Grocery market are described on the website and include following: providing customers with healthy and high-quality products; inspiring people to reduce the waste in their shopping routine; cultivate an alternative environmental responsible consumption system. (Nada Grocery 2018.)

The assortment of the Nada Grocery market includes various package-free products, such as pet food or household goods, but mostly focuses on the organic food, which comes to the counter from the local urban farms. Obviously, an important role in such type of business play bulk bins, the main task of which is to storage the food in safe condition and prevent it from the spoilage. Bulk bins are also supposed to be comfortable in operating for both clients and staff and in Nada Grocery case to create a low impact on the environment. (Nada Grocery 2018.)

In June of 2017 the research of the most sustainable bulk bins design has started. The aim of it was to define a simple and sustainable design for bulk bins. The main criteria for them included simplicity, sustainability and ecological friendliness as a key factor. The procedure and the outcome of the research will be covered below.

3 Market survey

The major part of the research is based on the survey which took place in the summer of 2017 among bulk bin markets. The research was done in order to collect information about the experience of bulk bins usage and to answer some questions, which Nada Grocery as a young market was interested in. The survey was done in a form of e-mail questionnaire and primarily included 8 questions, which are the following ones:

1. What type of bulk bins do you use (gravity, scoop, etc)?
2. Who are your bulk bin supplier(s)?
3. Why did you choose to work with this supplier?
4. What material are the bins that you use made of?
5. Is it easy/difficult for your staff to operate with the bins (clean, refill, etc)?
6. Have you ever faced any challenges while using bulk bins (hygiene problems, material cracking, etc)?
7. What do your customers say about your bins?
8. What is your weighing system/process?

These questions were sent to approximately 40 bulk bin markets, located in Europe, Canada and the USA. 12 out of 40 markets replied back and took part in the research. After collecting answers 2 additional questions have appeared and 5 markets out of 12 have answered to the additional questions as well. The additional questions included:

9. How do you refill your scoop bins in case there is still a small amount of product in it? Are you taking it away and fill with the fresh product or just leave it there?
10. What is the optimal volume for the gravity/scoop bins to your opinion?

The answers by the markets were presented in free form and were various in length and elaboration. There were some similarities in the answers as well as some differences. Thus the data of the research was decided to be presented in the form of answers overview. (Nada Grocery 2017.)

The overview is divided in three sections. The first section includes a brief description of scoop and gravity bulk bins in order to provide some idea of its basic construction. In the same section the overview of the answers on 1 and 10 questions is presented. The second section includes a short overview of the suppliers (question 2), including the reasons of the markets' choice and materials each manufacture uses (questions 3 and 4). In the third and final section the feedback from the perspective of both customers and staff is provided (questions 5-7), enumerating the possible challenges in the usage or disadvantages in the construction. The answers for questions 8 and 9 about the weighing and refilling processes are omitted in this research. Though Nada Grocery was interested in them, they have nothing in relation with the design question of this thesis.

The names of the markets, that took part in the research, are included in the thesis as appendix.

3.1 Scoop and gravity bins

The descriptive part of this chapter is based on the observance of the gravity and scoop bins. No literature is used.

A scoop bin presents itself as a transparent plastic box which could be filled with some kind of bulk product to be distributed in the packages by customers with the help of scoop or tongs (Figure 1). The product is protected by the cover base at the top and the lid. Each scoop bin is accomplished by a scoop or tongs and has a built-in holder for them. Some models also include the false front which allows seeing the product, even when the bin is not full. Scoop bins can be refilled with goods from both the lid and the cover base. Such type of a bin is an optimal choice for "hard to flow" products such as pet treats, large candies, dried fruits and etc.



Figure 1. Scoop Bin SB300-20 (HL Display 2018)

Gravity bins are also known as gravity dispensers. The construction parts of such bins usually include a tightly sealed lid, a false front, the main body, a spout and a handle or a wheel (Figure 2). The goods in gravity bins are fully protected from the external contact. Gravity is used for distributing a product from the bin to the package. Optimal products for such kind of a bin are free flowing products such as grains, nuts, coffee, cereals and etc because the size of the product unit is restricted by the diameter of the spout. Construction of the gravity bin can vary upon the type of the release mechanism, for example it can be a portion control wheel, a handle or one-hand system (when spout itself is used as a release mechanism).

