S-Cane Pack

by

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Mechanical Engineering Programme
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in partial fulfilment of the requirement for the
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Approved by,

____
(Dr. Azmi Bin Abd. Wahab)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

January 2013

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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Nurafiqah Binti Hata Suhaimi

ABSTRACT

Eco-friendly products are gaining market in recent years as public is coming to value the benefit of environment friendly products and practices.Awareness rise as the world population is expanding, demanding greater need for materials, meanwhile landfills are filling up and pollution on Earth increases. The project is aimed as part of contribution towards environmental cause. S-Cane Pack is a food packaging prototype that will be made from sugarcane waste.It is an experimental based project in which raw sugarcane waste will be processed to extract the fiber, formed into paper and molded into a packaging shape.Recently, there are many researches and few commercialize products made from plant fibers such as wheat straw, cotton, flax, corn waste, rice husk, ramie and palm oil waste. Plant fiber resources are in favor because it is renewable, widely distributed, available locally and also biodegradable.Creating S-Cane Pack has the potential to be a partial solution to many environmental problems such as deforestation and shortage of landfill space. Presently, huge amount of trees are being cut off to obtain wood for pulping process in paper making industry. The significance of the project is to seek alternatives for wood in the paper making process to reduce deforestation by utilizing farm waste such as sugarcane. Not only the rate of deforestation will be reduced, S-Cane Pack also promotes recycling of waste rather than just being thrown away and further increases the landfill space. The outcome of the project is a packaging prototype made from sugarcane waste which exhibit reasonable properties in terms of its tensile strength and also appearance wise. Tensile strength of the prototype is also compared with the existing packaging available in the market such as Styrofoam, cardboard and paper. S-Cane pack is found out to have a comparable tensile strength with Styrofoam but weaker than cardboard and paper in terms of tensile strength. However, there are future recommendations to be made to further enhance the quality of the prototype. Creating a biodegradable packaging material from sugarcane waste would not only have significant benefits for today’s environment, economy, technology and society but for the future as well.

ACKNOWLEDGEMENTS

I, Nurafiqah Hata Suhaimi would like to thank Universiti Teknologi Petronas for the opportunity to complete my Final Year Project for semester May 2013. The project enhance my knowledge theoretically as well as in practical area. Upon completion of the project, titled S-Cane Pack, I am able to apply some theoretical knowledge into an experimental project. Utmost appreciation is expressed to Dr. Azmi Abd Wahab, my supervisor, for the continuous guidance and support upon completion of theproject. Appreciation is also expressed to Dr. Mohd Zaki Abdullah, my co-supervisorfor his continuous cooperation throughout the project.The two semesters Final Year Project delivers an experience to develop my personal skills through anticipation in planning and execution of the project. It also give a closer exposure to hands-on experimentallab environment. The opportunity to work with supervisors, lecturers, lab technicians and team mates within the university enhances communication skill and introduces me to work culture. Greatest gratitude to everybody that was directly or indirectly involved during the project. The successful completion of this project hopefully contributes to Universiti Teknologi Petronas in fulfilling its organizational objectives. S-Cane Pack also aims to promote environmental awareness to the community by producing a useful product through waste recycling. Again, I would like to thank Universiti Teknologi specifically to Dr. Azmi Abd Wahab on the permission to publish this Final Year Dissertation Report.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

The pulp and paper industry has a great influence on global forests as it is one of the largest industry in the world. The sector which produces products such as office paper, glossy paper, tissue and paper-based packaging, uses over 40 percent of all industrial wood traded globally. Pulp and paper productions have had devastating impacts on some of the world's most ecologically places and species. The project is to investigate on the alternative source to replace wood for paper productions. S-Cane Pack is a food packaging prototype that will be made from sugarcane waste. The fiber from sugarcane waste (bagasse) is recycled and reused for packaging material in the project.The paper is then to be fabricated into a paper-based packaging container which is usable and comparable in its properties

1.2 Problem Statements

The significance of the project is to find alternative to replace wood as natural fibers for paper making. This is to reduce deforestation which is in great concern these years. Shortage of landfill space also imparts awareness to utilize and recycle raw waste. Rather than the waste being thrown away and increase landfill spaces it is beneficial if there is ways to transform it into useful products. Therefore, studies and methods to manufacture usable products by recycling some of the waste are in high demand.

1.3 Objective

The main objective of the project is to create paper from sugarcane waste as the fiber component and to transform it into a packaging prototype (S-Cane Pack). The prototype is then compared with typical packaging materials in terms of appearance and tensile strength.

1.4 Scope of Study

The scope of the project will be first to experiment on paper making process using bagasse as the fiber. Different natural adhesives/bonding agents for the paper making process are varied during the experiment. The experimental procedure will also be optimized and modified based on the outcome. After paper making process, the aim is to produce a usable packaging prototype based on the paper. Progress in the project will also accommodate mechanical testingas well as some qualitative testing on the prototype. This is to determine the mechanical properties of the product and its qualitative aspects.

CHAPTER 2

LITERATURE REVIEW

Literature review on natural fibers, sugarcane fibers (bagasse), paper making processes, packaging prototyping and testing methods are done to further enhance the author knowledge on the subject. Previous research and some examples of already existed recycled plant based products are also referred to.

2.1 Natural Fibers

In many countries, wood is inadequate to meet the rising demand for paper (Atchison 1987, Judt 1993). Research is done to find alternative raw material to replace wood as a fiber for paper production. In developing countries, about 60% of natural fibers originate from non-wood raw materials such as bagasse,cereal straw, bamboo, reeds, esparto grass, jute, flax, and sisal (Gullichsen 2000). The fiber properties used in papermaking is important to increase its mechanical properties.

2.2 Sugarcane Fiber (Bagasse)

Sugarcane (Saccarhum officinarum) bagasse is a residue produced in large quantities by sugar industries. It is the by-product left after the crushing of sugar cane for juice extraction. On average, about 32% of bagasse is produced from every tonne of sugar cane been processed. The total plantation area of sugarcane in Malaysia is nearly 34,500 Acres. About 1,111,500 tonnes of sugar cane is produced in 2002. Hence bagasse can be easily obtained in Malaysia. (S.C. Lee, M. Mariatti, 2008). Increasing concern of disposal of bagasse residual creates interest to explore the potential application of this material. The major current application of bagasse is as biomass fuel to generate energy. Nevertheless, there are also fewresearches on utilizing bagasse for pulping process in paper making process and packaging industry.

Bagasse is one of the agricultural residues used for pulp manufacture. Bagasse pulp is used for all grades of papers (Atchison 1987b). The ratio of fiber length and width can estimate the pulp quality.

The fibrous constituent is the most important part of the plant. The composition and amount of fibers is reflected in the properties of cell walls where cellulose is the principal components. Table 1 shows that bagasse have 32-44% amount of alpha-cellulose percentage which is comparatively higher among other plant species such as rice, wheat, bamboo and kenaf. This is one of the reasons why bagasse fiber is chosen among other fibers. Some other reasons include the abundance and availability of bagasse in Malaysia and also the high percentage that bagasse is produced by sugar industries.

TABLE 1: Content of alpha-cellulose, lignin, pentosan, ash and silica (% of dry matter) in selected fibre plants. Adapted from Hurter (1998).

Plant species	Alpha-cellulose %	Lignin %	Pentosans %	Ash %	SiO_2 %
Stalk fibres (grass fibres)					
Cereals -rice	28–36	12–16	23–28	15–20	9–14
-wheat	29–35	16–21	26–32	4–9	3–7
-oat	31–37	16–19	27–38	6–8	4–7
-barley	31–34	14–15	24–29	5–7	3–6
-rye	33–35	16–19	27–30	2–5	0.5–4
Grasses -esparto	33–38	17–19	27–32	6–8	2–3
-sabai	–	17–22	18–24	5–7	3–4
Reeds -common reed	45	22	20	3	2
-bamboo	26–43	21–31	15–26	1.7–5	1.5–3
-bagasse	32–44	19–24	27–32	1.5–5	0.7–3
Bast fibres					
Fibre flax	45–68	10–15	6–17	2–5	–
Linseed straw	34	23	25	2–5	–
Kenaf	31–39	15–18	21–23	2–5	–
Jute	–	21–26	18–21	0.5–1	<1
Leaf fibres					
Acaba	61	9	17	1	<1
Sisal	43–56	8–9	21–24	0.6–1	<1

2.3 Paper Making Process

Paper consists of pulp fibers derived from wood or other plants from which lignin and other non-cellulose components combined. In paper making process, the fibers, lignin and other non-cellulose components are separated by chemical and mechanical pulping process. The pulp is then washed, bleached, treated and combined with other additives to improve its properties. In the final stages of papermaking, the pulp mixture is deposited on a wire screen and water is removed by gravity, pressing, suction and evaporation (Biermann 1993a).

2.3.1 Pulping Process

Pulping for papermaking is a process of delignification, whereby lignin is chemically dissolved permitting the separation of fibers in the raw material. Cellulosic pulp is manufactured from the raw materials, using mechanical and chemical means.

Mechanical pulping separates fibers from each other by mechanical force such as chipping and grindingon the fiber matrix causing the gradual break of the bonds between the fibers and the release of fiber bundles, single fibers, and fiber fragments (Smook 1992; Biermann 1996b).

