FINAL YEAR PROJECT

FINAL REPORT

EFFECT OF TOTAL OUTDOOR ENVIRONMENTAL EXPOSURE ON SURFACE CRAZING OF RUBBER STOPPER MATERIAL AT THE LATITUDE OF 4.417° AND LONGITUDE OF 100.983° IN BANDAR SERI ISKANDAR AREA

by

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12307

Bachelor of Engineering (Hons)

(Mechanical Engineering)

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CERTIFICATION OF APPROVAL

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Approved:

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TRONOH, PERAK

SEPTEMBER 2011

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 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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ASYRAF BIN JA'AFAR

ABSTRACT

Rubber which we used in our daily life was exposed to the risk of degradation from day by day. The exposure of the rubber to the outdoor environment is one of the reasons to this problem. There are many components of outdoor environment such as solar radiation, temperature, moisture, atmospheric oxygen and other secondary factors of weather. This experiment objectives is to prove the factor of the weather that affects the rubber and to determine the flow of the rubber degradation to the weather in the period given. In this experiment, the study of the polymer degradation is really needed to distinguish the type of degradation that the rubber material having. It also needs the understanding of weathering components which were the main reasons of the rubber degradation. In order to determine the degradation, the using of Metallurgical Optical Microscope is needed to images the surface crazing that the rubber material have. The books and some of journals is the main source to all of the information about rubber material and the outdoor weather in this experiment. The results are expected to show that the degradation of the surface craving on the rubber material is increasing from time to time.

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CHAPTER 1
INTRODUCTION

1.1 Background of Study

Rubber is one of the materials which completed our life. Every year the world produces about 4 million long tons of natural rubber and 7 million long tons of man-made rubber. About 70 % of this rubber goes to the automobile industry but rubber has many more uses than that. Rubber is a substance which is elastic, flexible and absorbs shock well and that is why it has countless uses examples like the soles and heels of our shoes, the backing of our carpet and our raincoats are all made from rubber. The use of rubber is widespread, ranging from household to industrial products, entering the production stream at the intermediate stage or as final products. Over all, there are almost 50,000 products are made from rubber.

Some people think that all rubber is made from latex produced from trees. This is not, in fact the case were only about 25-30% of all rubber is made from latex. There are different types of rubber like Natural Rubber and Synthetic Rubber. The latex is a mixture of organic compounds which are produced in special cells of a tree called Hevea Brasiliensis. Rubber trees are mostly found in Amazon, South East Asia and Africa. The trees are cut to a narrow, slanting mark about half way round the trunk and just deep enough to pierce the living layer of cells beneath the bark. At the bottom of the cut, there is a metal spout and below it a cup in which a milky white latex is oozed from the cut. The molecules of the rubber within these tiny tubes consist of 5 carbon and 8 hydrogen atoms. A large number of such molecules linked together form long, chain-like molecules called polymers.

After the World War Two, the demand of rubber rapidly increase which make the scientist and chemist find another ways to produce rubber. Therefore they came with solution, the Synthetic Rubber. Synthetic Rubbers are artificially produced materials with properties similar to natural rubber. Most are obtained by polymerization or polycondensation of unsaturated monomers. A wide range of different synthetic rubbers have emerged, reflecting the various different applications and the chemical and mechanical properties they require. Copolymerization of different monomers allows the material properties to be varied across a wide range.

As Malaysia is located close to the equator, therefore a warm weather is guaranteed. At Tronoh,Perak the GPS location was at latitude 4.4167° and longitude of 100.983°. The temperatures generally range from 32°C at noon to about 26°C at midnight. But like most Southeast Asian countries, Malaysia's sun-shining days are interrupted by Monsoon season from November and February every year, and night temperatures can hit a low of about 23°C on rainy days. This is the reason to choose this location as in Malaysia the sunlight exposure was longer here.

1.2 Problem Statement

1.2.1 Problem Identification

Rubber stopper material had been used in our daily life. The observations found that when the rubber stopper is exposed to the agencies which constitute "weather", they undergo profound change. The rubber stopper may lose elasticity, it may split or crack, or the surface may take on a crinkled appearance in a wide variety of design. Therefore the question to this problem is to what factor does the weather contribute to the change of the rubber stopper surface? Does the changes of the surface material were changing during the period given?

1.2.2 Significant Of the Project

Through this project, all data such as the condition of the material surface every week is important. These data can be use as an additional source to the manufacturer or scientist as a reference in making more durable rubber stopper. Although the data will be collect around the UTP environment but these data can be similar at the place where the geological are almost same with here.

