รายงานสหกิจศึกษาฉบับสมบูรณ์

การปรับแต่งบรรจุภัณฑ์ชนิดยืดหยุ่นให้มีความเหมาะสมในกระบวนการผลิต เพื่อลดต้นทุนในการผลิต

นาย ฐิติพล วงศ์น้อย

รายงานนี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรวิศวกรรมศาสตร์บัณฑิต
หลักสูตรวิศวกรรมปิโตรเคมี ภาควิชาวิศวกรรมเคมี คณะวิศวกรรมศาสตร์
สถาบันเทคโนโลยีพระจอมเกล้าเจ้าคุณทหารลาดกระบัง
ปีการศึกษา 2562

Cooperative Title: Flexible material optimization

By: Mr.Titipon Wongnoi

Field of study: Petrochemical Engineering

Advisor: Asst.Prof.Dr. Thachanan Samanmulya

Mentor (Position): Ms.Nataporn Khurukul (RD Packaging Dev. Supervisor)

Company: Unilever Thailand

Abstract

Unilever is a large-scale consumer which has many products and manufactured from flexible material. The company aims to reduce the cost of manufacturing process using this material. Thus, they assigned 3 projects consist of reduced %headspace in pouch, find possibilities of BOPP material and outer case optimize specification.

In the first project, responsible in pack size 200 and 450 ml. We want to reduce %headspace to 35%. Started from construct competitor analysis to use for develop pouch. Then as a result, it can be reduced by only 38% for pack size 200 ml, but size 450 can be reduced to 35%. In the second project experiment with the BOPP material trial in production line to see the function of the machine. Founded problems with temperature affecting the quality of seal this is due to material changing and customizing the machine, but it can be produced. The third project reduced the corrugated carton specification due to the use of the paper grade too high. Combined with the introduction of outer case components, experiment according to UMA methods, outcome and defect on the product against the current specification.

Key words: Packaging, Flexible material, Pouch, BOPP film, Corrugated box

Acknowledgements

I would like to express my sincere thanks to Unilever Thailand for giving opportunity with cooperate program. Also, I especially thank you to Ms.Piyanuch Thirardkuerkoon (Skin Cleansing R&D Development Manager), Ms.Nataporn Khurukul (RD Packaging Dev. Supervisor). For 6 months, I had learned many things It is also helpful to help guide the deployment time allocation, including the use of equipment in the laboratory.

In addition, I am grateful for the teacher of petrochemical engineering, Asst.Prof.Dr. Thachanan Samanmulya for suggestions and all help.

Finally, I most gratefully acknowledge my parents and my friends for all their support throughout the period of this research.

Titipon Wongnoi

Table of Contents

Page

Table of Content (Cont.)

List of Figures

List of Tables

Table Page

CHAPTER I

INTRODUCTION

1.1 Statement and significant of the problem

Unilever (Unilever) is a manufacturer of consumer goods, beverage, detergent and personal hygiene products, with more than 400 brands. In Thailand. There are two main offices in Rama 9 called Unilever House, and there are two factories including Minburi Factory at Ladkrabang Industrial Estate, Bangkok and Gateway at Gateway City, Chachoengsao, In this research, will be related to Ladkrabang factory, which in order to produce the goods using plastic materials and paper called flexible material

One in the company's brand, the Lux, which is a shower cream, is responsible for the kind of filling bag (pouch). The survey has found the lux would like to create a point of sale so that customers feel satisfied by reducing the % headspace down (a gap inside the product). Make the customer feel provide more product (bulk), but when adding product, we need to find a way to lower the cost by adjusting the size of the bag to compensate for more fluid use. It is also likely to change the type of material produced as pouch, so it is necessary to find out. The possibility of machine operation when modifying the material type and in the production of the goods is therefore collected and transported. What is necessary is the corrugated cardboard box, but because the paper box is currently the paper grade specification is too high. It leads the project to optimization to reduce its cost.

The Unilever Company has a vision to conduct business with sustainability. Have ways to reduce costs, therefore assigned to optimize the flexible material used to produce the company's products, both in terms of customer satisfaction and in terms of cost reduction due to the use of material specifications that are higher than necessary. In this research, consist of 3 parts the first part is reduce % headspace in pouch. The second part is find possibilities of BOPP material. And the last is an outer case optimize specification.

1.2 Objectives

1.2.1 Reduce % headspace in pouch.

- To study opportunities to reduce %headspace into 35% for pouch.

1.2.2 Find possibilities of BOPP material.

- To find the possibility of the machine working for BOPP material.

1.2.3 Outer case optimize specification.

- To study opportunities of outer case optimize specification.
- To compare type and level of damage in current option with optimize option.

1.3 Scope of this research

1.3.1 Reduce % headspace in pouch.

- Reduce %headspace to 35% in pouch lux brand size 200 ml and 450 ml.

1.3.2 Find possibilities of BOPP material.

- Take pouch BOPP material size 500 ml to trial in production line to find the possibilities of machine operation.

1.2.3 Outer case optimize specification.

- Optimize outer case for save cost by remove partition or reduce grade of paper in following product name. Lux 80 ml, Lux 100 ml, Lux 500 ml, Lux 500 TP, Lux 950 ml, Lux pouch 450 ml, Lux pouch 600 ml and VSL 450 ml.

1.4 Process of the study

1.4.1 Reduce % headspace in pouch.

- Make competitor analysis.
- Optimize pouch height and level of product in pouch.
- Take pouch that optimize material to trial in production line.

1.4.2 Find possibilities of BOPP material.

- Mock up pouch sample.

- Take to trial in production.

1.4.3 Outer case optimize specification.

- Investigation current specification and component of outer case.
- Try to reduce or remove component of outer case to find opportunities

Table 1.1: Process of the study.

No.	Title	1 month	2 months	3 months	4 months
1.	**Reduce % headspace in pouch.**				
1.1	Make competitor analysis for pouch.				
1.2	Calculation pouch height and weight of product.				
1.3	Take pouch in step 1.2 trial run in production line.				
1.4	Solve problem and trial run again.				
2.	**Find possibilities of BOPP material.**				
2.1	Request sample				
2.2	Trial in production line				
2.3	Solve problems				
2.4	Trial in production again.				
3.	**Outer case optimize specification.**				
3.1	Observation outer case components for each pack size. And **optimize** Corrugated box.				
3.2	Order in the designed specification in order to conduct experiments.				
3.3	Test following Unilever Method Analysis (UMA)				

1.5 Expected Outputs

The company will receive the following benefits.

1.5.1 Reduce % headspace in pouch.

- Know the characteristics of the company's products compared to the competitors in market.
- Know the guidelines for pouch design when wanting to reduce %headspace in pouch.
- Know the problems that occur in the production line. When changing specifications pouch and materials of pouch.
- Know the ways to solve problems that occur in the production line. Due to the specification and materials change.

1.5.2 Find possibilities of BOPP material.

- Known the problems that occur in the production line. When changing materials of pouch.
- Known the guidelines to solve problems that occur in the production line. Due to the materials change.

1.5.3 Outer case optimize specification.

- Known a guideline for reducing costs due to reduced specification or remove the corrugated box components.
- Known the issues and guidelines for editing. When adjusting corrugated paper.
- Known the type and level of damage to the product. Both in the use of corrugated boxes, the current specification and the specification has been adjusted.

CHAPTER II

THEORY AND LITERATURE REVIEW

Packaging is the technology of enclosing or protecting products for distribution, storage, sale, and use. Packaging also refers to the process of design, evaluation, and production of packages. Packaging can be described as a coordinated system of preparing goods for transport, warehousing, logistics, sale, and end use. Packaging contains, protects, preserves, transports, informs, and sells. In many countries it is fully integrated into government, business, institutional, industrial, and personal use [3].

It is necessary to study the matters relating to the packaging as a basis to lead to the understanding of the development and design of the packaging that looks right for the product. Therefore, in order to make this study according to the aim of the most developed, the development operator has explored the relevant papers and studies and has been processed to guide the development of this particular subject. The documents and related studies are divided into the following details.

2.1 Definition

The meaning or definition of packaging is an academic and expert as follows:

- กองส่งเสริมอุตสาหกรรม Packaging is a container that is used to transport products to the source, utilization by economical and safe.[1]

- Nikaido Clecture Packaging is a promotional technique with the benefit between objects and containers. It is intended to protect during transportation and storage in the stock. [2]

- Webster's new collegiate Dictionary Packaging is a box or package that is made to be maintained or transported. [3]

- สุดาดวง เรืองรุจิระ Packaging is various activities that arise throughout the marketing process related to the design. Create containers or parcels for the product. [4]

- ประชิด ทิณบุตร Packaging is a unit of the external object of the product, which protects the protection or encapsulation of the product inside, not to damage. Convenient to transport and benefit from trade and per consumption. [5]

- Briston And Neill The meaning of the packaging is two broad. [6]

1) The packaging is art, science and technology, preparing goods for transport and sales.

2) Packaging is a way to deliver products to consumers in a complete and reasonable price.

In conclusion, packaging design means defining the layout and structure of the packaging, in relation to the functional function of the product, to prevent damage to the product and to increase psychology value to the consumer. It is based on creative science and art.

2.2 Packaging function and form. [7]

The function of the packaging is as follows:

1. The functions of protecting to prevent damage or defect on product.

2. Facilitation functions (allows consumers to use the product easily and conveniently to sell in the store as well.

3. Marketing communication functions using for the space on the packaging, describing the properties to consumers about the quality of the product, methods of use, components and production sources.

4. Sale promotion functions by designing the packaging to be new, modern, suitable to the size and quantity. Helps to make a difference, able to sell more.