Chemical pulping is used on most papers produced commercially in the worldtoday (Smook 1992; Biermann 1996b). Chemical pulp is used for materials that need to be stronger to attain desirable characteristics. The fibers are separated by treatments by chemicals which partly remove the lignin and other non-cellulose components from the matrix.Some of the chemicals used in chemical pulping are sodium sulfite, caustic soda, and sulfurous acid.

2.3.2 Paper Formation

Since mechanical pulping still retained most of the original lignin, the raw pulp is bleached with chemicals, such as sodium hydroxide (caustic soda), potassium hydroxide, and hydrogen peroxides. Bleaching also makes the paper becomes whiter in appearance. Pulp is then washed with water after the bleaching process.

Next, different fiber components such as starch binders and other additives are added to the pulp to improve its properties. The slurry is then transformed into a paper sheet by using mould and deckle apparatus. The paper is pressed and dried. The inter-fiber bonding is important in determining the strength of the paper (Wood 1981, Phillip 1992).Figure 1 shows a simple flow diagram on paper making process.

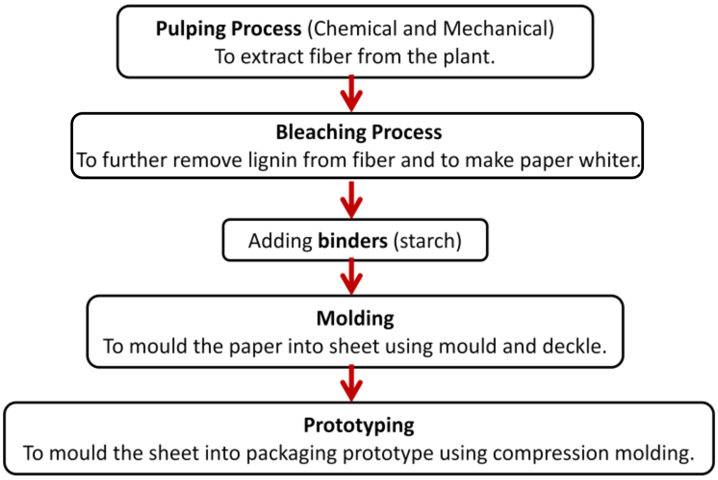


FIGURE 1: Flow Diagram of Paper Making Process.

2.4 Farm Based Paper

The idea is initiated in Universiti Teknologi Petronas (UTP) by a team which won the Science, Engineering and Design Exhibition (SEDEX) with their project titled Farm Based Paper. The team produced four types of paper from sugar cane waste, coconut husk, corn husk and banana trunk. Tensile test was performed to study the strength of the papers and Pugh Chart was tabulated to choose the best paper for the final product. The team finally came up with a prototype made from sugar cane waste.

The methodology used in paper making process for Farm Based Paper project:

30 grams of sugarcane waste was weighed and cut into small pieces. The waste is then boiled for 6 to 12 hours to soften it. Next, it is soaked in Skim Clog Remover for another 6 to 12 hours to breakdown the lignin covering the fibrous pulp and for bleaching purpose. The sugarcane is then washed with water to remove excessive alkali. To make the mush of the pulp, the treated sugarcane was blended with 25g corn starch and 5ml lemon extract was added to reverse the alkaline effect. 300ml of water, 5g of cinnamon and 4.5g of recycled A4 paper were added and the mixture was blended together.

The mush is transferred onto the mold and deckle in wet bath. Excess water was removed from the mush using sponge, blotter paper and towel. The moist paper was then transferred to be manually mold for its final shape before drying with a hair dryer.

This project is a continuity of the Farm Based Paper project with a more detailed approach in the experimental procedure, prototyping process and testing methods. The experimental procedure is refined by using potassium hydroxide and sodium hydroxide solutions to replace skim clog remover that were use as their bleaching agent in the pulping process. Lemon extract was also replaced with acetic acid solution in the neutralization process.

Furthermore, the first experiment to produce paper will not include any recycled paper as were used in the Farm Based Paper project. It is purely based only on bagasse fiber and tapioca starch as the binders.For the prototyping process, a mold will be designed and compression molding will be performed to produce the desired prototype.

The testing methods will accommodate mechanical testing; tensile and some qualitativetesting on the material such as water and oil absorption ability, ease of cutting or shaping.

2.5Packaging Prototype

Packaging is used to protect products for distribution, storage, sale, and use. Packaging provides physical protection as well as marketing value for the products. Package graphic design and physical design attracts potential buyers to purchase the product.The prototype of packaging material can be manufacture using several molding techniques such as injection molding, vacuum forming and compression molding. The molding technique that will be use in this project is yet to be concluded as the experiment progresses.

2.5.1 Compression Molding

Compression molding is a method in which preheated molding slurry is poured into a mold cavity. Then a second mold is pressed into it with a top force. Pressure and temperature is applied to compress the slurry to create a shape. The molten slurrythen takes the shape of the mould. Figure 2 shows a simple diagram on how compression molding is done.

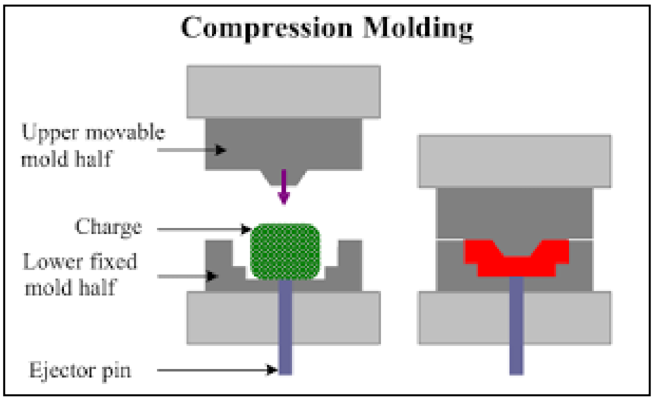


FIGURE 2: Compression Molding Assembly.

2.5.2 Casting

Casting is a simple process in which the slurry is poured into a mold and left to cool. The mold is then removed and the slurry hardened to the shape of the mould. This is the process done by the team with Farm Based Paper project to create their prototype.

2.6Existing Sample of Sugarcane Food Packaging

GO-GREEN Sugar Cane Tray

GO-GREEN is a commercialize company offering sustainable and eco-friendly packaging for a wide range of food applications. One of the products is the GO-GREEN Sugar Cane Tray. GO-GREEN Sugar Cane Tray is said to be 100% biocompostable, flexible in shapes and sizes, can afford colors and printing and also recyclable in conventional paper stream. Figure 3 shows a sample of GO-GREEN Sugar Cane Tray.

FIGURE 3: Sample of GO-GREEN Sugar Cane Tray.

GreenCentury® Sugar Cane Food Container

GreenCentury® Enterprises Inc. manufactures and supplies environmentally responsible, compostable and recyclable disposable food service, beverage, and prepared foods packaging and product solutions.

GreenCentury® Sugar Cane Food Container is made from sugar cane bagasse and reed fiber. It is marketed to be renewable, sustainable, and completely organic. It is also 100% biodegradable, compostable, and have thermal resistant up to 230°C. Figure shows a sample of GreenCentury® Sugar Cane Food Container.

FIGURE 4: Sample of GreenCentury® Sugar Cane Food Container.

2.5 Types of Testing

There are two types of testing that will be performed on the paper as well as the prototype produced; mechanical testing and qualitative testing.

2.5.1 Mechanical Testing

Tensile Test

A tensile test measures material's strength. It is a mechanical test where a pulling force is applied to a material from both sides until the sample changes its shape or breaks. It is a common and important test that provides information on the elongation, yield point, tensile strength, and ultimate strength of the material. Figure 5 shows a simple diagram on how tensile test is done.

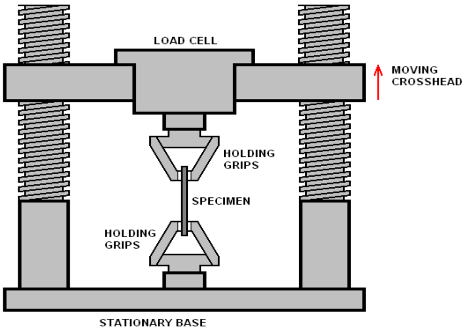


FIGURE 5: Mechanism of Tensile Test.

ASTM D 638 Tensile Strength Test

ASTM D638 is one of the common plastic strength specifications and covers the tensile properties of unreinforced and reinforced plastics. Since S-Cane Pack is a new material made from bagasse, ASTM D638 was chosen as the standard because it is closely comparable. This method uses standard “dogbone” shaped specimens under 14mm thickness. Figure 6 shows the “dogbone” shape. A universal testing machine (tensile test machine) is needed to perform this test.

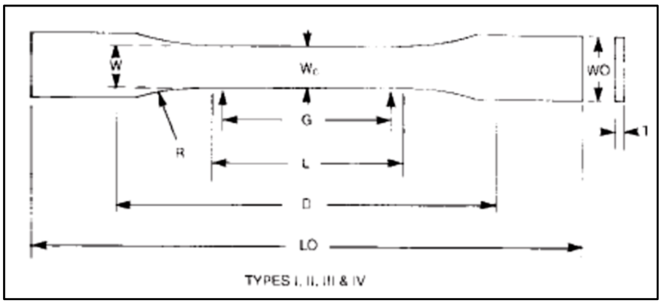


FIGURE 6: “Dogbone” Specimen Shape for ASTM D 638 Tensile Strength Test.