1.3 Objective

- To establish the effect of total simultaneous weather factors toward rubber stopper materials.
- To determine the trend of rubber stopper material degradation as a results of specific location in Bandar Seri Iskandar during 8 week starting from early July.

1.4 Scope of Study

The project is all about the materials effect. Therefore the scope of study is about the chemical reaction, polymers degradation, effect of sunlight to the material and polymers cross linking. The experiment will be done to prove the factors that affect the degradation of the material.

1.5 The Relevancy of the Project

The weathering factor that will be recognized will help the manufacturers or chemist to improvise the rubber stopper making in the future. This project also relevance as I am a mechanical student which had study about material.

1.6 Feasibility of the Project

This project is an experiment based project. In the time given, the experiment could be done. This project should be done within 2 months. Starting from early July until the end of August is the time period of the experiment. The objectives can be achieved if the procedures are closely followed.

1.7 Size of the Project

People: ASYRAF BIN JA'AFAR

Timeframe: 28 WEEKS (May 2011 – December 2011)

CHAPTER 2

THEORY AND LITERATURE REVIEW

2.1 Component of Outdoor Weathering

Outdoor weather was based on the geographical locations and the climate conditions (Wypych, George, 2002). Below are the component of weather that the rubber may have going through. These are the information about the types and ranges of degrading conditions to which the materials may be exposed.

2.1.2 Photophysics

The other names of photophysics is physics of light which included all important for weathering ranges of electromagnetic radiation including UV, visible, and infrared radiations. The fundamental theory by Maxwell about electromagnetic radiation is used nowadays to elaborate the properties of radiation such as the color of different wavelength and their diffraction, polarization, interference, etc. (Wypych, George, 2002).

$$C = v \times \lambda = 3 \times 10^8 \ ms^{-1}$$

Where:

c	radiation velocity
v	radiation frequency
λ	radiation wavelength

The energy must be absorbed by a molecule for it to start making changes in molecular structure by exceed to cause the degradation. (Wypych, George, 2002).

2.1.3 Temperature

The material temperature depends on air temperature, infrared radiation, air movement, and also properties of material itself. The air temperature in a location consists of the seasonal variations which also depend on the latitude, climatic conditions, and actual weather. For the infrared radiations, it absorbs about 40% of total energy of sun radiation on the earth surface which may cause the temperature changing. For the rate of heat penetration, it depends on the thermal diffusivity of the material and on its thermal conductivity. (Wypych, George, 2002). Below is the table to show that the air temperature behind awing material on sunny days.

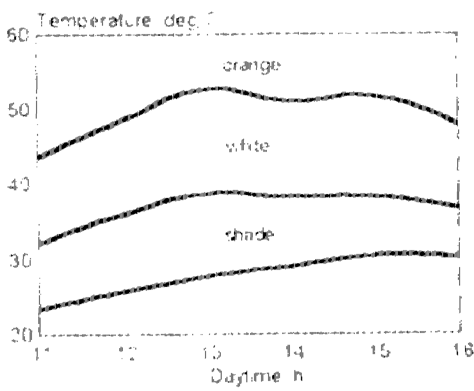

Figure 1: Air temperature behind awing material on sunny days.
[Data from W. Schnabel, *Polymer Degradation: Principles and Practical Applications*, 1981.]

2.1.4 Relative Humidity

Meteorological stations will have data on relative humidity that being collected. The continuously changing behavior in most locations during the daily was most important feature of relative humidity. The wetness time which are the data showing annual relative humidity in certain locations were only being measured by certain meteorological stations. The volume of the material will change due to the moisture absorption by material itself. The connections between a temperature reduction and high relative humidity will cause the production of a layer of condensed moisture on the top of material. The presence of water is the key component here. (Wypych, George, 2002).

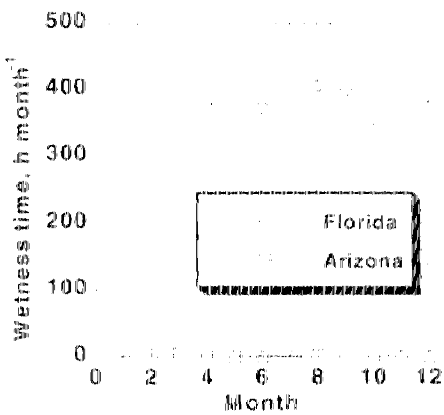

Figure 2: Wetness time vs. month in Miami,Florida and Phoenix, Arizona in 2000 for 5^0 titled surface. W. Schnabel, *Polymer Degradation: Principles and Practical Applications*, 1981.