5. Value added functions make products look better and more valuable, such as iron boxes containing chocolate. Glass jar containing coffee etc.

Currently, the packaging material used is divided into large categories.

(1) Plant-based groups are various textile wood paper.

(2) Plastic based

(3) Metal based

(4) Glass and ceramic based

It has a wide range of features and qualities, and can be produced in a wide range of packaging materials. Classification of packaging can be divided into many ways according to the following criteria.

2.2.1 Packaging types are divided according to the packing methods and the loading and unloading methods. There are 3 types. [8]

- Primary package or Individual package is a packaging that touches the first layer of the product, with the first objective is to increase commercial value, such as defining a specific effect or providing a suitable shape, to hold and facilitate the use of internal products, while also providing protection to the product directly.

- Secondary package or Inner package is the second-floor packaging. It is the duty to gather on the first layer packaging together as a set. In total sales from 2-24 or more, with the first objective is to protect the product from moisture. Heat, lighting, and facilitate retail sales. Examples of this type of packaging include a cardboard box that contains 1 jar of drinks, 1 dozen soap etc.

- Out package or Shipping package is a large total unit of transport. Usually, the buyer does not see this type of packaging because it only protects the product during transport. The characteristics of this type of packaging are: wooden chests, large cardboard boxes that contain products inside the outside, will only tell you the information that is required to transport such as the brand code number, manufacturer etc.

2.2.2 Packaging classification according to the purpose of use.

- The consumer Package is a product that can be used by a single or multiple layer, which may be primary package or secondary package.

- Shopping or Transportation package is a package that supports or wraps a secondary packaging. The gathering of retail packaging is a large unit for safety and ease of storage and transport, such as corrugated cardboard boxes that contain toothpaste. 3 Dozen Boxes

2.2.3 Packaging classification according to its stability.[2]

- Rigid forms include glassware, ceramics, thermosetting plastic bottles, most of which are injection plastic. Pottery, wood and metal have strong, durable, favorable to use. And protect the product from the external environment well.

- Semi-rigid forms include packaging made from soft plastic. Paper and thin aluminum both price features weight and product protection are moderate.

- Flexible forms the packaging is made of soft materials. It has a very high popularity, because it is cheap (if used in large quantities and long-term), low weight has many forms and structures.

2.2.4 Divided according to the packaging material used Classification and name of the product packaging in the views of the manufacturer and the manufacturer or marketer will be different each package can be placed under the objective of package that is similar to protect products, distribute products and promote products.

2.3 Plastic Packaging

Nowadays, the popularity of plastic is the material to produce containers or parcels in various forms as well as other artifacts for use as a component of packaging products. It is used in many different forms and tends to increase due to plastic properties.

2.3.1 Properties of plastic for packaging. There are a few advantages:

2.3.1.1 The plastic advantages have good features and are extremely popular:

(1) Light weight, non-conductive heat and non-conductive electric.

(2) Is inexpensive. The cost of plastic is not high when compared with metal, glass or wood.

(3) Can prevent air penetration. Water or fat It is not rust, therefore, the cost of moisture and weather.

(4) Heat or cold resistant and resistant to acids, alkalis and chemicals based on each type of plastic.

(5) Easily processed and many types to choose from as appropriate plastic can be made into many forms of shrapnel in many ways. Both plastic and molded into a container.

(6) Can be used together with other packaging materials such as plastic coated with aluminum foil, plastic and paper

(7) Can print the pattern on the plastic container is not difficult.

(8) Can be recycled.

2.3.1.2 The disadvantage of plastic has disadvantages. Which should be considered as follows.

(1) Less stiff but there is a way to make the plastic stronger, stable, size by mixing strengthening agents such as glass fiber into about 30 percent of the raw materials.

(2) Difficult to destroy causing garbage problems and create pollution to the environment.

(3) Affect the health of consumers, such as the case of packing food products, if the use of plastic is not suitable. Or reducing the cost of business too much Causing consumer safety problems Because there will be contamination of various chemicals.

2.3.2 Bottom Gusset Pouches

Figure 2.1: Bottom gusset pouches [9]

Bottom gusset pouches are the most commonly used stand-up pouch (SUP) in the industry and is ideal for light weight products. It is basically a sealed plastic pouch and has a round bottom; it has been designed in a way that it can stand up-right. The edge of the gusset is welded to the sides of the walls for better strength and support.

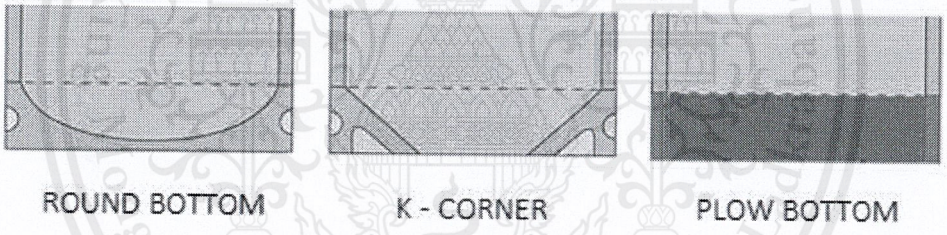


Figure 2.2: Type of bottom gusset pouches [9]

K-Seal Bottom and Plow Bottom are two more types of bottom gusset pouches which are modified from the round bottom pouches for extra weight capacity. Bottom Gusset Pouches are normally used for storing several types of food and non-food items. These pouches can be aseptically filled or with the help of packaging lines.

2.3.2.1 Headspace in pouch

Headspace is the vertical distance in mm height measured from upper level of liquid filled in pouch to top boundary of pouch when pouch is filled with desired volume of product and kept open stretching ends. Headspace is important criteria in pouch sizing at design

stage. Specially for home care liquids when it creates sloshing and foaming during filling pouch on-line. Wrong headspace can cause contamination in top seal areas leading to leakage.

Headspace can calculate by this equation

$$\%\ Headspace = \left(\frac{Pouch\ height - Skirt\ height - Top\ seal\ width - Fill\ height}{Pouch\ height - skirt\ height - Top\ seal\ width}\right) \text{x } 100$$

2.3.2.2 Material

1. Polyamide (PA), also known as nylon, is a clear and printable thermoplastic that has a relatively high melting point, exceptional strength and toughness, and good oxygen barrier properties. It is also scratch, puncture, and flex-crack resistant and does not dissolve/absorb grease, oil, or acidic food. These properties make PA ideal for use in conventional and microwave cooking applications.

The two most popular grades of polyamides are nylon 6,6 and nylon 6. Both have the same ratios of carbon, hydrogen, oxygen, and nitrogen, and possess very similar properties. However, there are some differences; under similar processing conditions, nylon 6,6 is usually more crystalline and more ordered than nylon 6 resulting in slightly different physical properties such as higher melting point, higher modulus, and slower permeability and moisture absorption, whereas nylon 6 has somewhat better ductility and impact resistance.

2. BOPP films (Biaxially Oriented PolyPropylene Films) are produced by stretching polypropylene film in both machine direction and transverse direction. BOPP film is used in vast range of applications comprising packaging, labeling and lamination. BOPP Films are preferred substrate for food packaging globally because of its inherent moisture barrier properties, seal ability, high clarity and graphic reproduction and shelf appeal, best possibilities of the pack being a mono layer/homogeneous structure. For food packaging, it is prominently used as co-extruded heat sealable reverse printable film. In labeling, it is preferred because of its yield benefit (Lowest density of 0.55 for IML orange peel effect), recyclability with PP containers. BOPP Films has a strong demand globally which is driven by expanding flexible packaging industry. The advantages BOPP offers are numerous.

Biaxial Stretching: Biaxially oriented film

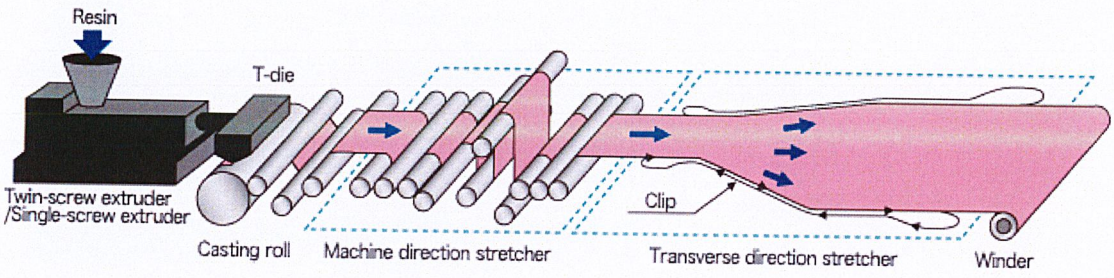


Figure 2.3: Biaxial stretching machine [10]

Which resins are melted in Twin screw extruder and forming a sheet with T-die. The sheets are pulled by casting roll parallel to the machine direction (MD) under temperature-controlled conditions. After that, the edges of the film are clamped by a clip and pulled out in a transverse direction (TD) with the extruder and cool down before roll by the winder.

1. **Shelf life extension**: Among all other commonly used plastic films, BOPP films provide excellent moisture barrier & its metallized variant provides better oxygen barrier to product. Both these properties of BOPP films play a key role in food packaging to extend the shelf life of products & thus reduce food waste.

2. **Product quality**: Apart from barrier properties, BOPP film provides consistent and excellent seal integrity because of narrow gauge spread. Good heat seal strength, lower seal initiation temperature, broad sealing window and good machinability further benefits into food packaging industry for protecting food quality.