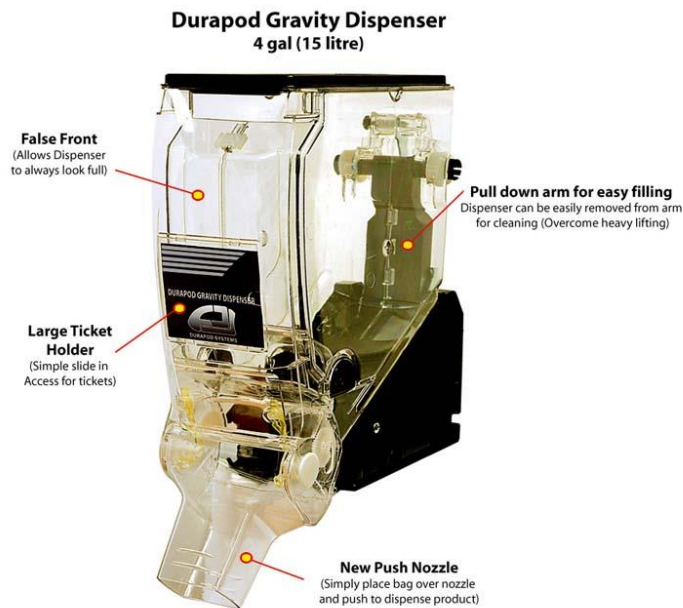


Figure 2. Durapod gravity dispenser with one-hand release system (Durapod Systems 2015)

When comparing scoop and gravity bins it is clear that gravity ones have a higher level of hygiene - the product is hermetically closed and protected from the airborne particles. Such a design helps to reduce the spillage of goods and protect them from spoilage. At the same time for customers it is not possible to reduce the quantity of a product after it is taken out, which can be seen as a disadvantage from the customer`s perspective.

The choice of the bins volume depends on the size of the market itself, which directly affects the number of customers per day. If the flow of the customers is high and the product is popular it is obvious that the bin with the higher volume in this case is preferred. However from the survey two of the markets mentioned that according to their experience for the basic fast flowing products (like rice or grains) the volume of 20 l is enough. For other products 10 l volume is optimal in order to prevent the spoilage.

According to the survey all markets, except one, say that they use both gravity and scoop types of bins, plus most of them in addition use glass jars, boxes, cotton bags and other types of containers for the food. Only one company (Goods only, the Netherlands) decided to refuse from using both gravity and scoop bins because of the great challenges they faced in its operations, espe-

cially in the cleaning process. In the answers it was noticed that their experience shows that plastic is the material which is extremely difficult to clean. Thus the market decided to replace plastic bins with glass pots and bunkers.

3.2 Suppliers and materials

All in all, only 3 manufacturers were mentioned in the answers for question 2 of the survey. They are HL Display, Trade Fixtures and Applymage. Some markets named the retailers of these producers and others named the direct manufacturers themselves. All information about these companies was taken from the official websites.

The HL Display company was named by 3 markets plus 2 markets mentioned the retailers of this producer (which were ID Organics and Mobile Wood online markets). The common reason of choice was the price and the location of the supplier. Markets prefer to purchase bins from the local suppliers, because transportation obviously also affects the total costs.

HL Display is a company founded in Sweden. It is a supplier and manufacturer of the market merchandise. HL Display operates worldwide in over 50 countries. This company developed its own line of bulk bins named 3eBin™ (Figure 3). 3eBin™ line presents the line of scoop and gravity bins which are made out of PET plastic. The design of scoop bins is rather standard. According to the description each model includes an integrated scoop and a catch tray. The lid is soft closing, the front is low and curved for the convenience purposes. In gravity bin design the handle is used as a release mechanism. The construction includes false front, which allows the customers to see the product, even when the bin is not full. The intensity of the products flow can be varied by the staff. (HL Display 2018.)



Figure 3. 3eBin™ scoop and gravity bins (HL Display 2018)

Applmage was named by the French bulk bin market La Bonne Pioche. The market justified its choice by the reason that they were familiar with this supplier before.

Applmage is a French company, designer and producer of markets layout. The range of gravity and scoop bulk bins is presented under the trademark of APPLYVRAC™. Applmage uses PMMA (produced by Plexiglas®) as a material for its bins, small knobs are made from wood. The design of the Applmage bins is visually unique and easily recognizable (Figure 4). In the design straight lines and angled forms prevail. The role of the release mechanism for gravity bin is played by the leaf. Customers themselves are able to regulate the product flow by moving the leaf higher or lower. (Applmage 2018.)