2.1.5 Atmosphere Composition

The mechanism of degradation will change drastically after the presence of oxygen on the outdoor exposure to the material. The Earth contains the total of 5.1×10^{18} kg mass of air. The altitude plays the main role in changing the atmospheric density. Gas molecules in the atmosphere are continuously exchanged by the interaction of different sources and sinks. (Wypych, George, 2002). Below is the formula of the residence time of molecule in the systems.

$$F_i = F_o = A / \tau$$

Where:

F_i	flux of substance into the system
F_o	flux of substance out of the system
A	amount of substance in the reservoir
τ	residence time

The components of the atmosphere were divided into three groups depends on their residence time.

- Quasi-permanent gases 1000 years
- Variable gases a few years

- Highly variable gases 1 year

Below is the table that shows the classification above was used to group the components of the atmosphere.

Table 1: Composition of atmosphere, W. Schnabel, *Polymer Degradation: Principles and Practical Applications*, 1981.

Component	Unit	Concentration	Residence time
Permanent			
Nitrogen	%	[illegible]	
Oxygen	%	[illegible]	
Argon	%	0.934	
Neon	ppm	[illegible]	
Helium	ppm	5.24	
Krypton	ppm	1.14	
Xenon	ppm	0.087	
Variable			
Carbon dioxide	ppm	330	
Methane	ppm	1.5	4 years
Hydrogen	ppm	0.5	2 years
Nitrous oxide	ppm	0.3	[illegible] years
Highly variable			
Water	ppm	[illegible]	10 days
Ozone	ppm	[illegible]	up to 2 months
Carbon monoxide	ppm	[illegible]	[illegible] months
Nitrogen dioxide	ppm	[illegible]	1 day
Ammonia	[illegible]	5	5 days
Sulfur dioxide	[illegible]	5	4 days
Hydrogen sulfide	[illegible]	[illegible]	
[illegible] carbon	[illegible]	[illegible]	less than [illegible]

2.2 Types of polymer degradation

2.2.1 Photoinduced Degradation

Mostly commercial organic polymers are going through chemical reactions onto the irradiaton of ultraviolet (UV) light. This is because of the present of chromophoric groups which act as regular constituents that able to absorb UV lights. The UV light was presence in the spectrum of sunlight. Therefore, this type of degradation are usually happens when organic polymers are being exposed to the outdoors environment. (W. Schnabel , 1981)

2.2.2 Thermal Degradation

Thermal degradation of polymers is an important subject because it covers a broad field which ranging from the development of thermoresistant polymers and ablation problems to the stabilization of thermolabile polymers. A polymer consists of organic macromolecules which are stable only below a certain limiting temperature range usually around 100°c to 200°c, just a few special cases which it can endure up until certain degrees higher. The covalent bonds which linked the atoms together in the molecules had made the thermal sensitivity of polymers higher. At ambient temperature, the thermal energies produced an average value of $kT \approx 2.4$ hJ/mol which was really low to break the covalent bond. Therefore, usually the sufficient energy needed to exceed breaking the bond can only occur at temperatures higher than 400°c to 600°c. (W. Schnabel , 1981)

2.2.3 Chemical Degradation

Polymers reaction with oxygen molecules are importance because of the presence of oxygen in the air. Therefore, the oxidation processes had cause problems not only in outdoor exposures but also in processing. (W. Schnabel , 1981) Nowadays, the air pollution had becomes a worldwide problem, the behavior of pollutant gases has gained importance.

2.2.4 Biological Degradation

Biodegradation of polymers is familiar to everybody as far as natural polymers are concerned. It is quite obvious that all natural polymeric products will eventually be decomposed into small molecules until the death of the producing organism. The general mechanism of degradation of polymers into the small molecules employed by nature is a chemical one. Biopolymers attack by the enzyms that been produced by living organism can be happen. The attack is usually specific with respect to both the enzyme/biopolymer couple and the site of attack at the polymer. Therefore, the formation of specific decomposition products is produced. (W. Schnabel , 1981)