3. **Sustainability**: BOPP film has a relatively low carbon footprint as compared to other plastic films substrate such as polyester. After cellulose film, BOPP Film is the second most preferred substrate for its ecofriendly nature in flexible food packaging. Because of its low melting point, it requires lower energy to convert from one form to other. Reprocessed granules of BOPP resin are widely used to manufacture injection molded parts, household items like sitting mats, chair, table, automobile spares etc.

4. **Aesthetic / Graphics**: Excellent transparency in clear BOPP films allows providing high level of aesthetic appeal to product packaging. Half tone printing jobs with multi-

color printing are also carried out with ease on this film for high quality graphics. In white opaque film variant, excellent gloss, high opacity and superb whiteness provides an attractive look to product packaging. Metalized film variety gives superior metallic appearance to stand out your product on the shelf. Because of good surface tension, post lamination operations like foil stamping, UV spot coating and embossing could be carried out to enhance aesthetic look of product packaging.

5. **Density**: It is a unique property that BOPP films has among all other commonly used flexible packaging films. Low density results into more yield during conversion and thus supports less plastic consumption concept per product. Low density results into less weight per roll for the same length of other plastic film which provides ease of material handling.

2.4 Paper packaging

Paper is a packaging material that has been used for a long time and has been very popular.

There are many types of pulp produced from different quality, have advantages, disadvantages, and factors that are brought into consideration as follows:

2.4.1 Paper properties for packaging

2.4.1.1 Advantages There are many advantages of paper suitable for packaging. And made it popular as follows:

(1) It can be easily cut off the pub. It can be designed as a shape. Various shapes easily.

(2) Lightweight, makes it convenient and saves transportation costs can be folded flat when not in use Resulting in saving storage and transportation space.

(3) Can print colorful patterns easily, convenient to store and transport, beautiful by using general printing system in many ways including saving costs than printing on other materials. And can print various pattern colors that needs to be placed on a sheet of paper before being molded, assembled into packaging.

(4) Various types of paper can be used in different quality levels (e.g. toughness, thickness, tear resistance, Pull off pressure) according to requirement and cost.

(5) It is a simple material that can be used to process circulation (Recycle) easily biodegradable paper in natural conditions. It is not difficult to destroy the paper packaging, so it does not cause as much pollution problems as the other packaging types.

(6) The paper price is considered to be an inexpensive material. compared to certain types of materials.

(7) Can be used in conjunction with other materials to make better functions such as plastic coaled paper, wax laminated paper, grease proof paper.

2.4.1.2 The disadvantages of the paper packaging are as follows:

(1) Unable to prevent moisture therefore lose strength when exposed to water or in wet conditions because the properties of paper generally allow water and gas to penetrate well.

(2) Less strong than other types of packaging such as metal, glass, hard plastic molded because the paper is resistant to compression, the tearing force less than other.

(3) When combined with other materials such as aluminum and plastic will be difficult to destroy.

2.4.1.3 Paper property considerations the paper packaging has the qualifications taken into consideration the following:

- Smoothness / porosity
- Grammage
- Fat / oil resistance
- Anti-tension and elongation
- Fastness to bending (Coagulation)

- Abrasion resistance
- Thickness
- Brightness
- Water absorption
- Tearing and piercing resistance (toughness)
- Horizontal vertical pressure resistance

2.4.2 Types of paper packaging are as follows:

2.4.2.1 Papers, used in packaging applications, there are several kinds of details:

(1) Tissue Is a lightweight paper Made from many types of wood pulp at rates between 7-18 pounds per ream, it may be cardboard or soft. It may also improve the quality to be able to withstand wet tearing, use as a twist wrap or liner that may be wax coated or coated with other materials such as aluminum.

(2) Bleached or Natural Laminating Paper it is a paper produced from sulfate or sulfite pulp in the level of 10 -90 pounds per ream that may have a rough or fine skin, typically with a Fairy Porous skin if made from kraft pulp. Will be strong If made from fine wood pulp, it will get a smoother surface. Most of which are bleaching paper with salt of sulfuric acid.

(3) Bleach or Natural Printing Paper similar to paper type 2, but with at least 1 side of the paper that is smoother and finer, which must be mixed in clay to get the desired properties. The quality of the paper is controlled to be thick and can absorb the texture. Printing ink or permeability of ink suitable for the technique printing in each country as well.

(4) Pouch Paper it is made from compressed Virgin Kraft Pulp. It is usually bleached into good quality paper for coating or suitable for printing.

(5) Crease Proof made from high quality hydrated pulp with high density fine paper is waterproof, oil and odor resistant.

(6) Glassine made from hydrated pulp smooth skin Is a transparent wax paper (Transparency) at many levels, which often include plastic compounds. To reduce brittle and easily broken.

(7) Parchment is a smooth surface paper coated with a chemical process to prevent the penetration of water or oil.

2.4.2.2 Paperboard The cardboard used for the production of packaging is as follows:

(1) Chipboards it is a paper made from recycled pulp that is used to decompose new tissues (Reclaimed Fibers). There are rough or fine quality and toughness of the paper in many different levels, such as the bending boards can bend. To 180 degrees. The board makes the curving a moderate (Semi-Bending Board) bend to 90 degrees, etc. This type of paper is a fluffing paper. Or compressed paper, etc.

(2) Solid Manila Boards Is a cardboard made from used paper most of them have a white liner, which is strong and can bend well.

(3) Kraft Cylinder Boards Made from old and new kraft paper with a cylinder machine, which is a quality paper with excellent resistance to bending, folding and folding.

(4) Kraft for Drinker Boards made from 100% new kraft pulp. Very durable to bend. Which can be coated with various materials such as plastic, wax in case you want to prevent wetness.

2.4.3 Corrugated Paperboard Box

Corrugated paperboard box is a paper packaging with the highest role and consumption. It has the information that the packaging type of paper produced in Thailand over 74 percent is a secondary corrugated cardboard box and a multi-layered paper bag. There are 12 percent production quantities, general paper bags, 2% production proportion of the total paper packaging capacity [1], because corrugated cardboard boxes are lightweight but strong the load is more than cardboard, so it can be used in many different types of products and can be boosters in order to ensure the suitable of products and the environment,

such as choosing a corrugated paper grade. It can also be designed to shape different sizes according to your needs.

2.4.3.1 Corrugated paperboard box (according to the Thai Industrial Standard Institute, TISI 321-2522) made up of corrugated paper sheet (Corrugated Board), which refers to a structured piece of paper composed of a flat sheet for making the skin box least with the corrugated paper is at least for the use of the box, that is, a corrugated sheet consists of two kinds of paper, such as paper making surface (Liner-board) and corrugated paper making corrugations flute (Corrugating Medium). As of figure 2.1

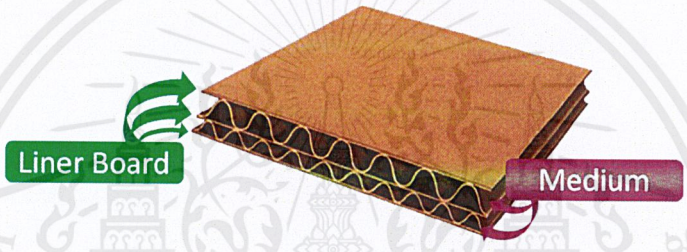


Figure 2.4: Corrugated Board [11]

2.4.3.2 Corrugations Flute the production of corrugated paper uses the principle of producing the curvature of the corrugated paper or "corrugation flute" and when attaching to the linerboard, it can withstand the curvature and pressure from all directions. There are many types of corrugations flute, with each type having different sizes and height. Including the suitability for use is also different. From Table 2.1, each type of flute is compared. And comparing the levels of advantages and disadvantages of each property of corrugated flute as shown in table 2.2

Table 2.1: Type of corrugations flute. [12]

Flute	Size	Flute height (mm.)	No. of flutes per meter	Properties
	A	4.2-4.7	104-125	It has excellent stiffness and short column crush resistance.
	B	2.1-2.6	150-184	Has good compression strength, compactness, printability and cost effective.
	C	3.3-3.8	120-145	Is very popular suitable for general products that can support medium weight.
	E	0.9-1.7	275-310	Best printing support suitable for small die cut boxes or offset boxes.
	BC	5.4-6.4	150-184	The combination of B and C flutes offers greater compression and stacking strength.

Table 2.2: Properties of corrugations flute. [13]

Properties	A-Flute	B-Flute	C-Flute	E-Flute
Stacking	Best	Fair	Good	Poor
Printing	Poor	Good	Fair	Best
Die cutting	Poor	Good	Fair	Best
Puncture	Good	Fair	Best	Poor
Storage	Best	Good	Fair	Poor
Score/bend	Poor	Good	Fair	Best
Cushioning	Best	Fair	Good	Poor
Flat crush	Poor	Good	Fair	Fair

Note: For BC flute is combine properties between flute B and flute C.

2.4.3.3 Type of combine board.

In general, we will divide plain paper into 3 types according to the number of layers of paper. There are 4 basic kinds of combined board:

- **Single Face:** One corrugated medium is glued to one flat sheet of linerboard.
- **Single Wall:** The corrugated medium is glued between two sheets of linerboard. Also known as Double Face.
- **Double Wall:** Three sheets of linerboard with two mediums in between.
- **Triple Wall:** Four sheets of linerboard with three mediums in between.

