Scanfill sheet as alternative material in the thermoforming industry in the Philippines

An exploratory study

Zyra Mae Oliman

MASTER´S THESIS

Packaging Logistics
Lund University

This Master's thesis has been done within the Erasmus Mundus Master Course FIPDes, Food Innovation and Product Design.

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Abstract

Title (in English):	Scanfill sheet as alternative material in the thermoforming industry in the Philippines: An exploratory study
Title (in Swedish):	Scanfillark som alternativt material i termoformningsindustrin i Filippinerna – en explorativ studie
Author:	Zyra Mae Oliman
Division:	Packaging Logistics, Department of Design Sciences, Faculty of Engineering, Lund University
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Issue of study:	Rigid plastic packaging, the end-product of thermoforming, has become ubiquitous as it offers convenience and ease of transport in today's society. However, ambivalence to its use remain. On one hand, its durability has become an advantage in terms of wide range of applications, while a disadvantage in terms of utilization as it reaches end-of-life. Companies and research agencies alike continue to focus their efforts on potential alternative materials to help minimize the impact of this packaging category.
Purpose:	The overall purpose of the study is to identify and describe the factors that could influence the adoption of an alternative raw material for thermoformed products used as food packaging in the Philippines.
Method:	A mixed method approach combining case study and action research was used in this study. A case study that was explorative in nature focused on the contemporary phenomenon within the context of the Philippine manufacturing industry for rigid plastic packaging. A logic model was used to describe the inputs, activities, outputs, short-term-outcomes, intermediate-term outcomes and long-term outcomes of the study. An action research strategy was also applied to gather and analyze quantitative data that relates to the technical aspect within the thermoforming industry.
Conclusions:	The quality and performance of Scanfill sheet were evaluated in relation to the standards and capabilities of the Philippine thermoforming industry. The Scanfill sheet dimensions were measured and the texture requirements were found to be at par with the standards.

The different steps in manufacturing thermoformed products were outlined and described. Similarities and differences in quality and performance of machine parameters and cups were investigated, using the control/reference group (existing PP clear sheet) and the test group (Scanfill white sheet).

The thermoforming machine's parameter setting showed that using Scanfill sheet required a lower temperature for the heating plates as compared with existing PP clear sheet. This could translate to lower electricity consumption and thus energy savings. However, the machine did not exhibit any difference in cycle time as compared when the PP clear sheet is ran, and both were at 13 cycles or shots per minute.

The cup attributes were measured and compared against the existing product standards. The cups produced using Scanfill sheet were acceptable in terms of aesthetic value with regards to gloss and matte texture. Cup attributes such as wall thickness and rigidity were at par with the standards. Rigidity of the cups was also found to be higher than the existing PP clear, which indicates a better and stiffer cup. The material used also complies with regulatory requirements for food safety. However, other cup attributes such as smooth rim, weight, height, top outside diameter and bottom outside diameter were not within set specifications. One of the factors might have contributed to this result such as non-optimal machine parameter setting. Also, since the thermoforming mold was originally intended for PP clear, the cutting plate of the tooling may not be sharp enough to cut the rim smoothly.

In conclusion, this study has proven the suitability and feasibility of the use of Scanfill sheet in the thermoforming industry in the Philippines. However, other issues such as desirability of the cups as well as viability can be improved and further studied.

Key words: thermoforming, rigid food packaging, polypropylene, calcium carbonate, Philippines

Executive Summary

Introduction

Rigid plastic packaging, the end-product of thermoforming, has become ubiquitous as it offers convenience and ease of transport in today's society. However, ambivalence to its use remain. On one hand, it offers a wide range of functions like food packaging applications while on the other, its durability has raised concerns about their end-of-life disposal (Philp, et.al., 2012). Companies and research agencies alike continue to intensify their efforts to formulate solutions to help minimize the impact of this packaging category.

Objectives

The overall purpose of the study is to identify and describe the factors that could influence the adoption of an alternative raw material for thermoformed products used as food packaging in the Philippines

The following objectives were formulated to meet the overall purpose within the context of Philippine thermoforming industry, which are:

- Outline the different steps in manufacturing thermoformed products
- Investigate similarities and differences in quality and performance of cups using Scanfill material in comparison with current polypropylene (PP) material.
- Formulate recommendations for future studies.

Methodology

A mixed method approach combining case study and action research was used in this study. A case study that was explorative in nature focused on the contemporary phenomenon within the context of the Philippine manufacturing industry for rigid plastic packaging. A logic model was used to describe the inputs, activities, outputs, short-term-outcomes, intermediate-term outcomes and long-term outcomes of the study. An action research strategy was also applied to gather and analyze quantitative data that relates to the technical aspect within the thermoforming industry.

Results

Logic Model Findings

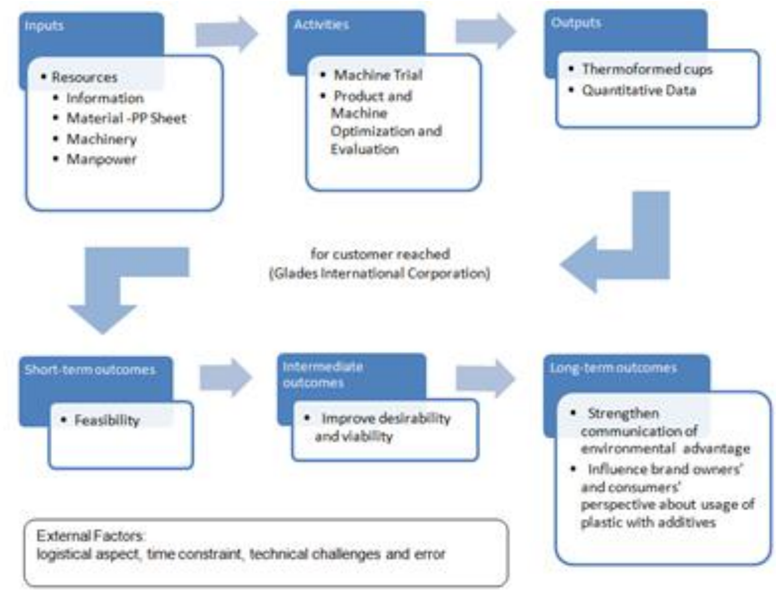

Figure 1. Elements of the study based on logic model

The elements of the study were embedded within the logic model. The *inputs* included the resources provided by the collaborating companies: Scanfill AB provided the information about their raw materials, the innovation potential of their products and technologies, its applications in food packaging and technical expertise since the beginning of the study. Scanfill AB also facilitated the connection to its sister company, Polykemi Compounds (Kunshan) Co. Ltd. The Polykemi Group's subsidiary in China made it possible to produce the Scanfill sheets in a more proximate location and also handle the logistical aspect of trasporting the sheets via sea freight to the Philippines. On the other end, Glades International Corporation provided the warehousing facility to receive the sheets, the thermoforming machine and mold for the trial as well as the manpower assistance to carry out the trial (QA and Process Technician). The management of the company also gave support by arranging with the planning department about the proposed schedule of the trial. The laboratory facilities and instruments were also utilized to gather quantitative data after the cup samples were collected. Suggestions and recommendations by the personnel who the researcher worked with during the trials were also noted.

The *activities* included the thermoforming machine trial, as well as product and machine evaluation and optimization within the manufacturing industry. Additionally, it is important to mention the planning and coordination phase that was done by the researcher with the contact persons in the collaborating companies.

The *outputs* included the thermoforming cups and the quantitative data gathered. The data from the cups were compared and analyzed to that of the existing standards.

The *short-term outcome* showed the feasibility of using Scanfill sheet. It is possible to use the new material using the existing technology and machineries in the thermoforming company, although modifications in the machine and mold (i.e. optimizing parameter settings and sharpening the cutting plate) might be necessary.

The *intermediate outcomes*, on the other hand, showed that there are still measures or modifications that need to be done in order to improve the desirability and viability of the material being studied. The desirability can be improved by improving the quality of the cups (i.e. producing a smooth rim and weight requirements). The viability, on the other hand, deals with the business and financial aspect of the product, so it can be mutually beneficial to all the companies concerned. The pricing, demand and added value of the material should be further discussed. To study whether capital expenditure is worth allocating for the thermoforming company (i.e. predryer) can be considered. In the comparison of industry processes of the collaborating companies, it was mentioned that both are capable of extrusion operation. In the future, the supplier could explore the possibility of formulating a Scanfill granulate that would not require pre-drying so it can also be used in the extrusion operation as well.

The *long-term outcomes* could include the need for strengthening of the communication of environmental advantages especially to manufacturing industries, brand owners and consumers. This, in turn, could influence brand owners and consumers to prefer the use of plastics with non-oil based additives. Although the Philippines is relatively undeveloped in the area of sustainability and recent events have driven legislative changes in the use of rigid plastic packaging even up to imposing its ban in the cities in the surrounding the capital, opportunities for innovative packaging solutions can still prevail. This can also be seen as an opportunity to educate and promote alternative packaging materials.

The *external factors* such as logistical aspect, time constraint and technical challenges had to be managed in order to carry out the study successfully. The logistical aspect included the shipment of the materials from one country to another, so the knowledge and coordination of import and export personnel from both sides were essential. The time constraint was also part of the challenge of the study. A total of 5 hours was the time period allocated for the trial. The reason for this is that machines and molds for the sole purpose of pilot studies are not available, only commercial-scale were. The same equipment are also used produce packaging products for customers who are expecting timely deliveries, so extension was not possible. Lastly, during the machine trial, challenges were faced such as having to start on a trial and error basis to configure the machine parameter settings, which eventually was solved within the given time frame. The researcher also regrettably committed an error by referring to the the wrong standard for the weight of cups during the trials, therefore instructing the process technician to adjust parameter settings based on the assumed target weight.

Material Specifications, Machine Parameters and Cup Attributes

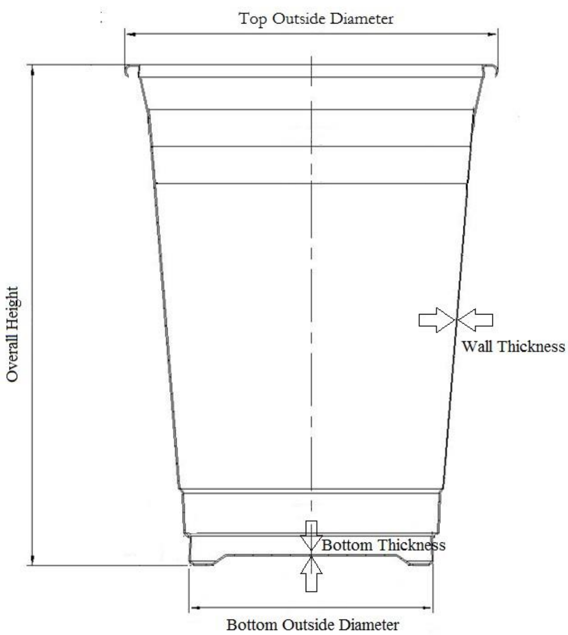

Figure 2. 16 oz cup product drawing and attributes

The quality of the Scanfill sheet was verified by checking the specifications. The sheet was opaque white and had glossy or matte texture on either side. The sheet had a thickness and width profile of 1.10 mm x 580 mm. The measurements showed that the sheet was within ± 5% tolerance, which was between 1.045 mm to 1.155 mm range.

The machine parameters were recorded to compare if there was significant difference between the cups that used clear PP sheet (existing, reference group) and Scanfill sheet (white PP with calcium carbonate). Thermoforming machine heater temperatures and cycle time were tabulated. The results showed lower machine heater temperatures were required to process Scanfill sheet as compared to the existing clear PP sheet in the thermoforming company. An average difference of 36.88 °C for the upper heaters and 21.88 °C for the bottom heaters were observed. This could be an indication of lower

electricity consumption and thus energy savings. On the other hand, there was no difference observed in the cycle time for the both clear PP sheet and white Scanfill sheet which was at 13 shots per minute.
Lastly, the attributes of the cups that used Scanfill sheet material were measured and analyzed. The resulting cups were opaque white, glossy on the outside and matte (almost paper-like) texture on the inside. There was one notable quality issue that was observed in the cups, which was the rough rim. The rough rim was caused by the dull cutting of the thermoforming mold during processing. The mold is currently allocated for PP clear, and the added stiffness of the Scanfill sheet made it somewhat difficult for the mold to compensate and achieve smooth rim for the cups.
The results showed that all the cups were above the weight range of 9.7 ± 0.3 g. Unfortunately, there was a major source of error identified by the author only after the trial. The researcher referred to the product specifications of one of the products which had the same sheet and product profile except for the weight, as a consequence the process technician modified the machine parameters to meet the assumed weight.

The overall height for all cups were below the minimum tolerance of 130.70 mm. The wall thickness was within the acceptable range of 0.20 mm to 0.30 mm. The top outside diameter for all cups were above the maximum tolerance of 93.80 mm. This is due to the excess plastic material caused by the rough rim. The bottom outside diameter for all cavities was above the maximum tolerance of 59.00 mm. Finally, the bottom thickness of cups from cavities 2 and 3 were within the acceptable limits of 0.25 mm to 0.35 mm while cups from cavities 3, 4 and 5 were above the maximum limit of 0.35 mm. The rigidity of all the cups were also measured and was higher than the existing PP cups, which means a stiffer product. The suitability for food contact was also verified as Scanfill sheet, along with other material grades from Scanfill AB, is approved for direct contact with food (Scanfill, 2014). The material complies with EU Regulations 1935/2004, 2023/26 and 10/2011, as evidenced by their Certificate of Compliance (CoC) for food contact materials. Material Safety Data Sheet (MSDS) and Technical Data Sheets (TDS) are also provided.

Conclusion

The quality and performance of Scanfill sheet were evaluated in relation to the standards and capabilities of the Philippine thermoforming industry. The sheet dimensions were measured and the texture requirements were found to be at par with the standards.

The different steps in manufacturing thermoformed products were outlined and described. Similarities and differences in quality and performance of machine parameters and cups were investigated, using the control/reference group (existing PP clear sheet) and the test group (Scanfill white sheet).

The thermoforming machine's parameter setting showed that using Scanfill sheet required a lower temperature for the heating plates as compared with existing PP clear sheet. This could translate to lower electricity consumption and thus energy savings. However, the machine did not exhibit any difference in cycle time as compared when the PP clear sheet is ran, and both were at around 13 cycles or shots per minute.