Specimen dimension type IV^{B}of ASTM D638 was chosen from Table 2because thickness, T of S-Cane Pack is less than 4mm (T≤4mm).

TABLE 2: Specimen Dimensions of ASTM D 638 for Variable Thickness.

Dimensions (see drawings)	Specimen Dimensions for Thickness, *T*, mm [in.][A]					Tolerances
	7 [0.28] or under		Over 7 to 14 [0.28 to 0.55], incl	4 [0.16] or under		
	Type I	Type II	Type III	Type IV[B]	Type V[C,D]	
W—Width of narrow section[E,F]	13 [0.50]	6 [0.25]	19 [0.75]	6 [0.25	3.18 [0.125]	±0.5 [±0.02][B,C]
L—Length of narrow section	57 [2.25]	57 [2.25]	57 [2.25]	33 [1.30	9.53 [0.375]	±0.5 [±0.02][C]
WO—Width overall, min[G]	19 [0.75]	19 [0.75]	29 [1.13]	19 [0.75	...	+ 6.4 [+ 0.25]
WO—Width overall, min[G]	...	...	...	...	9.53 [0.375]	+ 3.18 [+ 0.125]
LO—Length overall, min[H]	165 [6.5]	183 [7.2]	246 [9.7]	115 [4.5]	63.5 [2.5]	no max [no max]
G—Gage length[I]	50 [2.00]	50 [2.00]	50 [2.00]	...	7.62 [0.300]	±0.25 [±0.010][C]
G—Gage length[I]	...	...	...	25 [1.00	...	±0.13 [±0.005]
D—Distance between grips	115 [4.5]	135 [5.3]	115 [4.5]	65 [2.5]	25.4 [1.0]	±5 [±0.2]
R—Radius of fillet	76 [3.00]	76 [3.00]	76 [3.00]	14 [0.56]	12.7 [0.5]	±1 [±0.04][C]
RO—Outer radius (Type IV)	...	...	...	25 [1.00]	...	±1 [±0.04]

As to comply to the standard at least five specimens was tested for each type of sample produced.Speed of testing was chosen from Table 3 below:

TABLE 3: Designations for Speed of Testing for ASTM D 638.

TABLE 1 Designations for Speed of Testing[A]

Classification[B]	Specimen Type	Speed of Testing, mm/min [in./min]	Nominal Strain[C] Rate at Start of Test, mm/mm· min [in./in.·min]
Rigid and Semirigid	I, II, III rods and tubes	5 [0.2] ± 25 %	0.1
		50 [2] ± 10 %	1
		500 [20] ± 10 %	10
	IV	5 [0.2] ± 25 %	0.15
		50 [2] ± 10 %	1.5
		500 [20] ± 10 %	15
	V	1 [0.05] ± 25 %	0.1
		10 [0.5] ± 25 %	1
		100 [5]± 25 %	10
Nonrigid	III	50 [2] ± 10 %	1
		500 [20] ± 10 %	10
	IV	50 [2] ± 10 %	1.5
		500 [20] ± 10 %	15

Analysis that can be obtained from the test:

1. Tensile Strength
2. Elongation
3. Modulus of Elasticity

Brief summary of the test procedure:

1. Cut the specimens into “dogbone” shapes.
2. Load the specimen into tensile grips.
3. Attach the extensometer to the specimen.
4. Begin the test by separating the tensile grips at a constant rate of speed. (5 mm/min) The target time from start of test to break should be from 30 seconds to 5 minutes.
5. End of test after specimen break (rupture).

Equipment required:

1. Universal Testing Machine (Tensile Test Machine).

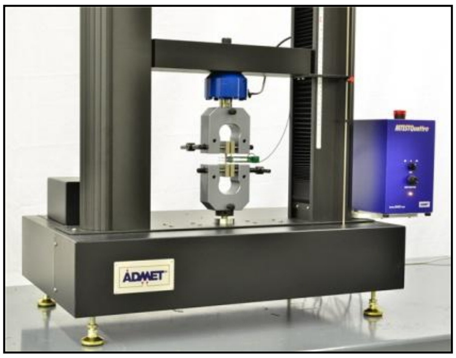


FIGURE 7: Tensile Test Machine

2. Extensometer

   Required for two reasons:

   - The linear region of plastics is very small and happens suddenly so grip separation is just not accurate enough.
   - "Dogbone" specimens do not have uniform widths so there will be errors when both the wide and narrow sections of the "dogbone" shaped specimen elongate at different rates.

3. Data Acquisition

   - Software or suitable electronics are required to operate the machine and take measurements. Basic system will provide the raw data, and stress-strain charts.

4. Tensile Grips

   - Any grip with serrated faces is usually adequate for the test.

2.5.2 Qualitative Testing

There will also be several quality test done on the paper and prototype such as flexibility, texture of the surface, easy to cut or shape, and also can be drawn and written on.

CHAPTER 3

METHODOLOGY

Methodology is properly planned to provide organization and guidance towards the project completion.Gantt chart is also constructed to measure the progress of the project. Gantt charts are attached in Appendix 1 and Appendix 2. The forecasted outcome of the project is a prototype of packaging material made from sugar cane waste with desirable mechanical properties.The methodology is divided into three main phases. Figure 8 below shows the flowchart of the three main phases.

First Phase

- Prepare mold and deckle for paper.
- Design of packaging mold.
- Sent packaging mold for fabrication.
- Collecting raw materials and equipment.

↓

Second Phase (Paper Making)

- Mechanical pulping of the fiber which involves cutting and boiling.
- Chemical pulping of the fiber which involves treatment with Sodium Hydroxide solution, Potassium Hydroxide solution and Acetic Acid Solution.
- Adding binders to bind the fiber.
- Filtration of pulp on silk screen.
- Drying process of paper.

↓

Third Phase

- Prototyping of the paper into a packaging shape using the fabricated mold.
- Qualitative and mechanical testing of the prototype to compare with existing packaging material

FIGURE 8: Main Phases of the Methodology.

3. 1 First Phase

The first phase is to produce a mold and deckle for the paper sheet. In the first experiment, the mold and deckle for the paper sheet was bought at a bookstore. However, the size is not adequate for further prototyping process. Nevertheless, the mold and deckle is used as trial to produce sheets of paper during the first experiment. The next step would be to design a mold for the packaging prototype. A burger box was set as a reference to the packaging design. Preliminary design drawings of the mold are attached in the Appendix 3, Appendix 4 and Appendix 5. Detailed design drawings are attached in Appendix 6 and Appendix 7. The mold design was sent for fabrication using stainless steel as the material. Pictures of the completed burger box shaped mold for the packaging prototype are attached in Appendix 8. Meanwhile, an adequate amount of raw sugarcane waste is collected.

3.2 Second Phase

The second phase will be the paper making process. During this stage, mechanical pulping and chemical pulping are performed on the raw material. Mechanical pulping includes drying, cutting the bagasse into smaller size up to 1cm small and boiling it for several hours to soften the fiber. Deionized water is used in the experiment because deionized water is free from ions. Tap water is usually full of ions from the soil, pipes and other sources. Often during chemical experiments, the ions in water will be the interference. After being boiled, the bagasse is dried for the next process.

Next is the chemical pulping process in which the bagasse will be soaked in 10% potassium hydroxide, KOH solution for several hours, washed and filtered then followed by soaking it in 10% sodium hydroxide, NaOH solution for several more hours. This process allows the breakdown of lignin from the fiber needed and also a bleaching process for the fiber. To neutralize the alkaline effect acetic acid was added slowly to the fiber until the pH is neutral. The mixture is then blended and starch is added to the mixture as a binder for the first experiment. The following experiments will have the variation of the binders used such as tapioca starch or glutinous rice starch. 10% recycled paper is also added to enhance the rigidity of the prototype. The ratio of weight composition used in the experiment is 6:3:1 (Bagasse fiber : Starch : Recycled Paper).

The mixture is then transferred onto the mold and deckle in a wet bath. The mush is evenly distributed, drained and filtered on the silk screen of the deckle. Excess water is removed from the residue by using a sponge. The paper is left to be dried at open air. Figure 9 shows a simple diagram on paper making process.

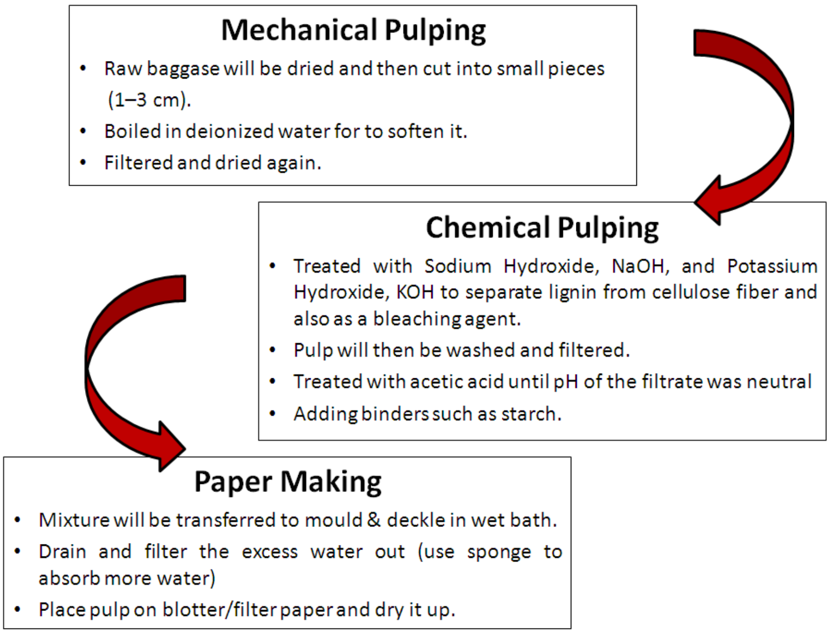


FIGURE 9: Paper Making Process.