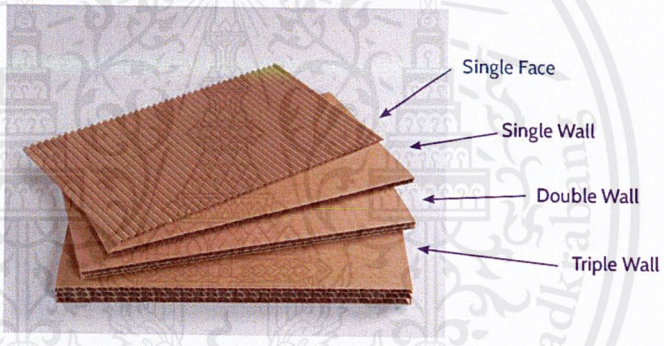


Figure 2.5 Type of combine board.[14]

Corrugated Box Strength It depends on the structure of the corrugated sheet. The type of paper (the quality and weight of the paper), and the style of the box, is the result of the box's properties, such as boxes made of 2-layer corrugated sheets.

2.4.3.4 Board combination

Liner 1	Paper made to the surface of the outer box.
Medium (BF)	Paper made flute (B-Flute).
Liner 2	Medium sticky paper.
Medium (CF)	Paper made flute (C-Flute).
Liner 3	Paper making the inside of the box.

- W170 / CM125 / CM125 / CM125 / A230 BC-Flute or W170 / 3CM125 / A230 BC-Flute means 5 layers of corrugated paper, BC outer surface paper grade KW KW170, Corrugated flute Paper B grade CA125, medium sticky paper grade CA125, corrugated paper grade CA125, inner surface paper grade KA230.

2.4.3.5 Paper quality

The type and quality of paper is directly related to the quality of the corrugated paper box. Therefore, choosing the right paper for the job needs to consider the following five features:

(1) Type of paper

"Kraft liner" or "Liner board" with natural colors as brown But can be bleached however, the bleaching process will result in 5 - 10% decrease in paper toughness. In some cases, the used pulp may be mixed into long fiber. This type of surface paper is called "Test liner". Corrugated boxes made from this type of paper have lower strength than "Kraft liner", especially when the box is used under hot, humid weather. And surface paper, divided into 5 categories as follows:

Liner Board: KS Referring to the white kraft paper emphasizing the beauty and color of printing, has a high surface smoothness, can be used to produce a strong box Help promote the image value of the product Commonly used for packing boxes, electrical appliances, medicine and medical devices. Frozen food for export and food such as dairy products, beverages, vegetables, fruits, etc. Basis weight 170 grams / sqm.

Liner Board: KA Referring to the golden yellow kraft paper Grade A golden yellow crafting paper, especially strong, durable, consistent color in every lot of production, making it a very popular product for domestic and export carton packaging. Certified according to the Thai Industrial Standards Institute TISI 170-22-2529 Suitable for producing various types of

product boxes, including electronic parts, circuit boards, frozen food for export, canned food, engines, textiles, etc. Basis weight 125, 150, 185, 230 grams / sqm.

Liner Board: KB Kraft paper for corrugated board making Has strong anti-impact strength for making different corrugated flute every wave to get high quality strong and suitable for the standard weight of paper including popular use as paper to make the box surface also able to make the box surface to be the most economical price as well. This is a way to reduce the cost of the company to make a brown box with that can reduce the cost of making the box for customers to deliver the product at the cheapest price as well. Basis weight: 105,125 grams / sqm.

Liner Board: KI stands for colorless kraft paper, environmentally friendly. It is a natural light color paper of pulp, with the second strength. Light color tones allow for the printing of dark color prints well. Suitable for packing domestic products. Popular usage is used for packing boxes of various products such as consumer products such as canned food, snacks, beverages. It is also used to pack leather. Furniture etc. Basis weight 125, 150, 185 grams / sqm.

Corrugating Medium: CA means craft paper for making corrugated sheets. Emphasizing the strength characteristics of the stacked parts and the strength of the corrugated flute to prevent impact of the product. Can make various sizes of corrugated sheet as required strength will increase with more basis weights. Certified in accordance with Thai Industrial Standard Institute TISI. 321-2530 for use in making corrugated sheets of size A, B, C standard weight 105, 115, 125, 185, g / sqm.

(2) Basis Weight

The basis weight or grammage is basic physical property of paper and paperboard. The basis weight of paper is calculating by the weight per unit area. It is mainly expressed as GSM (grams per square meter) and pounds per ream (500 sheets) of a specific size. It is also expressed in kg/m^2, pounds per 1000 sq. ft etc. Grammage are used in non-metric countries.

There are many grades of paper are found in market such as printing 80 GSM, 60 GSM, 70 GSM etc. 80 GSM means, the weight of one square meter is 80 grams.

(3) Ring crush resistance

The ring-pressure resistance represents the ability of the paper to get pressure, which is very necessary for putting a heavier parcel into the packaging, as it determines how much of the parcel can be placed. If the parcel or items that are put into place are more weight than the paper is supported, the paper can be penetrated or folded, which can lead to problems later.

(4) Bursting strength

Pressure resistance is a thing that indicates the capacity of the paper. Because the corrugated paper came into that packaging. Some businesses or companies can also provide various sharp ends, such as knives, scissors, glass pens, etc. So, in addition to wrapping the goods or parcels, the box itself must have a strong and sturdy support for puncture, so that the parcel is put into reach the recipient safely.

(5) Box Compression Strength

The pressure resistance of corrugated paper is the ability of the corrugated paper to resist the pressure exerted on the box until the corrugated paper is deformed or cannot bear further pressure. Which determines whether we can weigh different things how much can be superimposed on the box Because in the event that your box must go below other boxes to be stacked before shipping If that box has a low compressive ability May cause the collapse of the box And resulting in the parcel the items inside are also damaged.

BCT value or Box Compression Test. This value is often tied to a company's packaging specification as part of their performance spec requirements. That means that depending on a number of factors (the weight of the box contents, stacking pattern, safety factor, length of

storage, storage conditions, etc.) a company may call out a target compression value that their secondary packaging must meet as a minimum threshold for performance. [15]

Equation $$Box\ Compression\ Test\ (BCT) = k1 \times ECT \times \sqrt{h \times Z}$$

Where:

k1 = a constant value of 5.87

ECT = edge crush test in kPa/cm.

H = corrugated Fiberboard (CFB) thickness (inches).

Z = box perimeter (inches) = 2(L+W).

But in this research, we use BCT formulation modified from above to find BCT required. Then sent this value to supplier for produce outer case cover BCT required.

Equation

$$\text{BCT required} = \text{S.F} \times [Weight\ of\ product\ \ per\ case(kg) \times ((layer\ per\ pallet \times 2) - 1) + \frac{weight\ of\ pallet}{No.\ of\ case\ per\ layer}]$$

Factors that cause the box quality to decrease. [5]

In the use of corrugated boxes, which are containers used for the carriage of goods from the manufacturer to the end users. Corrugated boxes have to meet many different conditions during the use of corrugated boxes. Some of these relevant conditions are the factors that cause corrugated boxes to lose quality. Therefore, it is important to understand the effects of why the various factors affect the quality of the corrugated box before choosing the paper making boxes as follows:

1. Factors due to the amount of moisture in the air.

Since the paper is a material with an approximate humidity, change in the amount of moisture in the air. When the air has a relative humidity (Relative Humidity) higher. The moisture content in the paper is also higher, but it makes the box less pressure resistant.

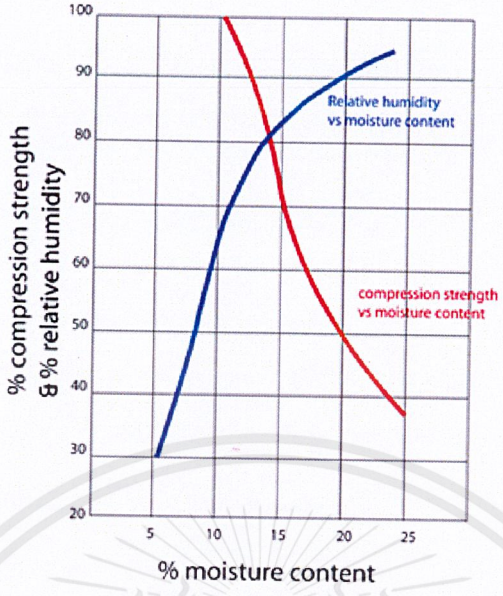


Figure 2.6 Relation between moisture content and % compression strength, relative humidity. [16]

2. Factors due to the period of storage box.

When the stack length is greater. Make the box less resistant to pressure.

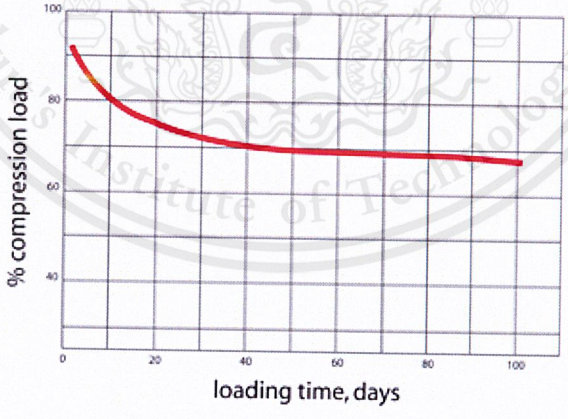


Figure 2.7 Relation between loading time and compression load. [16]

3. Factors due to the stacking characteristic,

Including the appearance of the area where the box is placed. It affects the ability to withstand the box pressure. (Box Compression Test or BCT)

Table 2.3: Stacking characteristic and % BCT remained. [12]

Stacking characteristics		% BCT remained
Not pallet	Column stacking	85%
Not pallet	Interlocking	60%
On pallet	Column stacking	75%
On pallet	Interlocking	50%

4. Factors due to the number of moves.

The number of moving boxes throughout the use of the box will result in less resistant to the BCT.