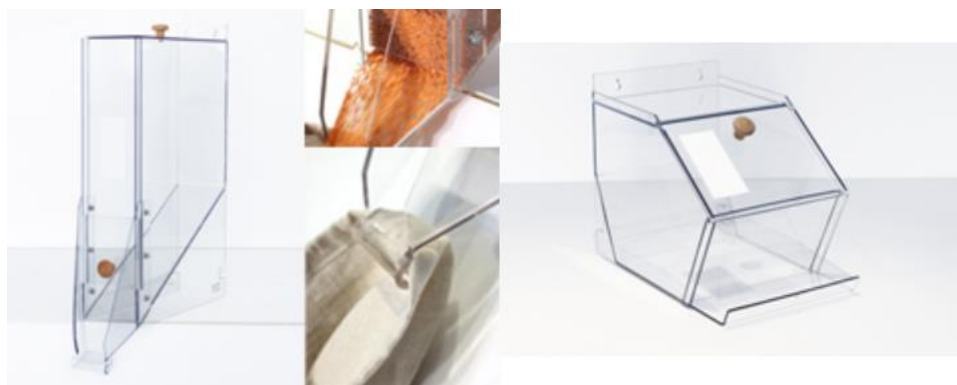


Figure 4. APPLYVRAC™ gravity and scoop bins (Applmage 2018)

Finally Trade Fixtures company was named by 2 markets (Canadian and Austrian ones). The Canadian market Green mentioned the Brencar as the supplier, which offers the production of Trade Fixtures on the website. Green market mentioned that this is the only supplier of bulk bins in Canada. Lunzers Maß-Greißlerei, the Austrian market, decided to rely on the experience of the Whole Foods Market (an American and British chain of food markets), which works with this supplier (Whole Foods Market 2018).

Trade Fixtures acts as a merchandise supplier of the retail food markets. It was founded in Arkansas and is nowadays operating all over the USA and in 45 countries worldwide. It has its own design lines of gravity and scoop bins, named Trade Fixtures and New Leaf. Eastman Tritan™ copolymer is used for the bulk bins production. (Trade Fixtures 2018.)

It can be seen that the design of Trade Fixtures gravity bins (Figure 5) has some similarities with the design of HL Display (false front, handle as a release mechanism, ability to control the flow). The scoop bin has a curved front (which is higher compared with HL Display scoop bin) and a special place for the scoop. Each scoop is attached to the bin itself (Trade Fixture 2018).



Figure 5. Trade Fixtures gravity and scoop bins (Trade Fixtures 2018)

New Leaf and Trade Fixtures bulk bins have the same description in the product section of the Trade Fixtures website. All differences in the design may be seen from the picture (Figure 6).



Figure 6. New Leaf gravity and scoop bins (Trade Fixtures 2018)

Two markets from the survey found it difficult to name one exact manufacturer, because both of them use different types of bins in order to find the most suitable option. And one company (Coöperatie de Nieuwe Graanschuur, the Netherlands) uses its own designed gravity bins. This case appeared to be very interesting for Nada Grocery and thus will be described separately in more details in the next subchapter.

To sum up the most important factor for the markets in choosing the supplier is the price and the location. Few organizations mentioned that there is not a wide range of the suppliers in their countries, so in the meaning of logistics they just purchased local brands, which were available on the market.

3.3 Design of Coöperatie de Nieuwe Graanschuur

The Coöperatie de Nieuwe Graanschuur market, located in the Netherlands, Amersfoort, uses its own unique gravity dispensers design. This design was created by Stephan Lehner and Diana Wildschut from Fablab Amersfoort.

Fablab is a shortened name for “fabrication laboratory”. It is a small-scale workshop, usually located at universities, which offers an open access to various digital fabrications. All volunteers may come and create anything they want, freely using the available tools with the help of desktop machines. The tools usually include 3D-printers, laser cutters, CNC-routers, vinyl cutters and etc. It can be described as a community of sharing ideas and blueprints. There are

over 600 laboratories worldwide nowadays and a lot of designs are presented on the websites by the creators in a form of an open source, which can be shared among the users. (FabLab Amersfoort n.d.)

Fablab Amersfoort focuses onto different methods of materials recycling and reusing (FabLab Amersfoort n.d.). The design of gravity dispenser was created specially for the Coöperatie de Nieuwe Graanschuur market. Though the blueprints of the gravity bin design were lost, the market shared the photographs (Figure 7 and Figure 8) and the description of it.



Figure 7. Gravity bins of Coöperatie de Nieuwe Graanschuur market (Coöperatie de Nieuwe Graanschuur market 2017)



Figure 8. Release mechanism of the gravity bin (Coöperatie de Nieuwe Graanschuur market 2017)

The assembly of these bins was done by the volunteers. Beer barrels were used as a foundation of the body, when another kind of PET was used for the production of the release mechanism.

The mechanism is rather simple. When the handle is twisted, the hole of the mechanism overlaps with the hole in the bottom of the body. Such kind of a mechanism allows customers to control the flow of the product.