The cups produced using Scanfill sheet were acceptable in terms of aesthetic value with regards to gloss and matte texture. Cup attributes such as wall thickness and rigidity were at par with the standards. Rigidity of the cups was also found to be higher than the existing PP clear, which indicates a better and stiffer cup. The material used also complies with regulatory requirements for food safety. However, other cup attributes such as smooth rim, weight, height, top outside diameter and bottom outside diameter were not within set specifications. One of the factors might have contributed to this result such as non-optimal machine parameter setting. Also, since the thermoforming mold was originally intended for PP clear, the cutting plate of the tooling may not be sharp enough to cut the rim smoothly.

In conclusion, this study has proven the suitability and feasibility of the use of Scanfill sheet in the thermoforming industry in the Philippines. However, other issues such as desirability of the cups as well as viability can be improved and further studied.

As for suggestions for further study, it can be an objective and future work to optimize the thermoforming machine performance specifically in terms of cycle time. A machine run time that would be longer than what was carried out in this study (i.e. > 5 hours) can be considered. The quantification of the environmental impact of Scanfill sheet (i.e. savings in electricity, fresh water use) in the Philippine setting can serve as a better communication tool to convey the advantages of the material. Another interesting topic in the future could be an in-depth study of consumer behavior and acceptance of the cups produced using Scanfill sheet and compare them with existing rigid food packaging in the market.

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I want to say thank you to Glades International Corporation for the support and trust as I carried out the machine trials in the manufacturing plant. It was such a delight to work with a team who extends assistance in every area imaginable. *Maraming salamat po!*

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I want to express my gratitude to my family (Papa, Mama, Mark, Vincent, Claire and Shaine), friends and former colleagues for all the support and encouragement throughout my master's studies. Thank you for reminding me to do my best in every circumstance and to put in mind that I have what it takes to overcome challenges.

Last and certainly not the least, I want to thank God for giving me life, strength, grace, knowledge and wisdom throughout this journey. Thank You for sustaining me with Your faithfulness and love. All honor and praise belongs to You!

Zyra Mae Oliman

Lund, July 2014

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I. Introduction

1.1 Background

Thermoforming is a generic term encompassing many techniques for producing useful plastic articles from flat sheet. In one of its more advanced forms, it involves automatic high-speed indexing of a freshly extruded sheet having very accurately known temperature into a forming and trimming station. This study focuses on ”thin gauge thermoforming”, a process category that is primarily used to manufacture rigid plastic packaging such as disposable drinking cups, food containers, lids, trays, blister packs, clamshell packaging and other products for food and general retail industries. A thermoplastic sheet is usually considered to be thin gauge when its thickness is less than 60 mils, 0.0060 in, 1500 µm or 1.50 mm (Throne, 1996).

In this process, thermoplastics are used as raw materials since these are types of polymers that become pliable or moldable above specific temperature and returns to a solid state upon cooling (Throne, 1996). Some of the thermoplastics used for food packaging are polypropylene (PP), polystyrene (PS), polyethylene (PE) and polyethylene terephthalate (PET).

Rigid plastic packaging, the end-product of thermoforming, has become ubiquitous as it offers convenience and ease of transport in today’s society. However, ambivalence to their use remain. On one hand, it offers a wide range of functions like food packaging applications while on the other, its durability has raised concerns about their end-of-life disposal (Philp, et.al., 2012). Companies and research agencies alike continue to intensify their efforts to formulate solutions to help minimize the impact of this packaging category.

Sweden is known to be one of the top ten countries in the area of innovation (Bloomberg, 2014; INSEAD, 2014). As far as the author is aware, the application of innovative solutions from Sweden to the Philippines in rigid plastic packaging is not well documented, thus this study aims to initiate in bridging the gap and contribute both to industrial and academic advancement of knowledge in this area.

1.2 Research Purpose

The overall purpose of the study is to identify and describe the factors that could influence the adoption of an alternative raw material for thermoformed products used as food packaging in the Philippines

The following objectives were formulated to meet the overall purpose within the context of Philippine thermoforming industry, which are:

- Outline the different steps in manufacturing thermoformed products
- Investigate similarities and differences in quality and performance of cups using Scanfill material in comparison with current polypropylene (PP) material.
- Formulate recommendations for future studies.

1.3 Research Focus and Limitations

This study is focused on the limited knowledge on the innovation potential of packaging technologies from Sweden and its diffusion to Southeast Asia, specifically to the Philippines. The theoretical and case focus of the study starts with the raw material supplier, the transport of the material and the events in the manufacturing industry during and after the thermoforming trials.

A limitation of this study is that the author has scarce knowledge in mechanical engineering or polymer science, as such, the descriptions in the literature review for the different concepts involved in plastic manufacturing are discussed briefly.

The exploratory nature of this study is not meant to encompass all thermoforming companies in the Philippines, due to factors such as equipment specifications, capacity and capabilities as well as manpower competencies.

Furthermore, confidential information such as detailed product formulations and compounding process undergone by the raw material will not be disclosed, due to the Intellectual Property Rights (IPR) of Scanfill Group. Material costing will also not be disclosed in this report.

1.4 Outline of Thesis

Chapter 1: Introduction

This chapter serves a springboard for the reader to understand the thesis. The chapter gives a brief definition of keywords, the research purpose and demarcations.

Chapter 2: Case Description

This chapter presents the context of the study. The company profiles and capabilities of collaborating companies as well as the comparison of their industrial processes are elaborated.

Chapter 3: Theoretical Framework

This chapter presents a synopsis of relevant theories to the thesis. Discussions about the general functions of food packaging, which then focuses to the use of plastics as packaging is given. The theories involved in rigid plastic manufacturing as well as current trends are also discussed.

Chapter 4: Methodology

This chapter presents the researcher's background and approach of the study. The reseach strategies applied are also elaborated. The methodology was developed to meet the overall aim and objectives of this study.

Chapter 5: Results and Discussion

The findings of the research is discussed then analyzed in relation to the overall research aim and objectives. The quantitative results were presented followed by the discussion using the logic model.

Chapter 6: Conclusions and Suggestions for Further Research

This last chapter presents the conclusions of the study and recommendations for future research.

II. Case Description

II.1 The Philippines: overview and packaging industry trends

The Philippines is an archipelago of 7,107 islands located on the western rim of the Pacific Ocean (Figure 1). The country lies approximately 800 km off the coast of Indo-China, north-east of Malaysia and north of Indonesia. The group of islands is approximately 900 km in length from north to south, with Manila as its capital city (Euromonitor International, 2014).

Figure 1 Map of the Philippines

The population of the country reached 98.4 million in 2013 and ranks 12th in the world's most populous countries. The Philippines has a relatively younger population compared to its neighboring Asian countries with the median age of 22.9 years. (Euromonitor International, 2014). The country is classified as a developing country with a Gross National Income (GNI) of 2,500 USD such that the 25.2% of the total population live below the poverty line (World Bank, 2014). On the other hand, 37.9 million Filipinos are currently part of the labor force (Philippine Statistics Authority, 2013) of which a projected 2.9 million individuals are expected to boost consumer spending by 2020, contributing to 50% of the country's discretionary expenditure – that is, spending on categories other than basic needs (Euromonitor International, 2014). Expenditure other than basic needs could include purchases in quick-service restaurants for dine in or take away. With this expected upward trend in demand for fast food, packaging industry's priorities would be placed on economy, ease of use and convenience due to busier lifestyles as dual income households and single-person household also continue to increase (Euromonitor International, 2014).

II.2 The Supplier: Scanfill AB and Polykemi Compounds (Kunshan) Co. Ltd.

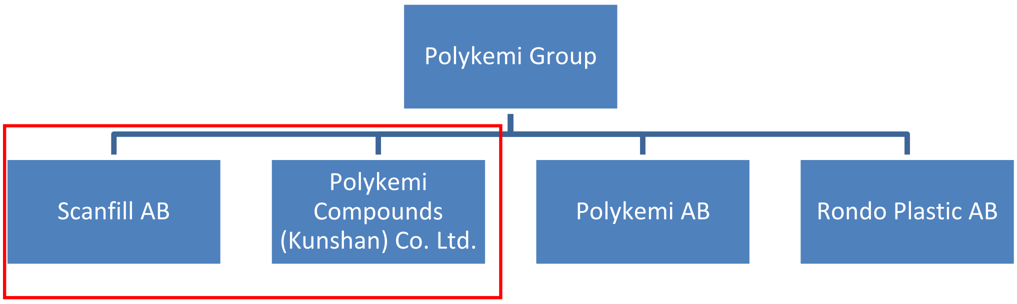


Figure 2 Organizational structure of Polykemi Group

The Polykemi Group is an entity whose core business revolves around the production of custom-designed plastic compounds. The group consists of Scanfill AB, Polykemi Compounds (Kunshan) Co. Ltd., Polykemi AB and Rondo Plastic AB (illustrated in Figure 2). Scandinavia serves as their main market but the group is also active worldwide, covering most European countries, as well as China, U.S. and Australia. (Polykemi, 2014). For the interest of this study, the focus will be given to the two collaborating subsidiary companies, Scanfill AB and Polykemi Compounds (Kunshan) Co. Ltd.

Scanfill AB is a wholly owned-subsidiary of Polykemi Group with the business concept of offering efficient and eco-friendly packaging solutions. Scanfill AB is located in Ystad, Sweden and was founded in 2008. It fully focuses on one of Polykemi Group's newest and most promising business segments. The unique Scanfill material, which consists of 50% abundant raw material calcium carbonate, is mainly intended for refinement in the traditional extrusion blow molding, thermoforming and injection molding processes (Polykemi, 2014).

Figure 3 Two of the products of Scanfill AB - Scanfill foil and Scanfill sheet (Scanfill, 2014)

Polykemi Compounds (Kunshan) Co. Ltd. is located in Kunshan, outside of Shanghai and was founded in 2005. The company's production process is known in the industry as compounding, which means the mixing of different plastic materials, additives and reinforcements. Using extruders, the raw material is melted and while in that state a number of different raw materials are accurately distributed and mixed in to achieve an end-product that is quality-specific, dust-free and homogenous plastic granulate (Polykemi, 2014). In 2014, additional machineries were installed in the facility which made it possible for the Scanfill material to be produced in that side of the world (JB, 2014).

II.4 The Converter: Glades International Corporation

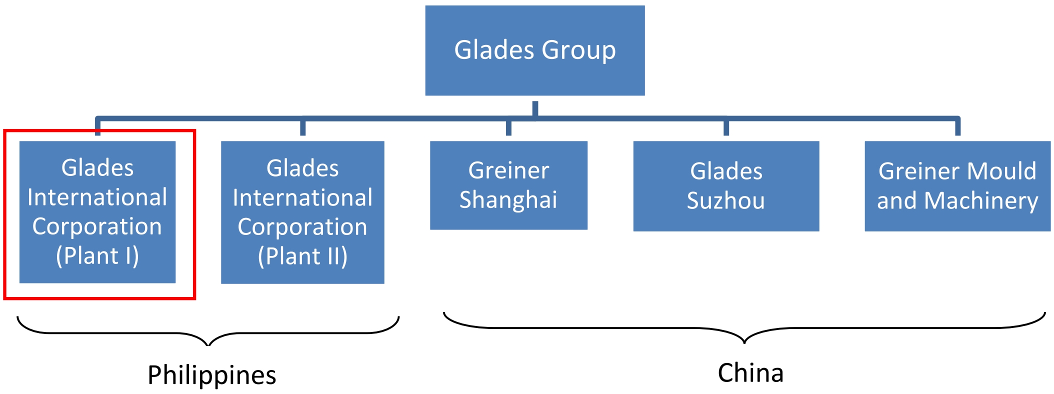


Figure 4 Organizational structure of Glades Group

Glades Group, on the other hand, has its core business revolving around supplying packaging materials made from plastic or paper, as well as in-house manufacturing of its molds and machineries. The group of companies consists of Glades International

Corporation (Plant I), Glades International Corporation (Plant II), Greiner Shanghai, Glades Suzhou and Greiner Mold and Machinery (illustrated in Figure 4). Focus will be given to Glades International Corporation (Plant I) as it is the collaborating company in this study.

Glades International Corporation (GIC) supplies thermoformed plastic cups, lids trays and bowls in the Philippines. The company was established on 1996 in Laguna, Philippines and is a family-owned business. It employs around 530 personnel, supplying top Quick Service Restaurants (QSRs) in the country as well as food packaging companies in southeast Asia (GIC, 2014).

Figure 5 Product range Glades International Corporation's (GIC, 2014)

Glades International Corporation's vision is "to be the preferred supplier of rigid plastic packaging solutions in the Asia Pacific Region". Its products include printed cups (made of PP, PS, PET), colored ice cream tubs and lids with labels (made of PS) and yogurt cups with shrink labels (PS). Additionally, it also manufactures injection molded products like cutleries and Tamper-Evident Plastic Cap (TEPC, made of LLDPE) for infant milk formula. Its current customers and business partners include some of the well-known international brands such as McDonald's, Starbucks, Nestle, Unilever, KFC and Del Monte, as well as Philippine companies such as San Miguel Corporation, Jollibee Foods Corporation and Goldilocks Bakeshop (GIC, 2014).