CHAPTER 3

METHODOLOGY

3.1 Research Methodology

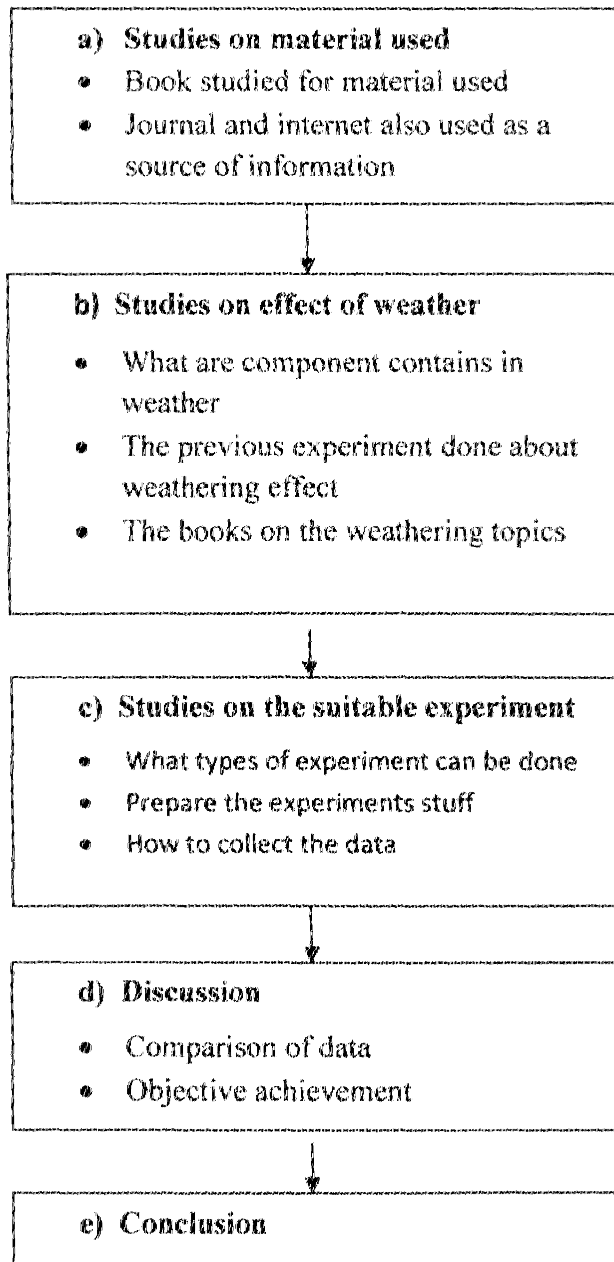

Figure 3: Flow chart of FYP 1 methodology

On the other hand, this project needs 3 stages to be completed which are:

1) **Preliminary research**

   In this stage, the research had been done to get the information on the weathering effects to the rubber material. There is lots of source which are books, journals and internet. The information need to be compiled for future references.

2) **Experimenting**

   After the research stage, the specimens need to be prepared. The specimens will be exposed to the environment by placing it at the open space.

3) **Data collection**

   The data will be collected every week to get the results. After 8 weeks, the result will be compiled.

