Bachelor assignment

Redesign of 1L plastic milk bottle

Bas Verschoor
s1199501

5th of june 2015
This report remains confidential until june 2020

FrieslandCampina

Redesign of 1L plastic milk bottle

Bachelor assignment

By: Bas Verschoor

Student number: s1199501

Study: Bachelor Industrial Design (University of Twente)

Commissioned by: FrieslandCampina

Tutor FrieslandCampina: Arie Pelle

Tutor University of Twente: Ellen Oude Luttikhuis

Examinor University of Twente: Eric Lutters

Number of pages report: 55

Number of pages appendix: 33

FrieslandCampina Innovation Centre
Bronland 20
6708 WH Wageningen
The Netherlands

UNIVERSITY OF TWENTE.

University of Twente
Drienerlolaan 5
7522 NB Enschede
The Netherlands

Summary

At FrieslandCampina a redesign has been made for a series of plastic milk bottles. For the 1L version of this milk bottle problems arose. Due to a larger bottle diameter the transportation costs were significantly higher in the redesign.

FrieslandCampina made two alternative versions of the same redesign with a smaller diameter. Here the transportation costs did not increase or was acceptable. However, all options had overhang on the pallet. One of the objective was to select the best of those options for further development where bottle performances were still guarenteed.
This was done by determining the displacement on the pallet, which leads to a practical overhang per option. Then a value of maximum overhang was investigated where bottle performances are still guarenteed. Combining the two outcomes resulted in a recommendation for the best option.

To give FrieslandCampina more options for further development of the project, alternative bottle designs were made where the maximum overhang and transportation costs were taken into account.

Also a difference was created between iconic bottles and generic bottles. Concepts have been made in four different categories:

- Iconic shape - family
  Bottle with iconic shape that fits in the redesign made by FrieslandCampina.
- Iconic shape - non-family
  Bottle with iconic shape, but does not fit in the family of plastic milk bottles.
- Iconic decoration
  Bottle with generic shape where it was tried to make the bottle for branded products iconic by using a distinctive decoration, where private label has 'normal' decoration.
- Generic
  Bottle with generic design suitable for both branded products as private label products.

As a result five options were given for further development of the project.
Recommended is to go for a generic bottle with iconic decoration.

Samenvatting

Bij FrieslandCampina is een herontwerp gemaakt van een serie aan plastic melk flessen. Voor de 1L variant van de fles waren echter problemen ontstaan. Door een grotere fles diameter waren transportkosten significant gestegen.

Er waren door FrieslandCampina twee alternatieve versies van dit herontwerp gemaakt met een minder grote diameter. Hierdoor stegen de transportkosten niet, of binnen het acceptabele. Echter hebben alle opties overhang op de pallet. Een van de doelen was om de beste optie te selecteren voor verder ontwikkeling binnen het project, waar de fles prestaties gegarandeerd kunnen worden.
Dit was gedaan door te onderzoek hoeveel displacement de flessen op de pallet hebben, wat leidde tot een praktische overhang per optie. Vervolgens was een maximale overhang onderzocht waar de flesprestaties nog steeds gegarandeerd zijn. Het combineren van deze twee uitkomsten leidde tot een aanbeveling voor de beste optie.

Om FrieslandCampina meer opties te geven voor verdere ontwikkeling in het project zijn alternatieve flesontwerpen gemaakt waar rekening gehouden was met de maximale overhang en transportkosten.

Ook was er onderscheid gemaakt tussen iconische en generieke flessen. Er zijn in vier categorieën concepten ontworpen:

- Iconische vorm - familie
  Fles met iconische vorm die binnen de familie van plastic melk flessen past.
- Iconische vorm - niet-familie
  Fles met iconische vorm die niet binnen de familie van plastic melk flessen past.
- Iconische decoratie
  Generieke fles waar geprobeerd is om door middel van decoratie de fles iconisch te maken voor branded producten private label producten krijgen een 'normale' label
- Generiek
  Generieke fles die zowel geschikt is voor branded als private label producten.

Dit alles resulteerde in vijf opties voor verdere ontwikkeling van het project.
Aanbevolen is om verder te gaan met een generieke fles met iconische decoratie.

Table of contents

Preface

This bachelor assignment is the result of 3,5 months of work at the Global Packaging Department at FrieslandCampina. This report is written within the context of the bachelor assignment Industrial Design. The assignment is part of the HDPE Aalter project at FrieslandCampina.

Working at FrieslandCampina was a great experience for me. All colleagues were very nice and did their best to show me as much as they could within the world of packaging. Along with this assignment I worked on various different projects within the department. By doing so I learned an awful lot of working in a business environment, and working within packaging development.

This assignment was my first introduction to packaging and I would like to thank all the colleagues at FrieslandCampina for their share in giving me this wonderful introduction. As indicated I learned a lot and everyone in the department has their share in this.

I would like to thank Arie Pelle (supervisor FrieslandCampina) for his pleasant way of supporting me, giving good and useful input in my assignment and giving me the freedom to learn as much as possible.
I would like to thank Pablo Albert (Packaging developer FrieslandCampina) for his input and help during my assignment and the very pleasant collaboration on other parts of the HDPE Aalter project at FrieslandCampina.
I also would like to thank Ellen Oude Luttikhuis (supervisor University of Twente) for her help, support and input in my assignment.

Enschede, June 2015
Bas Verschoor

1. Introduction

In this introduction some background information about the client (FrieslandCampina) is given as well as the occasion and goal of the project, with in the end the deliverables that will be answered in this report.

1.1 Client information (FrieslandCampina)

FrieslandCampina is a worldwide producer of different food products, especially dairy products. Covered by FrieslandCampina are many brands, including Campina, Chocomel, Dubbelfriss, Mona and many others in the Netherlands. But also foreign brands like Frisian Flag (well known in Indonesia), Dutch Lady (market leader in Vietnam and Malaysia), and many other international brands.

FrieslandCampina is a brand arose from a fusion in 2008 between the two big Dutch companies Friesland Foods and Campina. Today FrieslandCampina is one of the five biggest dairy producers in the world with a turnover of around 10 billion euros a year. (figure 1.1)

Figure 1.1: Corporate information FrieslandCampina

The history of FrieslandCampina starts around the year 1870. Around that year farmers bundled by starting local dairy factories. They started those factories to increase their position in the market, and to secure the sales of their milk.

The local factories became regional factories, which arose to country wide factories around the 1960's. From many fusions between companies, finally FrieslandCampina arose.

FrieslandCampina divided their activities in four different business units:

1. Consumer Products Europe, Middle East & Africa
2. Consumer Products Asia
3. Cheese, Butter & Milk powder
4. Ingredients

Each of those business units stands for a certain group of products, or for a certain region:

1. Milk, dairy beverages, cream, coffee creamers, yoghurts and desserts for consumers and the professional market in Europe, the Middle East and Africa.
2. Milk, milk powder, condensed milk, baby food and yoghurts, mainly in Asia.
3. Cheese and butter, worldwide
4. Ingredients for food- and pharmaceutical industry, worldwide.

1.1.1 Innovation

Innovation is at FrieslandCampina high on its agenda. In 2013 the FrieslandCampina Innovation Centre opened in Wageningen. The innovation centre was meant to bundle all research and innovation for new products in one building. The building is built on the campus of the Wageningen University, so there is a healthy collaboration between the researchers of the university, and the researchers of

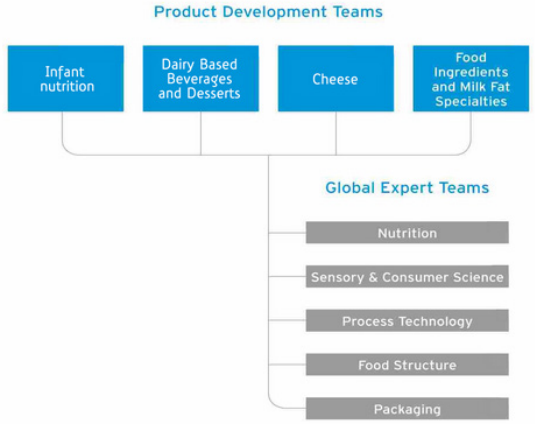


Figure 1.2: R&D divisions with Global Expert Teams

FrieslandCampina. This means better products can be developed. The R&D department at FrieslandCampina is divided in four different categories, supported by five different Global Expert Teams (figure 1.2).

1.2 Background and problem definition

At FrieslandCampina a redesign has been made for a series of plastic (HDPE) milk bottles. The series contains various volumes (200ml, 250ml, 500ml and 1L) and will be produced and filled in the plant in Aalter (B). In the redesign the various volumes of the bottles have family features, which means certain elements are implemented in all versions of the bottle. The bottles will also be lighter (which leads to cost reduction) than the current versions, and the caps will be harmonized for all versions.

This project will focus on the 1 litre variant of this new bottle.
The current 1L bottle produced in Aalter is a square, generic bottle as shown in figure 1.3. This bottle is both used for branded products and private label products. The bottle has a diameter of 80mm.

The redesign of the 1L bottle is a round bottle with the family features of the series of plastic milk bottles (figure 1.4). The use of family features makes the bottle iconic. The original version of the 1L redesign had a diameter of 86mm.

The change in diameter between the current bottle and the redesign caused problems for transport. The bigger diameter causes fewer bottles to fit on a pallet which increases transport costs. The increase of transport costs was higher than the cost reduction generated by the light weighting of the bottle, therefore other options were investigated so a cost reduction still remained.

Two proposals for a new version of the 1L bottle were made. Both have the same shape as the 86mm version of the new bottle but with a different diameter, 82,6mm and 84mm. Due to the different bottle diameter the extra transport costs are reduced (figure 1.5)

For both variations pallet patterns have been generated. This gives three options:

1. 82,6mm bottle with minimum extra transport costs and 39mm overhang on pallet.
2. 84mm bottle with 42k extra transport costs and 40mm overhang on pallet.
3. 82,6mm bottle with 42k extra transport costs and 26mm overhang on pallet.

All options have overhang on the pallet. The concern at FrieslandCampina is that a large amount of overhang will cause a significant reduction in bottle performances but eliminating all overhang will cause significantly higher transport costs.

The first part of this project will focus on the feasibility of the various options given.
This will be done by determining the amount of displacement on a pallet, which reduces the amount of theoretical overhang. Afterwards a maximum amount of overhang will be investigated where bottle performances are still guaranteed.
By combining the outcomes the given options will be tested for feasibility.

Based on the maximum amount of overhang, alternative bottle designs will be made where the transport costs and bottle performance are taken into account. These alternative designs give FrieslandCampina more options to choose for further development of the project.

Therefore a maximum bottle diameter will be determined based on both the minimum number of bottles per pallet required and maximum amount of overhang. Further requirements given by FrieslandCampina will be investigated. Afterwards concepts will be generated for further optimization of the bottle design.

Deliverables

1. Value for the amount of displacement for the new 1L HDPE bottle proposals (82,6mm and 84mm versions).
2. Standard for maximum overhang on a pallet for 1L HDPE bottles.
3. Optimized bottle design, based on demands from the commercial department, and the right pallet pattern, to reduce overhang within the maximum value.

Figure 1.3: Current 1L HDPE bottle

Figure 1.4: Redesign 1L HDPE bottle
Left: 82,6mm proposal. Right: 84mm proposal

	#bottles/pallet + pallet stability (colors)					savings (k€)			
	Euro 6 B	Euro 6 F	Mini	Euro 8	Industry	Transp cost	*Qual cost*	Weight	TOTAL (6)
Current	750	630 (1)	330	680	930 (*)	-	-60 (4)	-	-60
82.6mm 39 mm overhang	750 (b)	630 (1) (b)	330	680	900 (b)	- (2)	TBD (5)	227	167-227
84mm	690 (b)	630 (1)	330 (b)	680 (b)	840	-42 (2)	-	227	185
82.6mm a) 26 mm overhang	. 690 (c)	630(1)	330(c)	680(c)	840	-42 (2)	TBD (5)	227	125-185
86mm	630		300	560	840 (*)	-216 -55 (2)(3)	-	227	-44

Figure 1.5: Overview of various options for 1L HDPE bottle with number of bottles per pallet and savings given per option


FrieslandCampina
Germa
DAF

2. Analysis stage

The first stage in this project is the analysis stage.
First the displacement on the pallet for the 82,6mm and 84mm proposals will be calculated. Then the maximum amount of overhang will be investigated. There will be concluded if the 82,6mm and 84mm bottle are sufficient.
Then further requirements will be investigated for the optimized bottle design. To conclude a program of requirements will be given.