II.5 Industry Processes: An Overview

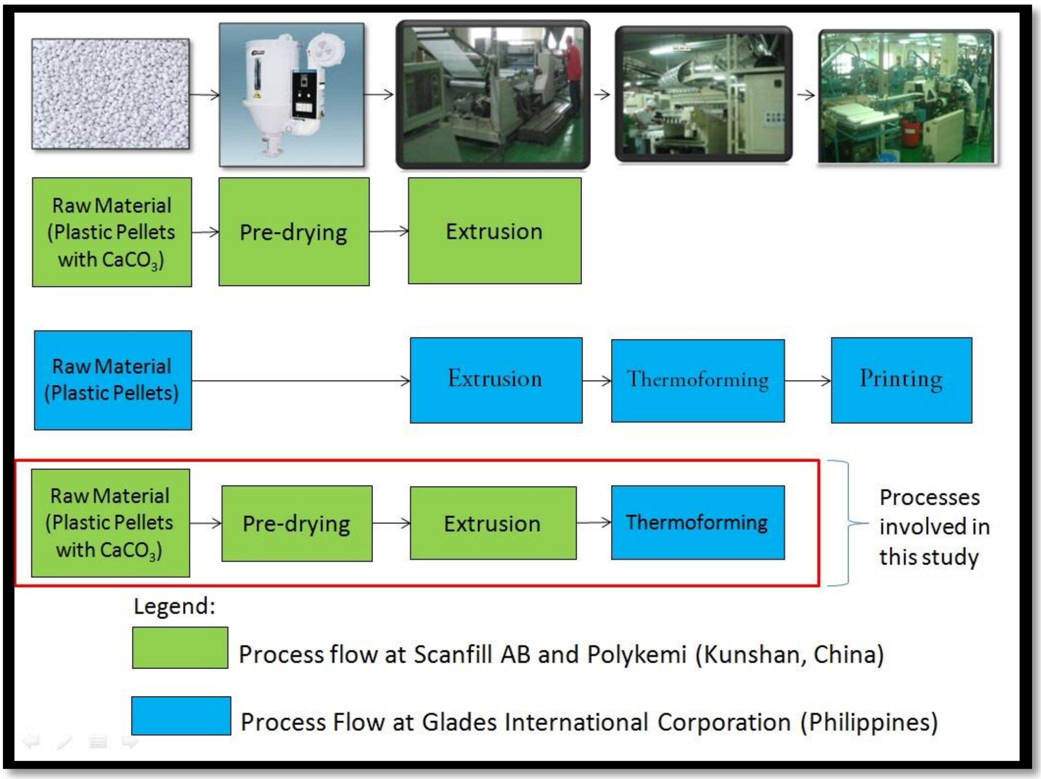


Figure 6 Comparison of industry processes of collaborating companies

To come up with the final thermoformed product, the process begins with the raw material in the form of plastic pellets or granules. The polymer resin in the form of pellets or granules is converted into a sheet in a process called extrusion. The resulting sheet is wound around a thick cardboard spool to produce plastic rolls. The plastic rolls are then loaded to the take-off station of the thermoforming machine where a combination of heat, pressure and mechanical force transforms the sheet into disposable cups. A more elaborate description of each process, particularly that of extrusion and thermoforming, can be read in the proceeding sections (III.2).

As illustrated in Figure 6 (above), Scanfill AB, Polykemi Compounds (Kunshan) Co. Ltd. and Glades International Corporation are both capable of carrying out extrusion process in their facilities. However, due to the specific requirement of the Scanfill material, a pre-drying step is necessary due to its hygroscopic nature (JB & ML, 2014). The pre-dryer machine is available both in Scanfill AB and Polykemi Compounds (Kunshan) Co. Ltd., but not in Glades International Corporation. For this reason, the Scanfill sheet was produced in Polykemi Compounds (Kunshan) Co. Ltd. in China, and then delivered via sea freight to Glades International Corporation in the Philippines for conversion to disposable cups (Figure 7).

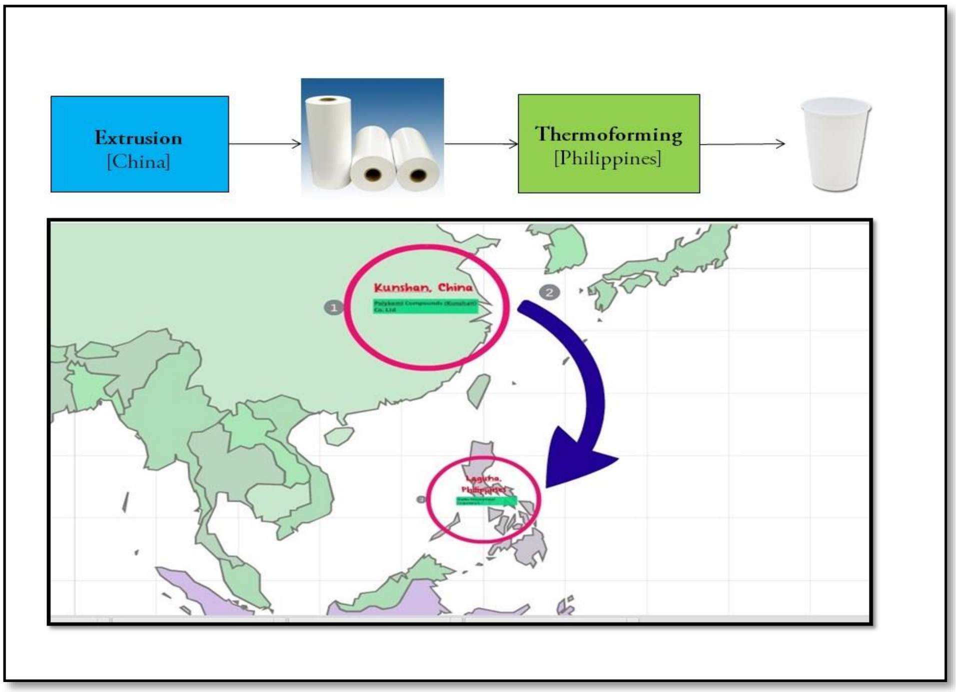


Figure 7 Logistics aspect of Scanfill material

The Scanfill sheet was manufactured via coextrusion. The sheet has three layers, having a PP-Scanfill-PP configuration. The sheet was delivered to Glades International Corporation with a total weight of 528 kilograms, divided into three rolls. The specification of the sheet was verified upon arrival. A thermoforming machine was allocated for the trial which took 5 hours from start-up to stabilization. Once the machine was stabilized, statistically acceptable number of samples were collected and quality attributes were measured. The cups produced during start-up, which were not of acceptable quality, were segregated.

As mentioned in the limitations of the study, the costing of Scanfill sheet and other grades of raw material that Scanfill AB and Polykemi Compounds (Kunshan) Co. Ltd. are capable of producing will not be disclosed. Such detailed discussions must occur between the collaborating companies involved. However, it will suffice to state that the whole study was made possible by taking into account the cost of the material, along with the advantages that Scanfill sheet has assured to deliver (i.e. reduced energy consumption, high heat conduction capacity, increased stiffness, reduced thickness with same weight, etc) (Scanfill, 2014). The cost-efficiency and price stability of Scanfill sheet having 50% non-oil based raw material has made this exploratory study worth pursuing.

III. Theoretical Framework

III.1 Food Packaging: Definitions and Functions

Food packaging in today's society is ubiquitous and essential (Robertson, 2013).It serves to protect, contain, preserve and communicate the product (Paine, 1981). Packaging has also been defined by Lockhart (1997) as cited by Robertson (2013) as "a socio-scientific discipline that operates in society to ensure the delivery of goods to the ultimate consumer of those goods in the best condition intended for their use." Other definitions of packaging are also available depending on the which socio-scientific discipline is emphasized, whether it be marketing, consumer behavior, design, logistics or food engineering.

In general, the functions of packaging for food have been discussed by Yam, et. al., (1992), Marsh (2001), Robertson (2006), as cited by Krochta (2007). The four basic functions of packaging are: Containment, Protection, Communication and Convenience.

1.) Containment involves the ability of the packaging to maintain its integrity during the handling involved in filling, sealing, processing, transportation, marketing and dispensing of the food.

2.) Protection includes the prevention of biological contamination (from microorganisms, insects, rodents), oxidation (of lipids, flavors, colors, vitamins, etc.), moisture change, aroma loss or gain, and physical damage. Protection can also include providing tamper evident features on the package (Rosette, 1997).

3.) Communication involves the conveying of information which are carried on the package, which meets both legal requirements and marketing objectives. Some examples include package graphics that are intended to communicate product quality and thus, sell the product, as well as recycling code in plastic containers for identification of plastic material.

4.) Convenience, which can also be referred to as utility of use or functionality, is provided to the consumers due to packaging characteristics such as range of sizes, easy handling, easy opening and dispensing, reclosability and food preparation.

Other functions of packaging include production efficiency, minimal environmental impact and package safety (Krochta, 2007).

III.1.1 Plastics used as Packaging

The word *plastic*, used as an adjective, was derived from the Greek word *plastikos* meaning easily shaped or deformed. From a more technical viewpoint, *plastics* are generic term for synthetic material made from a wide range of organic polymers. (Robertson, 2006). Plastics are obtained from petroleum as a result of complex processes such distillation, polymerization and polycondensation (Brydson, 1999). According to Robertson (2013), annual consumption of plastics is about 250 million tonnes, which requires 8% of world oil production; and roughly 30% of these plastics are used for packaging. With modern society higly dependent on plastics, continued research and development promises new combinations of established plastic materials in order to perform specific functions in more efficient and cost-effective ways. (Robertson, 2013).

Once plastics are transformed into packaging, the European Packaging and Packaging Waste Directive 94/62, Article 8 entitled ‘Marking and Identification’ states that “packaging shall bear appropriate marking either on the packaging itself or the label.” (APME, 2004). Today, the use of these identification codes are widely accepted and implemented among manufacturing industries including the Philippines (RG, 2014). For this study, the focus is directed towards polypropylene, (symbolized below as “05” inside a “recycling” logo) and the additive used by Scanfill AB which is calcium carbonate.

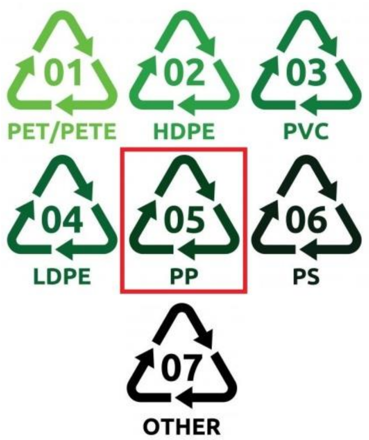


Figure 8 Plastic Packaging Identification Codes

III.1.2 Polypropylene (PP): Structure and Properties

Polypropylene is one of the many types of thermoplastic that was discovered to be of high value during the mid-1950s (Brydson, 1999). As described by Coles & Kirwan (2011), PP is an addition polymer of propylene formed under heat and pressure using Ziegler-Natta type catalysts to produce a linear polymer with protruding methyl (CH_2) groups. The resultant polymer is a harder and denser resin than PE and more transparent in its natural form. PP has the lowest density and the highest melting point of all the high volume usage of thermoplastics and has a relatively low cost. The versatile plastic can be processed in many ways and has many food packaging applications in both flexible film and rigid form. (Coles & Kirwan, 2011)

The high melting point of PP (160°C) makes it suitable for applications where thermal resistance is needed, for example in hot filling and microwave packaging. PP is chemically inert and resistant to most commonly found chemicals, both organic and inorganic. It is a barrier to water vapor and has oil and fat resistance. Aromatic and aliphatic hydrocarbons are, however, able to be dissolved in films and cause swelling and distortion. PP is not subject to environmental stress cracking (ESC). (ESC is a a surface phenomenon whereby cracks can appear in molded plastic as a result of contact with materials that affect the surface structure in critical parts of the design. This can lead to cracking without actually degrading the surface. There are specific tests to check for ESC, and shelf life tests with the actual product to be packed should also be carried out) (Coles & Kirwan, 2011).

PP is used in thermoforming from PP sheet, as a monoloyer, for many food products, such as snacks, biscuits, cheese and sauces. (Coles & Kirwan, 2011) More specifically, it can be used to form tubs, trays, cups and lids, usually intended for one-time use (Throne, 1996).

III.1.3 Additive in Plastics: Calcium Carbonate

Minerals used in plastics include naturally occurring minerals such as calcium carbonate, talc, clays, barium sulfate, diatomite, mica and wollastonite, as well as synthetic grades and nano-sized minerals. Minerals used as fillers in plastic compounds have traditionally been used to reduce material costs by replacing a portion of the polymer with a less expensive material (Markarian, 2004).

When added to plastics, minerals, such as calcium carbonate, generally increase density, stiffness and surface hardness, improve temperature resistance and reduce shrinkage (Markarian, 2004). The increased density of the resulting mixture of plastic and calcium carbonate translates to a higher specific gravity of the material, which further translates to a heavier end-product. This seems like a disadvantage, however, other improved properties such as stiffness ad impact resistance allows downgauging (lowering of the sheet thickness) in applications like polyolefin sheet thermoforming, thus the higher density of the mixture can be weight compensated (Markarian, 2004; Scanfill, 2014).

On an economic point-of-view, calcium carbonate is expected to have a rising demand according to a study conducted by Global Industry Analysts, Inc in the US. The global market for calcium carbonate ($CaCO_3$) is projected to reach 94 million tonnes by 2018, which will be driven by rising consumption in paper and plastics industries for both precipitated and ground calcium carbonate in Asia Pacific, Latin America and the Middle East. Asia Pacific represents the largest and fastest-growing regional market for $CaCO_3$, with its rapid progress of its plastics and paper industries expected to drive future growth. (Global Industry Analysts Inc, 2013)

III.2 Manufacture of Rigid Plastic Packaging

III.2.1 Extrusion

The plastic raw material, also known as resin, is supplied by the polymer manufacturer in the form of pellets or powder. The first major step in the conversion of plastic into sheets is to change the pellets from solid to liquid (or molten) phase in an extruder (Coles & Kirwan, 2011).

The plastic is melted by a combination of high pressure, friction and externally applied heat. This is done by forcing the pellets along the barrel of an extruder using specially designed, polymer-specific screw under controlled conditions that ensures the production of a homogenous melt prior to extrusion (Figure 4) (Coles & Kirwan, 2011).

In the manufacture of film and sheet, the molten plastic is forced through a narrow slot or die. In the manufacture of rigid packaging such as cups and lids, the molten plastic is forced into shape using a precisely machined mold. (Coles & Kirwan, 2011)

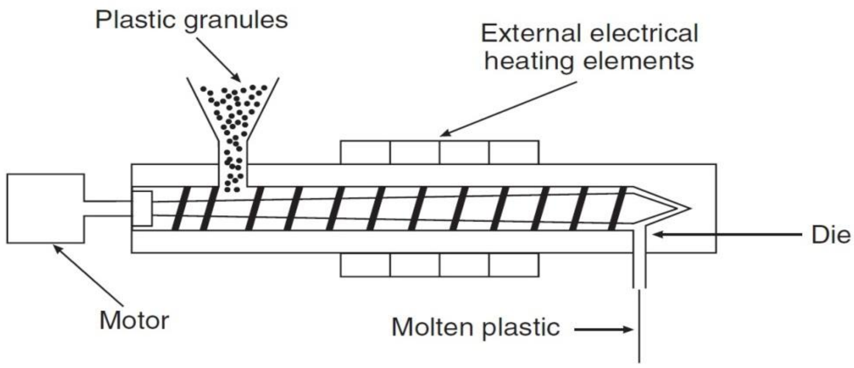


Figure 9 Single screw extruder used in monolayer extrusion (adapted from Coles & Kirwan, 2011)

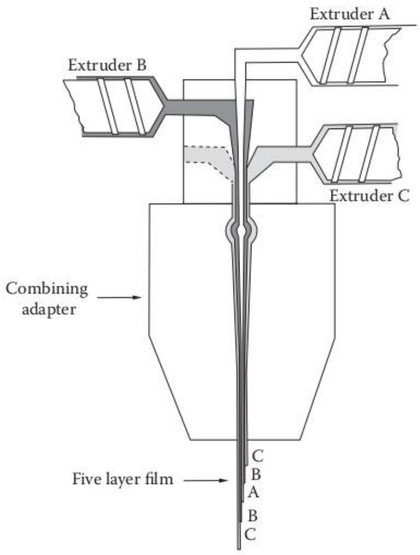


Figure 10 Three component slit die used in co-extrusion (adapted from Robertson, 2013).