- Dilution process to obtain 10% of Potassium Hydroxide, KOH:

30 grams of potassium hydroxide pallets is weighed and added slowly to 300ml of water. 300ml of 10% potassium hydroxide solution is produced.

- Dilution process to obtain 10% of Sodium Hydroxide, NaOH:

30 grams of sodium hydroxide pallets is weighed and added slowly to 300ml of water. 300ml of 10% sodium hydroxide solution is produced.

- Dilution process to obtain 10% of Acetic Acid, CH_3COOH:

30 ml of acetic acid is measured and added slowly to 300ml of water. 300ml of 10% acetic acid solution is produced.

3.3 Third Phase

The final stage is composed of mechanically and qualitatively testing the paper produced. This is to choose the best possible paper sample as the material for the prototype. Then the paper will be compression molded into the desired packaging prototype designed at earlier stage. Few tests on mechanical strength as well as other qualitative aspect are done on the final product. Comparison will be made with some existing food packaging as the benchmark. Finally, the result will be analyzed and discussed followed by a brief conclusion.

3.4 Mold Design

Design of mold was drawn using AutoCAD Software. Figure 10 shows the design drawing.

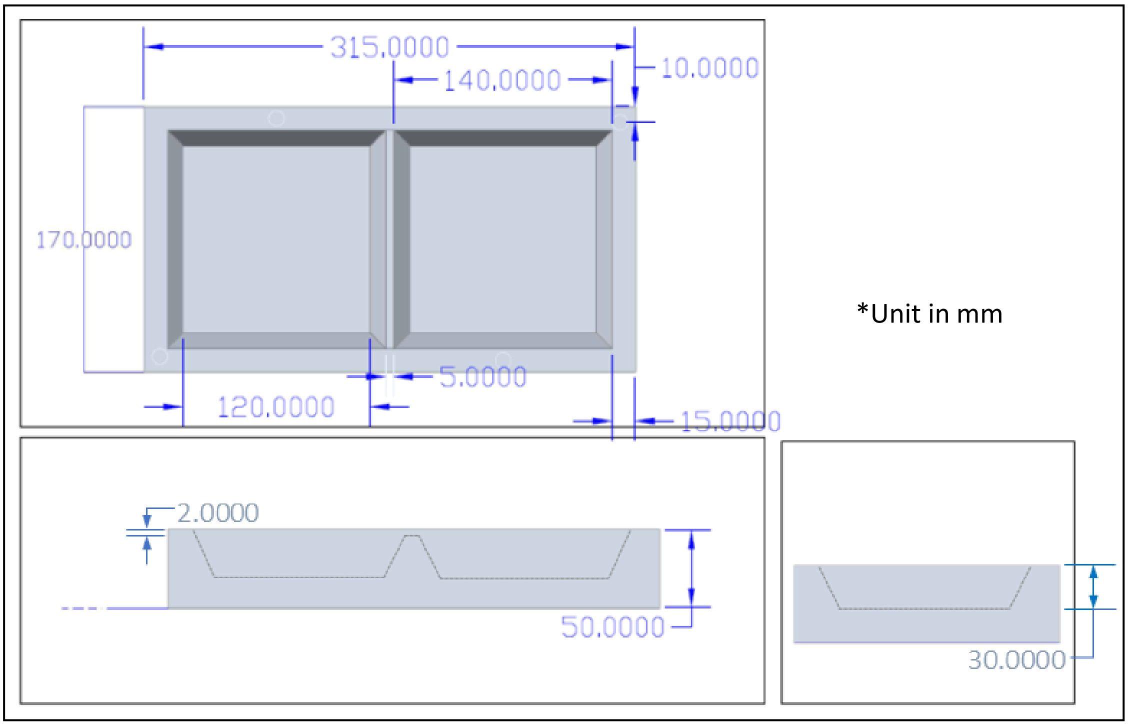


FIGURE 10: Design of the Mold in AutoCAD Software.

Detailed drawings with dimensions are attached in Appendix 6 and Appendix 7. The design was sent for fabrication using stainless steel material. The burger box shaped mold for S-Cane Pack prototyping is shown in Figure 11 below.

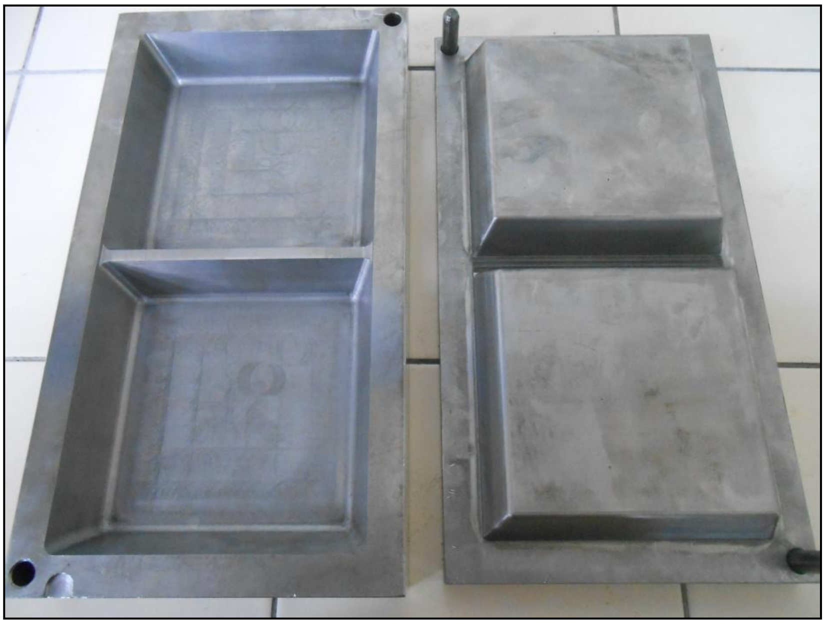


FIGURE 11: Mold for S-Cane Pack Prototype.

3.5 Materials and Equipment

The following materials and equipment are first prepared:

TABLE 4: List of Materials and Equipments with the required amount.

Material/Equipment	Amount/Unit
Bagasse	500g
Sodium Hydroxide, NaOH	1kg (M= 40.00g/mol)
Potassium Hydroxide, KOH	1kg (M= 56.11g/mol)
Acetic Acid, CH_3COOH	2.5L (M= 60.005g/mol)
Starch powder	100g
Deionized water	2litres
pH paper	100 strips
Measuring cylinder	100ml
Blender/food processor	1
Weighing scale	1
Mould & deckle	1 set
Sponge	1
Cloth	2 pieces
Filter/blotter sheet	2 pieces
Water bath	1

Safety Precautions:

In the experiment, the usage of corrosive chemicals such asPotassium Hydroxide, KOH, Sodium Hydroxide, NaOH, and Acetic Acid,CH_3COOH need to be handled safely. No direct contact with skin and eyes is allowed. Lab coat, safety goggle and protective glove are worn all the time to take care of the safety aspects. The disposal of the chemicals is also controlled.

An experiment was done last semester to initiate a starting point and to get the idea of paper making process. Several other experiments were done this semester to produce different types of paper as a comparison. The following is the sample experimental procedure of the experiments.

3.6Experimental Procedure

Three types of S-Cane Paper were produced with a variation of:

- The experimental procedure (chemical and mechanical pulping time).
- Different type of starch binders (tapioca and glutinous rice starch).

Basic Experimental Procedure

Mechanical Pulping Process

1. Raw bagasse is first dried under the sunlight to reduce moisture.
2. 100 grams of bagasse is weighed.
3. Bagasse is then cut into small sizes up to 1cm to ease up further mechanical pulping process.
4. The bagasse is washed thoroughly with running water to remove dirt and impurities.
5. Bagasse is then boiled in deionized water for 6 to 7 hours as part of the mechanical pulping process to soften the fiber.
6. After boiling process, the bagasse is wash thoroughly again with running water to remove further impurities and lignin.
7. Bagasse is then dried again after the mechanical pulping process.

Chemical Pulping Process

1. 300 ml of 10% potassium hydroxide, KOH is first prepared by diluting 30grams of potassium hydroxide pallets in 300ml water phase by phase.
2. The dried bagasse is then soaked in 10% potassium hydroxide solution for 5 to 6 hours to breakdown the lignin from the cellulose part of the fiber.

3. 300 ml of 10% sodium hydroxide, NaOH is first prepared by diluting 30grams of sodium hydroxide pallets in 300ml water phase by phase.
4. The bagasse is washed thoroughly with running water and been soaked with 10% sodium hydroxide solution for another 5 to 6 hours. This is to further breakdown the lignin from the cellulose part of the fiber.
5. The soaked bagasse is again washed with running water and filtered dried before being blended into mush form.
6. The bagasse mush is added with 10% acetic acid phase by phase for neutralization from the alkaline solution in the previous processes. pH paper is used to aid the neutralization process.