2.1 Displacement calculation

For transportation, filled bottles are packed by 6 or 8 in shrink foil around the bottles. Those 6- or 8-packs are stacked on a pallet where for extra stability also a stretch foil is wrapped around, or a stretch hood is applied.

Both the shrink foil and the stretch foil/hood apply force on the bottle (this is visualized in figure 2.1). Because the bottles stand side by side, they are compressed which results in a displacement.

This means that on a pallet pattern with overhang, the overhang can be lower in practice compared to the theoretical overhang. To give an indication of the practical overhang for the 82,6mm and 84mm proposals, the displacement in the bottles can be calculated.

The displacement is known for the current 1L HDPE bottle, but not yet for the 82,6mm and 84mm diameter proposals. This can be calculated with the aid of FEA simulations (performed by Logoplaste)

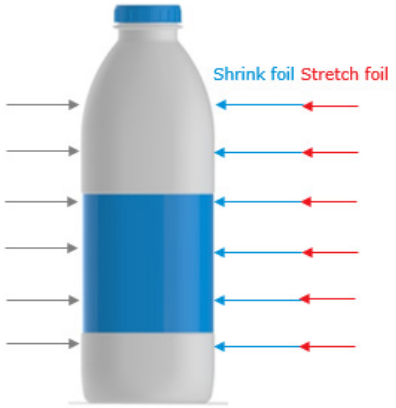


Figure 2.1: Visualization of forces applied on bottle by shrink and stretch foil

on both the current bottle (80mm), and the 86mm bottle.

In this FEM analysis the bottles were virtually pressed against each other in the side (see figure 2.2). This resulted a side load/displacement graph (appendix 2.1).

Because the displacement of the current bottle is known, a side load force can be read out of the graph. The side load force is applied by both the shrink foil around the 6-pack and the stretch-foil around the pallet combined.

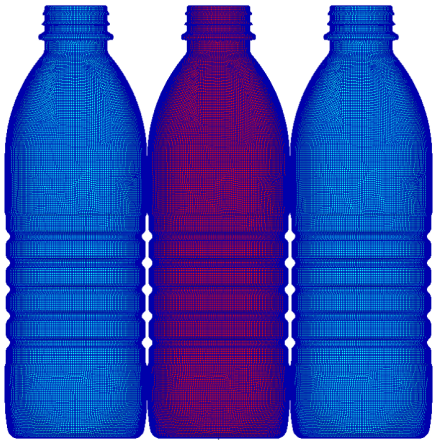


Figure 2.2: FEA simulation method for side load as used by Logoplaste

The theoretical overhang on one of the pallets of the current bottle is 40mm. In practice this overhang is 0mm. This means a total displacement of 40mm. On this side of the pallet there were 13 bottles, which results in a displacement per bottle of 3,1mm.

From the graph in the report of the FEM analysis there could be read that the side load force on the bottles should be around 27,5N.
In a practical side load test where a displacement of 3,1mm was calculated, the result was a side load of 25,5N was needed for a displacement of 3,1mm. This means that the graph from Logoplaste was quite accurate.

Now that the force applied by the shrink and stretch foil is determined, the displacement of the 86mm bottle can be read out of the graph.
The displacement of the 86mm bottle was read out of the graph at a side load force of 27,5N. The result is an displacement of around 1,2mm.

Because the geometry and weight of the 86mm, 84mm and 82,6mm bottles are all the same, the displacement of those bottles should also be about the same. Taken some margin into account for reading out of a graph the displacement per bottle for the new bottle proposals (82,6mm and 84mm) will be around 1,0mm per bottle.

To check this conclusion, a meeting with Logoplaste took place to discuss the procedure and the outcome of this study. Because the FEM analysis at Logoplaste was done for a static environment and this study also takes place in a static environment, the procedure followed was correct according to Logoplaste. Therefore the outcome for the 86mm bottle was confirmed.

To validate the method used to determine the displacement, and if the result for the 86mm was indeed also applicable for the 82,6mm and 84mm bottle designs, this question was also asked during the meeting. According to Logoplaste, because the geometry and the weight of the bottles are all the same the displacement will also be about the same. There can be a deviation of 0,1mm or 0,2mm, but that is covered in the margin that was taken into account. This means the procedure and the outcome of this study are confirmed.

To give an indication of the practical overhang on the calculated pallet patterns for the 82,6mm version of the bottle see table 2.1 and table 2.2, for the indication of the practical overhang for the 84mm version of the bottle see table 2.3.

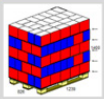
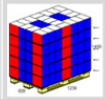
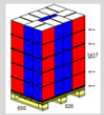
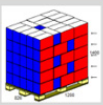
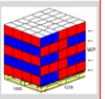
New (82.6mm)	6pack on Euro	6pack on Euro	6pack on Mini	8pack on Euro	6pack on Industry
Bottles/pallet	750	630	330	680	900
Efficiency %	106.6	89.5	93.8	96.7	102.3
Stable?	☺	😐	😐	😐	☺
Pallet Pattern					
Overhang l*b	39 x 26 mm	39 x 26 mm	26 x -43.6 mm	-43.6 x 26 mm	39 x -8.8 mm
Bottles per side	15*10	15*10	10*7	11*10	15*12
Practical overhang l*b	24*16mm	24*16mm	16*-50,6mm	-54,6*16mm	24*-20,8mm

Table 2.1: Practical overhang for 82,6mm (39mm theoretical overhang) bottle proposal

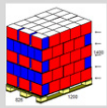
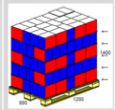
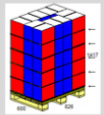
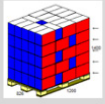
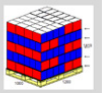
82.6 mm (max 26 overh.)	6pack on Euro	6pack on Euro	6pack on Mini	8pack on Euro	6pack on Industry
Bottles/pallet	690	630	330	680	840
Efficiency %	98.1	89.5	93.8	96.7	95.5
Stable?	☺	😐	😐	😐	☺
Pallet Pattern					
Overhang l*b	-43.6 x 26 mm	-43.6 x -56.6 mm	26 x -43.6 mm	-43.6 x 26 mm	-43.6 x 8.8 mm
Bottles per side	14*10	14*9	10*7	11*10	14*12
Overhang l*b	-57,6*16mm	-57,6* -65,6mm	16*-50,6mm	-54,6*16mm	57,6*-3,2mm

Table 2.2: Practical overhang for 82,6mm (26mm theoretical overhang) bottle proposal

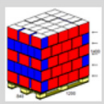
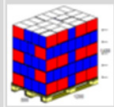
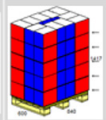
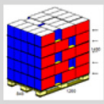
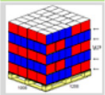
84 mm	6pack on Euro	6pack on Euro	6pack on Mini	8pack on Euro	6pack on Industry
Bottles/pallet	690	630	330	680	840
Efficiency %	101.4	92.6	97	100	98.8
Stable?	☺	😐	☺	☺	☺
Pallet Pattern					
Overhang l*b	-24 x 40 mm	-24 x -44 mm	40 x -23.2 mm	-22.6 x 40 mm	-24 x 8 mm
Bottles per side	15*10	14*9	10*7	11*10	14*12
Practical overhang l*b	-39*30mm	-38*-53mm	30*-30,2mm	-33,6*30mm	-38*-4mm

Table 2.3: Practical overhang for 84mm bottle proposal

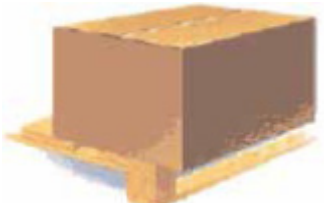
2.2 Maximum overhang study

For the study to the maximum amount of overhang various tests were performed.
First a small literature study was performed to check if any information about a maximum amount of overhang is already present.
Second, practical top load tests were performed for both single bottles as bottles in a shrink foil. During those tests overhang was simulated to measure any decrease in top-load strength on the bottles.
Finally a transport test was performed where overhang was created. After the test was performed, the bottles were visually tested on any damage. During the transport test also an interview was performed with someone from the logistics department to discuss overhang.

2.2.1 Literature study: Overhang on a pallet

In this small literature study there will be looked for some information about the effects on products on a pallet, when overhang is occurring. Overhang is the amount of load on a pallet that is protruding from the edges of the pallet. At the end there will be made up a hypotheses for the practical tests that will be done later on.

According to YRC Freight and R. ten Klooster, overhang on a pallet can cause a reduction of compression strength (top-load strength). There is no maximum amount of overhang given in this situation. This information is based on carton boxes.



Other points YRC mentions is that during normal handing and sorting operations, the load of the pallet will more likely be exposed to tearing/punctures or high impacts, which may damage the product. This is also mentioned by UPS, another big shipping company. UPS mentions to avoid overhang at all, because anything overhanging the edges of the pallet will be subjected to impacts that can result in punctures, abrasions and compression damage.

According to Monaghan and Marcondes, even a little bit of overhang causes a big reduction in compression strength, but as the overhang becomes more severe, the relation between the amount of overhang and reduction in compression strength becomes linear. Although this was concluded for cartons, this effect may be applicable for other shapes or materials as well.

Conclusion:

The information found was focused on carton boxes on pallets, although in general it will be applicable for other types of load as well. This has to be tested.
The other points YRC Freight and UPS mention about overhang is the damage of the load caused by external impact. Because the overhang load is sticking out, the first impact on for example a wall will be absorbed by the product, and not by the pallet. This may cause damage of the product by punctures, abrasions or dents. Also the side-load strength of the product may be decreased by high impacts.

Hypotheses practical tests:

For the practical tests with top load strength there is to be expected that even with a little bit of overhang will cause a significant amount of reduction in compression strength.

2.2.2 Practical top-load tests with overhang

Practical tests were performed on a top-load machine to determine if overhang has an effect on bottles with overhang, and when the overhang becomes too big and has a negative effect on the bottle performances.

For the test two types of bottles were used:

- Boni Selection or Delhaize (two private label brands with the same bottle)
  - Round bottle with diameter of 80,5mm
- Current Campina bottle.
  - Square bottle with diameter of 80mm

The tested bottles are shown in figure 2.3 and 2.4.

Figure 2.3: The tested bottles in six-pack.
Left - Delhaize (round), right - Campina (square)

Figure 2.4: The tested bottles.
Left - Boni Selection (round), right - Campina (square)

Question:

What is the effect of overhang on the top-load strength of single bottles?

Hypothesis:

As a result of a small literature study, the top-load strength is expected to reduce quite fast when there is little overhang. As the overhang gets bigger the amount of reduction will stabilize and the relation becomes linear.

It is expected that the side of the bottle where the overhang takes place is to be stretched, whereas the other side of the bottle is being compressed (the bottle will bend towards the overhanging side). This due to the bottom of the bottle at the side where the overhang takes place will not be supported.

Materials

The materials needed for this experiment:

- 1L HDPE bottles, squareish, Campina
- 1L HDPE bottles, round, Delhaize and Boni Selection (both the same bottles)
- Top load tester
- Notebooks (to simulate a pallet edge)
- 90 degree corner
- Calliper

Test setup:

To simulate overhang within the top-load tester, there will be put the samples on the edge of two notebooks. This will simulate the edge of a pallet. The overhang simulated will be the length in which the sample protrudes the edge of the notebook.