Extrusion can be classified into either monolayer extrusion or co-extrusion. Monolayer extrusion, as the name suggests, produces a single layer of plastic film or sheet. Co-extrusion, on the other hand, produces multiple layers of plastic film or sheet, which can be made from two or more polymers (Robertson, 2013).

Robertson (2013) describes co-extrusion as "the coupling of two or more extruders feeding different resins to a single die head to simultaneously extrude two or more different polymers that fuse at the point of film formation into a single web. A two component slit-die is capable of producing two- or three-layer film from two materials, while a three-component slit die (shown in Figure 11) can produce a five-layer film from five materials (Robertson, 2013).

Plastic film and sheet

By definition, plastic films have thicknesses or gages of less than 100 µm. Films are used to wrap products, to overwrap packaging (single packs, groups of packs, palletized loads), to make sachets, bags and pouches and are combined with other plastics and other materials in laminates, which in turn are converted into packaging. On the other hand, plastic sheets have thicknesses of up to 200 µm, and are used to produce semi-rigid and rigid packaging such as pots, tubs and trays (Coles & Kirwan, 2011).

The properties of plastic films and sheets are dependent on the plastics used and the method of film manufacture together with any coating or lamination. In film and sheet manufacture, there are two distinct methods of processing the molten plastic that is extruded from the extruder or die. In *cast* film process, the molten plastic is extruded through a straight slot die onto a cooled cylinder, known as the chill roll (Figure 12). The molten polymer is quickly chilled and solidified to produce a sheet that is reeled and slit to size (Coles & Kirwan, 2011)

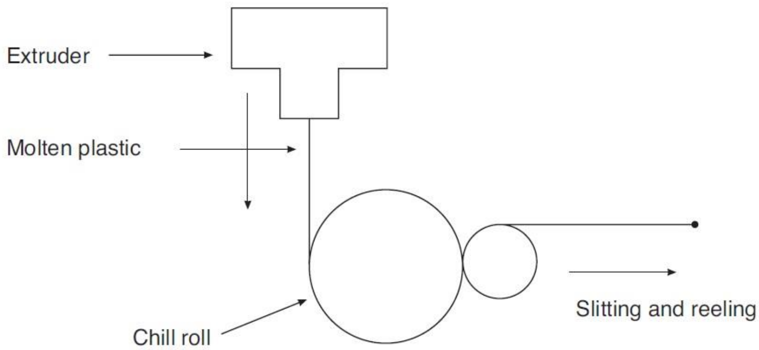


Figure 11 Production of cast film (adapted from Coles & Kirwan, 2011).

III.2.2 Thermoforming

After the reeled sheet is produced via the extrusion process, the sheet proceeds to the thermoforming step. In its simplest form, thermoforming is the stretching of a heated rubbery sheet into a final shape (Throne, 1996). The sequential steps involved in thermoforming as well as important concepts are further elaborated in the following sections.

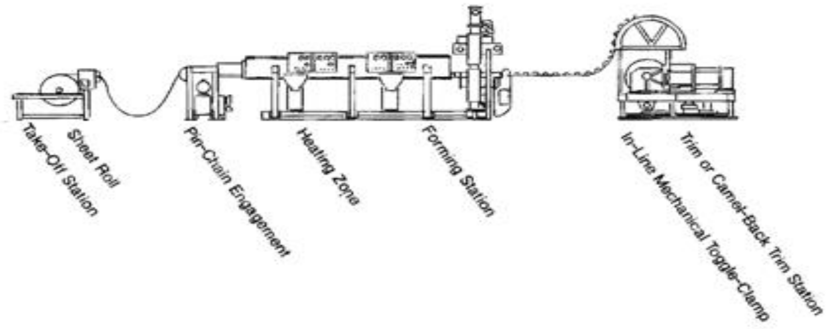


Figure 12 Roll-fed thin-gage thermoforming line with in-line trimming station – Barrenfeld Glencoe (adapted from Throne, 1996).

Clamping of Thin-Gage Sheet

Thin gage sheet is usually supplied to the former in rolls. The majority of applications such as blister pack, form-fill-seal packaging, foam sheet forming and biaxially oriented forming uses thin gage sheet. Formers that use roll sheet stock are called *roll fed* or *continuous sheet* formers. Clamping is by parallel continuous loop chain-fed pins or pin-chains that pierce the sheet at 1 in or 25 mm intervals at about 1 in or 25 mm from each edge. For high-temperature forming thermoforming of PP, the rails are shielded from the sheet heating source or are actively cooled. The edges of the sheet and the plastic between the formed product are trimmed, reground and re-extruded into sheet for forming (Throne, 1996).

Heating of Thin-Gage Sheet

There are three ways of heating the sheet: by conduction, convection or radiation. Conduction is where the sheet is placed in direct contact with the heating medium, such as a hot plate. Convection is where the sheet is heated with hot air, and finally, radiation is where infrared heat from metal wires, ceramic plates, or gas fired combustion is the primary means of heating the sheet. Thin gage, roll-fed sheet is usually heated by passing the sheet between banks of infrared radiant heaters. Combinations of radiation and convection heating are used as well (Throne, 1996).

Shaping Thin-Gage Sheet

Drape forming or male mold forming is defined as stretching or draping of a rubbery sheet over a male mold that requires no forming pressure and as such, there is no difference in pressure across the sheet thickness. Certain aspects of drape forming are used whenever male portions of female molds are employed (Throne, 1996).

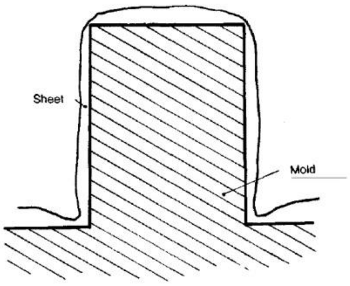


Figure 14 Male or Positive Mold Forming (adapted from Throne, 1996)

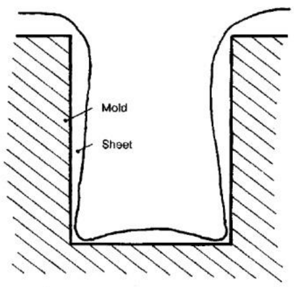


Figure 15 Female or Negative Mold Forming (adapted from Throne, 1996)

Vacuum forming or female mold forming is the application of differential pressure across the sheet thickness of up to 0.1 MPa. Since thin-gage sheet surface-to-volume ratio is very large, thin-gage sheet loses heat to its surroundings very rapidly. As a result, thin-gage sheet is usually formed very rapidly (in seconds). Furthermore, more than one part is formed at a time. Special clamps called cavity isolators are used to minimize non-uniformity in individual part wall thickness due to polymer pulling from one cavity to another during forming (Throne, 1996).

Trimming the Thin-Gage Sheet

Thin-gage sheet can be trimmed in the mold or in a separate in-line hydromechanical trimming device. A camel-back or hump-back trimmer with a roll-fed former is shown in Figure 7 (Throne, 1996).

Depth of Draw

Historically, thermoforming rules-of-thumb are based on the depth-of-draw of a given polymer into a given mold configuration. Depth of draw is the ratio of the depth of the sheet could be drawn into a female mold to the minimum dimension of the rim. It is frequently given the notation *h:d* and is usually applied for cylindrical shapes. For non-cylindrical shapes, definitions based on areal draw ratio and linear stretching provides more accuracy and also helps in describing the stretching process. *Areal draw ratio* is the ratio of the area of the formed sheet to that of the unformed sheet. The *linear draw ratio* is the length of an imaginary line drawn on the formed sheet to its original length (Throne, 1996).

Methods of Forming

In its simplest form, thermoforming is the stretching of a heated rubbery sheet into a final shape. As the sheet is stretched against the mold surface, it stops drawing. As a result, the final part has thick walls where the sheet touched the mold first and thin walls where it touched last (Figure 16) (Throne, 1996).

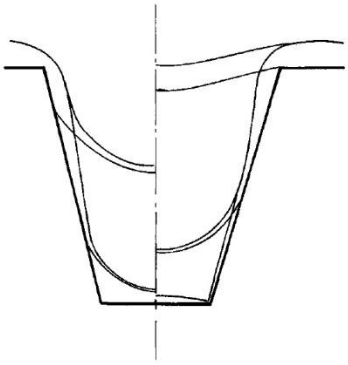


Figure 16 Wall thickness variation during draw-down in simple female vacuum forming (adapted from Throne, 1996)

Two-Step Forming with Pre-stretching

In the 1970s, highly automated multi-step forming of thin-gage roll fed sheet was developed, thanks to the development of plug-assisted pressure forming of PP below its melting temperature. The first step in multi-step forming is usually a form of sheet stretching, such as *plug assist* or *billowing.* The pre-stretched sheet is then pressed against the mold surface (Throne, 1996). For simplicity, the one that applies to manufacturing disposable drink cups will be discussed which mainly involves a plug assist:

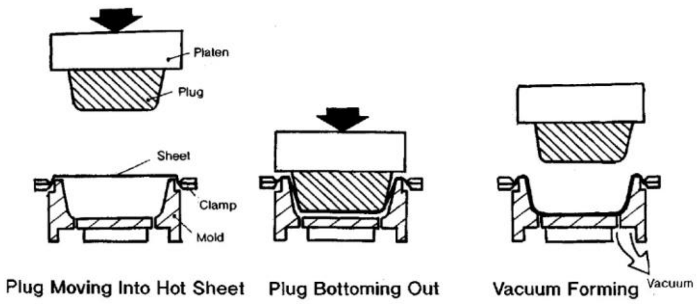
- The heated rubbery sheet is stretched with a mechanically driven plug. There are several plug assisted methods, as elaborated by Throne, (1996):
  - The most common form of plug assisted thermoforming is *plug assisted vacuum forming,* with a female mold (Figure 17). The sheet is pre-stretched by pressing the plug into it and forcing the sheet toward the bottom of the female mold cavity. Vacuum is then applied to pull the sheet against the mold surface.
  - 

Figure 17 Plug assisted vacuum forming into a female mold (adapted from Throne, 1996)

Trapped Sheet Forming

Trapped sheet forming is a variation of the thermoforming process used when the polymer is thermally sensitive, excessively saggy and the polymer sheet is highly oriented, such as with PP. The clamped sheet is held against a heated plate until the polymer reaches its forming temperature. Pressure is then applied through holes drilled in the plate, forcing the sheet away from the plate and against the female mold. Alternately, vacuum is applied, sucking the sheet away from the heater and against the mold. The plates are heated with electric rod heaters. Zonal or pattern heating is possible by using insulating plate sections that are heated to different temperatures (Throne, 1996).

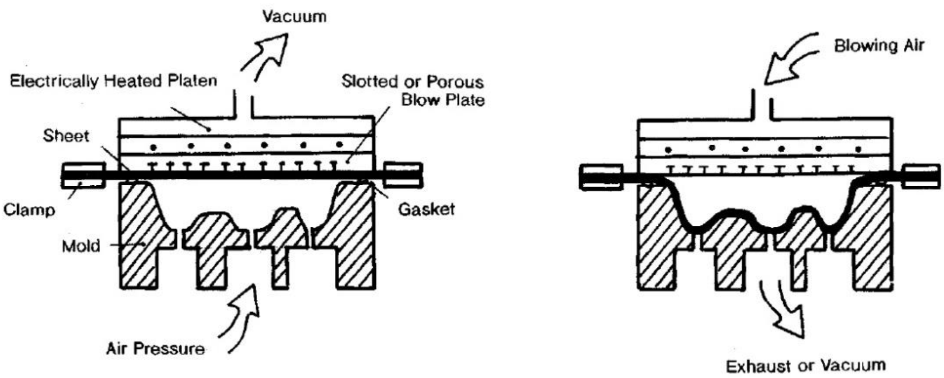


Figure 18 Trapped sheet forming with heating against a slotted or porous heated blow plate (adapted from Throne, 1996)

III.3 Packaging Trends for Plastics

There is a wide range of factors that have direct or indirect influence on packaging demands, irrespective of how the economy performs. According to a report published by World Packaging Organization (2008), these factors include: the ageing world population, trend towards smaller households, increasing requirement for convenience among consumers, rising health awareness among consumers, the trend towards 'on-the-go' lifestyles among increasingly time-poor consumers, growing requirements for brand enhancement, new packaging material development, the move towards smaller packs sizes as the incidence of families eating together at the dinner table becomes less common and increasing awareness of environmental issues, and the adoption of new regulatory requirements on packaging recycling (World Packaging Organisation, 2008).

Among these factors, the increasing requirement for convenience and trend of busier lifestyles are considered to be the priorities of the consumers in the Philippines. More specifically, conveniently transported packaging materials that are cheap yet deliver the best value is a deciding factor for majority of the budget constrained Filipino consumers (Euromonitor International, 2013).

For the Philippines, rigid plastic packaging and flexible packaging options are seen the most effective solutions. As such, rigid plastic packaging will likely continue to be the most dynamic types for beverages and are expected to benefit packaging sales across food and non-food products. The PET bottle has lead the growth for this category (Euromonitor International, 2013).