Table 2.4: Number of moves and % BCT remained. [12]

Number of moves	% BCT remained
2	95
5	80
10	64

CHAPTER III

RESEARCH METHODOLOGY

1. Reduce % headspace in pouch.

1.1 Apparatus

- Pouch in each brand
- Vernier & Steel scale
- Balance
- Light box
- Beaker
- Filling machine

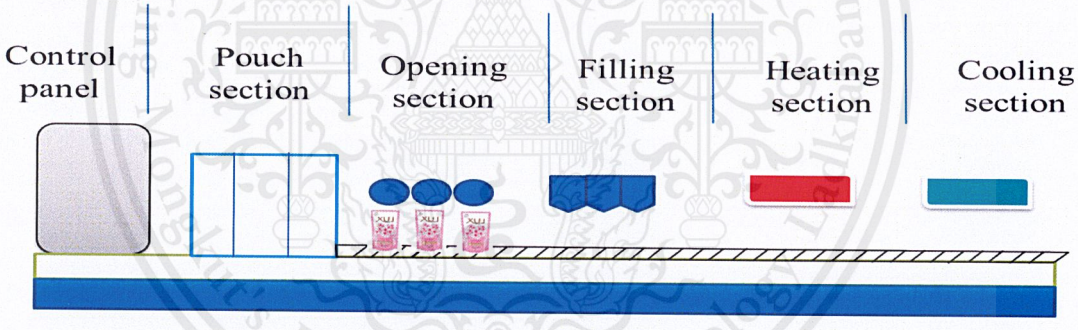


Figure 3.1: Machine that used for trial in production line.

The machine consists of the following components.

- Control panel is part of control temperature, speed of fill and fill weight
- Pouch section is part of Pouch section is part of that sucks pouch on a conveyor.

  Opening section is part of the rubber will be sucked pouch to open.
- Filling section it part of fill bulk into pouch by nozzle
- For heating and cooling section are part of sealing pouch.

1.2 Product and specification

Table 3.1: Specification of lux pouch.

Name	Pouch weight (g)	Total weight (g)	Filling weight (g)	Pouch height (mm)	Skirt height (mm)	Top seal width (mm)	Thickness (mm)	Fill height (mm)	% Headspace
Lux pouch 200 ml	6.39	245.79	239.40	185	8	10	0.11	80	52.10
Lux pouch 450 ml	10.31	515.89	505.58	250	8	10	0.16	125	46.12

1.3 Methodology

1.3.1 Construct competitor analysis.

Collect information about pouch in each product that is a commercial competitor in the market to study the nature of production such as designed, dimensions and amount of liquid filling, then take data to calculation % headspace for all brands.

1.3.2 Optimize and mock up pouch.

The data in step 1 is used to pouch the calculation to customize the 35% headspace before the trial.

1.3.3 Trial in production line.

Take sample test in production line to fine out problems that occur when actually works. Record the data and apply it to edit.

2. Find possibilities of BOPP material.

2.1 Apparatus

- Pouch BOPP material

- Filling machine (same as project 1)

2.2 Methodology

2.2.1 Mock up sample

Prepare pouch sample in pre-conditions following UMA methods before trial in production.

2.2.2 Trial in production line

Take sample test in production line to fine out problems that occur when actually works. Record the data and apply it to edit.

3. Outer case optimize specification.

3.1 Apparatus

3.1.1. Compression tester

A compression tester was used for determine the top load strength/compression force resistance of cartons, tubs/cups (made of plastics or carton board), cases/corrugated components.

3.1.2. Vibrating platform

A vibration tester was used for ascertain the amount and type of damage that may be expected from shipment of finished goods in their secondary or tertiary format.

3.1.3. Drop tester

A drop tester was used for test to ensure that a package will not break or burst during distribution, in store handling, if it is knocked from a shelf or if a consumer drops it.

3.2 Product name and specification

In this, part show current specification of the outer case as used in Unilever the detail show in table 3.1, as these specifications is used to determine the product in the next step.

Table 3.2: Specification of outer case.

No.	Product name	Weight of product/ pcs (kg)	Pcs/ case	Weight of product/case (kg)	ID outer case (mm)			Partition	Layer/ pellet	Case/ layer	Case/ pallet	Pallet pattern	Current material	BCT spec (kg•f)
					L	W	H							
1	Lux 80ml	0.100	96	9.6	398	208	296	Layer partition, Z partition	3	10	30		KS220/3CM127/KB220 (BC)	472.13
2	Lux 100ml	0.120	96	11.52	408	212	317	Layer partition	3	10	30		KS220/3CM127/KB220 (BC)	477.56
3	Lux 500ml	0.594	8	4.752	195	168	241	Divider and U partition	7	20	140		KS220/CM127/KB220 (C)	186.93
4	Lux 500ml TP	0.594	16	9.504	385	260	245	Divider Z partition	3	10	30		KS220/3CM127/KB220 (BC)	487.09
5	Lux 950 ml	1.0802	6	6.4812	275	195	263	Layer, Divider, U partition	3	18	54		KS220/CM127/KB220 (C)	212.7
6	Lux pouch 450ml	0.674	12	8.088	377	230	252	Short and long partition	3	10	60		KS220/3CM127/KB220 (BC)	472.52

7	Lux pouch 600ml	0.674	12	8.088	377	230	252	Short and long partition	3	10	60		KS220/3CM127/KB220 (BC)	472.52
8	VSL 450 ml	0.506	12	6.072	270	193	240	Layer and Divider partition	3	18	54		KS220/3CM127/KB220 (BC)	412.69

3.3 Methodology

3.3.1 Find opportunity

Learn the specification of an item from the specification sheet by Table 3.1 to see the box component dimensions and the item placement within the Inventory store box. See factors that affect the decrease in BCT value to take into account the safety factor that is used to calculate new BCT values that will continue to use.

3.3.2 Calculation BCT required and study actual product and design inner dimension of outer case.

This step will take the information from the previous two steps to design and customize a corrugated box. By considering various factors that have an effect.

3.3.3 Ordering product

In this step we sent BCT required and inner dimension to supplier then they will produce outer case that cover BCT required and change grade of paper due to safety factor.

3.3.4 Test following UMA method

3.3.4.1 Vibration Test [17]

Sampling: 1 Outer case (FGs inside) optimize option, 1 Outer case current option

Equipment: Vibrating platform

Experiment

- Precondition samples at 23oC / 50% RH for 24 hours before testing.
- Place the cases or pallet to be tested on the platform
- Vibrate the case/pallet (stood on its base) at a frequency so that the leading edge of the case lifts just enough to allow a 1.6 mm shim to move smoothly under the case.
- Maintain this frequency for 60 minutes.
- Record type and quantity of defect

Criteria: It will be passed if % defect less than or equal to % defect in current option.

3.3.4.2 Compression Test [18]

Sampling: 1 Outer case (FGs inside) optimize option, 1 Outer case current option

Equipment: Universal Tester

Experiment

- Place outer case at center of the Universal Tester.
- Set initial preload to (a) single-wall boxes, 223 N (50 lbf); (b) double-wall boxes, 446 N (100 lbf).
- Apply the test load at a rate of 13.0 mm/min.
- Record the load applied and the deformation until failure of the container.
- Compare FGs inside in optimize option with current option

Criteria: It will be passed if % defect less than or equal to % defect in current option.

3.3.4.3 Drop Test – SECONDARY PACK (Case of finished product) [19]

Sampling: 1 subject case containing product. optimize option, 1 subject case containing product current option

Equipment: Drop Tester

Experiment

- Pre-condition samples at 23 +/- 2 °C/ 50% RH for 24 hours.
- Drop from:

Weight (kg.)	Drop (cm)
0 - 10	105
10 - 20	90

- Drop each case in the following sequence: (10 drops per case)
  (1) Bottom
  (2) Side
  (3) Top
  (4) Opposite side

(5) End

(6) Opposite end

(7) Bottom corner with manufacturer's joint

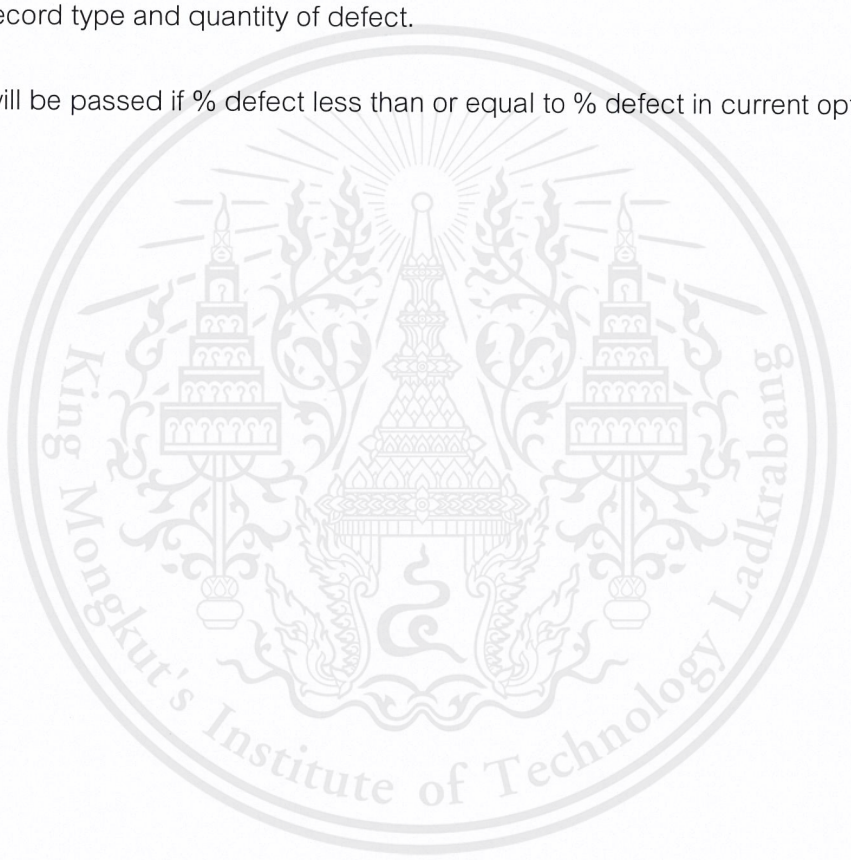
(8) Longest edge radiating from that corner

(9) Next longest edge radiating from that corner

(10) Shortest edge radiating from that corner

- Record type and quantity of defect.