The feedback from the market staff tells that bins are easy in refilling and cause no problems in cleaning. For some customers the release mechanism seems as unusual and sometimes instead of twisting the handle customers lean on it. Nevertheless, after getting used to it no other problems appeared. The market never faced hygiene problems, because bins are used only for dry products and the turnover in the market is very fast.

3.4 Feedback

The most common problem for staff in all markets is the gravity bins disassembly process due to the big number of details in its construction. All bins require a frequent cleaning with water and soap as long as they deal with the food prod-

ucts. To be cleaned up the bins (especially gravity ones) require disassembly and further reassembly and a big number of details makes this process difficult and time consuming.

A few markets also mentioned that they are not in favor of plastic material, which gravity bins are made of, especially when dealing with the sticky products like jelly candies. Such products often stick to the walls of the bin and it causes troubles to the product flow. Talking about plastic it is necessary to mention that some customers are also not satisfied with this material in their feedback. They do not find plastic eco-friendly and worry about the harmful potential compounds of the plastic, which can affect the food.

Bad flow control is named to be another problem in several markets. Though in the description of the bins in the official websites of manufacturers (Trade Fixtures and HL Display) flow control is listed as the function of their gravity bins, some markets still describe it as “bad”. Some of them name it “slow” and others “too fast”. Probably the reason for this lies in the fact that the intensity of the flow is set by the staff, not the customer. Obviously the chosen flow cannot be optimal for all customers, because the desired quantity of the certain product is different for each. And while slow flow control of a gravity bin takes time from the customer, the fast one usually leads to the spillage of the product.

For scoop bins the fast spoilage of the food seems to be the most common problem. The reasons for it were described above in the descriptive section of the scoop bins (frequent contact with air). Even pests appearance is detected in the worst cases. Hygiene is what a lot of customers mostly worry when using scoop bins.

In addition because of the first-in-last-out (FILO) turnover system of such type of bins there are some difficulties in refilling. When too little amount of product is left in the bin, usually it is not possible just to fill the bin with a fresh one, because this may cause a fast product spoilage. So firstly it is necessary to take the rest of the product out and only then fill it with the new one. This operation is seen by most markets as uncomfortable.

All these notes will be taken into account when creating new design suggestions.

4 Material selection

4.1 Ecological criteria

As long as the main goal of the thesis is to find the design which will be both sustainable and ecological friendly, the criteria of the eco-friendly design must be indicated.

First of all, the main points of ecological design are to reduce the waste, which is caused by the production process, to eliminate the harm to the environment and to save raw materials (Simonen 2012, pp. 6-7).

Talking about the product design process itself a source reduction method is needed to be mentioned. Source reduction is a way of saving raw materials in the very first stages of the product design both for economical and ecological reasons. Source reduction can be reached by two options. The first one is to create a design the way it demands as less material as possible (e.g. make thinner walls or reduce the amount of the details). And the second way is to create reusable products instead of disposable ones. (Strong 2006, p. 826.) This thought leads to the fact that a minor quantity of details in bins construction does not only save the time from the disassembly process, but also reduces the potential waste.

Anyway, in this case, a proper material selection is the decisive factor. And there are four criteria for choosing the material for ecological design, which are listed by Gaedel and Allenby (1995) (Simonen 2012, p. 17).

1. Choose non-toxic materials.
2. Choose materials that are renewable and close to nature.
3. Have as little different materials in one product as possible.
4. Choose materials that can easily be recycled.

Since “close to nature” materials are not always renewable it was decided to divide the second criteria in two. So, it means that the most favorable material from the environmental point of view must be:

- non-toxic
- natural
- renewable
- recyclable.

These criteria can help to find “green” materials for bulk bins design and first of all plastics will be checked from the ecological perspective. Obviously, it is difficult to call this material as one which is “close to nature”, but since all the bins in mass production are made out of plastics, it is necessary to look up at it closely and check on the toxicity and recyclability.

4.2 Plastics

A material for bulk bins must be tough, attractive to customers, resistant to the odors, non-toxic and have a reasonable price. Plastic is an ideal one, because of variety of properties it is able to perform. Nowadays plastic is a widespread material with a major applicable rate, which can be used in every aspect of our life. It substitutes a big range of traditional materials, such as wood or glass, by coping and improving their qualities. Upon the research all bulk bins are made from plastics with rare addition of some other materials (for example wood), mostly for decorative purposes than for ergonomic ones.

Plastic is a significant part of solid waste produced nowadays. As it was mentioned before, a lot of customers of the bulk bin markets do not like the fact that the bins are made from plastic, because plastic is not seen as a “green” material.