3.2 Project Activities

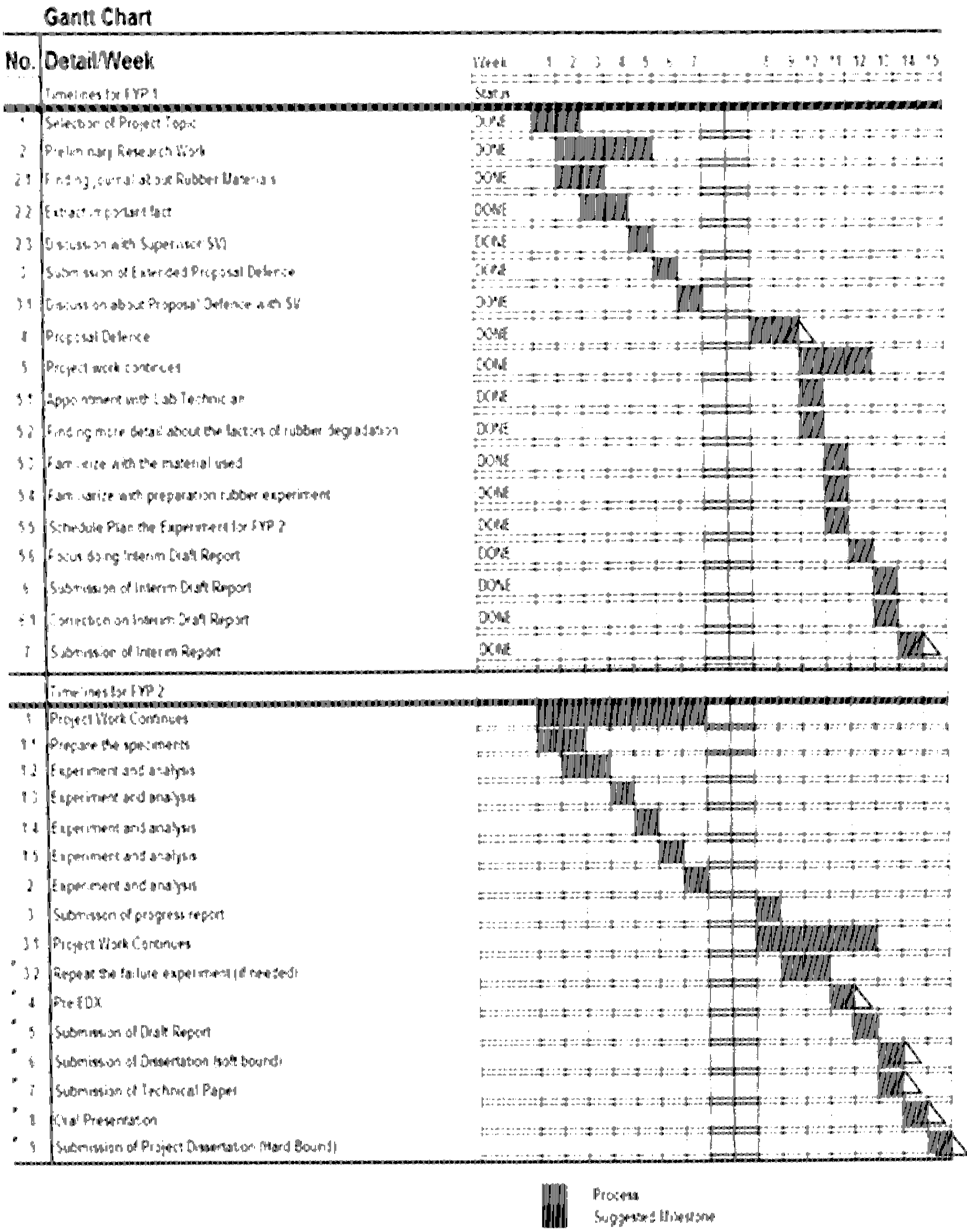

Table 2: Project activities Gantt chart and Key Milestones

3.3 Procedure

1. Prepare all the items to get the specimens ready to be exposed. There are:

    - Stopper rubber used to stop the water from get out of the bath tub.
    - Board of plywood.
    - Nails.
    - Pliers.
    - Plastic bag.
    - Marker pen.
    - Rope.
    - Cutter knife.
    - Marker pen.
    - Stapler.
    - Drilling machine.

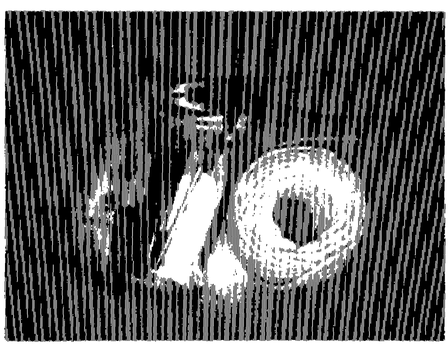

Figure 4: Equipments required.

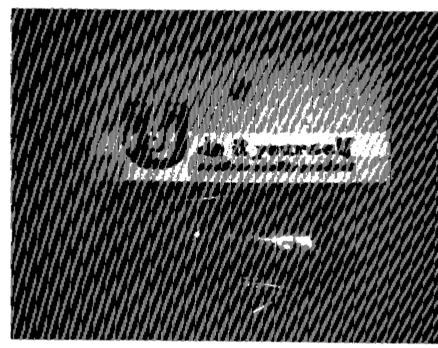

Figure 5: Stopper rubber.

2. Prepare the rubber specimens by cutting the rubber. Then making the hole by drilling the rubber.

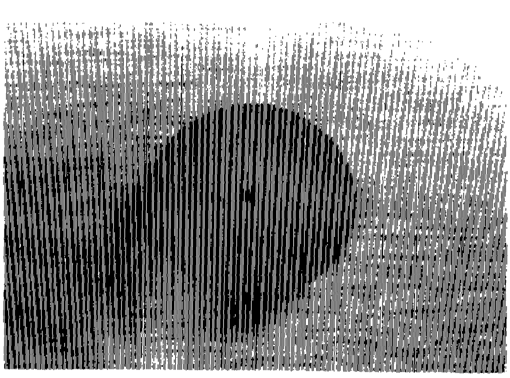

Figure 6: Rubber specimens after being cut.