Criteria: It will be passed if % defect less than or equal to % defect in current option.



CHAPTER IV

RESULTS AND DISCUSSION

The results from the experiments and their analysis particular topic are separately presented as follows:

Project 1: Reduce % headspace in pouch.

- Optimize and mock up pouch from competitor analysis table by considering that the optimize pouch are as follows: we need to add more bulk 82.35 g. When wanting to reduce% headspace to 35% for pack size 200, but still use current pouch height at 185 mm for save cost from plastic that use to height increasing. For pack size 450 will reduce pouch height from 250 mm to 220 mm and add bulk to 17.86 g. Although the height is lower than other brands in market but marketing department wants to keep it down to help reduce the amount of bulk to be added.

Trial in production line that provide result follow below

Table 4.1: Results of pack size 200 ml when trial in production line.

No.	Filling weight (g)	Problems	Solve	Results
1	270	Not found	-	Passed
2	280	Not found	-	Passed
3	290	Not found	-	Passed
4	300	- Contamination in top seal area.	- Load fill head down.	Passed
5	310	- Contamination in top seal area.	- Load fill head down. - **Decrease pressure of fill head.	Passed
6	311	- Contamination in top seal area and over flow.	- Load fill head down. - **Decrease pressure of fill head.	Failed

From table at filling weight 270 g, 280 g, and 290 g. and 310 g. of filling weight it needs to adjustment machine. Above 310 g of filling weight, even if the machine is adjusted, the results still failed.

Result of the Pack size 200. We want to fill up to approximately 321 g but when the fill reaches 300 g. The seal not completely due to the bubbles of the liquid spilling into the seal area. Solved by reducing the level of the nozzle down. And reduce the pressure which affects the velocity of the fill but when fill more than 310 g. Pouch can't seal because the liquid spills more because the level of liquid in the pouch is very high, so it can fill up to a maximum of 310 g. And results in table trial at condition bubble less than or equal 2% it can be seen that % bubble is important factor in the field. Therefore, from this equation 2, it used to calculate how many grams of liquid should be added if more than 2% of the bubble, so that there will be no sealing problems caused by bubble.

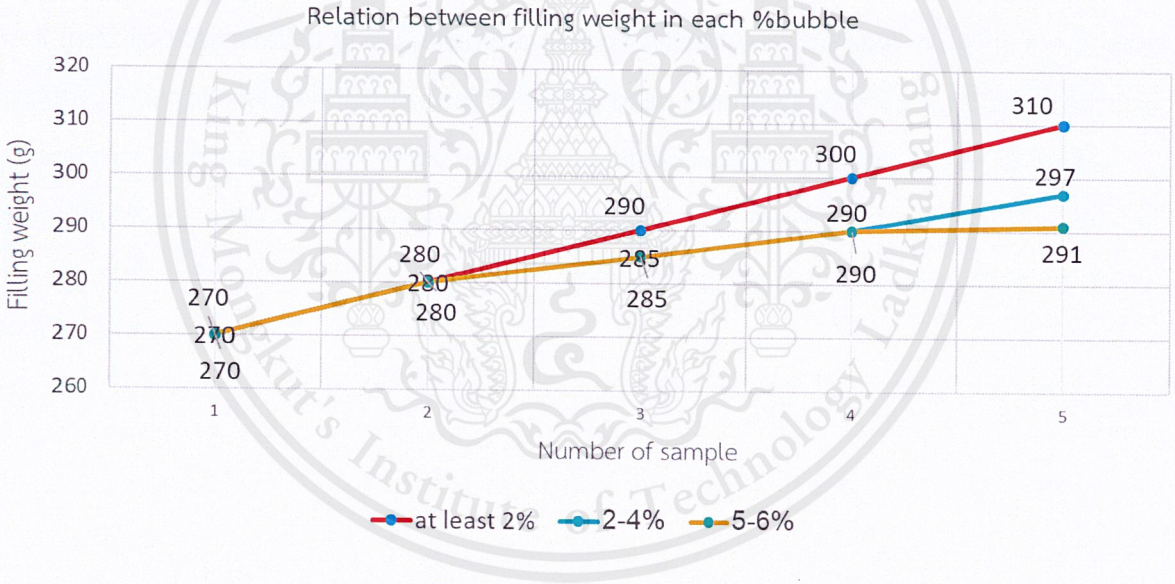


Figure 4.1: Relation between filling weight in each %bubble

This graph shown the relationship between the number of grams most fill in each% bubble. The x-axis is the number of sample 5 sample that can be filled with more weight, the y-axis is the filling weight. The red line is the line at %bubble less than 2%, it can fill max at 310g. The Blue line is at %bubble 2-4%, can fill max at 297 grams. The Yellow line is at % bubble 5-6%, can fill max at 291 g.

Project 2: Find possibilities of BOPP material.

When take BOPP sample to trial in production line by use machine and condition like lux pouch size 450 in part **reduce % headspace in pouch project.**

Table 4.3: Results of BOPP material when trial in production line.

No.	Filling weight (g)	Problems	Solve	Results
1	510	1. Pouch shorter filling head can't fill complete. Sealing and cooling bar can't work complete. 2. Suction rubber crash the base that we added. 3. Seal quality poor by temperature.	1. Build a base to compensate for the height. 2. Adjust load cell to control level of sucker panel. 3. Adjust temperature in sealing section.	Passed
2	515			Passed
3	520			Passed
4	525			Passed
5	530			Passed

This table show result of BOPP material we fill as the same lux size 450 ml and found 3 problems. First is pouch shorter filling head can't fill complete. Sealing and cooling bar can't work complete. Solve by build a base to compensate for the height. Next problem is Suction rubber crash the base that we added. Can solve by Adjust load cell to control level of sucker panel. And last problem about seal quality by temperature solve by try to adjust temperature to find suitable temp.

From chapter 3, you'll see that the block of heating section has three blocks. The block no.3 have problem we try adjusting temperature to suit the new material type.

Figure 4.2: Sealing defect at Front

Figure 4.3: Sealing defect on back.

This picture shows a defect of sealing caused by temperature, because the material changes. The seal will occur outside the required area. Cause the melting point of BOPP is lower than the original material, so it is necessary to adjust the Temp down until the adjustment from 160 to 120 a defect is lost.

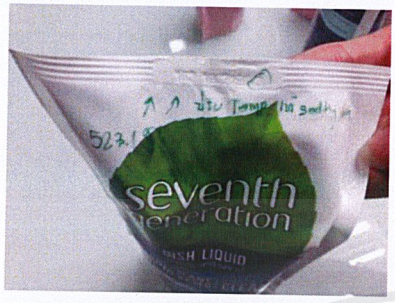


Figure 4.4: BOPP after solve sealing defect at front.

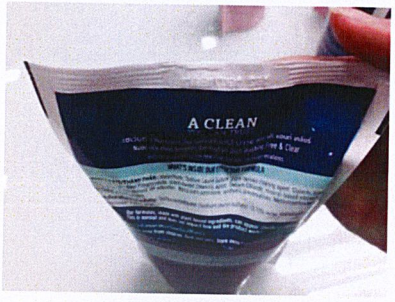


Figure 4.5: BOPP after solve sealing defect at back.

Project 3: Outer case optimize specification.

3.1 Find opportunity & Ordering product from supplier

Current Unilever use safety factor at 10 that is over spec provide outer case have high grade, it is not necessary to study the factors affecting BCT value, which affects the quality of the box. The transport not very serious. BCT calculation and inner dimension design.

Table 4.4: BCT required, components and ID adjusted of outer case when calculated by using safety factor equal to 6.

Product name	BCT required (kg•f)	Partition remain	ID (L x W x H)
Lux 80 ml	309.60	1 Layer partition	380 x 208 x 290 mm
Lux 100 ml	367.20	1 Layer partition	377 x 230 x 252 mm
Lux 500 ml	171.07	1 Divider partition	195 x 157 x 241 mm
Lux 500 ml TP	306.72	1 Divider partition	385 x 260 x 245 mm
Lux 950 ml	206.44	Divider partition	275 x 195 x 263 mm
Lux pouch 450 ml	264.24	Short and long partition	377 x 230 x 252 mm
Lux pouch 600 ml	264.24	Short and long partition	377 x 230 x 252 mm
VSL 450 ml	194.16	No partition	260 x 188 x 240 mm

Table 4.5: Specification of outer case from supplier that produce cover BCT required.