The amount of overhang will be measured by measuring the distance between the notebook and the edge of the sample. To make this more precise, there will be put a 90 degree corner on the edge, and measure at bottom of the notebook (figure 2.5).

The tests will be performed without sleeve, so that the bottle is clear to see.

Figure 2.5: Measuring method for overhang simulation

The samples have to be placed at the same way every test. At round bottles, the parting line had to be parallel to the edge of the notebook. At squareish bottles, the parting line is diagonal, but the bottles doesn't have to be placed diagonal because that isn't realistic on a pallet. Squareish bottles have to be placed with the straight side of the bottle parallel to the edge of the notebook.

Results

In appendix 2.2 the results from the practical test are shown. To conclude there is seen a significant reduce in top-load strength due to overhang. Between the two different bottles there is not much difference in the amount of reduction.

As you can see the top-load strength of the bottles without overhang is the highest, and the top-load strength of the bottles with the most overhang (20mm) is the lowest.

One consistent outcome is the reduction in top load performance at 20mm of overhang. Here the reduce at the square Campina bottle was around 26 percent, and at the round bottles around 22.5 percent.
Apart from some outliers, the results for the various bottles are comparable to each other.

From this test can be concluded that an overhang of 7.5mm is the maximum value for the Campina bottle. When the overhang becomes larger the damage on the bottle becomes too severe (figure 2.6).
Stretch foil around the bottles will protect the bottles more, so in practice the maximum overhang may be higher.
For the round bottles from Boni Selection or Delhaize counts that after 10mm the damage on the bottle becomes too severe.
For both bottles counts that the point of severe damage is at around 20% of decrease in top load strength.

Figure 2.6: Example of damage on a bottle after test (Campina > 7,5mm overhang)

Observations also gave a big difference in overhang and no overhang. The bottles with overhang all reacted about the same to top-load. The more overhang the bottle had, the more and faster the effect took place. Although without overhang the behaviour of the bottle was different.
With overhang all the bottles bended to the side where the overhang took place. That side of the bottle was stretched, the other side of the bottle was compressed (figure 2.7). The Campina bottle without overhang first compressed at both sides, and eventually also bended over to one side. But the Delhaize bottle without overhang, did not bend at all.

Two bottles in shrink foil

To test the effects of shrink foil around the bottles, a test with two bottles in shrink foil has also been done. This has been done for 0mm of overhang and for 10mm of overhang. It was expected that 10mm should still be good enough for bottles in shrink foil, where with single bottles 10mm is too high.
As expected, the shrink foil around the bottles protected the bottles in such a way that the decrease in top load strength was less with shrink foil than without shrink foil. The top load strength of the bottles with shrink foil with overhang was 91,1% of the top load strength without overhang.
Where single bottles experience a decrease of top load strength of around 25% with 10mm overhang related to no overhang, the bottles with shrink foil only experience a decrease of 8,9%

Figure 2.7: Effect of overhang by top load applied on a bottle

Conclusion

As expected from the literature study, the top-load strength at low overhang decreases quite fast. But as the overhang gets bigger, the reduction stabilizes.
The bottle behaves under the influence of top-load with overhang also as expected. The side of the bottle overhanging the pallet will stretch, where the other side of the bottle compresses.
Looking at single bottles, for top-load strength the maximum overhang should be 7.5mm, this gives a reduction in top-load strength but this reduction is limited.
Looking at bottles in shrink foil, 10mm of overhang still gives good results in top load strength. This should be tested in a transport test to make sure if this also counts for a whole pallet on transportation, where various extra forces will be applied to the bottle.

2.2.3 Transport test 1L HDPE with overhang

A transport test with the current 1L HDPE bottles was performed, to determine the effects of overhang on a fully loaded pallet. There was made sure that there was overhang on the pallet. Even after applying the stretch hood, there still was a (variable) amount of overhang on the pallet.

Pallet pattern

For the transport-test a new (non-existing) pallet pattern was made to make sure that there would be overhang on the pallet. It was based on an existing pallet pattern, but with one 6-pack per layer more, and less space between the 6-packs on some places. The pallet pattern used is shown in figure 2.8.

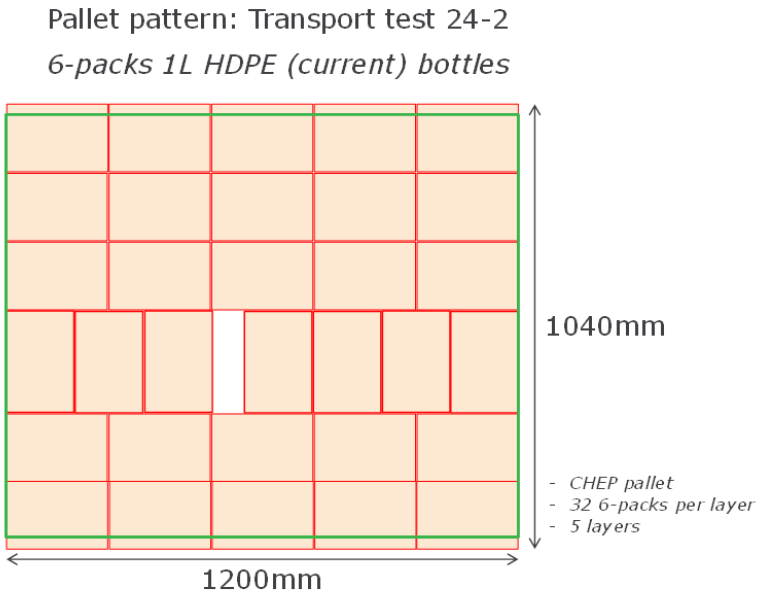


Figure 2.8: Pallet pattern used for transport test

The transport test was performed with a CHEP (industry) pallet (1200x1000mm). The pattern was made so that there were 32 6-packs per layer. The pallets were 5 layers high, with a (double) interlayer in between. After the pallets were build, a stretch hood was applied to the pallets to secure stability.

The overhang had to be on the small side of the pallet, because the pallets are being put in trucks two beside each other. The trucks are 2440mm wide; so on the long side there fit two pallets beside each other, with 40mm of play in total (20mm per pallet).

The theoretical overhang on the pallet is 40mm. On some spots on the pallet, this was the actual amount of overhang but because of the manual stacking, the amount of overhang was varied (on purpose) to create a variation of the amount of overhang over the pallet.

There were two pallets made, and they were both on transport from Aalter (factory where bottles are made) to Sleidinge (another factory) and back again. Then the pallets were checked for any damage on the bottles.

In figure 2.9 various photos of the building of the pallets are shown.

Figure 2.9: Building of the pallets for transport test

Interview with logistics

The transport test was arranged together with the logistics department of the FrieslandCampina plant in Aalter (B). On forehand some restrictions were given based on restrictions by the size of a truck.
A truck is about 2,44m wide. This means that 2 pallets with a 1200mm side, or 4 mini-pallets with a 600mm side, fit besides each other with 40mm of play left.

Results

The pallets were checked after the test was performed. In figure 2.10 the pallets are shown back from the transport test.
There was no significant damage on the bottles after the transport test. The two points of damage were:

- Bottles on the bottom layer (20mm overhang) were skewed after the test, the angle was not big but was observable (figure 2.11) .

The damage on the bottle isn't that big, but can be directly related to overhang due to earlier performed top load tests on single bottles, with overhang. The effects of the top load with overhang on bottle performance were similar as the effects shown on the concerned bottles.

- On both of the pallet there were dents on bottles in one of the corners of the pallet (figure 2.12). The dents are on the overhanging side. If the bottles weren't overhanging the pallet side, the dents were probably not be there, or less severe.

Conclusion

After the transport-test there can be concluded that overhang has an effect on the bottle performance. The top load on the bottom bottles is big, so with overhang the effect is observable, but not severe.
Also dents (or punctures with sharp objects) are more likely to happen with overhang, then without overhang.

Figure 2.10: The pallets back from transport test

Figure 2.11: Skew on a bottle of the bottom layer

Figure 2.12: Dents on bottles in the corner of the pallet

2.3 Conclusion

2.3.1 Displacement

For the bottle proposals with a diameter of 82,6mm and 84mm, the displacement on the pallet caused by shrink and stretch foil was calculated. The result is an expected displacement of 1mm per bottle.

With the aid of the expected displacement per bottle, the practical overhang can be determined for the proposed pallet patterns. The values for the maximum overhang per option given in chapter 1.2 is:

1. 82,6mm bottle with minimum extra transport costs and 39mm overhang on pallet.
   - *Maximum practical overhang: 26mm*
2. 84mm bottle with 42k extra transport costs and 40mm overhang on pallet.
   - *Maximum practical overhang: 30mm*
3. 82,6mm bottle with 42k extra transport costs and 26mm overhang on pallet.
   - *Maximum practical overhang: 16mm*

2.3.2 Maximum overhang

From the literature study there was learned that overhang on a pallet can cause dents and/or punctures in the bottles. This effect was also seen on the transport test. On both test pallets, there were bottles with dents. The dents were on the edge of the overhanging side, so the dents can be related to the overhang.

In the practical tests with individual bottles was learned that overhang has an effect on the top load strength of a bottle. With overhang the bottle behaves different to top load then without overhang. The result is that the bottle can become bended. Also this was seen on the bottles in the bottom of the test pallet at the transport test, although not very severe. The shrink sleeve around the 6-pack and stretch hood/foil around the pallet provides protection of the bottles. This was also seen in the practical tests with shrink foil, where the decline of top load strength was less severe.

From logistical point of view there are also demands for the maximum overhang. A standard truck is 2,44m wide. Sizes of pallets differ from each other, but there is (almost) always a side of 1200mm (normal Euro or CHEP) or 600mm (mini Euro or CHEP). This means that of the large pallets, 2 fit beside each other in a truck, and for the small pallets, 4 fit beside each other. In both cases with 40mm of play.
If the overhang on these pallets is too severe, the pallets won't fit beside each other anymore and there will definitely be damage on the bottles. This means that the maximum overhang also depends on the size and side of the pallet.
On mini pallets, the maximum overhang on the 600mm side is 10mm of overhang in total (5mm per side). On normal pallets, with a side of 1200mm, the maximum overhang on that side is 20mm in total (10 mm per side).

Looking for the other side of the pallet, the logistics department said that the maximum overhang should be 20mm in total. Anything more than 20mm is a lot according to them. The transport test showed that an overhang of approximately 40mm does indeed give a little bit of damage, and 20mm gives no damage.

To determine a maximum overhang is hard, but if an overhang of 40mm already gives damage, than 40mm of overhang is too much. It may be better to use the maximum overhang the logistics department handles (20mm) as a guideline. When using more than 20mm of overhang, the bottle has to be of high strength, and it may be necessary to use extra protection like corner edges.
In table 2.4 an overview is given of the maximum overhang values.

Pallet side	600mm	1200mm	Other
Maximum value	10mm	20mm	20mm

Table 2.4: Overview of values for maximum overhang

2.3.3 Bottle diameter proposals (82,6mm and 84mm)

By combining the results of the displacement calculation and the maximum value of overhang, the best option for the bottle proposals 82,6mm and 84mm can be given.

Option 1 and 2 are both not sufficient due to the practical overhang is bigger than the maximum value, so bottle performances cannot be guaranteed if one of those options is chosen.
Option 3 (82,6mm with maximum theoretical overhang of 26mm) is sufficient so it is advised if FrieslandCampina wants to continue with one of the proposals this option is chosen.

2.4 Competitor analysis

A comparison of measurements was made between various different bottles from both competitors and Campina (table 2.5). The value of the maximum top load was not investigated in this study, but was already investigated at FrieslandCampina before.