3. Put the specimens on the ply wood by nailing it.

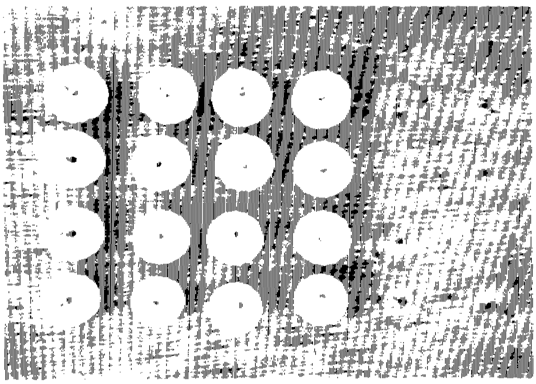

Figure 7: Nailing the specimens on the top of plywood.

4. Put the ply wood at the suitable place which was open to the environment. Using the rope to make sure that the ply wood was stable at its place. Every week collect the data by taking off the specimens and measure it.

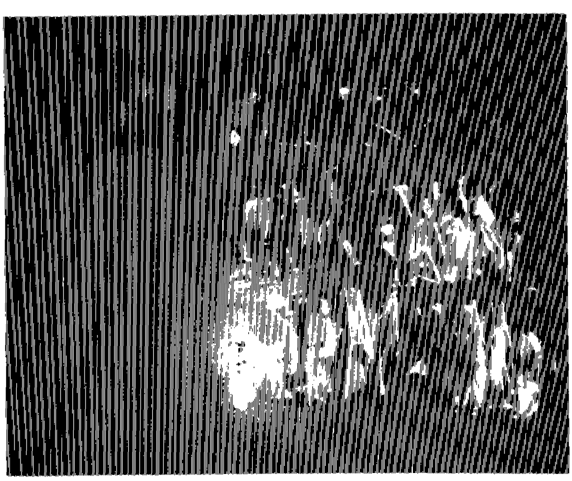

Figure 8: Collected specimens.

3.4 Tools/Equipments Required

3.4.1 Metallurgical Optical Microscope

The optical microscope is also known as light microscope. It uses the visible light and a system of lenses as a source to magnify images of small samples. Basic optical microscopes can be very simple but there are other design which focusing on the improvement of resolution and contrast.

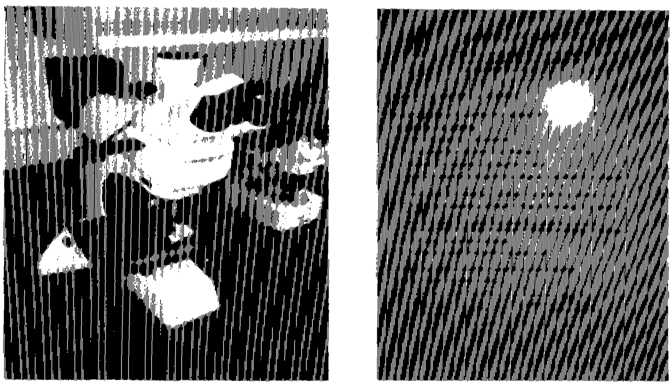

Figure 9: Metallurgical Optical Microscope and its Standard Operating Procedure (SOP).

3.4.2 Weighing Machine

The machine chooses were from model Mettler Toledo AX. This weighing machine was designed as an innovative analytical balance offering good weighing performance and user friendliness design. It also provides touch screen display and intelligence user guidance to bring the easier friendly weighing machine.

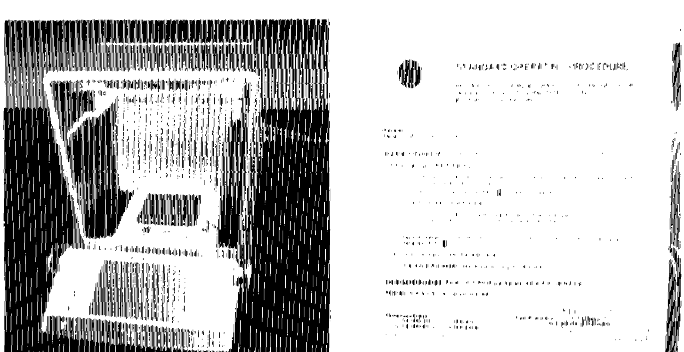

Figure 10: Weighing Machine and its SOP.

3.4.3 Drilling machine

There are two types of machine drill which are the bench drill and the pillar drill. What is the difference between these two types of machine was the bench drill is used for drilling holes through materials including a range of woods, plastics and metals. Usually this type of machine was already bolted to the bench so that it cannot be move over.