This point is proved by other surveys, which show that people see plastic as the most detrimental among other types of materials. Perhaps, such high alert about the plastics as a thread for the nature rises from the fact that it is used everywhere, especially in disposable products and packaging, which can be seen as a trash outdoors when not disposed properly. (Strong 2006, pp 825-

826.) Meanwhile, there are several scenarios of plastics end-of-life stage, which will be described further.

When talking about plastic disposal there are three obvious problems: resistance of most types of plastics to natural degradation, potential harmful gases which are given off when plastics are incinerated and difficulties that can be faced in the recycling process. (Strong 2006, p. 828.)

A more detailed explanation of handling with solid waste will be given in the following subchapter.

4.2.1 Handling with plastic waste

As long as this project relates to the “zero waste” movement, it is important to know about the end-of-life of the potential bulk bin and especially about the impact it will bring to the environment.

There are five ways of handling with solid waste which are: degradation, landfill disposing, incineration, regeneration and recycling (Strong 2006, p. 826).

Degradation is the natural process of breaking a material down into smaller molecules. By many people it is seen as the best way of getting rid of the waste, because there is a misconception that a degradable product just disappears through the time to nothing. Nowadays biodegradable plastics are invented, their structure is based on the plants and in theory such types of plastics will not cause any troubles to nature after its disposal. But the truth is that the degradation process is long and demands certain conditions to be fulfilled. Any biodegradable material should be decomposed properly instead of being thrown to a landfill, where the required conditions (such as presence of UV-light, certain level of temperature, presence of oxygen or microorganisms) are not met. Degradation in landfills is highly uncertain, but because of the lack of knowledge biodegradable plastics often end up their life there. (Strong 2006, pp. 835-838.) As a conclusion degradation seems as a good option, but only in the case of the proper decomposition.

Landfills are the most popular method of waste disposal and one of the least preferable ones from the ecological perspective. Landfill is the least expensive

way of disposing the waste and that is why it is usually preferred one over the others. It is unnecessary to say how much harm plastics bring to the environment by contamination of soils and groundwater with their additives and breakdown byproducts. (Strong 2006, p 838.)

Incineration is the process of burning the waste for the purpose of electricity generation. Incineration is described as a simple process because it does not demand any sorting and plastics can be burnt together with paper. Incineration causes a lot of worries among people due to the potential air pollution and impact to greenhouse effect, and those worries are well-founded. The issues of the incineration may include potential hazardous air-emissions, problems of ash-disposal and release of carbon dioxide, which causes global warming. (Strong 2006, pp. 839-840.) In many countries incineration is preferred even less than landfill due to the potential hazards it may cause.

Regeneration or so-called chemical recycling is an alternative to the traditional mechanical recycling, with the involvement of chemical processes. In comparing to the mechanical recycling, chemical one is less preferable, because as a rule it demands high energy requirements and has a greater potential to water and air pollution. (Strong 2006, pp. 840-841.)

Mechanical recycling is seen as the most preferred way of dealing with the solid waste. However, dealing with plastics meets a lot of hardships from the economical side of the question. First of all it is necessary to mention that almost all existing sorts of plastics can be recycled. The recycling process includes several steps of processing: collection, sorting, cleaning and end-use fabrication. Each step is costly and may face some difficulties. For example some types of plastics have similar appearance and because of it they are difficult to sort. In addition, the cost of recycled plastics is usually much higher than the cost of the virgin ones because of the expensive recycling process. That is why many types of plastics are not profitable to recycle and in the majority of cases recycling is not taking place. (Strong 2006, p. 828.)

To sum up landfills and incineration are the least favorable ways of waste disposal, when mechanical recycling is the most favorable one in the ecological

point of view. Chemical recycling is the second best option after the traditional one.

4.2.2 Plastics recycling

Usually all products made from plastics have a recycling symbol, which is molded onto the product itself to simplify the process of collecting and sorting for recycling. According to this system all plastics break into seven groups, each group has a number and represents a certain type of plastics family (Figure 9).



Figure 9. Plastic recycling symbols (Marck™ recycling 2015)

There are four categories of recycling activity, two of which belong to the mechanical recycling. Primary or closed-loop recycling is the mechanical reprocessing of a product into a new one with the equivalent properties. Secondary or downgrading recycling is a reprocessing of a product into another product requiring lower properties. Two other categories (tertiary - chemical recycling and quaternary - recovery of energy) do not belong to the mechanical category. (Hopewell, Dvorak & Kosior 2009.)