On the other hand, other types of packaging like plastic bags and disposable plastic containers, have received stricter regulations in recent years. Some environmental concerns has been raised due to the amount of waste generated after the use of these products. An increasing population, undeveloped recycling practices and lack of urban planning in the country intensify the problem. These concerns are especially highlighted during the rainy season, where the country is often visited by typhoons with heavy rainfall. These types of packaging end up becoming more visible – floating around flooded streets, canals and waterways along with other debris. As an immediate action, the legislators and local government units (LGU) in the Philippine capital has enforced ordinances that ban such materials and the use of paper-based, more eco-friendly or reusable packaging materials were encouraged as replacement. In 2013, more than half of the 13 million population in Manila were said to have been covered by these restrictions (Sky News, 2013). It was reported that 11 out of 17 cities in Metro Manila has enforced the ban, while the other 6 cities retain its usage, mainly because of the heavy concentration of plastic manufacturers in those areas, which could mean loss of thousands of jobs among the locals (GMA News, 2013).

Some influential organizations in the country take a different stand on the issue of banning of plastics. The Philippine Chamber of Commerce and Industry (PCCI) said in a statement that the indiscriminate throwing of trash – and not the use of plastic bags – is the main reason behind the worsening flood situation in Metro Manila. The group also added that the stricter implementation of existing laws on anti-littering, waste segregation and collection should be implemented (GMA News, 2013).

Euromonitor International (2013) further reports that consumers in the Philippines remained largely indifferent to environmental issues surrounding packaging. However, this has not stopped large companies from expressing their corporate social responsibility through various initiatives such as venturing into eco-friendly packaging, unbeknownst to the average consumer. A significant increase in awareness would still be required before the population fully embraces ecological choices in purchasing decisions for environmentally friendly packaging. This increase in education is not likely to be achieved quickly (i.e. in one year), as Filipinos are still more concerned with other factors, such as price and convenience, before finding socially-responsible alternatives (Euromonitor International, 2013).

The lack of support for eco-friendly options will be likely to restrict growth of packaging in this category. One of the major challenges would be higher costs, a key restraint even as the economy grows. However, as companies become more aggressive about their environmental initiatives, there is the likelihood that awareness campaigns would be utilized. As such, it is possible that consumers will also start to become aware of the differences in packaging materials when it comes to ecological concerns (Euromonitor International, 2013).

The shift would be likely to only happen if price concerns were also met, such as having eco-friendly packaging with more affordable pricing than its alternatives. If not, it remains unlikely that Filipino consumers will pay much attention to the eco-friendly packaging, in that case, packaging sales would continue to be unaffected by company efforts to produce such packaging (Euromonitor International, 2013).

In the area of sustainability, recycling does exist in plastics, although the developed facilities are mostly controlled by private industries. San Miguel Yamamura Packaging Corporation (SMYPC) has state-of-the-art recycling facility. It is capable of producing food grade post-consumer recycled (PCR) PET, and is one of the pioneers in Asia (SMYPC, 2014). Furthermore, hauling companies collect plastic wastes (PS, PP and PET) from industrial sources which are then reprocessed to produce household items such as clothes hangers, laundry bins, dippers and pails. Closed loop recycling also exists in items such as cardboard packages and glass. These items are usually collected by ambulant collectors who belong to low-income groups. In conclusion, the Philippines has yet to implement effective system for a nationwide, government-regulated waste management and recycling, and the combination of political, social and economic factors has to be addressed alongside with this issue.

IV. Methodology

IV.1 Researcher's Background

This research study came about through my own interest about the packaging innovations that are emerging in Sweden and how these can be disseminated to the rest of the world, particularly in Southeast Asia, where I hail from.

I worked at Glades International Corporation in the Philippines from 2009 to 2012 in the R&D department as a packaging specialist for rigid plastic packaging. I was under the direct supervision of RG, a department manager who had twelve years of experience in both quality and product development in that sector. As I left the company to pursue my master studies under Erasmus Mundus scholarship programme, RG and I continued to have a good relationship and stayed connected via social media. On October 2013, I sent her a private message about a conference in Lund that I will be attending that same month, called Top Packaging Summit organized by PackBridge. I asked if there are companies or packaging samples that might be of interest and I volunteered to get some samples to present to her, as I was planning to go back home and visit her and my former colleagues during the Christmas holidays. RG suggested for me to check for new packaging technologies, light weight plastic packaging using biodegradable materials and innovations for ice cream and chilled products. Meanwhile, during the conference, I came across JB of Scanfill AB who had some samples of plastic food trays and cups in the exhibition hall of the conference. We had a short discussion about the innovative raw material that was used for the food packaging he was presenting. Initially, I mentioned to JB about my previous work experience and familiarity with the thermoforming process. I also mentioned one of my purposes in the conference was to look for industry partners that have potential master's thesis projects I can work on. A few days after, I communicated to RG about the encounter I had with JB and described Scanfill AB and its product portfolio. From then on, the proposal of this master's thesis topic came about which later on led to collaboration with the participating companies, Scanfill AB, Polykemi Compounds (Kunshan) Co. Ltd and Glades International Corporation.

IV.2 Approach and Rationale

As stated in the research purpose, the overall aim of this thesis is to elucidate and find evidence on the suitability of Scanfill sheet as an alternative material in the thermoforming industry in the Philippines. In order to meet that aim, a case study that progressed to an action research were strategies used, hence, a mixed methods approach was utilized. Yin (2003) defines a case study as "an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident." Additionally, Eisenhardt (1989) points out that a case study "focuses on understanding the dynamics present within single settings... that aims to provide description (Kidder, 1982), test theory (Pinfield, 1986; Anderson, 1983) or generate theory (Gersick, 1988; Harris & Sutton, 1986)."

An action research strategy also came about during the process of the research study . A definition by Gilmore, Krantz, & Ramirez (1986) as cited by O'Brien (2001) states that:

> *"Action research...aims to contribute both to the practical concerns of people in an immediate problematic situation and to further the goals of social science simultaneously. Thus, there is a dual commitment in action research to study a system and concurrently to collaborate with members of the system in changing it in what is together regarded as a desirable direction. Accomplishing this twin goal requires the active collaboration of researcher and client, and thus it stresses the importance of co-learning as a primary aspect of the research process."*

Furthermore, O'Brien (2001) distinguishes this type of research from other professional practices, such that "action research emphasizes scientific study wherein the researcher studies the problem systematically and ensures the intervention is informed by theoretical considerations." In contrast with other research methodologies (i.e. historical research), it takes place in a real-world situation and aims to solve real problems. Finally, the initiating researcher, unlike in other disciplines, makes no attempt to remain objective, but openly acknowledges their bias to the other participants (O'Brien, 2001). As mentioned in the narrative of how the study came about, my bias was stemming from having specific competencies and professional network which are strongly linked to the thermoforming industry. Additionally, adoption of different roles at various stages of the process, including those of a planner, catalyzer, facilitator, observer and reporter was necessary to carry out the research. The main role, however, is to nurture other participants to the point where they can take responsibility for the process (O'Brien, 2001).

To help minimize bias, a mixed methods approach was employed in this research. Mixed methods research "is an approach to inquiry involving collecting both qualitative and quantitative data, integrating the two forms of data, and using distinct designs that may involve philosophical assumptions and theoretical frameworks. The core assumption of this form of inquiry is that the combination of qualitative and quantitative approaches provides a more complete understanding of a research problem than either approach alone" (Creswell, 2014). Although mixed-methods research required more of the researcher's time and energy, several good reasons were argued by Bryman (2006), Greene et.al., (1989) as cited by Leedy & Ormrod (2014) such as completeness, complementarity, hypothesis generation and testing, development of appropriate research tools and strategies, triangulation and resolution of puzzling findings.

This study stands on a pragmatic research paradigm, which is a philosophical orientation that "arises out of actions, situations and consequences rather than antecedent conditions (as in positivism)" (Creswell, 2014). Mixed methods approach tend to gear towards this paradigm due to its sequential, concurrent or transformative nature of inquiry. Pragmatism has a concern on applications-what works-and solutions to problems (Patton, 1990 as cited in Creswell, 2014).

IV.3 Data Collection

As an an action research type of study, the author's involvement within the research process was important not only to answer the research questions but also to produce mutually agreeable outcomes for all the participants (O'Brien, 2001). Data collection involved gathering both qualitative and quantitative information in a sequential manner. The former was obtained by holding meetings based on semi-structured interviews and email correspondence with the individuals within the participating companies, while the latter was obtained by carrying out a thermoforming machine trial using the Scanfill sheet within Glades International Corporation's manufacturing plant. After the machine trial, another round of interview was conducted in order to explore company views on the acceptability of the produced cups.

IV.3.1 Interviews and Email Correspondence

In order to collect qualitative data, meetings were scheduled in advance at a designated time with the participants and semi-structured interviews were conducted. Semi-structured interviews use pre-determined open-ended questions, with other questions emerging from the dialogue between interviewer and interviewee/s (DiCicco-Bloom & Crabtree, 2006). The interviews took between 30 to 45 minutes where the minutes of the meeting was transcribed and then forwarded via email to the concerned participants for their review and follow-up of necessary actions that were agreed upon on the meetings. Due to the confidential nature of information, the content of the meetings will not be elaborated but some will be embedded within the study.

Table 1 Participant Profile

Participant	Company*	Position
AG	GIC	Chairman
RG	GIC	QMD Manager
JB	SAB	VP
KB	SAB	Development Manager
ML	PCC	Managing Director

*GIC – Glades International Corporation; SAB – Scanfill AB; PCC – Polykemi Compounds (Kunshan) Co. Ltd.

IV.3.2 Machine Trial

The thermoforming machine trial is experimental in nature. The experimental approach concentrates on causal relationships and achieves objectivity by separating phenomena from its social context (Yin, 2003). Nevertheless, it is still important because it aims of testing theory or evaluation of an intervention (Gomm, et.al., 2000). Experiments are more concerned with relationships between variables, which are usually defined in advance (Farquhar, 2012). Also, the aim in an experiment is to manipulate the effect of an independent variable on a dependent variable (Collis & Hussey, 2009).

The trial was guided by the experimental research protocol stage activity adapted from Biggam (2011):

1.) Statement of the null hypothesis, H_0 and alternative hypothesis, H_1
2.) Determining sample groups
3.) Specify control and test groups
4.) Establishing sampling procedure
5.) Performing the experiment
6.) Analysis of raw data
7.) Accept or reject null hypothesis, H_0

Following the aforementioned steps, the null and alternative hypotheses are stated as follows:

H_0: There is significant difference in machine performance and quality of produced cups between Scanfill sheet and the current PP sheet.

H_1: : There is *no* significant difference in machine performance and quality of produced cups between Scanfill sheet and the current PP sheet.

To test these hypotheses, the sample groups or populations were identified which are the cups produced at the end of the thermoforming process. The cups made of current PP raw material served as control or reference group, while cups that were made using Scanfill sheet were treated as the test group. The sampling procedure of simple random sampling was used. Certain machine parameters and product attributes, such as appearance, weight, wall thickness and rigidity were measured and analyzed using statistical tool such as measures of central tendency. Based on the results obtained, acceptance or rejection of the null hypothesis was concluded.

IV.3.3 Documentation

Due to limitations of time and resources, the quantitative data pertaining to thermoforming machine parameters and product attributes of the control group (sheet dimensions, cup appearance, weight, wall thickness and rigidity) were gathered using the existing company records in Glades International Corporation.

The summary of the elements of the machine trial are tabulated below:

Table 2 Descriptions of elements for machine trial.

	Control / Reference Group*	**Test Group**
Material	100% PP sheet (Clear)	Scanfill Sheet (White, Opaque)
Thermoforming Machine	R21 - CXB Machine Shantou (S71/20A) S7 120A**	R21 - CXB Machine Shantou (S71/20A) S7 120A**
Thermoforming Mold Cavitation	5	5
Sample Group	16 oz Iced Coffee cup***	16 oz Iced Coffee cup***

* existing product in GIC
**Brand Name
*** filling volume of cup, (brimful) approx. 520 ml

Table 3 Description of quantitative data

Description	**Quantitative Data**
Thermoforming Machine Parameters	cycle time zone heater temperatures
Cup Attributes	appearance, weight, overall height, top outside diameter, bottom outside diameter, wall thickness, bottom thickness, rigidity

IV.4 Data Analysis

Data analysis consists of examining, categorizing, tabulating, testing or otherwise recombining both quantitative and qualitative evidence to address the initial propositions of a study (Yin, 2003). In this study, a logic model was adapted as an analytical technique. A logic model presents a plausible and sensible model of how a program will work under certain conditions to solve identified problems (Bickman, 1987 as cited in McLaughlin & Jordan, 1999). The "program" logic model, traces events when an intervention was intended to produce certain outcome or series of outcomes (Yin, 2003). The elements of the logic model are resources, activities, outputs, customers reached, short, intermediate and longer term outcomes, and the relevant external influences. (Wohley, 1983, 1987 as cited in McLaughlin & Jordan, 1999).

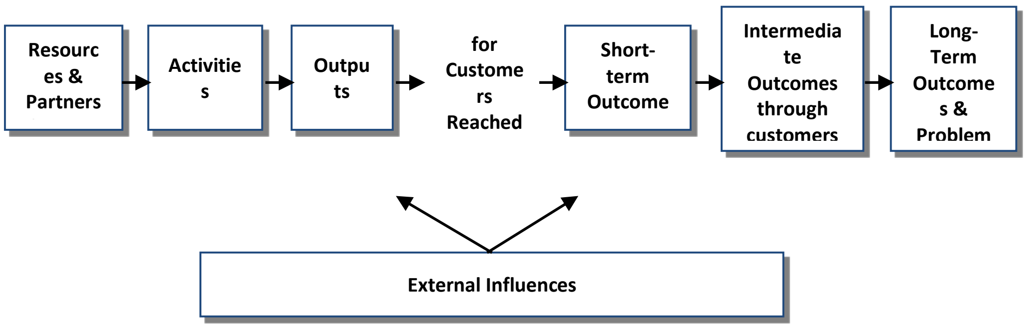


Figure 13 Elements of Logic Model (adapted from McLaughlin & Jordan, 1999)

The elements of logic model is further defined by McLaughlin & Jordan, (1999):

> *Resources* include human and financial resources as well as other inputs required to support the "program" such as partnerships. Information on customer needs is an essential resource to the program. *Activities* include all those action steps necessary to produce program outputs**.** *Outputs* are the products, goods and services provided to the programs direct *customers*. For example, conducting research is an activity and the reports generated for other researchers and technology developers could be thought of as outputs of the activity. *Customers* are the individuals who are served and directly benefit from the output. Placing customers, the users of a product or service, explicitly in the middle of the chain of logic helps program stakeholders better think through and explain what leads to what and what population groups the program intends to serve.
>
> *Outcomes* are characterized as changes or benefits resulting from activities and outputs. Programs typically have multiple, sequential outcomes across the full program performance story. First, there are *short term outcomes*, those changes or benefits that are most closely associated with or "caused" by the program's

outputs. Second, there are *intermediate outcomes*, those changes that result from an application of the short term outcomes. *Long term outcomes* or program impacts, follow from the benefits accrued though the intermediate outcomes.