Looking at the comparison in table 2.5 is shown that bottles of different brands vary in shape, height and diameter. However the differences limited due to the fact that all of the bottles contain 1L of milk. The shape of the bottle determines what dimensions the bottle should have to have the right volume.

What also is seen is that the shape/size and number of ribs or the weight of the bottle doesn't directly say that the bottle has high bottle performance. The Candia Viva bottle is the lightest within this comparison, and had the smallest and shallowest ribs, but still has the highest top-load strength.

This comparison gives an idea in possibilities and shapes/dimensions of bottles that are currently in the market. In figure 2.14 an overview of all competitors in the marked is shown. This was part of an analysis is already performed by FrieslandCampina. In this figure bottles with decoration and multipacks are shown.

	Campina (current bottle) *Figure 2.13 A*	**Boni Selection/ Delhaize** *Figure 2.13 B*	**Candia Viva** *Figure 2.13 C*	**Délisse** *Figure 2.13 D*	***Campina (82,6/84mm concept)***
Shape (mm)	Squareish	Round	Round	Squareish	*Round*
Diameter (mm)	80*80	80,5	86	83,7	*82,6/84*
Height without cap (mm)	243	246	241,5	242	*242,8/239*
Weight (gram)	32,4	32,7	29,1	31,2	*29,5*
Headspace (ml)	52	56	67	76	*65*
Number of ribs	5	6	5	7	*6 straight 4 curved*
Rib height (mm)	6,8	5,1	4,0	6,5	*5,2*
Rib depth (mm)	2,3	1,0	1,0	2,7	*2,5*
Space between ribs (mm)	8,5	13,5	10,7	6,0	*11,6*
Label area height (mm)	85	116	-	96	-
Label area depth (mm)	0,7	0,30	-	1,5	-
Max top load (N)	693	702	722	589	-

Table 2.5: Measurements of competitor bottles related to current Campina bottle and 82,6mm and 84mm new bottle proposals

A B C D

Figure 2.13: The bottles used for the analysis in table 2.3

Figure 2.14: All competitor bottles in the market with decoration and in multipack

2.5 Family features new HDPE bottle series

For the new design of the 1L HDPE bottle a comparison between the different bottles in the new HDPE bottle series (figure 2.15 & figure 2.16) is made to determine what features of the bottle are consistent for all different volumes.

Here an overview of the different family features:

- All bottles have the same neck with the same cap (harmonization in neck)
- Narrowing just above the bottom (10-15% of narrowing compared to the bottle diameter)
- Straight ribs from the top to the narrowing, in narrowing two curved ribs
- One (200ml) or two (all other volumes) curved ribs under the narrowing, those ribs are curved the same as the top rib in the narrowing

2.5.1 Neck and cap

Each volume in the current series of HDPE bottles has its own neck and cap. In the design of the new series, it has been taken into account that all bottles now have the same neck and cap. This result in a big cost saving: The new caps are lighter than the current caps, and the harmonization means that the caps can be bought in larger quantities so that a greater discount can be given by the supplier.

2.5.2 Narrowing

All the different volumes have the same kind of narrowing near the bottom of the bottle. Because all bottles have roughly the same shape the bottles look like they belong to the same brand/company which gives a family look and feel in the series.

2.5.3 Ribs

From the top rib, just below the shoulder, to just above the narrowing the ribs in the bottle are straight horizontally. The ribs are 2 or 2,5mm deep and around 4,5mm high. The space between the ribs is around 11mm on all bottle volumes.
In the narrowing there are two curved ribs. Those ribs are curved in a light, flowing wave with a height difference of around 3,5mm. The two curves are flowing opposite of each other (like sine and cosine).

Beneath the narrowing there are more curved ribs. On the 200ml bottle there is one curve left to the bottom, on the three volumes there are two ribs. Those ribs are curved like the top curved line in the narrowing.

Figure 2.15: Family of HDPE bottles
From left to right: 200ml, 250ml, 500ml & 1000ml (82,6mm new bottle proposal)

Figure 2.16: Pilot bottles of HDPE bottle series
From left to right: 500ml, 250ml & 200ml

2.6 Maximum bottle dimensions

A maximum bottle height (without cap) of 244,3mm has been given by the commercial department. This is due to the maximum pallet (load) height of 1,39m, with 5 layers of products, and 5 interlayers (6mm thick). The cap on the bottle has a height of 0,74mm.

For the width of the bottle, it is more complicated. The main limit is the maximum overhang, in relation with the number of bottles on the pallet. If the amount of bottles on a pallet is too little, the transportation costs are exceedingly high compared to the current situation.

An acceptable increase in transportation costs is 42k€ a year. This value is based on a decrease in the number of bottles per pallet compared to the current situation as calculated by Frieslandcampina.
Because the total savings by weight reduction and introducing the new cap is 227k€ a year, savings will remain.

With this information taken into account the maximum dimensions per pallet type were calculated. The lowest value that came out of this calculation is the required maximum bottle diameter. The calculation is shown in table 2.6 (the number of bottles per pallet is a fixed value)

From the calculation can be concluded that 82mm is the maximum diameter for the redesign of the bottle. In figure 2.17 the maximum bottle dimensions are visualized.

	Euro 6-pack (Belgium)	Euro 6-pack (France)	Mini Euro 6-pack	Euro 8-pack	Industry 6-pack (Bonomel)
Pallet dimensions (incl. max overhang) (mm)	820*1220	820*1220	610*820	820*1220	1020*1220
Number of bottles	690	630	330	680	840
Bottles per side	10*14	10*14	7*9	10*14	12*14
Maximum dimension per side (mm)	82,0*87,1	82,0*87,1	87,1*91,1	82,0*87,1	85,0*87,1

Table 2.6: Calculation of maximum bottle diameter based on minimum number of bottles per pallet

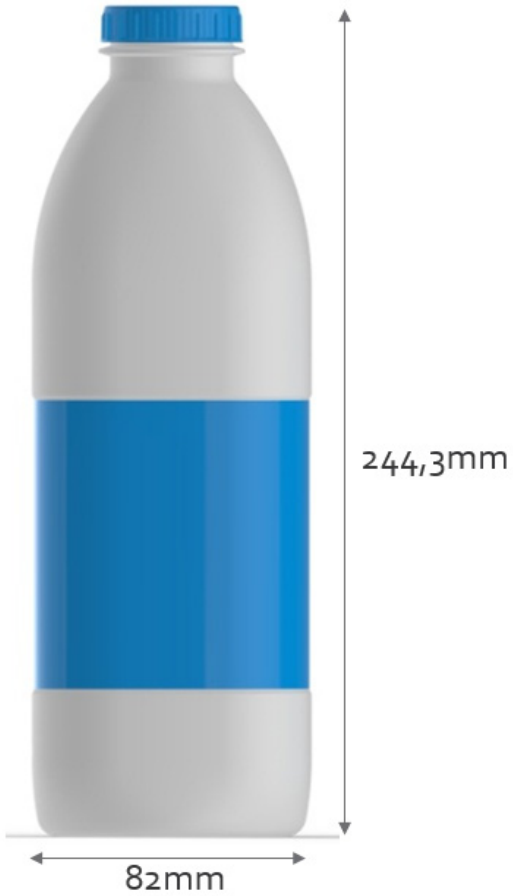


Figure 2.17: Maximum bottle dimensions

2.7 Production process

Because the bottle has to be produced at the current line an analysis has been done for the production and filling of this bottle.

In the diagram in figure 2.18 an overview is shown of the production process of the HDPE bottles to the part where the bottles go for transport. The single parts of the production process will be discussed in the following chapter.

2.7.1 Co-extrusion blow moulding

The products that will be filled in the bottles are ambient dairy products, among which plain milk. If plain milk is exposed to light, it will spoil faster. This means all light from the spectrum has to be blocked in the bottles, including infra-red and UV light. To make sure all light will be blocked, the bottles are multi layered.

The bottles consist of three HDPE layers:

- A white outer layer
- A black middle layer
- A inner layer made from crushed rejected bottles

The white and black layer are made from 'fresh' granulate. To recycle rejected bottles, the rejected bottles are crushed and used for the inner layer of the bottle. In figure 2.19 the granulate used for the various layers is shown.

To make sure that the bottle consists of three layers, the bottle is made with co-extrusion blow moulding. This is a variant of extrusion blow moulding, where multiple layers can be used. The machine used for co-extrusion blow moulding is shown in figure 2.20.

Extrusion blow moulding is done in the following way: An extruder melts the plastic granulate, and extrudes in a tube. When the extruded plastic reaches the bottom of the mould, the mould closes and moves away from the extruder. An air pin lowers into the mould, and air flows through the pin. Pressure builds up within the mould and the bottle will be blown.

After blowing, the air pin moves away from the mould and the excess polymer is being pushed together so that the bottle will be closed. This is to make sure that no dirt gets into the bottle. To release pressure in the bottle a small perforation is made.
The process is visualized in figure 2.21.

The bottles are being kept from the machine, and through air pipes being transported to silos.

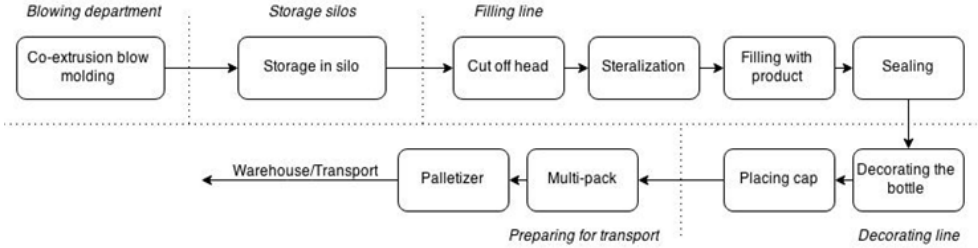


Figure 2.18: Flowchart visualizing the production process of HDPE bottles

Figure 2.19: Granulate used for production HDPE bottles.
Inner layer - middle layer - outer layer

Figure 2.20: Co-extrusion blow moulding machine

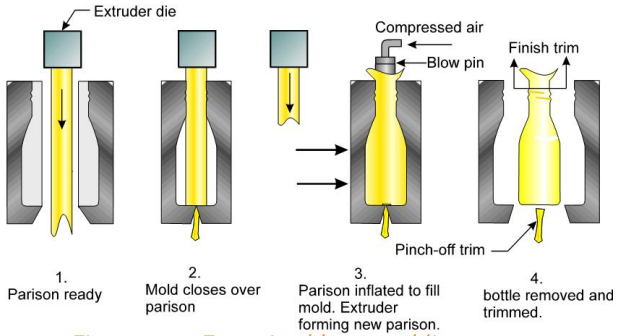


Figure 2.21: Extrusion blow moulding process

2.7.2 Storage in silos

Because HDPE bottles shrink in the first ±24-hour after producing, the bottles have to rest before being filled and sealed. This happens in large silos where the bottles are stored before going further in the line.
The silos are also a buffer between bottle production and the filling line. More bottles can be produced than needed at that moment in the filling line, so that there are always enough bottles ready for filling.
In figure 2.22 a screenshot of cameras in the silos is shown.

2.7.3 Filling line

The next step in the process is filling the bottles. The filling takes place in a closed environment so that no dust or dirt can accidentally be filled in the bottle.

The first step of the filling is cutting off the head of the bottles. In the blowing department the head of the bottle was kept, so no dust or dirt can come in. Now the head can be cut of (figure 2.23), without any dirt coming into the bottle.

When the head is cut off, the bottle is being sterilized with peroxide so all bacteria that are inside the bottle will be killed. This will preserve the health of the consumer and the shelf life of the product. Sterilization is being done by spraying peroxide inside the bottle from a nozzle. The nozzle gets inside the bottle, spays the chemicals and retracts. Then the bottle can go to the next step.

The next step is filling the bottles with the product. This also goes with a nozzle from above the bottle (figure 2.24). The bottle is filled until the right volume is reached, and then it goes to the sealing machine.