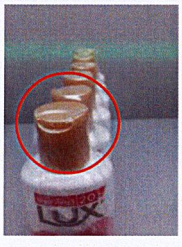
Product name	BCT spec (kg•f)	Material	Flute type
Lux 80ml	423.67	KS220/3CM127/KB150	BC
Lux 100ml	371.34	KS150/3CM127/KB150	BC
Lux 500ml	227.26	KS220/3CM127/KB150	BC
Lux 500ml TP	378.75	KS220/3CM127/KB220	BC
Lux 950 ml	258.60	KS220/CM197/KB220	C
Lux pouch 450ml	367.43	KS150/3CM127/KB150	BC
Lux pouch 600ml	367.43	KS150/3CM127/KB150	C
VSL 450 ml	256.67	KS220/CM197/KB220	C

From table 4, the result is calculated by using safety factor equal to 6, and BCT part of the partition to reduce the box specification and adjust the dimension to the box. From table 5 is the data of the corrugated paper box at the supplier, which covers the specification sent, with the BCT-grade paper and flute type, as shown in the table, then continue to test according to UMA methods.

In detail, from table 4 and 5, In size 80 ml, the grammage changed, the remove Z-partition and adjust dimension to compensate for the gap from removing the partition. In LUX 100 ml, the partition has been carried out before the upgrade to the next possible test. For Lux 500 ml we remove partition and decrease width of outer case. For Lux 950 ml we remove layer and u-partition but still use current dimension Because there is not much gap from remove partition. For lux 500 ml TP, lux pouch 450 and lux pouch 600 ml we optimize by reduce grammage of paper only. VSL450 we reduce flute type from BC to C and remove all partition and adjust dimension. For Lux 500 ml we remove partition and decrease width of outer case.

3.2 Test following UMA methods.

Table 4.6: Results of Lux 80 ml in following UMA methods.

Test methods	Observation	%Defect		Possible root cause	Remark
		Current	Optimize		
Vibration	- Sleeve scratched on side.	62.50% (10/16)	12.5% (2/16)	- Sleeve rub with other multipack.	
Compression	- No issue.	-	-	-	- Outer case can protect bottle.
Drop test	- Film laceration on cap area.	87.5% (14/16)	81.25% (13/16)	- Multipack rub with OC.	

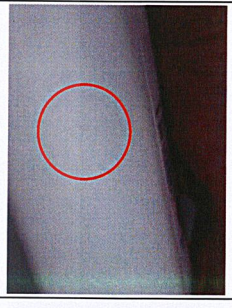
In size lux 80 ml, vibration test found scratch defect on film at side of multipack cause by remove partition that have space. So, bottle rub with each other. But bottle don't have scratch. Scratch occur random of multi pack in current design used Z-partition to prevent this defect but still encountering this problem. When removed Z- partition found scratch more than current but FGs don't have damage. Scratch defect can solve by reduce the length so that there are no spaces that can provide good result. For compression not found issue so outer case in new case can protect FGs. For drop test founded film on cap area laceration. But cap don't have defect. This defect caused by film rub with outer case in it solve by reduce height for decrease this defect.

Table 4.11: Results of Lux pouch 450 and 600 ml in following UMA methods.

Test methods	Observation	%Defect		Possible root cause	Remark
		Current	Optimize		
Vibration	- No issue	0%	0%	-	-
Compression	- No issue	0%	0%	-	-
Drop test	- No issue	0%	0%	-	-

In Lux pouch 450 and 600 ml, we optimize by reduce grammage of paper only. For all test methods not found defect on pouch both current and optimize option.

Table 4.12: Results of VSL 450 ml in following UMA methods.

Test methods	Observation	%Defect		Possible root cause	Remark
		Current	Optimize		
Vibration	- Bottle scratched on front and back of bottle.	100% (6/6)	100% (6/6)	- Bottle rub with other.	
Compression	- No issue	-	-	-	Outer case can protect bottle.
Drop test	- Damage on bottom of bottle	83.33% (5/6)	83.33% (5/6)	- Damage by impact from a fail. bottle.	

VSL450 we reduce flute type from BC to C and remove all partition and adjust dimension. Vibration test founded deep scratch on side of bottom because remove partition

CHAPTER V

CONCLUSION

5.1 Conclusion

Project 1. Reduce %headspace in pouch.

1. In size 200 ml, the result is failed because the maximum bulk filling weight is only 310 g. provide 38% headspace.

2. The pouch size 450 ml, which changes the height of the pouch. As a result, passed it can be reduced to 35%. But need to add a base and adjust the machine.

Project 2. Find possibilities of BOPP material.

1. Used machine same as first project and need a base and adjust some parts of machine.

2. Project passed if adjust the heating temperature for BOPP.

Project 3. Outer case optimize specification

For last project the results are passed when compare with current option. Because % defect and type of defect in optimization option are equal or less than current option.

5.2 Suggestion for future work

This 450 ml in reduced % headspace in pouch project can be seen as a cost reduction, but for size 200, reducing the % headspace required bulk too much. The original product is more suitable than optimize. For find possibilities of BOPP material project. There is not much process and cost in adjusting the machine. Which is good to replace the costly materials. And in outer case optimizes specification project some parts of the box are not needed and therefore suitable for removal. But may affect the internal product arrangement and the convenience of the staff therefore needs further development including the actual transport trial to see the damage.

REFFERENCES

[1] กองส่งเสริมอุตสาหกรรม, "Packaging Design ARTD3301," 1974. [Online]. Available: http://artd3301-bodin.blogspot.com/. [Accessed: 27-Jan-2020].

[2] "ARTD3302-การออกแบบบรรจุภัณฑ์: ความหมายของการออกแบบบรรจุภัณฑ์," 2015. [Online]. Available: http://artd3302-yuttana.blogspot.com/2014/09/1-packaging-251719-nikaido-clecture.html. [Accessed: 27-Jan-2020].

[3] N. Webster, *New collegiate dictionary. A Merriam-Webster.*, 2d ed. Springfield Mass.: G. & C. Merriam Co., 1956.

[4] สุดาดวง เรืองรุจิระ., *หลักการตลาด*, 9th ed. กรุงเทพมหานคร: ประกายพรึก, 2000.

[5] ประชิด ทิณบุตร, *การออกแบบบรรจุภัณฑ์*. โอเดียนสโตร์, 1988.

[6] T. . Briston, J.H. and Neill, *Packaging Management*. Epping, Essex: Gover press., 1972.

[7] G. L. Robertson, *Food Packaging: Principles and Practice. 3rd Ed.* 2013.

[8] อาชีวศึกษาสุราษฎร์ธานี, "บรรจุภัณฑ์ - Online learning series 4," 2016. [Online]. Available: https://sites.google.com/site/onlinelearningseries/hnwy-thi-1-phlitphanth/brrcuphanth. [Accessed: 27-Jan-2020].

[9] "Bottom Gusset Pouches | Bottom Gusset Bags | Doy Pack | Doyen Pouch," 2018. [Online]. Available: https://www.smartpouches.com/pouches/stand-up-pouches/bottom-gusset-pouches/. [Accessed: 27-Jan-2020].

[10] "Biaxially oriented polypropylene film," 2017. [Online]. Available: http://www.zaeteaw.net/2017/08/biaxially-oriented-polypropylene-film-bopp/. [Accessed: 27-Jan-2020].

[11] "เกี่ยวกับกระดาษ." [Online]. Available: http://leepaper.co.th/index.php/th/layout/layout-two. [Accessed: 27-Jan-2020].

[12] ค. อภิปรัชญาสกุล., *Goods and packaging*. กรุงเทพ: โฟกัสมีเดีย แอนด์ พับลิชชิ่ง, 2014.

[13] J. Packages, "Design of Corrugated Fiberboard Boxes," 2015. [Online]. Available: https://slideplayer.com/slide/1448671/. [Accessed: 27-Jan-2020].

[14] Cnelson, "Four types of combined board for corrugated - Lets Package," 2016. [Online]. Available: https://www.letspackage.com/four-types-combined-board-corrugated/. [Accessed: 27-Jan-2020].

[15] R. Kaszubowski, "Packaging Matters: Edge Crush Test vs. Box Compression Test," 2015. [Online]. Available: http://packaging-matters.blogspot.com/2015/05/edge-crush-test-vs-box-compression-test.html. [Accessed: 27-Jan-2020].

[16] "National Quality Infrastructure (NQI)." [Online]. Available: https://www.nqi.go.th/nqi/lab.php?item=527. [Accessed: 28-Jan-2020].

[17] T. T. Protocol, "UMA-HPC Packaging Test Method." pp. 1–8, 2006.

[18] O. T. Method, T. The, T. T. Method, M. Safety, and D. Sheets, "Compression test of fiberboard shipping containers," 2002.

[19] T. T. Protocol, "Drop Test," pp. 1–8, 2006.

Table A1: Competitor analysis for pack size 200 ml.

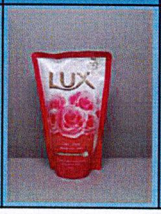
Components	Shokubutsu	LUX	Biore	Benice	Betadine	Kirei Kirei
Photo						
Type	Body wash			Hand wash		
Declare Volume (ml)	200	200	220	200	200	200
Actual volume (ml)	170	228	220	200	200	205
Bulk weight (g)	211.01	239.40	236.28	209.35	206.90	211.88
Pouch height (mm)	197.00	185.00	195.00	190.00	200.00	195.00
Skirt height (mm)	6.00	8.00	5.00	3.00	10.00	6.00
Total width (mm)	120.00				110.50	120.00
Top seal width (mm)	10.00	10.00	10.00	12.00	10.00	10.00
Pouch Thickness (mm)	0.11	0.11	0.15	0.10	0.12	0.12
Fill height (mm) (close/open)	90.00/70.00	85.00/80.00	100.00/75.00	76.00/74.00	93.00/80.00	85.00/72.00
%Headspace	61.33	52.09	58.33	57.71	55.56	59.78
Produced by	Lion Corporation (Thailand) Limited	Unilever Thai Holdings Ltd.	Kao Vietnam Co.,Ltd.	Neo Factory Co., Ltd.	Milott Laboratories Company Ltd., of Thailand	Lion Corporation (Thailand) Limited

Table A2: Competitor analysis for pack size 400 ml and 450 ml.