Obviously closed-loop recycling is the goal for any production, because it means that the same material may be used over and over again with no major losses in quality. And this type of recycling will be seen as the favorable property for the potential material. That is why it was decided to look closely at the PET plastic due to its practical potential for the closed-loop recycling (Hopewell et al. 2009).

4.2.3 PET

Polyethylene terephthalate, also known as PET, is one of the most widespread plastics due to its high accessibility in various fields. Especially it is widely used as a material for packaging and soft-drink containers. PET is rugged and transparent, has a low permeability to carbon dioxide and is odor resistant and inexpensive. (Strong 2006, pp. 273-276.)

PET goes under #1 in the recycling grades. Nowadays PET is the most widely recycled plastic in the world. The reasons are because PET has a specific appearance and is easily recognizable, which makes the sorting process much easier and cheaper. Recycling of PET seems as a good alternative to the production of the new one. (Strong 2006, p 849.) Moreover, as it was mentioned before, PET is the plastic, which is able to undergo a closed-loop recycling (Hopewell et al. 2009). This means that in theory if the PET products are always recycled, no waste will be produced.

According to studies ecological toxicity has a minor significance in the case of PET (Xie, Qiao, Sun, Zhang 2011). So the material can be identified as non-toxic.

4.2.4 PLA

Polylactic acid or PLA is an example of bioplastics, which belong to the grade #7 of plastics recycling symbols. Bioplastics are considered as renewable and non-toxic materials, because the structure of such plastics is based on a living source. (Happonen 2012.)

PLA is a naturally transparent plastic, that can be colored with dyes (Figure 10). It is produced from corn starch and can be compared to such oil-based plastics as PP and PE due to the similarities in properties. Nowadays PLA is used mostly in packaging production. Though it is a soft plastic it can be reinforced by some additives (for example glass fibers), which improve both mechanical and thermal properties of it. (Happonen 2012.)



Figure 10. Reusable drinkware made from PLA (Debco 2012)

PLA is badly recycled in the mechanical way due to its sensitivity to thermal degradation. However there is a way to close the loop in the life cycle of polyactic acid by chemical recycling. In chemical recycling monomers of the plastic are recovered and repolymerized into the original polymer, so a virgin resin can be synthesized. Moreover chemical recycling in the case of PLA is cost-effective, because of the process simplicity. It does not demand any high temperatures or pressure, so the operational costs are appeared to be low. (Anneaux, Campanelli, Foley 2018.)

Another way to dispose PLA is through industrial composting. Compared with chemical recycling it is less favorable, because it brings no value and decomposed PLA product still seems as waste. Moreover PLA can be composted only with the help of specialized industries, since the operation is difficult and demands special treatment. (Happonen 2012.)

4.3 Alternatives

As long as a favourable material for bulk bin production is supposed to be transparent the only natural analogue which can come to mind is glass. The major component of the glass is quartz, which is the primary constituent of sand. Compared with plastics the main disadvantage of glass is its tendency to break and shatter because of the low impact resistance. (Altenpohl 1980.) Although sand is not a renewable component it is highly unlikely that the world one

day will run out of sand and in many sources glass is referred to a renewable material.

Glass is fully recyclable and is able to perform closed-loop recycling. Glass recycling is profitable from the economical point of view as well. During the recycling process glass pieces are mixed with virgin glass and such way the cost for the material is lowering. (Glass Packaging Institute 2014.)

Transparency of bulk bins is the property which allows customers to observe offered goods. This property is necessarily needed to be applied to the body of the gravity bin, because there is no other way for customers to see the product before purchasing. However, at the same time such parts of the bin, as the release mechanism, do not need to be transparent.

As an example of a suitable renewable material, which can be applied for certain parts of bulk bins design is bamboo (Figure 11). Nowadays bamboo seems as a substitution for a range of various materials, including plastics. Bamboo is a recyclable material and as any other natural fibre composite, may be further used for the cellulose production (Awoyera &Ugwu 2017).



Figure 11. Range of products made from bamboo (bamboo™ 2018)

Metals are another natural resource, which is not renewable however. Anyway, aluminum can be a possible option, since it is one of the most efficient recyclable metals. Its recycling process is easy and saves 95% of energy cost of processing new aluminum (International Aluminium Institute 2009).

In the end it is needed to be mentioned that usage of a recycled material (glass, plastic, metal) instead of a virgin one is always a much more environmental friendly solution. Though plastic is not considered to be “green” there is a way to make it ecological-friendly: to reuse it again in order to make a new product out of it (Simonen 2012, p. 14). The design of Coöperatie de Nieuwe Graanshuur, which was described in the subchapter 3.3, is a good illustration of plastic product reusing.