The larger version is called pillar drill. The advantage of this type of machine is it can be used to drill the larger pieces of material and produce larger holes compared to the bench drill.

Figure 11: Drilling machine.

3.4.4 The Basement and Material

The basement here is made by plywood which needs to be cut according to the measurement given. This basement will place the specimen for the whole experiments period. The material is put into the holes and being expose to the outdoor environment.

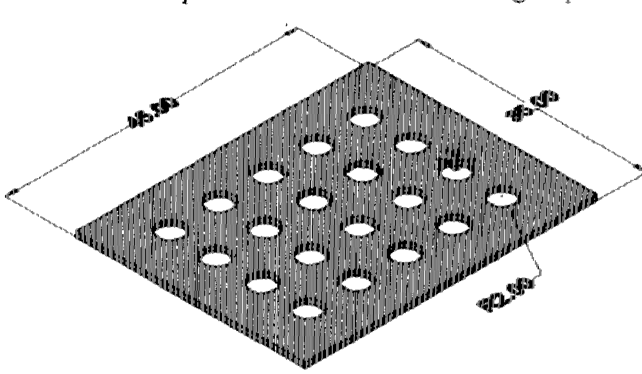

Figure 12: The basement.

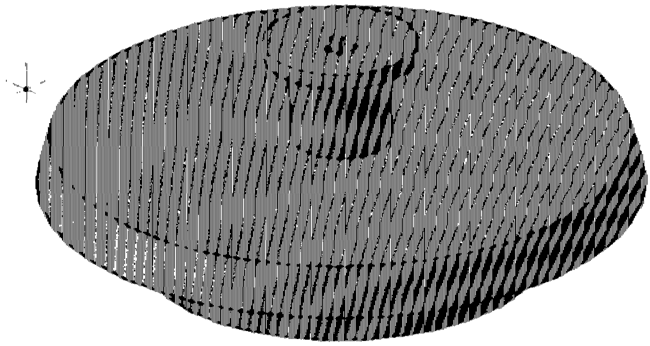

Figure 13: The Material Used (Up view)

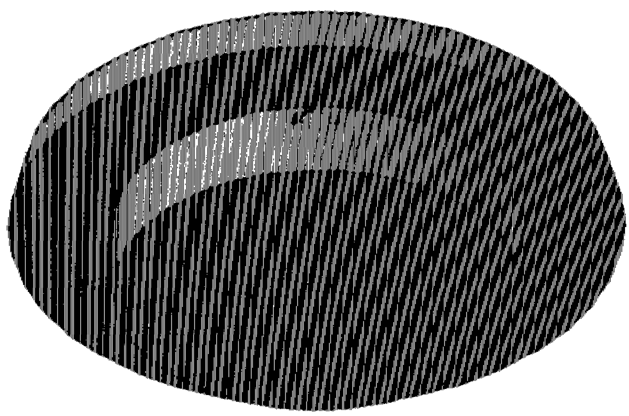

Figure 14: The Material Used (Down view)

CHAPTER 4
RESULT & DISCUSSION

For the results of this project is based on the data collected every weeks. The specimens will be measured by weight and also the condition of the surface. Below are the results after 7 weeks. The comparison made to differentiate the degradation of surface crazing of the rubber material.