The next step in the filling line is sealing the bottle. The sealing happens with aluminium seals over the opening of the bottles. By sealing the product will not be exposed to the outside until the seal is being removed. After the product is being sealed, the product can go out of the closed environment, and gets transported to the next step in the line.

As a last step, outside the closed environment, the bottles are being tested if the sealing is right. The bottles are being squeezed by a leaking sensor. If the bottles are leaking they are being removed from the line.

Figure 2.22: Screenshot of cameras placed in silos

Figure 2.23: Head trimming machine where head is removed

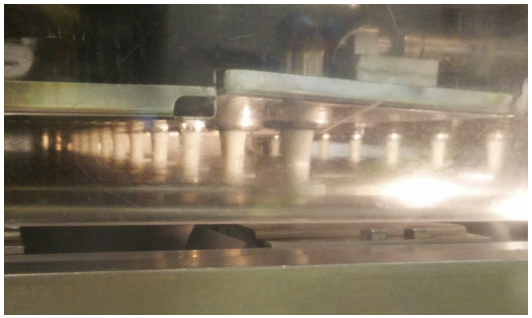


Figure 2.24: The milk flowing out of the nozzle into the bottle

2.7.4 Decorating

The next step in the line is twisting the cap and decorating the bottle.

First, the cap with the colour matching the product inside will be twisted on the bottle. Then the bottle is ready for decoration. A label or sleeve with all the necessary information will be applied around the bottle.

1L HDPE bottles now all have paper labels around them. A label is wrapped around the bottle, and glued at the point where the both ends of the paper come together.
Bottles with lower volumes often have shrink sleeves. A shrink sleeve is a plastic sleeve around the bottle, which will be shrunk to fit the contour of the bottle.

On some bottles with lower volumes (200/250ml), a straw may be applied depending on the product inside the bottle. Then the bottle is ready for consuming. The next step in the process is preparing the bottles for transport.

In figure 2.25 the bottles with cap, just before applying the label, is shown.

2.7.5 Preparing for transport

For good transport, and sometimes selling multiple bottles at a time, the bottles are being collected into multipacks. Depending on the destination the bottles are being sorted by 2-6-8--10-12-24-... and bundled together. When bottles are collected into 2-packs, most of the time the 2-packs are bundled together again into for example 12x2-packs.

Some bundles go onto a tray, and get a shrink foil around the tray. Some other multipacks are bundled without tray, and are kept together by just shrink foil.
After the bottles are being bundled, the multipacks go to palletizers, which collect the multipacks and put them on pallets. This all goes according to a pallet pattern that was determined beforehand.

To ensure the stability of the pallet, a stretch foil or stretch hood is applied over the pallet. This way the loose multipacks can't fall off.
After this, the pallet will be transported to a warehouse, from where it goes to the final destination.

Figure 2.25: Bottles with cap just before the labelling machine

2.8 What makes packaging iconic?

Because both iconic and generic bottles are going to be investigated, it is important to define a difference between iconic and generic bottles. Therefore the question was asked: 'What makes packaging iconic?'

2.8.1 Iconic by shape

According to Kaustubh Goswami (packaging designer at FrieslandCampina), the first thing that makes packaging iconic is its silhouette. When a customer sees a product on a shelf, the first thing that stands out is the silhouette of the product. A product with a silhouette strikingly different than its competitor stands out and is more recognizable than the rest of the products on the shelf.

A good example of is the Coca Cola bottle. This bottle is a very iconic bottle, because a lot of people would combine the silhouette of the bottle, with the product name.

For Coca Cola, the silhouette of the glass bottle introduced in 1915 became the shape customers would directly connect to the Coca Cola brand. Therefore Coca Cola kept on using this silhouette from then on, on all its bottle designs (figure 2.26).
Only a few brands have such iconic packaging that only the silhouette makes a package iconic. For these brands, if they change the silhouette of their packaging customers wouldn't recognize the product anymore in the shelf.

A collage of iconic packaging shapes is shown in figure 2.26.

Figure 2.25: History of Coca Cola bottles with from 1915 on the iconic bottle shape

Figure 2.26: Collage with examples of packaging iconic by its shape

2.8.2 Iconic by decoration

A small marked research found out that not only the silhouette of the packaging is determinative if a package is iconic or not. Also visual elements like ribs or embossments can make a package iconic. But also a regular (generic) package can become iconic just by decoration. When the decoration on a package is strikingly different than the decoration of other products on the shelf, the product itself stands out to its competitors. This is what makes a package iconic.

A good example for this is the Marlboro cigarette pack. This pack has the same shape as all other cigarette brands, but just by its decoration everyone familiar with the brand recognizes the brand immediately. This is due to the red top and the white triangle and bottom. It is distinctive compared to other brands and used for many years already.
A collage of iconic decoration is shown in figure 2.27.

Another example is visualized in figure 2.28. In this comic the white products in the shelf are directly recognizable while the package shapes are the same as competitors. If this would be a real brand, it would have had a very recognizable brand identity.

Figure 2.27: Collage with examples of packaging iconic by its decoration

2.8.9 Conclusion

Whether a package is iconic or not is determined by the way it stands out to its competitors on the shelf. The first thing a customer notices is the silhouette of a package. If the silhouette already stands out to its competitors, the product is more recognizable and thus iconic.

Also an important part in what makes a package iconic is its decoration. By a decoration that stands out by colour, shape, logos, etc. the product will be more recognizable and more iconic.

To make a package iconic, the choice lies in making an iconic package shape, an iconic decoration on the package or a combination of both.
What should be taken into account is that a package only becomes iconic when it's being used for a long time. Only then consumers will recognize the brand by the package or decoration.

Figure 2.28: Cartoon showing the power of a distinctive packaging in the shelfs

2.9 Requirements

2.9.1 Starting points

The starting points of this project are defined by the commercial department. They have a few demands on which the bottle has to satisfy. These demands have to be taken into account when designing the new bottle shape. Below is an overview of those demands:

- The bottle has to have the same neck and cap as the other HDPE bottles from Silgan/ Portola:
  Harmonizing the neck and cap results in savings by a lighter cap and higher purchasing volumes so higher discounts by the supplier
- Label height for branded products has to be 110 or 120mm, for private label products the label heights has to be 80mm:
  This is to differentiate between branded products and private label products
- Headspace has to be 65ml:
  The headspace of 65ml is higher than in the current situation, but this is required due to foaming of skimmed milk. Skimmed milk foams during filling where a larger headspace is required, otherwise the product comes at the sealing surface and the bottle wouldn't seal.
- Maximum height of the bottle has to be 244,3mm without cap:
  This is due to the maximum pallet height of 1390mm, and 5 layers of bottles on a pallet.
- Bottle weight has to be 29.5 grams:
  Light weighting results in big costs savings
- Maximum increase in transportation costs compared to current situation may be €42k a year:
  In this situation the savings are still significantly higher than the extra costs

It is not clear if the commercial department wants a bottle belonging to the family of HDPE bottles (or any other iconic bottle shape), or a more generic bottle which can also be used for private label products. In accordance with Arie Pelle (supervisor from FrieslandCampina) it is concluded that this assignment will continue for both possibilities. Concepts for both versions of the bottle will be made so an overview of the options is delivered.

2.9.1 Program of requirements

After the performed analysis and collecting the requirements of the commercial department, a program of requirements can be made.

Because it is not yet decided if the project will go with an iconic bottle or a generic bottle, this assignment will result in four different concepts. Every concept will focus on a different solution.

In the study for what makes packaging iconic was investigated that there are two ways to make packaging iconic. This can be done by shape (silhouette) and by decoration.

The four different concept directions are:

- Iconic shape - family
  Will focus on an iconic bottle that fits in the by FrieslandCampina designed HDPE bottle series.
- Iconic shape - non-family
  Will focus on an iconic bottle with an alternative design (not part of the HDPE bottle series).
- Iconic decoration
  Will focus on a solution to make a generic bottle iconic by decoration. By making the decoration iconic, the bottle can also be used for private label products (when 'normal' decoration is applied).
- Generic
  Will focus on a generic bottle that will be suitable for both branded as private label products.

The requirements are divided in three categories: Primary, secondary and tertriary packaging.

The requirements for the primary packaging focus on the bottle itself. In this category the requirements are sorted in sub-categories. There are requirements that count for all concepts, but also requirements that only count for one of the concepts.

Primary packaging

All concepts:

- The bottle should have a maximum height of 244,3mm without cap.
- The bottle should have a maximum diameter of 82mm.
- The bottle should have a maximum weight of 29,5 grams.
- The bottle should have a brimful volume of 1065ml.
- The bottle should have the harmonized (Silgan/Portola) neck and cap.
- The bottle will be produced and filled on the existing blowing/filling line with minimum adjustments.
- The height of the label for branded products should be 110mm *(wish: 120mm)*.
- The height of the label for private label products should be 80mm.

For concept 1 (Iconic shape - family):

- The bottle should contain iconic elements of the series of other HDPE bottles.

For concept 2 (Iconic shape - non-family):

- The bottle should contain distinctive elements.
- The bottle should still look like a milk bottle (it should fit in the self).

For concept 3 (Iconic decoration):

- The bottle should be generic and not contain distinctive (shape) elements.
- The decoration for the branded product should be distinctive related to competitors.
- The private label product should have a 'normal' straight label.

For concept 4 (Generic):

- The bottle should be generic and not contain distinctive elements.

Secondary requirements

- The secondary packaging will be applied on the existing packaging machinery, with existing packaging materials.

Tertiary requirements

- The pallet patterns should have at least the minimum number of bottles per pallet as shown in table 2.6.
- The overhang on the pallets in the pallet patterns may not exceed the values shown in table 2.4 (p. 20).

Pallet type	Minimum number of bottles
Euro pallet with 6-pack	690
Euro pallet with 8-pack	680
Mini Euro pallet with 6-pack	330
CHEP pallet with 6-pack	840

Table 2.6: Minimum number of bottles per pallet

FrieslandCampina plant in Aalter (B) where amongst others the HDPE bottles this project focusses on is produced


DAF
CF
FrieslandCampina

3.Idea generation

Now the analysis is finished and a program of demands is determined, a start can be made in idea generation.

This was done by making dynamic sketches for iconic bottles to give an idea of the possibilities. A morphological scheme was made with solutions for various parts of the bottle. Ideas were made with the help of the morphological scheme.

3.1 Concept direction categories

The ideas have been divided in three categories: Iconic by shape, iconic by decoration and generic.

Category 1: Iconic by shape

The iconic by shape category gives ideas of bottles with an iconic shape. However private label products cannot be sold with this type because the bottle wouldn't be iconic anymore if more brands were sold in the same bottle.

This category can be divided in two sub-categories, the family shape and the non-family shape. The family shape bottle has the shape of the other designed HDPE bottles, while the non-family shape gives a new design iconic design.

82,6mm bottle family design

During the analysis it was concluded that the 82,6mm bottle proposal is sufficient when displacement is taken into account. However, in this study still alternatives for an iconic bottle will be generated. This is due to the fact that if FrieslandCampina would like an iconic bottle, but the 82,6mm turns out not to be sufficient, another alternative will be ready for development. If the 82,6mm bottle turns out to be sufficient, this study can be used as input for future projects.

Category 2: Iconic by decoration

The iconic by decoration category gives an idea of (generic) bottles that can be made iconic by an out of the box type of decoration. By applying a more generic type of decoration, the private labels can also be sold in this bottle design.

Category 3: Generic

For bottles in the generic category, both private labels and branded are sold because there are no iconic elements on the bottle. The design and decoration shape will be the same for both branded and private labels.

In the end, for each category usable and feasible ideas were generated which will form a base for concept generation. In the next step for each of the (sub-) categories one concept will be generated.