4.4 Materials comparison

None of the listed materials was claimed as toxic. Also all the materials are recyclable, so the question about recyclability transformed is to the question if the material is able to perform closed-loop recycling or not. This way all suggested materials are compared via three criteria (Table 1). The first column “transparent” helps to indicate which of the listed materials is suitable for the transparent parts of bins.

| | Transparent | Natural | Renewable | Closed-loop recycling |
|--------|-------------|---------|-----------|--------------------------|
| Al | no | yes | no | yes |
| Bamboo | no | yes | yes | no |
| Glass | yes | yes | y/n | yes |
| PET | yes | no | no | yes |
| PLA | yes | yes | yes | yes (chemical recycling) |

Table 1. Comparison of the suggested materials

It follows that PLA and glass are the most ecological friendly solutions, while PET is a less favourable one from the environmental point of view, because it fulfils only one criterion out of three.

Some of these materials will be used in the further suggestions for the design.

5 Design solutions

5.1 Gravity bin

For this design suggestion it was decided to take an example of product reusing, inspired by the experience of the Coöperatie de Nieuwe Graanshuur mar-

ket (Figure 12). A regular glass jar was taken as a foundation for the body of the gravity bin. Potentially it can be replaced with any other transparent container with a convenient shape, such as PET barrel, like in the case of the Netherlands market. The presented model consists of the body and the mechanism, which also plays a role of a cap. The release mechanism works when the catch is pulled. The small funnel helps customers to identify the right position for their containers.



Figure 12. Gravity bin

The mechanism of this bin is made in a form of a cap (Figure 13). The flow can be controlled by the customer and depends on the force, applied to the catch. The catch is pulled by the customer and depending on the position two holes of the mechanism overlap in a more or less way, forming a flow. After letting go of the catch the mechanism returns in the closed position automatically with the help of two springs.

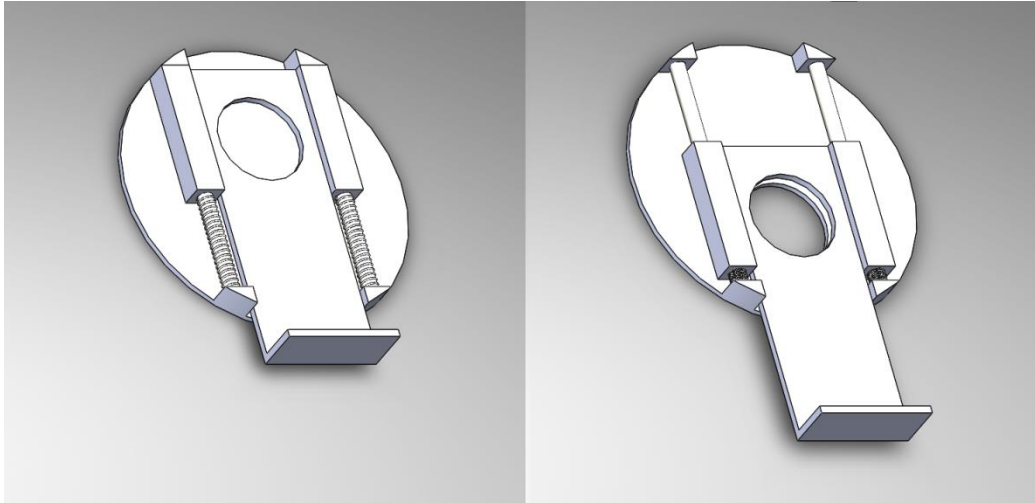


Figure 13. Release mechanism

The size of the mechanism depends on the size of the chosen body. It can be made out of PLA plastic. Since this type of plastics is widely used in the 3D printing, it makes the production process of this mechanism easy and fast.

Since this model consists only of two parts, the disassembly process is performed simply by taking the cap off the body for cleaning or refilling. If the FIFO system is desired the bottom part of the jar may be cut and covered with another cap to make the process of the bin refilling from the upper side possible.

5.2 Scoop bin

As long as the major problem of the scoop bins exploitation is rapid product spoilage it was decided to offer some kinds of solutions in the design, which can help to prevent it.

First of all, in the offered case the whole body is made from the non-transparent material, bamboo (Figure 14). In this way the major part of the product will be protected from the photodegradation and discoloration caused by the light (Department of Food, Nutrition and Packaging Science 2012).