A critical feature of the performance story is the identification and description of *key contextual factors* external to the program and not under its control that could influence its success either positively or negatively. It is important to examine the external conditions under which a program is implemented and how those conditions affect outcomes. This explanation helps clarify the program "niche" and the assumptions on which performance expectations are set. Doing this provides an important contribution to program improvement. (Weiss, 1997). Explaining the relationship of the problem addressed through the program, the factors that cause the problem, and external factors, enables the researcher to argue that the program is addressing an important problem in a sensible way.

IV.5 Reliability and Validity

Whether conducting a qualitative, quantitative or mixed-method research study, reliability and validity concerns must be addressed. The validity and reliability of research may influence: the extent to which a researcher can learn something about the phenomenon under investigation; the probability that the researcher will obtain statistical significance in any data analysis; and the extent to which the researcher can draw meaningful conclusions from the data (Leedy & Ormrod, 2014)

In general, reliability "is the consistency with which a means of measurement yields a certain, consistent result when the entities being studied has not changed" (Leedy & Ormrod, 2014). On the other hand, validity "determines whether the research truly measures that which it was intended to measure or how truthful the research results are" (Bashir, Afzal, & Azeem, 2008). Validity can take be further described in several forms, depending on different situations. Construct validity was important to establish in this study. Construct validity is defined as the "extent to which a characteristic is measured, although it cannot be directly observed but is assumed to exist based on patterns in people's behavior (such a characteristic is a construct)" (Leedy & Ormrod, 2014).

Reliability in obtaining quantitative data was ensured by using statistically accepted modes of sampling and analysis, as well as the use of calibrated measuring tools such as digital weighing scale, digital calipers and micrometers within GIC. To ensure reliability and construct validity of the study, the thesis was reviewed by the the individuals in the participating companies.

V. Results and Discussion

V.I Verification of Sheet Dimension

The quality of the Scanfill sheet was verified by checking the specifications. The sheet was opaque white and had glossy or matte texture on either side. Prior to the machine trial, the sheet dimension was verified for the test group to ensure that the measurements are within the tolerance limits of the converter.

Table 4 Sheet specifications for test group

Specifications	Test Group
Sheet Dimension (thickness x width)	1.10 mm x 580 mm
Material	PP (with $CaC0_3$)
Color	White

Six cut sheets with dimensions of 150 mm x 580 mm were measured. Using a Mitutoyo® Series 293 digital micrometer, 9 points were selected across the sheet and the thickness variation was determined. The detailed measurements can be seen in Appendix I.

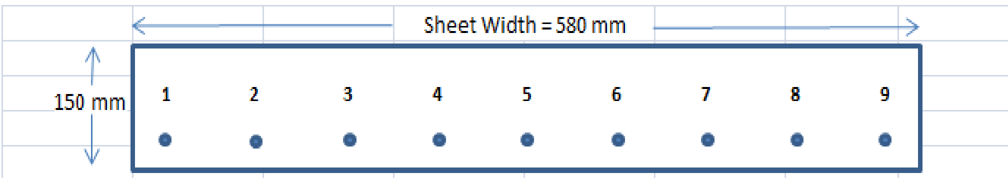


Figure 14 Cut sheet sample.

Based on the measurements, the average thickness of the cut sheets were as follows:

Table 5 Scanfill Sheet Thickness, mm

	AVERAGE, mm
Cut Sheet 1	1.134
Cut Sheet 2	1.129
Cut Sheet 3	1.119
Cut Sheet 4	1.111
Cut Sheet 5	1.103
Cut Sheet 6	1.115
Tolerance	at 5%
	0.055
Lower Limit	1.045
Upper Limit	1.155

It can be observed that the measurements were within the thickness tolerance of 1.045 mm (lower limit) and 1.155 mm (upper limit), therefore the sheet was of acceptable quality. Furthermore, matte texture on one side and glossy texture on the other side of the sheet was requested beforehand, and this requirement was also met. This was requested in order to come up with the end-product that has a matte texture on the inside and glossy texture on the outside.

Figure 15 Cross-section of thermoformed cup.

V.II Thermoforming Machine Parameters

V.II.1 Cycle Time

Cycle time is defined as the period required to complete one cycle of an operation (Business Dictionary-1a, 2014). For this study, the machine ejects 65 cups per minute based on the cycle time. During thermoforming, there was no observed difference in the cycle time for both group which was at 13 shots per minute.

V.II.2 Zone Heater Temperatures

During the thermoforming process, the machine parameters were obtained once the machine was stabilized. The temperature readings were displayed through the machine's control panel. The detailed readings can also be seen in Appendix II.

Table 6 Top Heater Temperature, °C

	Control/Reference Group	Test Group	Temp. Difference
TOP 1	365	325	40
TOP 2	300	265	35
TOP 3	300	265	35
TOP 4	305	265	40
TOP 5	290	265	25
TOP 6	280	260	20
TOP 7	250	265	-15
TOP 8	430	315	115
		Total	295
		Average	36.88

Table 7 Bottom Heater Temperature, °C

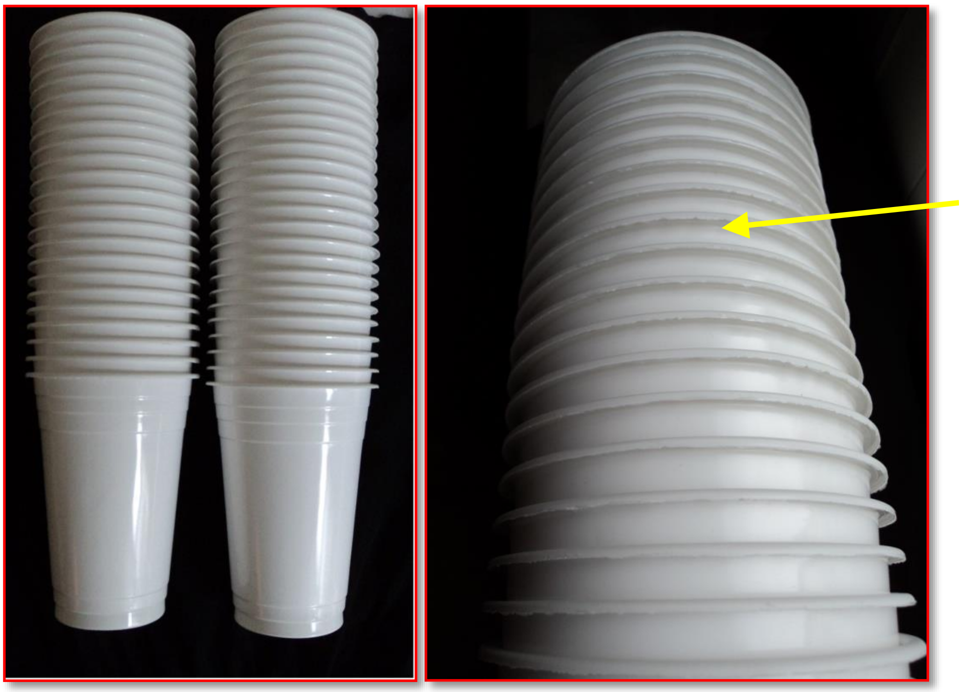
B. Bottom Heater Temperature (°C)			
	Control/Reference Group	Test Group	Temp. Difference
BOTTOM 1	370	330	40
BOTTOM 2	320	300	20
BOTTOM 3	320	300	20
BOTTOM 4	320	300	20
BOTTOM 5	315	300	15
BOTTOM 6	315	300	15
BOTTOM 7	320	310	10
BOTTOM 8	380	345	35
		Total	175
		Average	21.88

From the results above, it can be seen that the test group, which is the Scanfill sheet, has required lower temperature for forming as compared to the PP sheet. An average difference of 36.88 °C for the upper heaters and 21.88 °C for the bottom heaters were observed.

V.III. Cup Attributes

V.III.1 Appearance

The resulting cups were opaque white, glossy on the outside and matte (almost paper-like) texture on the inside. There was one notable quality issue that was observed in the cups, which was the rough rim.



The rough rim can be explained by the dull cutting of the thermoforming mold during processing. The mold is currently allocated for PP clear cups, and the added stiffness of the Scanfill sheet made it somewhat difficult for the mold to compensate and achieve smooth rim for the cups.

V.III.2 Other Cup Attributes / Product Dimensions

To shape the cups, female or negative mold forming was utilized. The thermoforming mold has five cavities where an etching of the cavity number, identification code for PP and company logo at the bottom ejector can be found. The markings transfer to the cup bottom as it is formed and serve as an identification for the cups.

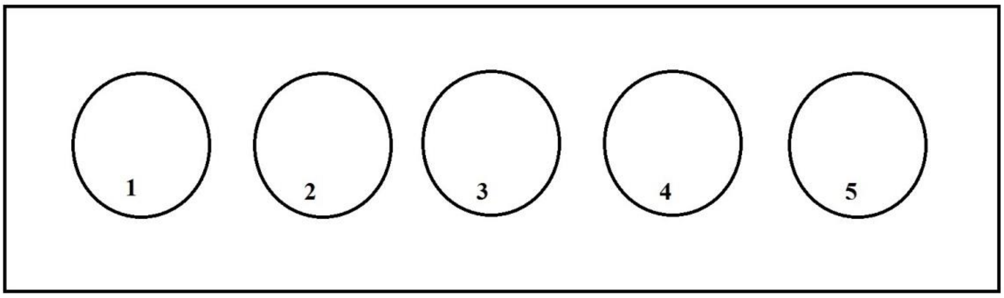


Figure 16 Orientation of cavities in the mold

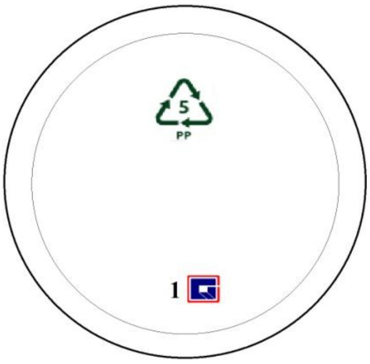


Figure 17 PP logo, cavity number and Glades logo at the cup bottom

The other cup attributes were then obtained using a digital weighing scale and Mitutoyo® digital caliper and were compared to the product specifications. An illustration of the product dimensions measured can be seen in Figure 19.

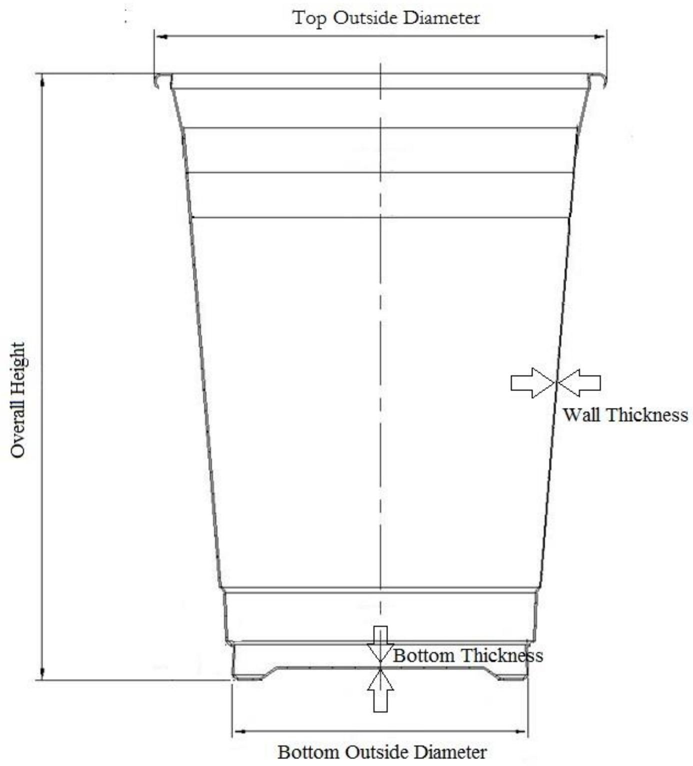


Figure 18 Description of product dimensions of 16 oz cappuccino cup

The product dimensions of the reference group served as the standard for comparison for the test group.

REFERENCE GROUP
Type of Material: PP Clear
Sheet Dimensions: 1.58 mm x 580 mm
Product Name: 16 oz Iced Coffee

Product Dimensions	Standard	Tolerance
Weight	8.20 g	± 0.3 g
Overall Height	131.20 mm	± 0.50 mm
Wall Thickness	0.25 mm	± 0.05 mm
Top Outside Diameter	93.50 mm	± 0.30 mm
Bottom Outside Diameter	58.70 mm	± 0.30 mm
Bottom Thickness	0.30 mm	± 0.05 mm

TEST GROUP:
Type of Material: PP White
Sheet Dimensions: 1.10 mm x 580 mm
Product Name: 16 oz Iced Coffee Cup

Cavity No.	WEIGHT (g)	OVERALL HEIGHT (mm)	WALL THICKNESS (mm)	TOP OUTSIDE DIAMETER (mm)	BOTTOM OUTSIDE DIAMETER (mm)	BOTTOM THICKNESS (mm)
STANDARD	8.20 ± 0.30	131.20 ± 0.50	0.25 ± 0.05	93.50 ± 0.30	58.70 ± 0.30	0.30 ± 0.05
1	9.4	129.79	0.22	94.26	59.57	0.32
2	9.8	130.65	0.21	94.15	59.17	0.35
3	10.4	129.44	0.21	94.12	59.61	0.50
4	9.6	130.55	0.22	93.92	59.44	0.43
5	10.0	130.32	0.22	94.06	59.28	0.41

The results showed that all the cups were above the weight range. Unfortunately, there was a major source of error identified by the author only after the trial. The researcher referred to the product specifications of one of the products which had the same sheet and product profile except for the weight.