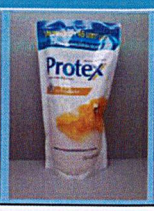
Components	Betadine	Be nice	Dettol	Protex	Shokubutsu	LUX	Essence
Photo							
Type	Body wash						Hand wash
Declare Volume (ml)	400	400	400	400	450	450	400
Volume contained (ml)	400	400	390	390	450	470	400
Bulk weight (g)	403.48	406.17	399.21	389.58	454.44	505.58	400.49
Pouch height (mm)	235.00	245.00	240.00	245.00	245.00	250.00	218.00
Skirt height (mm)	10.00	3.00	8.00	8.00	8.00	8.00	8.00
Total width (mm)	130.50	130.50	140.00				
Top seal width (mm)	10.00	10.00	9.00	12.00	10.00	10.00	10.00
Pouch Thickness (mm)	0.15	0.12	0.16	0.12	0.14	0.16	0.12
Fill height (mm) (close/open)	115.00/102.50	110.00/101.00	108.00/95.00	105.00/96.50	115.00/111.00	130.00/125.00	115.00/99.50
% Headspace	52.33	55.51	57.40	57.11	51.10	46.12	50.25
Produced by	Milott Laboratories Company Ltd., of Thailand	Neo Factory Co., Ltd.	Colgate Palmolive (Thailand) Limited	Lion Corporation (Thailand) Limited	Unilever Thai Holdings Ltd.	Lion Corporation (Thailand) Limited	Rubia Industries Ltd.,

Table A3: Result of calculation filling weight required and pouch height when needed 40, 35 and 30 % headspace for lux pack size 200 ml.

Otimization size 200 ml								
pouch weight	Fill +pouch weight (g)	Filling weight (g)	Pouch height (mm)	Skirt height (mm)	Top seal width (mm)	Thickness (mm)	Fill height	% Head Space
6.39	245.79	239.40	185.00	8.00	10.00	0.11	80.00	52.09580838
6.39	298.13	291.74	185.00	8.00	10.00	0.11	100.20	40
6.39	313.17	306.78	190.00	8.00	10.00	0.11	103.20	40
6.39	320.03	313.64	195.00	8.00	10.00	0.11	106.20	40
6.39	326.58	320.19	200.00	8.00	10.00	0.11	109.20	40
6.39	328.14	321.75	185.00	8.00	10.00	0.11	108.55	35
6.39	339.43	333.04	190.00	8.00	10.00	0.11	111.80	35
6.39	352.89	346.5	195.00	8.00	10.00	0.11	115.05	35
6.39	365.5	359.11	200.00	8.00	10.00	0.11	118.30	35
6.39	356.61	350.22	185.00	8.00	10.00	0.11	116.90	30
6.39	373.34	366.95	190.00	8.00	10.00	0.11	120.40	30
6.39	383.84	377.45	195.00	8.00	10.00	0.11	123.90	30
6.39	396.82	390.43	200.00	8.00	10.00	0.11	127.40	30

Table A4: Result of calculation filling weight required and pouch height when needed 40, 35 and 30 % headspace for lux pack size 450 ml.

Optimization size 450 ml								
pouch weight	Fill +pouch weight (g)	Filling weight (g)	Pouch height (mm)	Skirt height (mm)	Top seal width (mm)	Thickness (mm)	Fill height	% Head Space
10.31	515.89	505.58	250.00	8.00	10.00	0.16	125.00	46.12068966
10.31	586.35	552.31	250.00	8.00	10.00	0.16	139.20	40
10.31	558.34	548.03	240.00	8.00	10.00	0.16	133.20	40
10.31	536.84	526.53	230.00	8.00	10.00	0.16	127.20	40
10.31	485.43	475.12	220.00	8.00	10.00	0.16	121.20	40
10.31	637.52	612.14	250.00	8.00	10.00	0.16	150.80	35
10.31	600	589.69	240.00	8.00	10.00	0.16	144.30	35
10.31	577.88	567.57	230.00	8.00	10.00	0.16	137.80	35
10.31	533.75	523.44	220.00	8.00	10.00	0.16	131.30	35
10.31	691.6	670.04	250.00	8.00	10.00	0.16	162.40	30
10.31	644.97	634.66	240.00	8.00	10.00	0.16	155.40	30
10.31	617.37	607.06	230.00	8.00	10.00	0.16	148.40	30
10.31	583.13	572.82	220.00	8.00	10.00	0.16	141.40	30

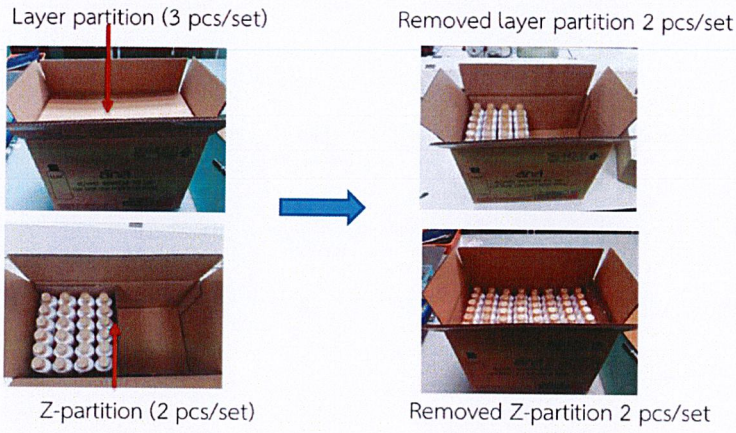


Figure A1: Corrugate box and product arrangement inside for lux 80 ml.

Figure A2: Corrugate box and product arrangement inside for lux 100 ml.

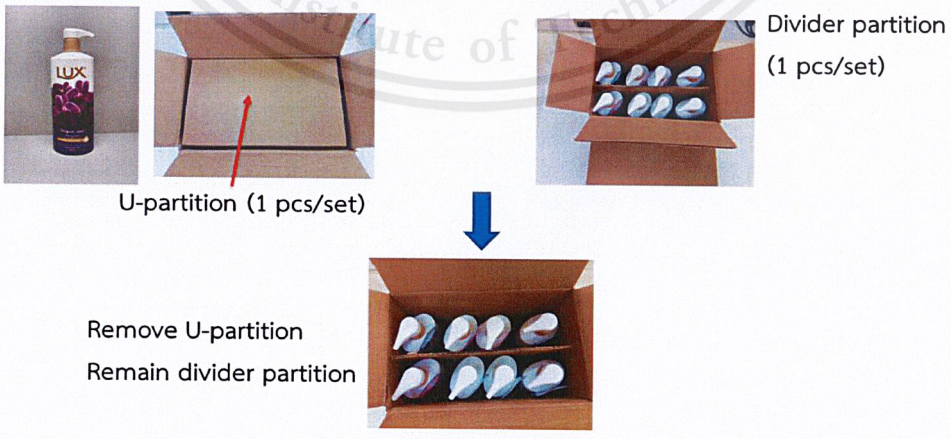


Figure A3: Corrugate box and product arrangement inside for lux 500 ml.

Figure A4: Corrugate box and product arrangement inside for lux 500 TP ml.

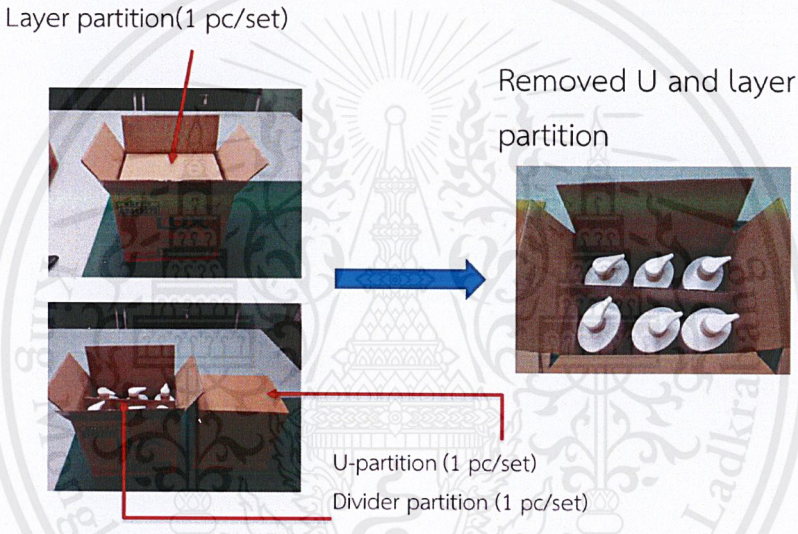


Figure A5: Corrugate box and product arrangement inside for lux 950 ml.

Figure A6: Corrugate box and product arrangement inside for lux pouch 450 and 600 ml.

BIOGRAPHY

Name: Titipon Wongnoi

Date of Birth: 26 August 1996

Address: 89/261 Sa-mae Dum Bang Khun Thian, Bangkok 10150

E-mail: Titipon_wongnoi-alone@hotmail.com

Academic Background:

- 2012 – 2014: High School

  Rattanakosinsomphodbangkhuntian Scchool, Bangkok
- 2016 – Present: Bachelor Degree of Petrochemical Engineering.

  Faculty of Engineering, King Mongkut's Institute of Technology Ladkrabang.

Working Experience:

- June 2019 – December 2019: Unilever Thai Holding Co.,Ltd.

  Internship Program 2019 and Co-operative Education Program 2019