3.2 Dynamic sketches iconic bottles

To make a first start at idea generation, dynamic sketches of iconic bottles were made (figure 3.1). This gave ideas of how an iconic shaped bottle could look like. This wasn't done for generic bottles because generic bottles are more straight forward without an interesting design.

To conclude, there are a few ways to make a bottle iconic. This can be done by creating narrowings or curves in the shape, by adding an iconic embossment or by giving the ribs a certain shape.

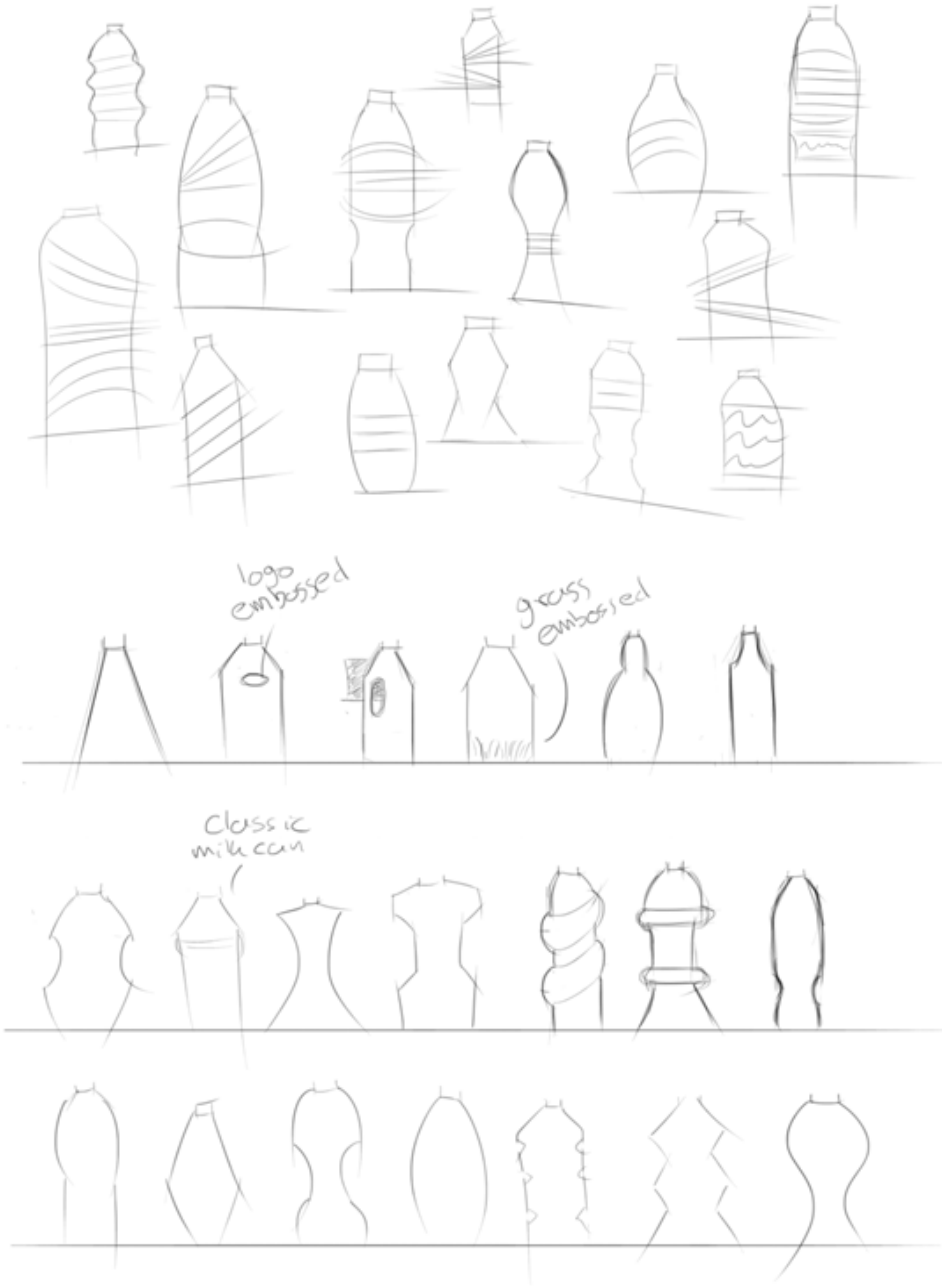


Figure 3.1: Dynamic sketches of iconic bottles

Group	Explanation
Iconic shape	Whether the bottle design (without decoration) is iconic or not. This can be by shape, embossments, etc.
Pallet layers	Currently there are 5 layers of products on a pallet. An option is to eliminate one layer, while keeping the pallet height of 1,39m. This means that the bottles will be higher (new max. bottle height of 340,8mm). Because the bottles can be higher, they can also be smaller and more bottles fit on one layer.
Shape	The bottles can be round or square.
Shoulder	Various possible shapes of the shoulder of the bottle are shown here.
Ribs	The number of ribs on the bottle (low, medium, high or none).
Rib shape	The shape of the ribs on the bottle (straight, skewed, curved or combined).
Ribs visible	Whether the ribs should be visible for the customer or not. The ribs can also be behind the decoration so that the ribs are not visible. The ribs can also be partly visible, and partly hidden.
Step-in protection	Whether the bottle has step-in protection for the decoration. This means that there is a small space in the bottle where the decoration is placed. This prevents the decoration from being damaged during e.g. transport.
Decoration	The kind of decoration may cause a different bottle shape. Therefore it is needed to think about this on forehand. Label: A label is a piece of paper or plastic which is wrapped around the bottle and glued together. Sleeve: A sleeve is applied around the bottle. This can be done in two different ways. - Shrink sleeves are shrunk around the bottle. - Stretch sleeves are stretched around the bottle.
Decoration shape	The decoration can be applied in various different forms and shapes. A few shapes are shown here.

Table 3.1: Explanation per group of the morphological scheme

3.3 Morphological scheme

After the dynamic sketches of iconic bottles, it was decided that making a morphological scheme is a good way of idea generation for this case. A morphological scheme is applicable for all iconic by shape, iconic by decoration and generic category.
The morphological scheme is shown in appendix 3.1.

In table 3.1 an explanation per group is given.

3.4 Ideas per category

Ideas were made based on the morphological scheme, and the dynamic sketches were used to give ideas for the iconic by shape category. In figure 3.2 an overview of the generated ideas is given. In the next part some the ideas are further explained.

Iconic by shape

The iconic by shape category can be divided in two sub-categories namely family and non-family. The family sub-category consists of bottles with elements of the other designed HDPE bottles, the non-family iconic bottles are bottles with an iconic look, but that doesn't contain elements of the other bottles.

Family shape

To give alternatives for the family shape, three ideas in this category were generated. These ideas give alternatives in case the 82,6mm bottle doesn't fit all requirements. The ideas generated are a square version of the designed bottle, a more round version and a high (4 pallet layers) version of the bottle. The ideas and its routes used on the morphological scheme are shown in appendix 3.2.

Non-family shape

There were also ideas generated that do not fit the family of HDPE bottles. This was done to give alternatives in case a family shaped bottle isn't requested, or the family shaped bottles do not feed requirements. The ideas and its routes used on the morphological scheme are shown in appendix 3.3.

Iconic by decoration

For the iconic by decoration category various ideas were generated with two ways of decoration, one iconic way of decoration and one generic. By applying two different kinds of decoration the bottle looks different although the silhouette is similar. The shape of the bottles in this category are more generic, but give possibilities for the decoration to be either iconic or generic.

Both versions of the ideas, with the routes used on the morphological scheme are shown in appendix 3.4.

Generic

The ideas generated for the generic bottles will be able to sell branded labels as well as private labels. This means that the bottle shouldn't have very recognizable elements in which the consumer directly recognizes the bottle as for one brand (e.g. Campina brand). The generated ideas and its routes used on the morphological scheme are shown in appendix 3.5.

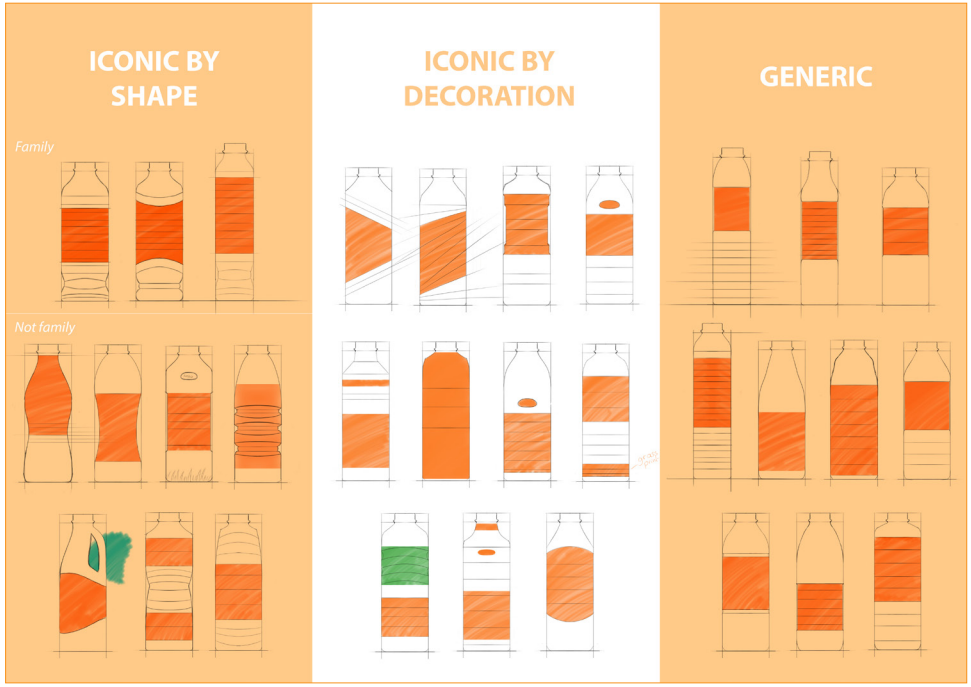


Figure 3.2: Overview of generated ideas for


Campina
Halfvolle
melk

4. Concept stage

During this stage of the project, concepts will be developed as a result of the generated ideas in previous chapter. Those concepts will be developed to determine final shape and dimensions, pallet patterns and a concept for decoration. Afterwards the concepts will be verified with the program of demands.

4.1 Concept generation

Now that the ideas are generated for each category a concept will be made. This means four concepts will be developed from the idea generation:

- Iconic by shape – Family bottle
- Iconic by shape – Non-family bottle
- Iconic by decoration
- Generic

For each category the ideas were evaluated and the most useful ideas were selected. For some categories elements of different ideas are being combined to generate the concept. In this chapter for each category the concepts will be explained.

4.1.1 Iconic by shape – Family

In this sub-category three ideas were generated. Each of the ideas is based on the shape of the other bottles in the by FrieslandCampina designed series. An overview of the ideas with commentary form evaluation is given in appendix 3.2.

The most interesting and usable idea in this category is the first idea (figure 4.1). The square version of the family shape encloses the family shape the best compared to the other two ideas. A round version of the family bottle (the 82,6mm in diameter bottle mentioned earlier) also fits the requirements, so the square version gives a good alternative should the round bottle not be usable in the end.

Figure 4.1: Final version concept 1

The idea doesn't have to be updated or combined before concept development because the shape is already determined. During concept development the final measurements will be determined.

4.1.2 Iconic by shape – Non-family

For this sub-category seven ideas were generated with each a different iconic shape. It was taken into account that the silhouette of a bottle makes a bottle iconic, but there is also one idea which has a more generic shape with iconic embossing. An overview of the ideas with commentary from evaluation is given in appendix 3.3.