Sheet Specifications Reference Group	Product Name	Weight (g)
1.58 mm x 580 mm (PP Clear)	Iced Coffee Cup 16 oz Cappuccino Cup 14 oz Cappuccino Cup	8.2 ± 0.3 g
	16 oz McCafe Cup	9.7 ± 0.3 g

However, if the weight specifications will be based on 16 oz McCafe, all cavities are within the acceptable tolerances except for cavity 3 which is overweight. Based on interview with QMD personnel, the weight of the cups can be adjusted based on the alterations of the machine parameter settings.

The overall height for all the cavities were below the minimum tolerance of 130.70 mm. The wall thickness was within the acceptable range. The top outside diameter for all cavities was above the maximum tolerance of 93.80 mm. This is due to the excess material caused by the rough rim. The bottom outside diameter for all cavities was above the maximum tolerance of 59.00 mm. Lastly, the bottom thickness of cavities 2 and 3 were within the acceptable limits while cavities 3, 4 and 5 were above the maximum limit of 0.35 mm.

V.III.3 Rigidity

Rigidity is defined as the stiffness of the material that allows it to resist bending, stretching, twisting or other deformation under a load. It is a function of the material's modulus of elasticity (Young's modulus) and shape (Business Dictionary-1b, 2014) . Essentially, the higher the rigidity profile of the cup, the higher resistance it has to the aforementioned forces. Using a Stiffness Tester RH-BT10® by Guangzhou Runhu Instruments Co. Ltd., the rigidity of the cups were measured and compared. The whole set of data can be found in Appendix V. Based on the measurements, it can be observed that the test group has higher rigidity values across all cavities measured.

Table 8 Rigidity measurements of cups, in kgf

CAVITY NO.	1	2	3	4	5
TEST GROUP (AVERAGE) kgf	164.99	176.21	189.67	168.66	186.20
REF. GROUP (AVERAGE) kgf	161.73	161.93	187.83	165.19	138.48
Difference (kgf)	3.26	14.28	1.84	3.47	47.72

V.III.4 Suitability for Food Contact

Along with other functions of packaging, package safety and protection of end-user are essential requirements that must be met especially when dealing with materials which are intended for direct food contact.

Scanfill sheet, along with other material grades from Scanfill AB, is approved for direct contact with food (Scanfill, 2014). The material complies with EU Regulations 1935/2004, 2023/26 and 10/2011, as evidenced by their Certificate of Compliance (CoC) for food contact materials. Material Safety Data Sheet (MSDS) and Technical Data Sheets (TDS) are also provided (see Appendix VI).

V.IV Logic Model Findings

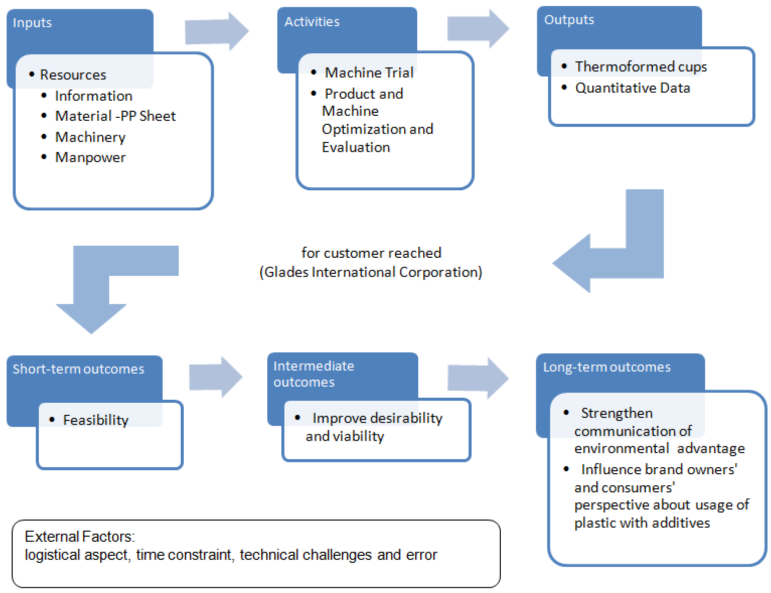


Figure 19 Detailed elements of study based on the logic model

The elements of the study were embedded within the logic model and elaborated below:

The *inputs* included the resources provided by the collaborating companies: Scanfill AB provided the information about their raw materials, the innovation potential of their products and technologies, its applications in food packaging and technical expertise since the beginning of the study. Scanfill AB also facilitated the connection to its sister company, Polykemi Compounds (Kunshan) Co. Ltd. The Polykemi Group's subsidiary in China made it possible to produce the Scanfill sheets in a more proximate location and also handle the logistical aspect of trasporting the sheets via sea freight to the Philippines. On the other end, Glades International Corporation provided the warehousing facility to receive the sheets, the thermoforming machine and mold for the trial as well as the manpower assistance to carry out the trial (QA and Process Technician). The management of the company also gave support by arranging with the planning department about the proposed schedule of the trial. The laboratory facilities and instruments were also utilized to gather quantitative data after the cup samples were collected. Suggestions and recommendations by the personnel who the researcher worked with during the trials were also noted.

The *activities* included the thermoforming machine trial, as well as product and machine evaluation and optimization within the manufacturing industry. Additionally, it is important to mention the planning and coordination phase that was done by the researcher with the contact persons in the collaborating companies.

The *outputs* included the thermoforming cups and the quantitative data gathered. The data from the cups were compared and analyzed to that of the existing standards.

The *short-term outcome* showed the feasibility of using Scanfill sheet. It is possible to use the new material using the existing technology and machineries in the thermoforming company, although modifications in the machine and mold (i.e. optimizing parameter settings and sharpening the cutting plate) might be necessary.

The *intermediate outcomes*, on the other hand, showed that there are still measures or modifications that need to be done in order to improve the desirability and viability of the material being studied. The desirability can be improved by improving the quality of the cups (i.e. producing a smooth rim and weight requirements). The viability, on the other hand, deals with the business and financial aspect of the product, so it can be mutually beneficial to all the companies concerned. The pricing, demand and added value of the material should be further discussed. To study whether capital expenditure is worth allocating for the thermoforming company (i.e. predryer) can be considered. In the comparison of industry processes of the collaborating companies, it was mentioned that both are capable of extrusion operation. In the future, the supplier could explore the possibility of formulating a Scanfill granulate that would not require pre-drying so it can also be used in the extrusion operation as well.

The *long-term outcomes* could include the need for strengthening of the communication of environmental advantages especially to manufacturing industries, brand owners and consumers. This, in turn, could influence brand owners and consumers to prefer the use of plastics with non-oil based additives. Although the Philippines is relatively undeveloped in the area of sustainability and recent events have driven legislative changes in the use of rigid plastic packaging even up to imposing its ban in the cities in the surrounding the capital, opportunities for innovative packaging solutions can still prevail. This can also be seen as an opportunity to educate and promote alternative packaging materials.

The *external factors* such as logistical aspect, time constraint and technical challenges had to be managed in order to carry out the study successfully. The logistical aspect included the shipment of the materials from one country to another, so the knowledge and coordination of import and export personnel from both sides were essential. The time constraint was also part of the challenge of the study. A total of 5 hours was the time period allocated for the trial. The reason for this is that machines and molds for the sole purpose of pilot studies are not available, only commercial-scale were. The same equipment are also used to produce packaging products for customers who are expecting timely deliveries, so extension was not possible. Lastly, during the machine trial, challenges were faced such as having to start on a trial and error basis to configure the machine parameter settings, which was solved eventually within the given time frame. The researcher also regrettably committed an error by referring to the the wrong standard for the weight of cups during the trials, therefore instructing the process technician to adjust parameter settings based on the assumed target weight.

VI. Conclusion and Suggestions for Further Research

In this study, the quality and performance of Scanfill sheet was evaluated in relation to the standards and capabilities of the Philippine thermoforming industry. The sheet dimensions were measured and the texture requirements were found to be at par with the standards.

The different steps in manufacturing thermoformed products were outlined and described. Similarities and differences in quality and performance of machine parameters and cups were investigated, using the control/reference group (existing PP clear sheet) and the test group (Scanfill white sheet).

The thermoforming machine’s parameter setting showed that using Scanfill sheet required a lower temperature for the heating plates as compared with existing PP clear sheet. This could translate to lower electricity consumption and thus energy savings. However, the machine did not exhibit any difference in cycle time as compared when the PP clear sheet is ran, and both were at around 13 cycles or shots per minute.

The cups produced using Scanfill sheet were acceptable in terms of aesthetic value with regards to gloss and matte texture. Cup attributes such as wall thickness and rigidity were at par with the standards. Rigidity of the cups was also found to be higher than the existing PP clear, which indicates a better and stiffer cup. The material used also complies with regulatory requirements for food safety. However, other cup attributes such as smooth rim, weight, height, top outside diameter and bottom outside diameter were not within set specifications. One of the factors might have contributed to this result such as non-optimal machine parameter setting. Also, since the thermoforming mold was originally intended for PP clear, the cutting plate of the tooling may not be sharp enough to cut the rim smoothly.

In conclusion, this study has proven the suitability and feasibility of the use of Scanfill sheet in the thermoforming industry in the Philippines. However, other issues such as desirability of the cups as well as viability can be improved and further studied.

As for suggestions for further study, it can be an objective and future work to optimize the thermoforming machine performance specifically in terms of cycle time. A machine run time that would be longer than what was carried out in this study (i.e. > 5 hours) can be considered. The quantification of the environmental impact of Scanfill sheet (i.e.

savings in electricity, fresh water use) in the Philippine setting can serve as a better communication tool to convey the advantages of the material. Another interesting topic in the future could be an in-depth study of consumer behavior and acceptance of the cups produced using Scanfill sheet and compare them with existing rigid food packaging in the market.

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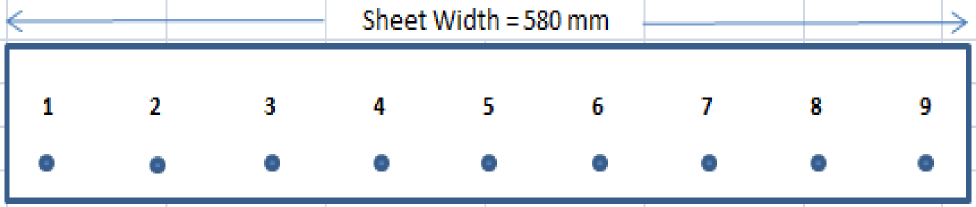
Appendices

Appendix I. Sheet Thickness Verification

TEST GROUP (Scanfill Sheet)

Type of Material: PP White

Sheet Dimension: 1.10 mm x 580 mm



Scanfill Sheet Thickness, mm

Point	1	2	3	4	5	6	7	8	9	AVERAGE
Cut Sheet 1	1.136	1.137	1.137	1.137	1.13	1.132	1.129	1.134	1.133	1.134
Cut Sheet 2	1.123	1.123	1.129	1.126	1.127	1.131	1.133	1.131	1.134	1.129
Cut Sheet 3	1.119	1.114	1.112	1.114	1.118	1.116	1.127	1.121	1.129	1.119
Cut Sheet 4	1.112	1.108	1.115	1.115	1.113	1.111	1.114	1.103	1.105	1.111
Cut Sheet 5	1.108	1.103	1.101	1.102	1.103	1.102	1.102	1.102	1.102	1.103
Cut Sheet 6	1.117	1.119	1.118	1.123	1.116	1.119	1.108	1.107	1.108	1.115

Tolerance	at 5%
	0.055
Lower Limit	1.045
Upper Limit	1.155

Appendix II. Standard Parameter Setting

CXB Machine Shantou (S71/20A) S7 120 A

Product Name: 16 oz cup Iced Coffee

Number of cavities: 5

Standard Weight: 9.7 ± 0.3 g

Cycle time or Number of strokes: 13 shots per minute

REFERENCE GROUP

Type of Material: PP Clear

Sheet Dimension: 1.58 mm x 580 mm

A. Heater Temperature (°C)

TOP 1	365
TOP 2	300
TOP 3	300
TOP 4	305
TOP 5	290
TOP 6	280
TOP 7	250
TOP 8	430

BOTTOM 1	370
BOTTOM 2	320
BOTTOM 3	320
BOTTOM 4	320
BOTTOM 5	315
BOTTOM 6	315
BOTTOM 7	320
BOTTOM 8	380

B. Pre-heater Temperature (°C)

UPPER	150
LOWER	150

TEST GROUP

Type of Material: PP White

Sheet Dimension: 1.10 mm x 580 mm

A. Heater Temperature (°C)

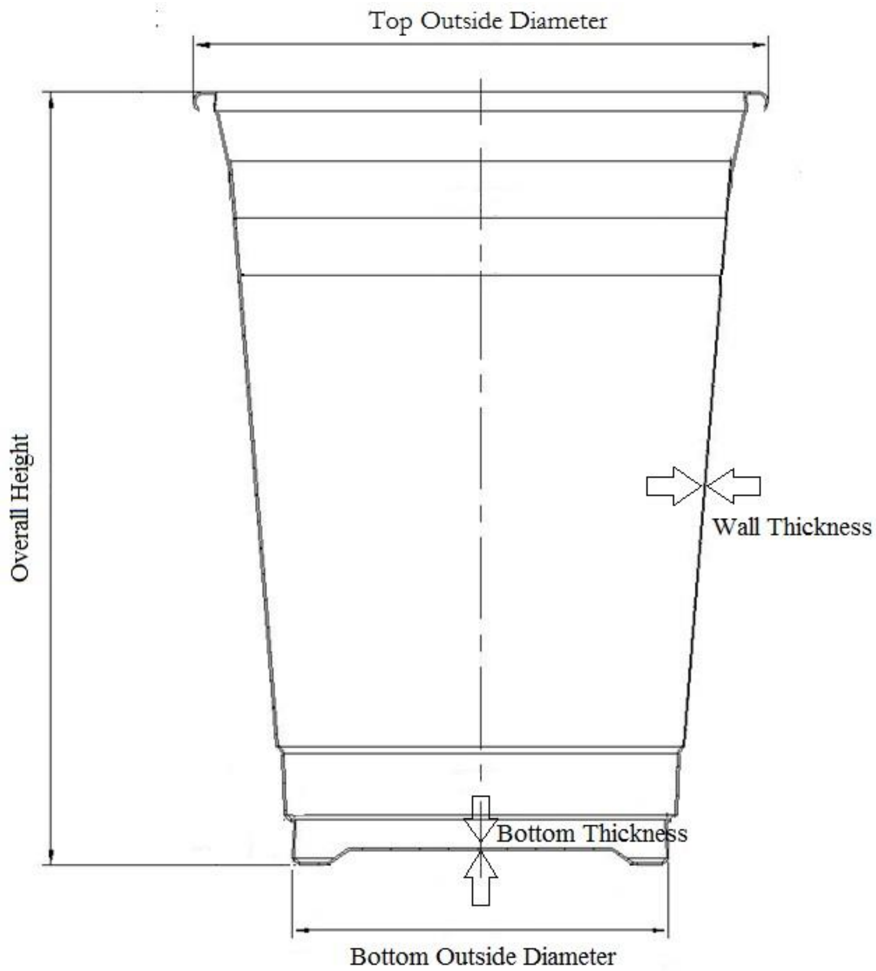
TOP 1	325
TOP 2	265
TOP 3	265
TOP 4	265
TOP 5	265
TOP 6	260
TOP 7	265
TOP 8	315