Paper Making Process

1. 50grams of tapioca starch powder is added to the treated bagasse mush. The starch powder functions as a binder to bind the fibers together. Recycled paper is also added to the mixture.
2. The mixture is poured into a wet bath.
3. The mould & deckle is soaked in the wet bath and the fiber is filtered on the silk screen.
4. The filtered residue is dried up with sponge and left to dried.

S-Cane Paper 1

S-Cane Paper 1 was produced with the following variables:

- Longer mechanical and chemical pulping time (6 hours approximate for each pulping process).
- Tapioca starch binders.
- 6:3 ratio compositions (bagasse fiber: starch).

S-Cane Paper 2

S-Cane Paper 2 was produced with the following variables:

- Shorter mechanical and chemical pulping time (3 hours approximate for each pulping process).
- Tapioca starch binders.
- 6:3 ratio compositions (bagasse fiber: starch).

S-Cane Paper 3

S-Cane Paper 3 was produced with the following variables:

- Shorter mechanical and chemical pulping time (3 hours approximate for each pulping process).
- Glutinous rice starch binders.
- 6:3 ratio compositions (bagasse fiber: starch).

Illustrated experimental procedures are attached in Appendix 9, Appendix 10, Appendix 11, Appendix 12 and Appendix 13.

CHAPTER 4

RESULTS

4.1 S-Cane Paper

The experiment was done in which two samples are being produced for each type of S-Cane Papers. The papers produced are reasonably hard and slightly deformed in shape due to over drying process. It is also opaque and the surface texture is a little coarse. The paper can be easily cut using a scissor into desired shapes and also can be written on. Figures shown are the final result of the papers. Samples of the produced papers are attached in the Appendix 14.

S-Cane Paper 1

FIGURE 12: Texture of the paper produced.

FIGURE 13: Two sheets of paper produced from 100g bagasse.

Figure 12 and Figure 13 shown are the papers produced using S-Cane Paper 1 variables. The texture are reasonably smooth but slightly deformed in shape due to over drying process. It is also opaque and the surface texture is a little coarse. The paper can be easily cut using a scissor into desired shapes and also can be written on.

S-Cane Paper 2

FIGURE 14: S-Cane Paper 2.

Figure 14 shown are the papers produced using S-Cane Paper 2 variables. The texture are a little bit coarse than S-Cane Paper 1. It is also slightly deformed in shape due to over drying process. The surface is opaque and the paper can be easily cut using a scissor into desired shapes and also can be written on.

S-Cane Paper 3

FIGURE 15: S-Cane Paper 3.

Figure 15 shown are the papers produced using S-Cane Paper 3 variables. The texture are a coarse and rougher than S-Cane Paper 1 and S-Cane Paper 2. It is also slightly deformed in shape due to over drying process. The surface is opaque and the paper can be easily cut using a scissor into desired shapes and also can be written on.

4.2 S-Cane Pack

The best paper chosen and then molded into packaging shapes using mold. Figures below show some of the prototype of S-Cane Pack.

FIGURE 16: S-Cane Pack (Burger box shape).

FIGURE 17: S-Cane Pack (Styrofoam food container shape).

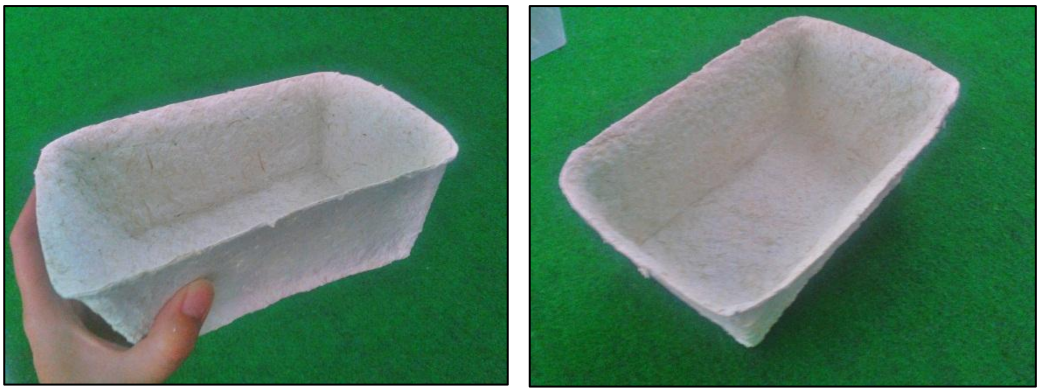


FIGURE 18: S-Cane Pack (Plastic food container shape).

Figure 16 shows the pictures of S-Cane Pack molded into a burger box shape using the fabricated mold. The surface is reasonably course and the structure is slightly rigid. Figure 17 shows the picture of S-Cane Pack molded into a Styrofoam food container shape. The surface roughness of this prototype is smoother and finer than the other two. Figure 18 shows the pictures of S-Cane Pack molded into standard plastic container shape. The structure is reasonably hard and rigid in form.

4.3 Mechanical Testing Result

Tensile test is done to measure the properties and of S-Cane Pack and to compare it with existing Styrofoam pack and Cardboard.ASTM D638standard is used as the test method. It uses standard "dumbell" or "dogbone" shaped specimens under 14mm of thickness. Example shown in Figure 19 below:

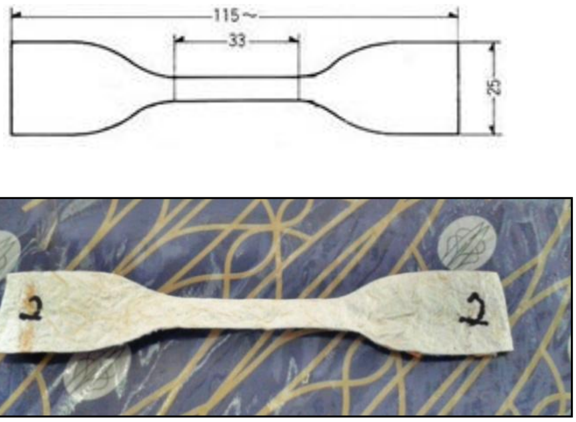


FIGURE 19: Standard ‘dumbell’ or ‘dogbone’ shaped specimen.

A universal testing machine (tensile testing machine) at Blok 13 of Civil Engineering Department is used to perform thetest. Laboratory session for the testing is supervised by Mr. Faris, a lab technician from Mechanical Engineering Department. Analysis obtained from the test is the tensile strength.

ASTM D-638 Tensile Test Procedure

Five specimens are prepared and the average readings will be taken. Specimens are placed in the grips of the universal tester at a specified grip separation and pulled until failure.

1. Cut the material into the "dumbbell" shapes
2. Load the specimen into tensile grips.
3. Begin the test by separating the tensile grips at a constant rate of speed. The test speed is 5 mm/min [±25%].
4. End the test after sample break (rupture).

Results and Calculations (S-Cane Pack)

The initial graph obtained from the tensile test is a force vs. elongation graph. By calculation, a graph of stress vs. strain is plotted to determine the tensile strength of the specimens. The S-Cane Pack specimen's dimensions are given in Table 5. Table 6 shows the area at the gage length of S-Cane Pack's specimen. Table 7 is the calculation done to obtain the tensile strength value for S-Cane Pack.

TABLE 5: Specimen Dimensions. (S-Cane Pack)

Dimension	Unit (mm)	Unit (m)
Width	7.45	0.00745
Thickness	1.53	0.00153
Length	117	0.11700

TABLE 6: Area at Gage Length. (S-Cane Pack)

Dimension	Unit (mm)	Unit (m)
Area (width x thickness)	11.399	1.140E-05

TABLE 7: Tensile Strength of S-Cane Pack.

S-Cane Pack Specimen	Tensile Strength (MPa)
1	0.54
2	0.80
3	0.75
4	1.10
5	0.81
Average Value	**0.80 ± 0.16**

Results and Calculations (Other Packaging Material)

Table 8 shown are the average tensile strength value of other existing packaging material available in the market as a comparison with S-Cane Pack.

TABLE 8: Average Tensile Strength of Other Packaging Material.

Packaging Specimen	Average Tensile Strength (MPa)
Styrofoam	0.98 ± 0.13
Cardboard	5.00 ± 0.20
Paper	3.30 ± 0.00

4.4 Graphical Comparison

A graphical comparison of the average tensile strength values for S-Cane Pack, Styrofoam, Cardboard and Paper is shown in Figure 20 below.