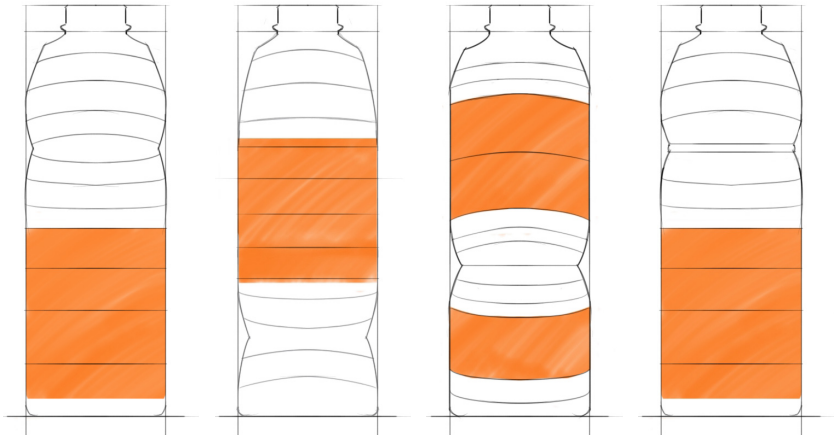


Figure 4.2: Variations for concept 2

It is important that consumers still have an association with milk when they see the bottle. Besides that the bottle has to be iconic, it still has to look a bit like a milk bottle. Therefore the competitor analysis and generic bottles were used to determine per idea if the bottle still looks a bit like a milk bottle.

From the seven ideas, two were usable. It is decided that these two ideas will be combined to a concept. The neck from idea 6 will be combined with the narrowing from idea 5. Variations for the combination are made and shown in figure 4.2. The combination between the two bottles will be a round bottle.

It is decided to develop variation B further. This was decided because this variation is iconic while it still looks like a milk bottle. Variation C also is iconic, but this variation looks a bit too fancy for a milk bottle. The bottle still hast to fit on the shelf between the competitors. Variation B looks distinctive compared to competitors, while it still fits on the shelf.

Figure 4.3: Final version concept 2

This also counts for variation A and D, but those variations have the iconic elements on the top half of the bottle. By dividing the iconic elements over the bottle, they will be highlighted more in the design which makes the bottle more iconic.

In figure 4.3 the final version of this concept is shown.

4.1.3 Iconic by decoration

For this category 11 ideas were generated with each two different ways of decoration; one iconic way of decoration and one generic decoration. There was taken into account that the bottles have to look different with each type of decoration applied. The results with commentary from the evaluation are shown in appendix 3.4.

One of the ideas really gave a difference in appearance between the iconic and the generic version of the bottle. It is decided to develop this idea further combined with one element from some other ideas; the Campina logo sticker above the label. This element will be implemented in the concept, because the extra sticker makes the bottle look more iconic. In figure 4.4 the final versions are shown.

Figure 4.4: Final versions concept 3

4.1.4 Generic

For the generic category 10 ideas were generated. It is taken into account that the bottle has to be sold for branded products, as well as for private labels. Therefore the design of the bottles should be really straight forward and simple. For the most ideas this is suitable, but some ideas have some iconic elements or don't look like milk bottles. For those bottles commentary is added, the suitable bottles are marked as suitable. This is shown in appendix 3.5.

The idea shown in figure 4.5 is chosen to be developed further as a concept. This decision was made with the aid of the competitor analysis. The idea in figure 4.5 looks like competitor bottles, while still having distinctive elements.

Figure 4.5: Final version concept 4

4.2 Concept development

In this chapter all four concepts will be developed until the final dimensions are known, the pallet patterns are determined and a concept for decoration is given.

The dimensions calculated are based on the required brimful volume. There was calculated that a total volume (brimful volume + material volume at 29,5 grams) of 1095cm^3 is needed to fit the requirements. All concepts have been modelled in SolidWorks and the dimensions have been adapted to the required volume. Here it was tried to give the bottle a diameter as small as possible so for most concepts a height of 244mm was fixed.

4.2.1 Concept 1 Iconic by shape – family

This concept is a square version of the already designed HDPE concepts. If the 82.6mm proposal turns out not to be sufficient this concept gives an alternative in which the bottle keeps its iconic shape.

The final version of the bottle is shown in figure 4.6.

Dimensions

Due to the square shape of the bottle, the dimensions will be smaller compared to the round version. This means that the overhang on the pallet will also be smaller or even gone. To determine the dimensions, the design was modelled in SolidWorks. The dimensions are based on the required volume, and maximum height.

The required total volume (inner volume + material volume) is around 1095cm^3. This is calculated by adding the material volume (29,5 gr / 0,97 gr cm^{-3} = 30,4cm^3) by the required brimful volume of 1065cm3 (1000ml + 65ml headspace).

This required volume is achieved with the following dimensions:

Height: 244mm
Diameter: 78mm

The technical drawing with full dimensions is shown in appendix 4.1

Pallet pattern

To check if with the determined dimensions the transportation requirements are still achieved pallet patterns for the concept will be generated.
The sizes of the bottles with shrink sleeve around are shown below:

6-pack: 156*234*245mm
8-pack: 156*312*245mm

After calculating pallet patterns, the maximum number of bottles per pallet is:
Euro 6-pack = 750 bottles
Euro 8-pack = 680 bottles
Mini Euro 6-pack = 330 bottles
CHEP (industry) 6-pack = 930 bottles

The overhang per side on each pallet pattern is:
Euro 6-pack = -30mm* -20mm
Euro 8-pack = -54mm * -10mm
Mini Euro 6-pack = -20mm * -54mm
CHEP (industry) 6-pack = -30mm * 14mm

The full pallet patterns are shown in appendix 4.2.

Decoration

The decoration on this concept will be done by a straight label. The height of the label will be 110mm. The wish of 120mm could not be accomplished due to the narrowing in the bottom. If the narrowing would be 10mm lower or smaller, the narrowing would become too low or too narrow.

The label does not need to be oriented around the bottle. Although the front/back side of the bottle is different than the left/right side due to the different orientation of the ribs, orientation of the label is not required. If there is a wish for orientation it is still possible to align the curved ribs in the bottom with the front of the label, although it requires more equipment on the line.

An example for a label design with the right height has been designed. The label wrapped around the bottle is shown in the renders in figure 4.7.

The whole label is shown in appendix 4.3. The label design can also be used on other concepts with a straight label.

Figure 4.6: Concept 1 with final dimensions

Figure 4.7: Concept 1 with label wrapped around

4.2.2 Concept 2 Iconic by shape – Non family

This bottle has an iconic shape but is not based on the family of other HDPE bottles. Due to the iconic shape the bottle is still only be suitable for branded products.
The final version of the bottle is shown in figure 4.8.

Dimensions

For this bottle also the dimensions were determined based on the required total volume of 1095cm3. Due to the round shape of the bottle the dimensions are close to or on the maximum value.

The dimensions for this bottle are:

Height:	244mm
Diameter:	82mm

The technical drawings with the full dimensions are shown in appendix 4.4.

Pallet pattern

To check if with the determined dimensions the transportation requirements are still achieved pallet patterns for the concept will be generated.

The sizes of the bottles with shrink sleeve around are shown below:

6-pack:	164*248*245mm
8-pack:	164*332*245mm

After calculating pallet patterns, the maximum number of bottles per pallet is:
Euro 6-pack = 690 bottles
Euro 8-pack = 680 bottles
Mini Euro 6-pack = 330 bottles
CHEP (industry) 6-pack = 840 bottles

The overhang per side on each pallet pattern is:
Euro 6-pack = -44mm * 20mm
Euro 8-pack = -40mm * 20mm
Mini Euro 6-pack = 20mm * -24mm
CHEP (industry) 6-pack = -48mm * -8mm

The full pallet patterns are shown in appendix 4.5.

Decoration

This concept will be decorated by a straight label wrapped around the bottle. The height of this label is slightly lower than determined in the requirements, namely 100mm. This decision is made based on the note in the requirements of the commercial department that the required 110mm label height is to differentiate from the private label bottle. This means that a slightly smaller label should not be a problem because the bottle is already iconic, and private labels will not be sold in this bottle.
The smaller label was needed to make some space for both the neck and the narrowing in the bottom so that both wouldn't be more compressed.

In figure 4.9 a comparison between the designs for a 110mm label and the 100mm label is shown. Here you can see the difference in compression of the narrowing in the bottom.

Also on this bottle the label does not have to be orientated around the bottle, with the same arguments used for concept one: Orientation is not required on this bottle, but it is still possible by adding orientation equipment to the line. This can be done if the wish for orientation with the curved ribs rises.

For the label around this bottle, the same label can be used as in concept one (only 10mm lower). An example of the decorated bottle is shown in figure 4.10.

Figure 4.9: Two versions of concept 2
Left: 110mm label - Right 100mm label

Figure 4.8: Concept 2 with final dimensions

Figure 4.10: Concept 2 with label wrapped around

4.2.3 Concept 3 – Iconic by decoration

This concept is an iconic bottle for branded products due to an iconic decoration. The bottle shape is made generic so that there are no iconic elements in the bottle design. For private label products a 'normal' label will be used while for the branded product a curved label will be used.
The final version of the bottle is shown in figure 4.11.

Dimensions

This concept is a round bottle where the dimensions were based on the required total volume of 1095cm3. Although the shape is round, the diameter of the bottle is not at the maximum value. This might be due to no narrowing in the bottle, and a relative small neck.

The dimensions for this bottle are:

Height:	244mm
Diameter:	80mm

The technical drawings with the full dimensions are shown in appendix 4.6.

Pallet pattern

To check if with the determined dimensions the transportation requirements are still achieved pallet patterns for the concept will be generated.

The sizes of the bottles with shrink sleeve around are shown below:

6-pack:	160*240*245mm
8-pack:	160*320*245mm

After calculating pallet patterns, the maximum number of bottles per pallet is:
Euro 6-pack = 750 bottles
Euro 8-pack = 680 bottles
Mini Euro 6-pack = 330 bottles
CHEP (industry) 6-pack = 900 bottles

The overhang per side on each pallet pattern is:
Euro 6-pack = omm * omm
Euro 8-pack = -80mm * omm
Mini Euro 6-pack = omm * -40mm
CHEP (industry) 6-pack = omm * -40mm

The full pallet patterns are shown in appendix 4.7.

Decoration branded

In this concept the decoration for the branded product consists of a shaped label and a sticker with the Campina logo. The label is shaped so that from the side of the bottle it looks like the label is going in a straight sloping line up and down, but from the front and the back it looks like a curve (see figure 4.12).

In the idea the sticker of the Campina logo was placed in the front of the bottle, there was decided to move the sticker to the back of the bottle. This is decided because on the front of the label already is a Campina logo placed, and none in the back. Also the sticker in front did not make the label more iconic than with the sticker placed on the back of the bottle. (see figure 4.12)

Orientation of label in respect to the bottle is not needed because the bottle is axi-symmetric. The only orientation that is needed is the sticker above the back of the label. A special orientation line may not be needed if it is possible to apply the sticker directly after applying the label (where all labels are still pointing in the same direction). But if this is not possible extra orientation equipment might be needed.

For the print of the label also an example design has been made. This example around the bottle is shown in figure 4.12 and the full label is shown in appendix 4.3.

Because the shape of the label makes the bottle iconic, it is important that the label has to show the contour of the label. In the example design given this is done by the green band on top of the label and the grass in the bottom of the label. By showing the contour the shape of the label is being made visible, which makes the bottle iconic by just its decoration.

Decoration private label

In this concept the private label product has a different label shape than the branded product. The private label product has a 'normal' straight label of 80mm high. To give an example of this bottle with a private label product a label design has been made which is shown on the bottle in figure 4.13. The full design of this label is shown in appendix 4.3.

To compare the both versions of the bottle, the bottles are shown together in figure4.14. In figure 4.15 the proposed labels are placed on the bottle of Boni Selection (round as is the concept) to give a comparison. Here you can see that by just the decoration the look of the two versions of the bottle is different. The branded product bottle is recognizable by the shape of the label while the private label bottle is just a regular milk bottle.