BOTTOM 1	330
BOTTOM 2	300
BOTTOM 3	300
BOTTOM 4	300
BOTTOM 5	300
BOTTOM 6	300
BOTTOM 7	310
BOTTOM 8	345

B. Pre-heater Temperature (°C)

UPPER	110
LOWER	110

Appendix III. Product Drawing
Product Name: 16 oz Iced Coffee Cup



Appendix IV. Thermoformed Product Attributes
Product Name: 16 oz Iced Coffee Cup

REFERENCE GROUP
Type of Material: PP Clear
Sheet Dimension: 1.58 mm x 580 mm

Product Dimensions	Standard	Tolerance
Weight	8.2 g	± 0.3 g
Overall Height	131.20 mm	± 0.50 mm
Wall Thickness	0.25 mm	± 0.05 mm
Top Outside Diameter	93.50 mm	± 0.30 mm
Bottom Outside Diameter	58.70 mm	± 0.30 mm
Bottom Thickness	0.30 mm	± 0.05 mm

TEST GROUP
Type of Material: PP White (with $CaCO_3$)
Sheet Dimension: 1.10 mm x 580 mm

Cavity No.	WEIGHT (g)	OVERALL HEIGHT (mm)	WALL THICKNESS (mm)	TOP OUTSIDE DIAMETER (mm)	BOTTOM OUTSIDE DIAMETER (mm)	BOTTOM THICKNESS (mm)	REMARKS
STANDARD	8.20 ± 0.30	131.20 ± 0.50	0.25 ± 0.05	93.50 ± 0.30	58.70 ± 0.30	0.30 ± 0.05	
1	9.4	129.79	0.22	94.26	59.57	0.32	All cavities are overweight
2	9.8	130.65	0.21	94.15	59.17	0.35	All cavities are underheight
3	10.4	129.44	0.21	94.12	59.61	0.50	due to below minimum
4	9.6	130.55	0.22	93.92	59.44	0.43	stacking height
5	10.0	130.32	0.22	94.06	59.28	0.41	All cavities have rough rim
							Cavities 2 & 3 - offset bottom

Appendix V. Cup Rigidity or Stiffness Measurement
Product Name: 16 oz Iced Coffee Cup

REFERENCE GROUP
PP Clear

Cavity No.	1	2	3	4	5
RIGIDITY VALUES (kgf)	182.53	148.88	193.75	155.00	158.06
	142.76	175.39	192.73	176.41	136.64
	145.82	164.17	180.49	174.37	134.60
	167.23	159.08	181.51	153.98	131.54
	170.29	162.13	190.69	166.21	131.54
AVERAGE	161.73	161.93	187.83	165.19	138.48

TEST GROUP
PP White

Cavity No.	1	2	3	4	5
RIGIDITY VALUES (kgf)	171.31	181.51	188.65	159.08	187.63
	168.25	185.59	186.61	173.35	186.61
	158.06	163.15	185.59	168.25	187.63
	159.08	182.53	192.73	166.21	193.75
	168.25	168.25	194.77	176.41	175.39
AVERAGE	164.99	176.21	189.67	168.66	186.20

Appendix VI. Certificate of Compliance (CoC), Material Safety Data Sheet (MSDS) and Technical Data Sheet (TDS)

scanfill®
BRINGS OUT THE BEST IN PACKAGING

Certificate of compliance

Food contact materials

Materials:

- SCANFILL Foil ABYX52C1 shaped as pellets
  Polyolefin & mineral compound
- SCANFILL Sheet shaped as sheet in one or more layers whereof at least one is based on above mentioned SCANFILL Foil ABYX52C1. Other layers are based on pure polypropylene.

The material is intended for packaging of all types of food and complies with following European regulations:
1935/2004, 2023/2006, 10/2011

Overall migration:

Test on monolayer SCANFILL Foil ABYX52C1
In 10% alcohol: <0,1mg/dm²
In 50% ethanol: <0,1 mg/dm²
In 3% acetic acid: 8,8 mg/dm²
In olive oil: <0,1 mg/dm²

Test on PP side of multilayered sheet
In 10% alcohol: <0,1mg/dm²
In 20% alcohol: <0,1mg/dm²
In 50% ethanol: <0,1 mg/dm²
In 3% acetic acid: 0,3 mg/dm²
In olive oil: <0,1 mg/dm²

Specific migration:

-Aluminum hydroxybis [2,2'-methylenebis (4,6-di-tert-butylphenyl) phosphate]
Limit 5 mg/kg, Result <1 mg/kg
-Trade secret substance calculated as lithium
Limit 0,6 mg/kg, Result <0,1 mg/kg
-cis-endo-bicyclo [2.2.1] heptanes-2,3-dicarboxylic acid, salts
Limit 5 mg/kg, Result <1 mg/kg

Scanfill AB, Box 14 SE-271 21 Ystad Sweden
Tel:+46 411 170 30 Fax:+46 411 167 30. www.scanfill.se

Primary aromatic amines:
In 10% alcohol: <0,01 mg/kg
In 3% acetic acid: <0,01 mg/kg
In 50% ethanol: <0,01 mg/kg
In olive oil: <0,01 mg/kg

Heavy metals:
In 10% alcohol, 3% acetic acid, 50% ethanol and olive oil respectively:

Metal	Limit	Result
Barium	1 mg/kg	<0,1 mg/kg
Cobalt	0,05 mg/kg	<0,01 mg/kg
Copper	5 mg/kg	<0,5 mg/kg
Iron	48 mg/kg	<1 mg/kg
Lithium	0,6 mg/kg	<0,1 mg/kg
Manganese	0,6 mg/kg	<0,1 mg/kg
Zinc	25 mg/kg	<1 mg/kg

The materials do not contain dual additives.

The information provided in this certificate is to the best of our and our suppliers' present knowledge. Future research may show new results.

Ystad 2013-03-13

Karl Banke
Development manager
M.Sc.Chemical Engineer

polykemi

Datum - Date - Ausfertigungsdatum:
2012-06-29

VARUINFORMATION
MATERIAL SAFETY DATA SHEET
PRODUKTINFORMATION

Conforms to 1907/2006/EG, 453/2010/EG

1. Produkt - Product name - Produktname

SCANFILL Foil ABYX52C1 - all colours

1.2. Produktbeskrivning - Nature of product - Produktbeschreibung

Granules for thermoplastic processing

1.3. Tillverkare - Manufacturer - Hersteller

POLYKEMI AB, Box 14, S-271 21 Ystad, SWEDEN
Tel: +46 411-170 30 Telefax: +46 411-167 30
www.polykemi.se safety@polykemi.se

Emergency information: +46 411-170 30 (office hours)

2. Farliga egenskaper - Dangerous properties - Gefährliche Eigenschaften

At thermal degradation or fire hazardous gases may occur.

3. Sammansättningsuppgifter - Information of ingredients - Angaben über die Zusammensetzung

Name	%	CAS-nr	EINECS/ELINCS nr
Polypropylene/Polyethylene	48		
Mineral	52		
Pigments and additives	<2		

4. Första hjälpen - First aid - Erste Hilfe

Allmänt/In general/generell:	At thermal degradation, hazardous gases may occur.
Förtäring/Consumption/Verzehrung:	
Inandning/Inhalation/Einatmung:	
Ögonkontakt/Eye contact/Kontakt mit den Augen:	Flush with lots of water
Hudkontakt/Skin contact/Hautkontakt:	As above

5. Åtgärder vid brand - Measures if fire - Massnahmen bei Feuer

Fire is quenched with water or CO2.

6. Åtgärder vid spill/oavsiktliga utsläpp - Accidential release measures - Massnahmen bei Unfall

Take notice of local regulations.

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Datum - Date - Ausfertigungsdatum:
2012-06-29

VARUINFORMATION
MATERIAL SAFETY DATA SHEET
PRODUKTINFORMATION
Conforms to 1907/2006/EG, 453/2010/EG

SCANFILL Foil ABYX52C1 - all colours

7. Hantering och lagring - Handling and storage - Handhabung und Lagerung

Store at a dry place.

8. Personliga skyddsåtgärder - Personal protection - Persönliche Schutzmassnahmen

Use safety goggles, safety gloves and possibly protection clothes when hot material is handled.
At thermal degradation or fire hazardous gases may occur.

9. Fysikaliska och kemiska egenskaper - Physical and chemical properties - Physikalische und chemische Eigenschaften

Produktens form/Physical form/Physikalische Form:	Granules	Kokpunkt/Boilingpoint/Siedepunkt:	na° C
Färg/Colour/Farbe:	All	Flampunkt/Flame point/Flammpunkt:	>150° C
Löslighet/Solubility/Löslichkeit:		pH koncentrat/ pH consentrate/pH-Konzentrat:	
Smält-stelningspunkt/ Melting point/Schmelz-Erstarrungspunkt:	150°C	pH lösning/pH solution/pH-Lösung:	
Densitet/Density/Dichte:	1,40	Sönderdelningstemp./Decompostion temperature /Zersetzungstemperatur:	° C
Explosionsgr %-% /			
Löslighet i vatten/Solubility in water/Löslichkeit in Wasser:	insoluble		

10. Stabilitet och reaktivitet - Stability and reactivity - Stabilität und Reaktionen

This product is estimated as stable at normal handling and storage conditions.
At thermal degradation or fire hazardous gases may occur.

11. Toxikologisk information- Toxicological information - Toxikologische Information

Allmänt/In general/Generell:	At thermal degradation or fire, hazardous gases may occur
Inandning/Inhalation/Einatmung:	Enter fresh air, or visit medical educated people
Hudkontakt/Skin contact/Hautkontakt:	Flush with lots of water
Ögonkontakt/Eye contact/Kontakt mit den Augen:	As above
Förtäring/Ingestion/ Verschlucken:	As above

12. Ekotoxikologisk information - Ecotoxicological information - Ökotoxikologische Information

Not applicable.

13. Avfallshantering - Scrap disposal - Handhabung der Abfälle

Take notice of local regulations.

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Datum - Date - Ausfertigungsdatum:
2012-06-29

VARUINFORMATION
MATERIAL SAFETY DATA SHEET
PRODUKTINFORMATION
Conforms to 1907/2006/EG, 453/2010/EG

SCANFILL Foil ABYX52C1 - all colours

14. Transport information - Transportinformation - Transportinformation

Generellt/In general/Generell: Ej transportklassificerad./Not regulated/ Nicht kennzeichnungspflichtig.

15. Gällande bestämmelser - Regulatory information - Restriktionen

Denna produkt är ej märkningspliktig enligt svensk lagstiftning./This product is not regulated by Swedish law./Dieses Produkt ist nicht kennzeichnungspflichtig laut schwedischem Gesetz.
Beakta statliga och lokala föreskrifter. /Take notice of federal, state and local regulations. /Beachten sie staatliche und lokale Vorschriften.

16. Övrig information - Further information - Besondere Angaben

Enligt idag tillgänglig information klassificeras inte denna produkt som farlig enlig lagar och bestämmelser.
According to Swedish law this product is not classified as dangerous.
Dieses Produkt ist kein gefährlicher Arbeitsstoff im Sinne der schwedischen Gefahrstoffverordnung and somit nicht kennzeichnungspflichtig.

Ersätter varuinformationsblad av:/ This material safety data sheet is substituting sheet:/

Diese Produktinformation ersetzt Produktinformation:

Exposure Scenarios (ES) are not applicable

polykemi

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polykemi

SCANFILL

FOIL ABYX52C1

Thermo forming

Parameter	Recommended Value	Unit
Melt temperature	190-220	°C
Drying temperature	70-90	°C
Drying time in circulation dryer	2-4*	h
Drying time in fresh-air dryer	2-4*	h
Drying time in dessicant air dryer	2-4*	h

*Predry until moisture-content < 0.03%

During production stops, emptying the cylinder is recommended. Leave the screw in its front most position. For polycarbonate it is also recommended to leave the cylinder temperature at 160-180°C and that the heating on the feeding zone is on. When producing details in flame retardant material, corrosion protected steel is to recommend for the mould. For further information, see the material safety datasheet (MSDS).

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SCANFILL

FOIL ABYX52C1

Thermoforming grade

Property	Value	Unit	Standard
Density	1,40	g/cm³	ISO 1183
MFI at 230°C/2,16kg	2	g/10min	ISO 1133
Flexural modulus at +23°C	3900	MPa	ISO 178
Maximum flexural strength	43	MPa	ISO 178
Maximum tensile strength	23	MPa	ISO/R527
Elongation at break	5	%	ISO/R527
Elongation at yield	4	%	ISO/R527
Impact strength			
Notched Charpy at +23°C	4	kJ/m²	ISO 179
Notched Charpy at -20°C	2	kJ/m²	ISO 179
Unnotched Charpy at +23°C	16	kJ/m²	ISO 179
Unnotched Charpy at -20°C	9	kJ/m²	ISO 179
Filler content	52	±2%	Polykemi
Heat Distortion Temperature			
HDT 120°C/h at 455kPa (B)	122	°C	ISO 75/1
HDT 120°C/h at 1820kPa (A)	76	°C	ISO 75/1
Softening temperature			
Vicat 50°/h at 9,81N (A)	133	°C	ISO 306
Vicat 50°C/h at 49,05N (B)	89	°C	ISO 306
Flammability			
GWT at 2 mm	650	°C	IEC 695-2-1
UL94 at 1.6 mm	HB		UL94
Mould shrinkage (with flow)	0,8-1,1	%	ISO 2577
Mould shrinkage (across flow)	0,8-1,1	%	ISO 2577

Version 3 2013-09-26

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