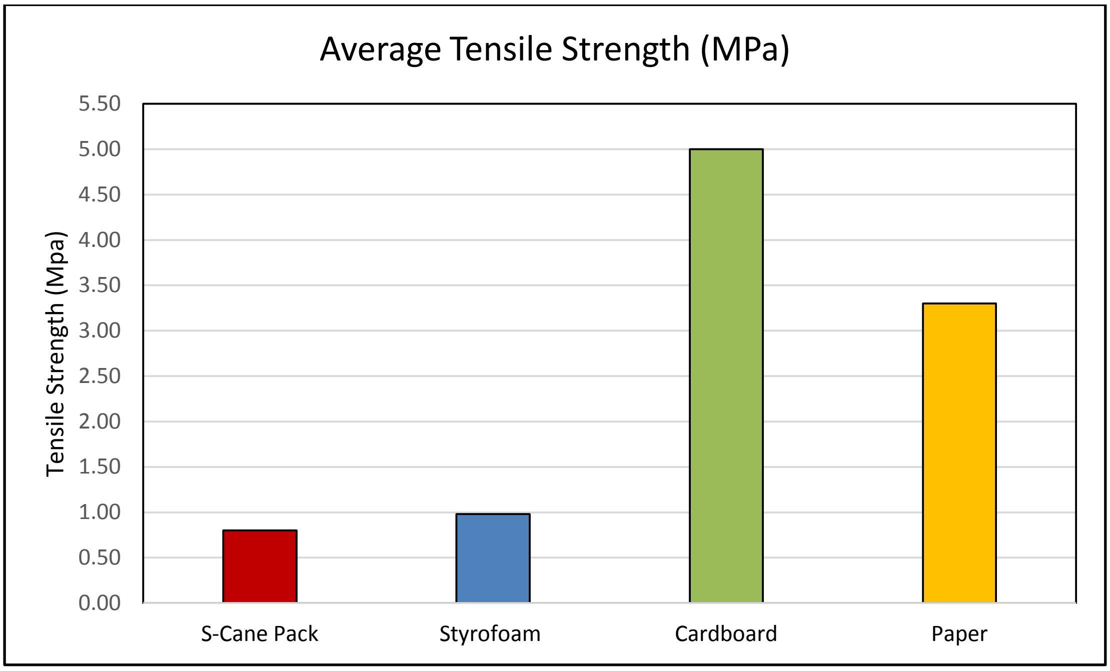


FIGURE 20: Tensile Strength of S-Cane Pack, Styrofoam, Cardboard and Paper.

Based on the graph in Figure 20, Cardboard exhibits the highest tensile strength and as compared to Styrofoam, S-Cane Pack and Paper. It has the highest ultimate tensile strength value of 5 MPa while Styrofoam reaches only 0.98 MPa, S-Cane Pack with only 0.8 MPa in value and Paper with 3.3 MPa. From the graph, Cardboard is the highest in strength followed by Paper, Styrofoam and S-Cane Pack.

Physical Properties

In terms of the appearance and texture, S-Cane Pack has a considerably rough surface. The color is yellowish-white. S-Cane Pack can be written and drawn on and cut into desired shapes or pattern.

CHAPTER 5

DISCUSSION AND CONCLUSION

5.1 Discussion

Based on the results, S-Cane Pack exhibits lower tensile strength as compared to Styrofoam, paper and cardboard. This is due to the prototyping process in which the mass production of Styrofoam paper and cardboard are more refined with advanced machinery and materials throughout the production process. The production of a single prototype S-Cane Pack is only done by manual unrefined processes with economical material. Further recommendation may be to have a more refined experimental procedure and process in the prototyping process. For example, by adding more additives to enhance the properties of the products. As of now the starch is the only additive added as the binder. Other than that, the use of grinding machine to grind the raw material as a replacement to the manual mechanical pulping process by cutting is also recommended.

5.2 Conclusion

S-Cane Pack, a packaging prototype made from sugarcane waste is successfully produced. Several experiments are done to produce the desired papers and packaging boxes. Mechanical testing using ASTM D638 is also done on the packaging boxes, Styrofoam and cardboard to compare the strength. However, the results show that the product is still not comparable with the existing Styrofoam, cardboardor paper in terms of its tensile strength and overall appearance. Therefore, there is a lot of further improvement can be made to the experimental procedure to enhance the properties of the product.

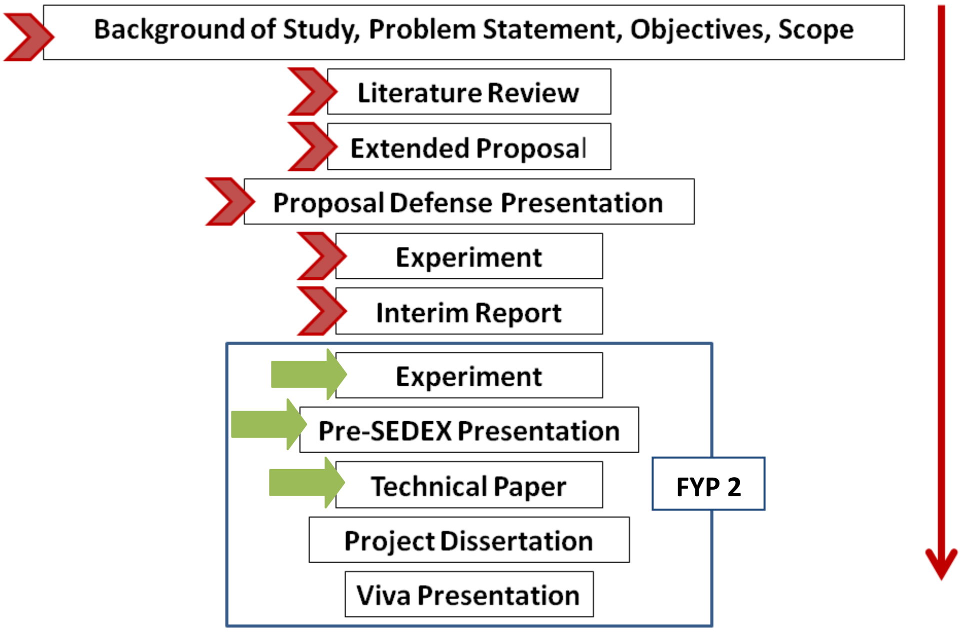
5.3 Further Recommendations

Several recommendations are drawn to further enhance S-Cane Pack properties in the future. Based on the experiment, by adding an amount of recycled paper to the mixture, the structure of the paper and prototype produced is more rigid and firm. Therefore as future recommendation, adding other additives will enhance the properties of S-Cane Pack such as mineral fillers to add more strength to the structure, optical brightener and pigments to make the color whiterand also wet strength additives to ensure that when the paper is wet, it still can retain its strength.

Other than that, the use of grinding machine to grind the raw sugarcane waste as part as the mechanical pulping to replace the manual cutting process will also enhance its properties. Based on the results obtained, the prototype is deformed in shape due to wrinkles during the drying process. So, to further refine the experimental procedure, introduction of heating and cooling during the molding process will prevent rapid drying that causes wrinkle on the surface of the product. Aslight compressive force can also be added during the prototyping process by using the mechanical compression machine to induce a form of rigidity to the structure of the product. If available, usage of advanced machinery during the pulping and molding process for future mass production of the product will also enhance the structure.

Since S-Cane Pack is a food packaging prototype to be used daily, safety in terms of properties and chemical content is also important. By performing more mechanical, physical and chemical testing S-Cane Pack will achieve a comparable properties as the existing food packaging. S-Cane Pack must also be fabricated to comply to Malaysia regulations of Food Act 1983 and the international Food & Drug Administration outlining the general requirements for safe food packaging.

Key Milestone



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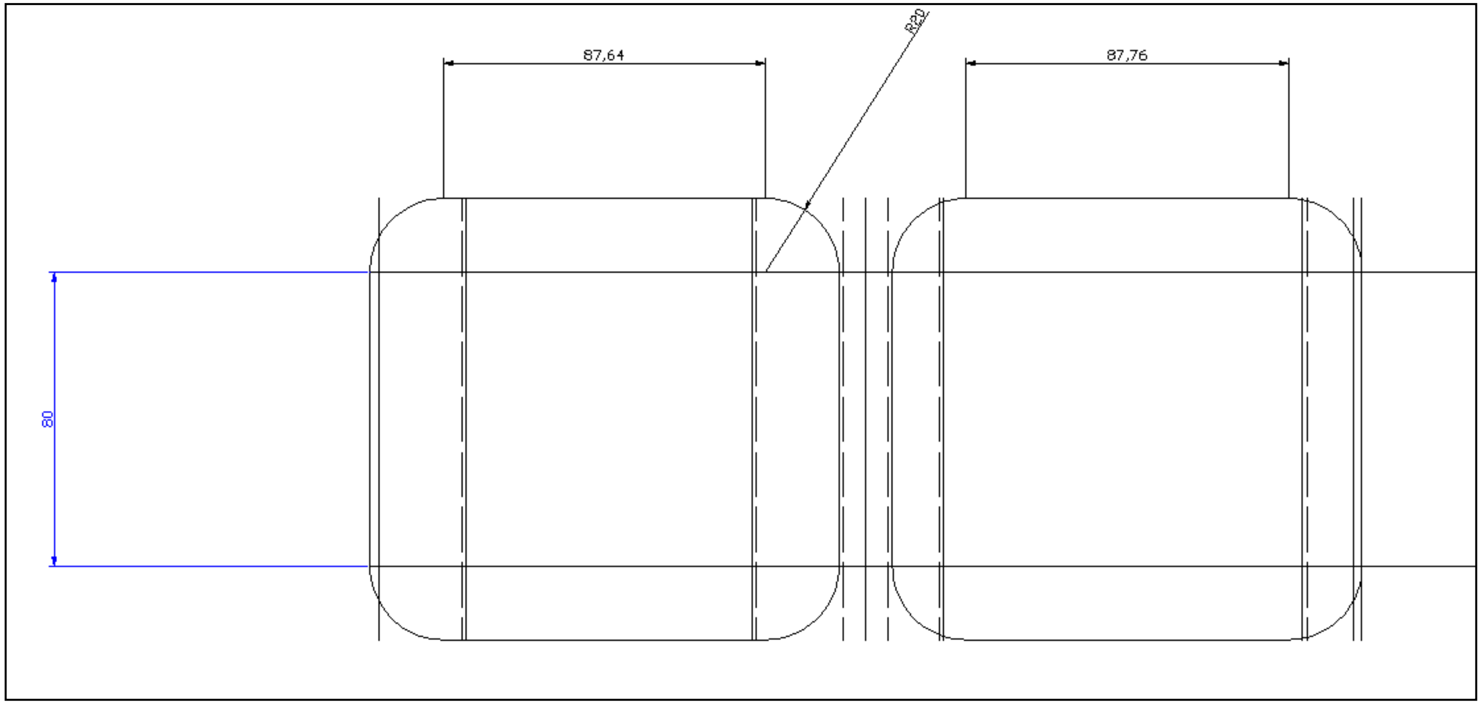
No.	Detail/Week	1	2	3	4	5	6	7	Mid-semester break	8	9	10	11	12	13	14
1	Selection of Project Topic															
2	Preliminary Research Work															
3	Study on Literature Review															
4	Preparation of Extended Proposal															
5	Submission of Extended Proposal															
6	Continuous Study on Literature Review															
7	Preparation of Proposal Defense Presentation															
8	Proposal Defense Presentation															
9	Drawing of Packaging Mold Design															
10	Source for Materials and Equipments															
11	Conduct Experiment 1															
12	Analysis of Experiment 1															
13	Preparation of Interim Report															
14	Submission of Interim Report															