Figure 4.11: Concept 3 with final dimensions

Figure 4.12: Concept 4 with the branded label wrapped around

Figure 4.13: Private label version of concept 4

Figure 4.14: Both versions of concept 4 together

Figure 4.15: Mock-ups of both versions of the bottle

4.2.4 Concept 4 – Generic

This concept is a generic bottle that can be used for both branded and private label products. As determined in the requirements, the label height for branded and private label will be different to differentiate between the two, but both versions will have a generic look.
The final version of the bottle is shown in figure 4.16.

Dimensions

The shape of this bottle is square, and because there is no narrowing or whatsoever the dimensions of the bottle are lower than of the other concepts. This makes a small and compact bottle. The dimensions are also determined based on the required total volume of 1095cm3.

The dimensions of this bottle are:
Height: 233,4mm
Diameter: 75mm

The technical drawing with the full dimensions is shown in appendix 4.8.

Pallet pattern

To check if the determined dimensions still fit the transportation requirements. Therefore pallet patterns for the concept are generated.

The sizes of the bottles with shrink sleeve around are shown below:
6-pack: 150*225*234,4mm
8-pack: 150*300*234,4mm

After calculating pallet patterns, the maximum number of bottles per pallet is:
Euro 6-pack = 780 bottles
Euro 8-pack = 800 bottles
Mini Euro 6-pack = 390 bottles
CHEP (industry) 6-pack = 900 bottles

The overhang per side on each pallet pattern is:
Euro 6-pack = 0mm * -50mm
Euro 8-pack = -0mm * -50mm
Mini Euro 6-pack = -50mm * -40mm
CHEP (industry) 6-pack = 0mm * -100mm

The full pallet patterns are shown in appendix 4.9.

Decoration

For both branded as private label product the decoration on this bottle will be done by a straight label wrapped around the bottle. The only difference is that the label of the branded product will be larger (120mm) than the label for private label products (80mm). In figure 4.17 examples are given of both versions of the bottle.

Orientation of the label in respect to a specific side of the bottle is not needed, only the front of the label has to be placed on a straight side of the bottle (not in an edge). This kind of orientation also exists on the current bottle and doesn't require extra equipment. The bottle is being orientated by the transportation belts, where the bottles can only go straight and not twisted.

Figure 4.16: Concept 4 with final dimensions

Figure 4.17: Both versions of concept 4

4.3 Verification of requirements

To check if the concepts fit the determined requirements the concepts will be validated. All requirements are checked.

In table 4.1 the results of the verification are shown.
Because the requirements were strictly taken into account during the design, almost all requirements are fulfilled by all the concepts. Only one requirement does not fit for concept 2, and two requirements partly fit for concept 3.
An explanation is given per point that did not fit requirements.

Explanation

1. Concept 3 does not need adaptations to the production line. However it might be nessecary to add orientation equipment for applying the logo-sticker to the back of the bottle.
2. The label on concept 2 is smaller than required (100mm while 110mm is required). This should not be a problem because the label height of 110mm was required to differentiate between the private label product and the branded product. Because concept 2 is an iconic bottle and will only be used for branded products, the differentiation is not needed.
3. The label for branded products on concept 3 is curved, this results in a variable height across the label. The maximum label height is 140mm while the minimum label height is 80mm. Therefore it does not directly fit the requirement of 110mm but is distinctive enough compared to the label for private label products to differentiate.

Requirement:	1. Family	2. Non-family	3. Decoration	4. Generic
All concepts				
Maximum heigth				
Maximum diameter				
Maximum weigth				
Brimful volume				
Portola neck/cap				
Existing line			(1)	
Label height branded products		(2)	(3)	
Label height private label products				
1. Family				
Iconic elements from family				
2. Non-family				
Distinctive elements				
Look like milk bottle				
3. Decoration				
No distinctive shape				
Distinctive decoration				
Straigt label for private label product				
4. Generic				
No distinctive elements				
Secondary packaging with existing equipment				
Minimum number of bottles per pallet				
Maximum overhang not exceeded				

Legend:
Fits requirement
Partly fits requirement
Does not fit requirement

Table 4.1: Verification of the requirements per concept

All concepts next to each other

5.Conclusion and recommendations

Now that all four concepts have been developed, conclusions can be made. The deliverables are being answered and recommendations to FrieslandCampina are given.

5.1 Deliverables

During this project various conclusions have been made where all deliverables are answered:

1. Value for the amount of displacement for the new 1L HDPE bottle proposals (82,6mm and 84mm versions).
   The displacement on a pallet of the 1L HDPE bottle proposals with a diameter 82,6mm and 84mm will be around 1mm per bottle.

2. Standard for maximum overhang on a pallet for 1L HDPE bottles.
   The maximum overhang on a pallet can be 20mm in total (10mm per side). On a mini pallet with a 600mm long side the overhang on this side has a maximum of 10mm in total (5mm per side)

3. Optimized bottle design, based on demands from the commercial department and the right pallet pattern, to reduce overhang within the maximum value.
   Four concepts are given as an optimized bottle design. For all concepts the maximum dimensions were determined based on the maximum value of overhang and pallet sizes. The concepts give FrieslandCampina extra options for further development of the project

5.2 Best bottle diameter proposal (original family bottle)

In chapter 1.2 (Background and problem definition), three options were given for a new bottle diameter for the round family bottle after the transportation problems with the 86mm bottle occurred.

The three options are:

1. 82,6mm bottle with minimum extra transport costs and 39mm overhang on pallet.
2. 84mm bottle with 42k extra transport costs and 40mm overhang on pallet.
3. 82,6mm bottle with 42k extra transport costs and 26mm overhang on pallet.

There is concluded that the only suitable option in this case is option 3.
Option 1 and 2 did not fit the maximum value of overhang on a pallet, so for these options the bottle performances could not be guaranteed.
Option 3 did fit the maximum value of overhang on a pallet, so the bottle is suitable for further development.

5.3 Options and recommendations for further development

Alternative bottle designs have been made to give FrieslandCampina more options for further development of the project.

All options are suitable according to the requirements, but give a different result of the project. Because all options give a different result, the commercial department of FrieslandCampina has to decide which direction they will go with the project.

Figure 5.1: All options for further development

There can be chosen between the following options (also see figure 5.1):

- Iconic bottle with family shape:
  1) Go for 82,6mm round family bottle
  2) Go for square version as given in concept 1.

- Iconic bottle without family shape:
  3) Go for iconic bottle as given in concept 2, without a family look

- Iconic decoration:
  4) Go for iconic decoration as given in concept 3, same bottle will be used for private label

- Generic:
  5) Go for generic bottle where decoration also is generic as given in concept 4

If FrieslandCampina choses to go further with the initial alternative (option 1), not all costs savings will be achieved because the bottle can only be used for the branded products. Because two types of bottles have to be produced and filled on the same line, this might also lead to extra logistical costs (extra mould change-overs in the blowing department, reserving silos for specific bottles, etc.).

Therefore, the recommendation to the commercial department is to go for option 4 (figure 5.2). With this option all (material) cost savings will be achieved because the bottle is usable for both branded and private label products, while still having a distinctive appearance for the branded products. Using this distinctive appearance for a longer period of time, the bottle will become iconic by its decoration.

Further development

After choosing an option the design has to be developed further. This means that the design has to be validated by several FEM analysis and/or pilot productions with validations afterwards before the bottle is ready for implementation. This is all according to standard procedure at FrieslandCampina.

Figure 5.2: Concept 3; the recommended best option for further development

Flags outside the FrieslandCampina Innovation Centre

Glossary

Branded product:
Branded products are products sold under the brands of FrieslandCampina (A-brands). In case of this project, branded product refer to the milk sold under the brand of Campina.

Private label product:
Private label products are products not sold under the brands of FrieslandCampina, but under brands of an external party (B-brands). An example of a private label product is the milk of Milbona (a brand by supermarket Lidl).

Logoplaste:
Company from Portugal with expertise in designing bottles. Logoplaste has a packaging laboratory where they can perform real or virtual tests.

Silgan/Portola:
Company from England with expertise in designing closures. Silgan/Portola is the designer and supplier for the harmonized cap on the family of HDPE bottles.

Family of HDPE bottles:
The Family of HDPE bottles refers to the redesign FrieslandCampina made for the series of HDPE bottles produced on the plant in Aalter (B). (see figure 2.15)

82,6mm and 84mm bottle proposals:
The 82,6mm and 84mm bottle proposals refers to the proposals made by FrieslandCampina to solve the problem of the transportation costs at the new 1L design. (see figure 1.4)

Overhang:
Overhang is anything protruding the edge of a pallet. The amount of overhang is the distance the load protrudes the pallet edge.

Displacement
In this report, displacement refers to the horizontal compression of bottles on a pallet under influence of shrink or stretch foil around the bottles/pallet.

Theoretical overhang:
Theoretical overhang is the amount of overhang calculated at the pallet patterns. The pallet patterns are determined based on the bottle dimensions, but without displacement taken into account.

Practical overhang:
Practical overhang is the amount of overhang what will occur in practice, with displacement included.

Brimful volume:
The brimful volume of a bottle is the total amount of volume inside the bottle (the volume up until the opening).

References

Chapter 2.2.1

- YRC Freights, 'A shipper's guide tot packaging', website: http://my.yrc.com/national/pdf/shippersGuide.pdf (17-02-2015)
- UPS, website: http://my.yrc.com/national/pdf/shippersGuide.pdf (17-02-2015)
- Martin H. DiSalvo (1999), 'Interactive effects of palletizing factors on fiberboard packaging strength', Master's Theses at San Jose State University
- Prof. dr. ir. R. ten Klooster (2008), 'Zakboek Verpakkingen'

Chapter 2.7.1

- Figure 2.21: http://designtekplastics.com/wp-content/uploads/2014/01/Extrusion-Blow-Molding-process.jpg (04-06-2015)

Chapter 2.8

- US News, website: http://www.usnews.com/news/articles/2015/01/13/coke-and-pepsi-shrink-their-can-sizes (04-06-2015)
- Coca Cola Company, website: http://www.coca-cola.co.uk/125/coca-cola-bottles-history.html (04-06-2015)
- Packworld, website: http://www.packworld.com/package-design/structural/can-your-brand-pass-silhouette-test (04-06-2015)
- Designcue, website: http://www.designcue.com/case/jack-daniels/ (04-06-2015)
- Figure 2.25: http://www.coca-cola.co.uk/125/coca-cola-bottles-history.html (04-06-2015)
- Figure 2.28: https://xkcd.com/993/ (04-06-2015)

Figure 2.26:

- http://www.prosportstickers.com/product_images/m/absolut_vodka_bottle__34872.jpg (04-06-2015)
- http://imgbuddy.com/coca-cola-bottle-png.asp (04-06-2015)
- http://www.sweety4all.nl/images/pic11.png (04-06-2015)
- http://www.biernet.nl/images/soort/12006-Grolsch.jpg (04-06-2015)
- http://www.tekstblog.nl/wp-content/uploads/2011/08/Danoontje_Powerrr.jpg (04-06-2015)
- http://www.danoontje.nl/images/assortiment/assortiment-full-xtra-.png (04-06-2015)

Figure 2.27

- http://ashevillemunchies.com/wp-content/uploads/2014/01/Marlboro-72s1.jpg (04-06-2015)
- http://www.mommysavers.com/wp-content/uploads/2011/02/tomato.jpg (04-06-2015)
- http://www.wanttoknow.nl/wp-content/uploads/hak-conserven.jpg (04-06-2015)
- http://www.marketingonline.nl/sites/default/wget/Chocomel.Regular.Blik.250ml.02mol.jpg (04-06-2015)
- http://caloriesproper.com/wp-content/uploads/2012/06/can-of-Coca-Cola.jpg (04-06-2015)
- http://images.amazon.com/images/G/01/electronics/apple/apple-11q3-macminiserver-box-lg.jpg (04-06-2015)