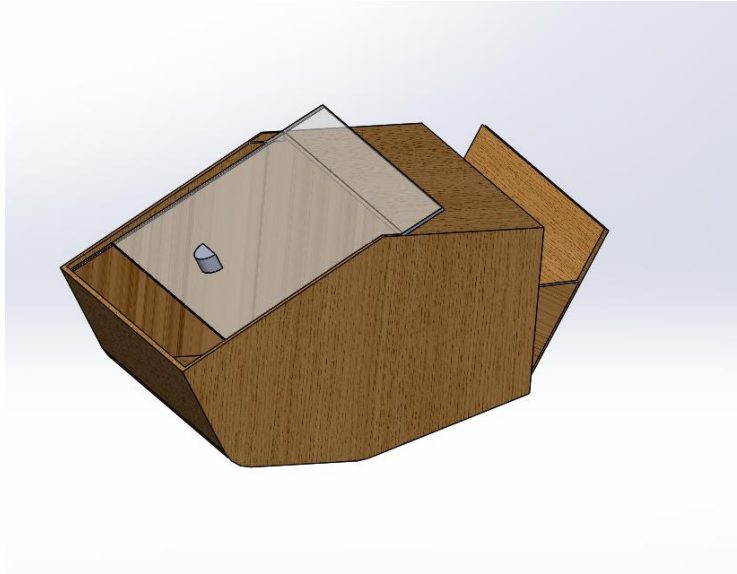


Figure 14. Scoop bin

The bin is accomplished by the sliding lid, which is adjoined to the body tighter in comparison with an ordinary one and thus in closed position better protects the products from the contact with air. The material for the lid should be transparent to allow customers to see the goods. So it can be made out of glass or a transparent bioplastic, such as PLA.

In the offered design the bin could be refilled from both, front and back sides. On Figure 14 the back lid is shown in the open position. It is designed to offer a kind of FIFO system of rotation, which although will not work in the case if some amount of product is left in the bin.

The back part of the bin is slightly inclined in respect to the front part to make the food moving down in case of refilling the bin from the back side. The front is also inclined in respect to the customer to make the process of the product reaching easier. The angles are curved to prevent small particles of food from sticking in the seams and make the cleaning process easier.

6 Summary and discussion

The thesis dealt with the alternative designing of bulk bins. In the beginning two main targets were settled: to detect and improve the disadvantages of the bulk bins design and to replace the plastic with another more ecological substitution.

The studies took into account the internet information researching, literature reviewing and the experience of the bulk bin markets. All this information was used while creating new design suggestions. In order to find an eco-friendly substitution to plastic the explanation of the ecological design was given. According to it the potential substitutions were listed. Two possible models of bulk bins based on the findings were presented as an outcome of the thesis, where the most frequent hardships, which the bulk bin markets face, were attempted to be covered.

Anyway, it should be mentioned that the decisions upon the material selection is highly subjective and meets many nuances. The suggested materials are only examples, and the range of the possible materials may be expanded upon the further research.

The offered design solutions are only concepts which need to be tested in practice and see if there are any improvements in the exploitation process and if it is more comfortable to operate in comparison with regular bins or not. After the testing the further improvements might be applied to the suggested design models.

Figures

- Figure 1. Scoop Bin SB300-20 (HL Display 2018), p. 10
- Figure 2. Durapod gravity dispenser with one-hand release system (Durapod Systems 2015), p. 11
- Figure 3. 3eBin™ scoop and gravity bins (HL Display 2018), p. 13
- Figure 4. APPLYVRAC™ gravity and scoop bins (Applymage 2018), p. 13
- Figure 5. Trade Fixtures gravity and scoop bins (Trade Fixtures 2018), p. 14
- Figure 6. New Leaf gravity and scoop bins (Trade Fixtures 2018), p. 15
- Figure 7. Gravity bins of Coöperatie de Nieuwe Graanshuur market, p. 16
- Figure 8. Release mechanism of the gravity bin, p. 17
- Figure 9. Plastic recycling symbols (Marck™ recycling 2015), p. 23
- Figure 10. Reusable drinkware made from PLA (Debco 2012), p. 26
- Figure 11. Range of products made from bamboo (bamboo™ 2018), p. 26
- Figure 12. Gravity bin, p. 28
- Figure 13. Release mechanism, p. 29
- Figure 14. Scoop bin, p. 30

Tables

Table 1. Comparison of the suggested materials, p. 27

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Appendices

Appendix 1 List of markets

Coöperatie de Nieuwe Graanschuur (Netherlands)

Das gramm (Austria)

GOODsONLY (Netherlands)

Gram (Sweden)

Green (Canada)

Kabas (Belgium)

La Bonne Pioche (France)

La Juste Dose (France)

Lunzers Maß-Greißlerei (Austria)

OHNE Gent (Belgium)

O'Sillo (Belgium)

Schüttgut (Germany)