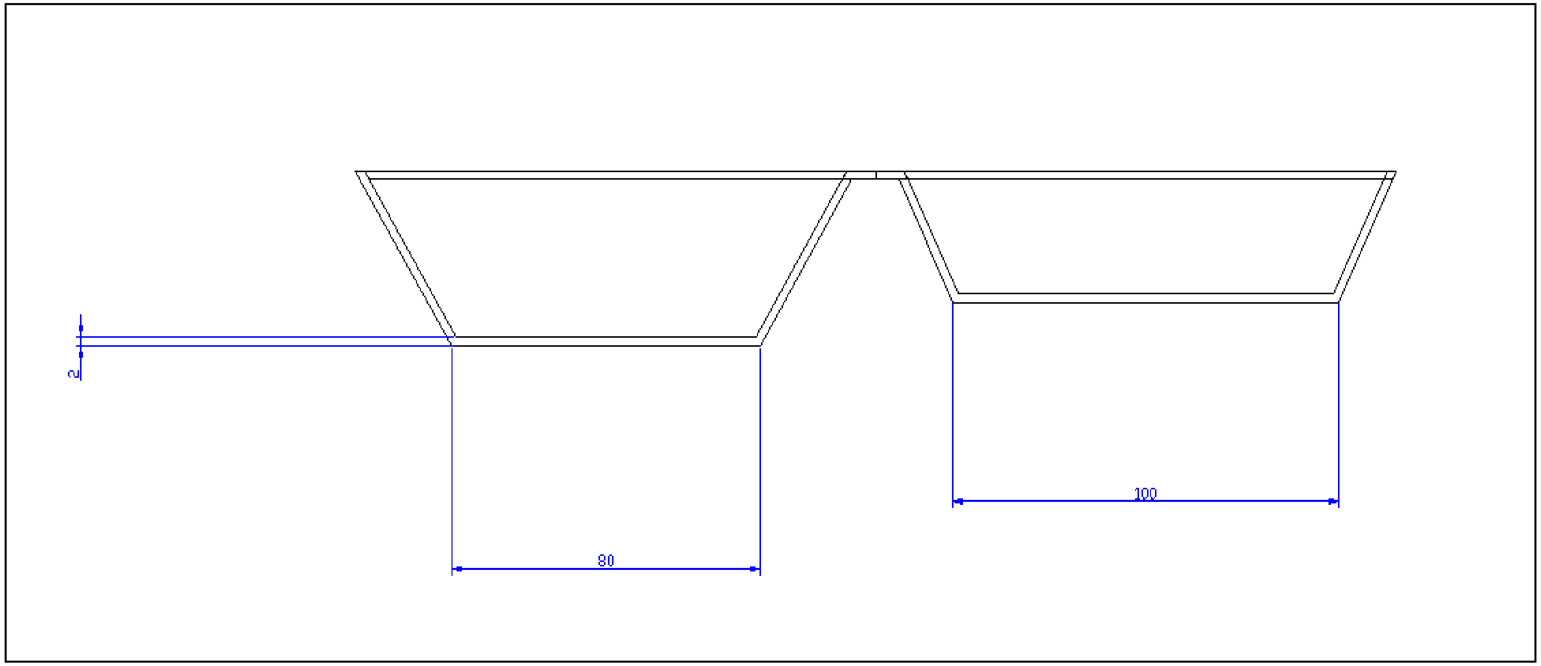
APPENDIX 1: FYP 1Gantt Chart

No.	Detail/Week	1	2	3	4	5	6	7		8	9	10	11	12	13	14	15
1	Finalizing Packaging Mold Design Drawing								Mid-semester break								
2	Send Mold Design Drawing for Fabrication																
3	Finalize on the Parameters/Variables Variation																
4	Outline Detailed Experimental Procedure																
5	Continuos Study on Literature Review																
6	Conduct Experiment 2																
7	Analysis and Testing of Experiment 1 & 2																
8	Conduct Experiment 3																
9	Analysis and Testing of Experiment 3																
10	Conduct Experiment 4																
11	Analysis and Testing of Experiment 4																
12	Preparation of Progress Report																
13	Progress Report Submission																
14	Packaging Prototyping (Compression Molding)																
15	Mechanical and Qualitative Testing of Prototype																
16	Preparation for Pre-SEDEX																
17	Pre-SEDEX																
18	Report Compiling of Results and Analysis																
19	Submission of Draft Report																
20	Finalizing the Whole Project																
21	Complete Compiling of the Project Report																
22	Submission of Dissertation (soft bound)																
23	Submission of Technical Paper																
24	Oral Presentation																
25	Submission of Project Dissertation (Hard Bound)																

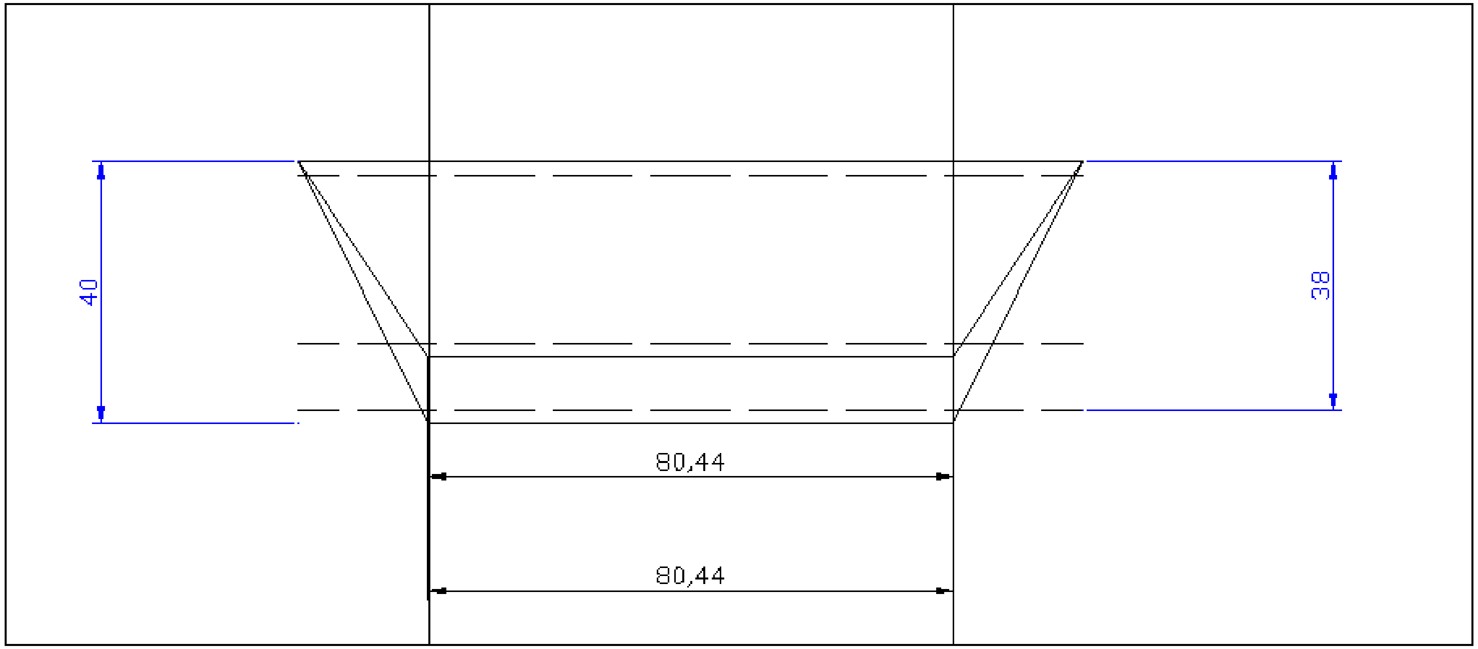
APPENDIX 2: FYP 2Gantt Chart



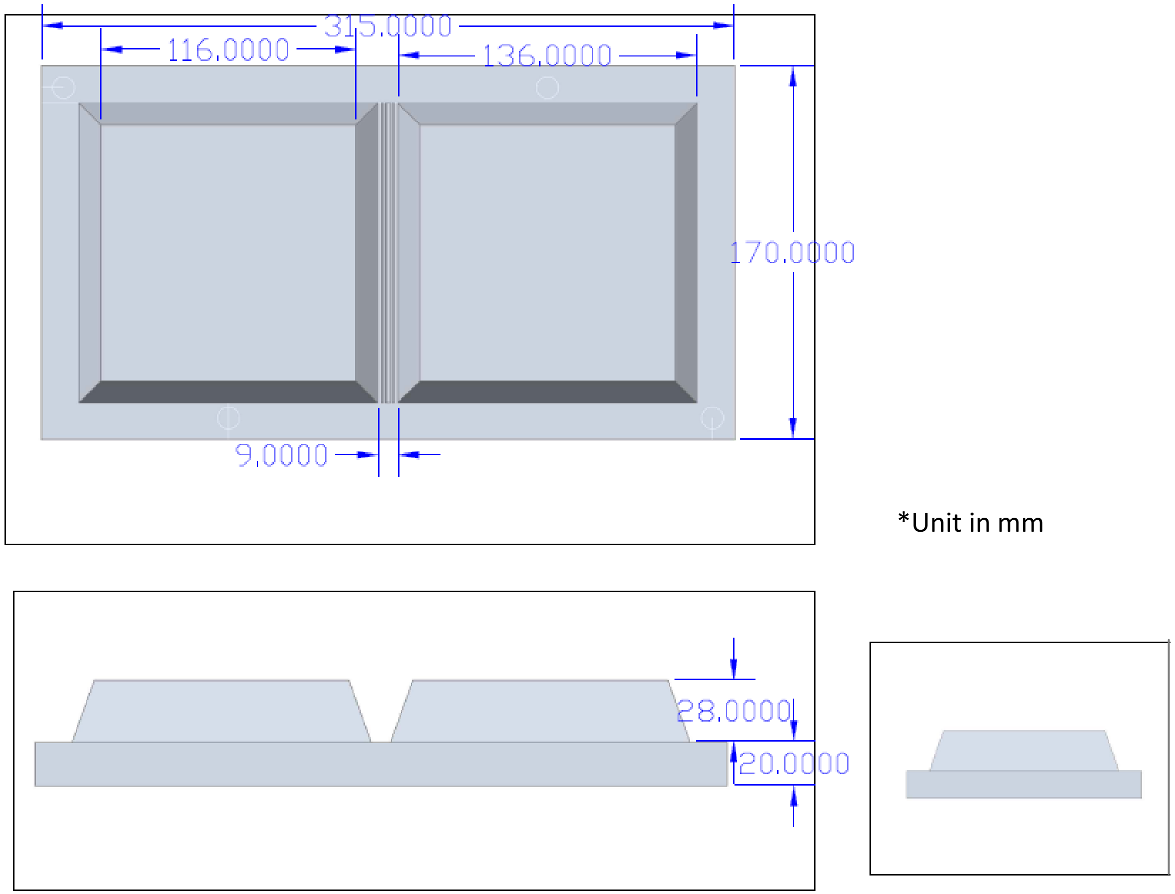
APPENDIX 3: Preliminary Mold Design Drawing (Top View)



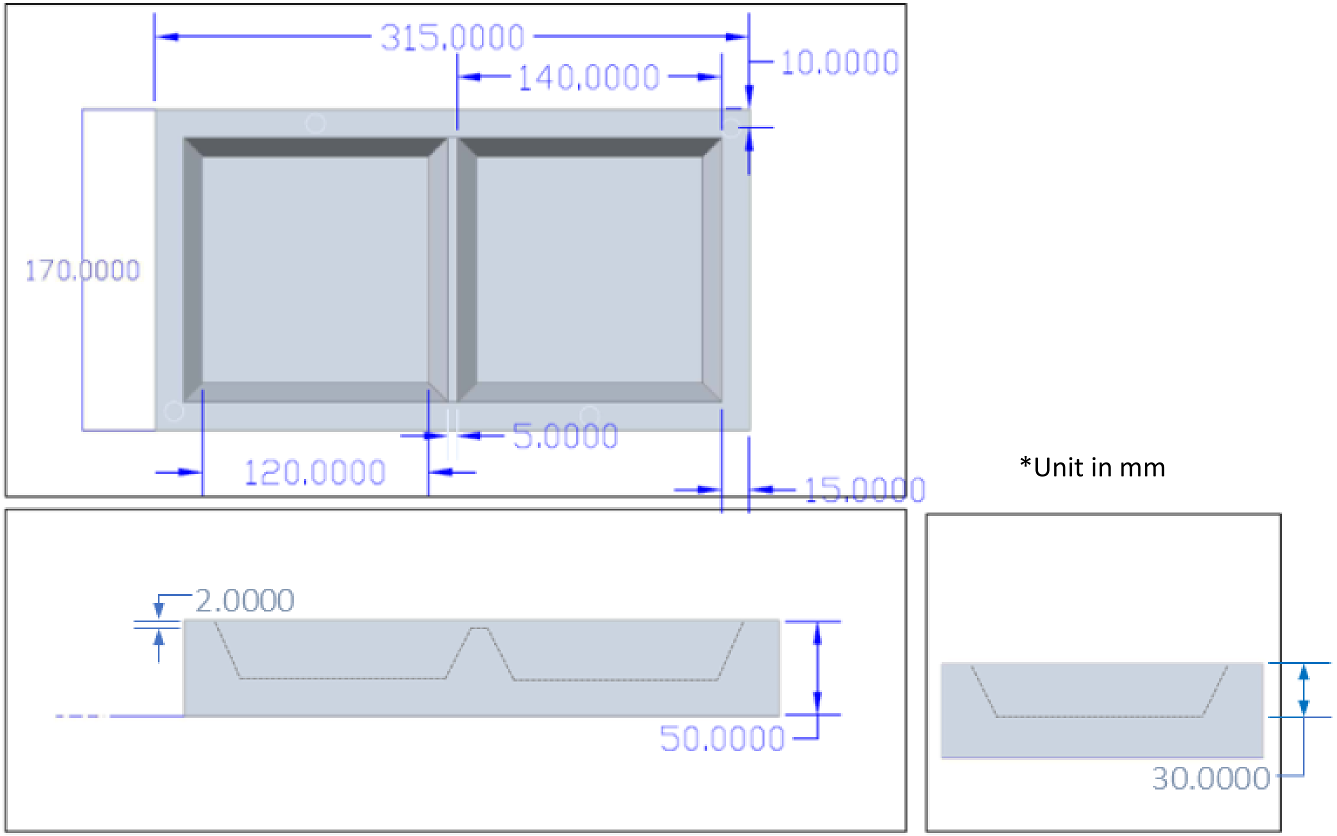
APPENDIX 4: Preliminary Mold Design Drawing (Front View)



APPENDIX 5: Preliminary Mold Design Drawing (Side View)



APPENDIX 6: Detailed Mold Drawing Design (Top Half)



APPENDIX 7: Detailed Mold Drawing Design (Bottom Half)

APPENDIX8: Mold for S-Cane Pack.

1.Drying of raw bagasse.

2. Weighing of bagasse.

3.Bagasse is cut into smaller pieces.

4. Bagasse is washed thoroughly.

APPENDIX9: Illustrated Experimental Procedures.

5.Boiling process

6. Bagasse condition after boiling.

7.Potassium Hydroxide, KOH pallets.

8. Bagasse is soaked in 10% potassium hydroxide solution.

APPENDIX10: Illustrated Experimental Procedures.

9.Sodium Hydroxide, NaOH pallets.

10. Bagasse is soaked in 10% sodium hydroxide solution.

11. Bagasse is blended into mush.

12. Neutralization with acetic acid.

APPENDIX11: Illustrated Experimental Procedures.

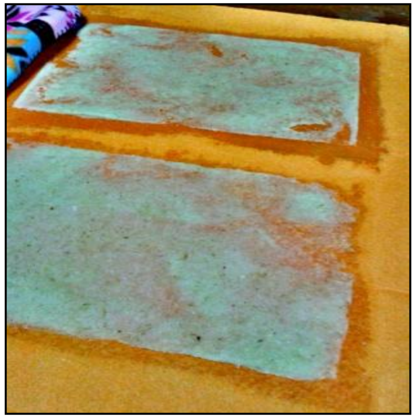
13. Adding binder to the fiber.

14. Mixture in the wet bath.

15. Filtration of the pulp on the silk screen.

16.Filtration of the pulp on the silk screen.

17. Drying up of the filtered residue with sponge



18. The paper is left to dry.

APPENDIX12: Illustrated Experimental Procedures.

19. Molding process.

20. After molding and drying.

21. Mechanical testing.

APPENDIX13: Illustrated Experimental Procedures.

APPENDIX14: Sample of S-Cane Papers.