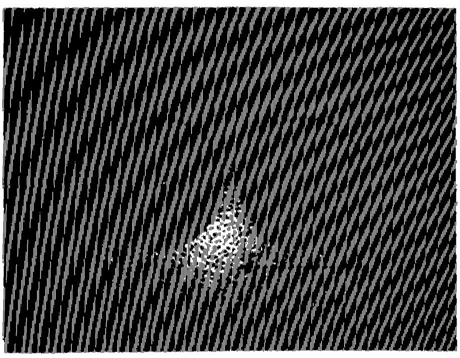

Figure 15: Week 1 and Week 2

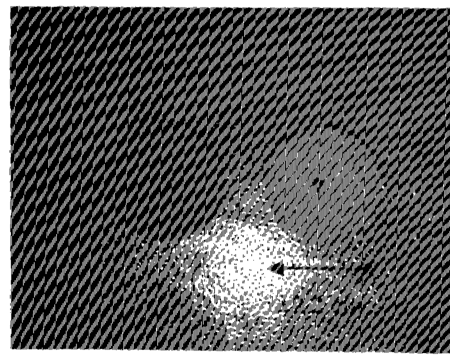

Figure 16: Week 1 and Week 3

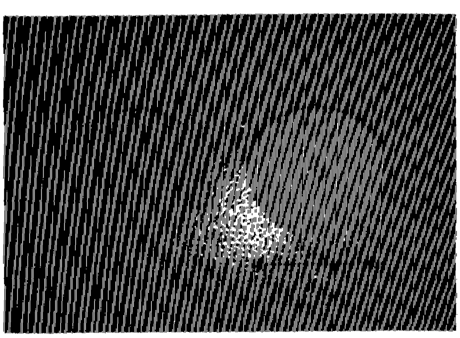

Figure 17: Week 1 and Week 4

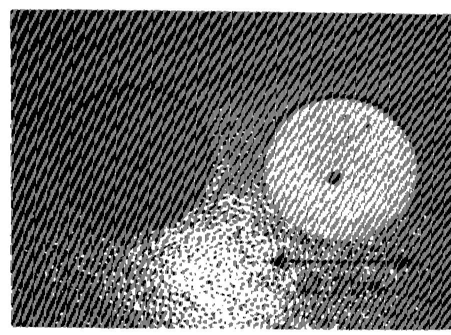

Figure 18: Week 1 and Week 5

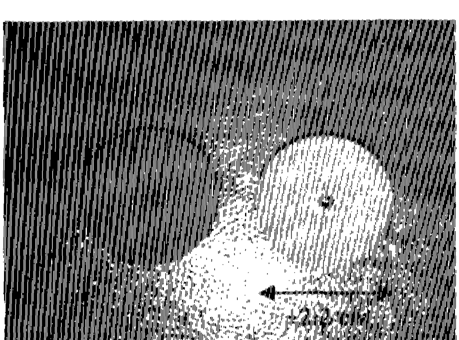

Figure 19: Week 1 and Week 6

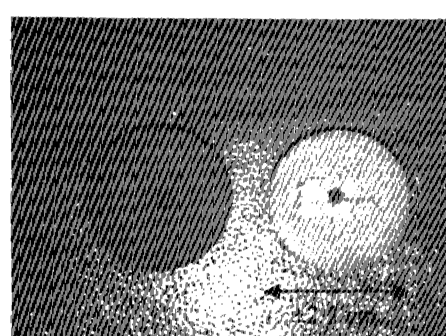

Figure 20: Week 1 and Week 7

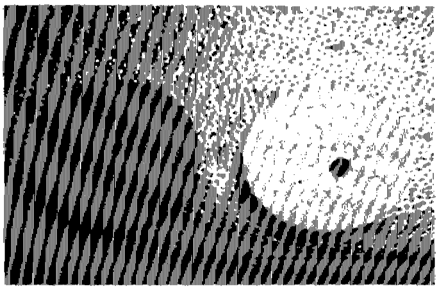

Figure 21: Week 1 and Week 8

Below is the measurement made by using weighing machine. There were 4 samples for every weeks which the average of the weight will be compared and analyze after week 8. The graph will be made after all the data were collected.

Table 3: Results after 8 weeks.

Weeks Sample	1	2	3	4	5	6	7	8
1	4.464	4.105	3.829	3.862	4.297	4.733	3.601	4.664
2	5.51	5.565	4.514	5.082	5.294	5.354	4.888	4.881
3	5.884	5.717	5.659	5.585	5.759	6.036	5.942	5.956
4	4.903	5.454	6.626	5.958	5.142	5.221	5.843	5.271
Average	5.19	5.21	5.157	5.122	5.123	5.336	5.069	5.193

Table 4: Results before the specimens were exposed to the environment.

Weeks Sample	1	2	3	4	5	6	7	8
1	4.464	4.113	3.838	3.871	4.318	4.763	3.632	4.709
2	5.511	5.574	4.523	5.09	5.319	5.392	4.929	4.935
3	5.884	5.724	5.669	5.595	5.785	6.077	5.993	6.011
4	4.904	5.461	6.637	5.97	5.166	5.261	5.874	5.32
Average	5.191	5.218	5.167	5.132	5.147	5.373	5.107	5.244

Table 5: Results of the difference before and after

Weeks sample	1	2	3	4	5	6	7	8
Before	5.191	5.218	5.167	5.132	5.147	5.373	5.107	5.244
After	5.19	5.21	5.157	5.122	5.123	5.336	5.069	5.193
Differences	0.001	0.008	0.01	0.01	0.024	0.037	0.038	0.051
Percentage Difference	0.1	0.8	1	1	2.4	3.7	3.8	5.1

Here is the graph which shows the degradation of the rubber based on the weight percentage and week. The graph tells that the degradation happens to be increase when the rubber was exposed to the environment.

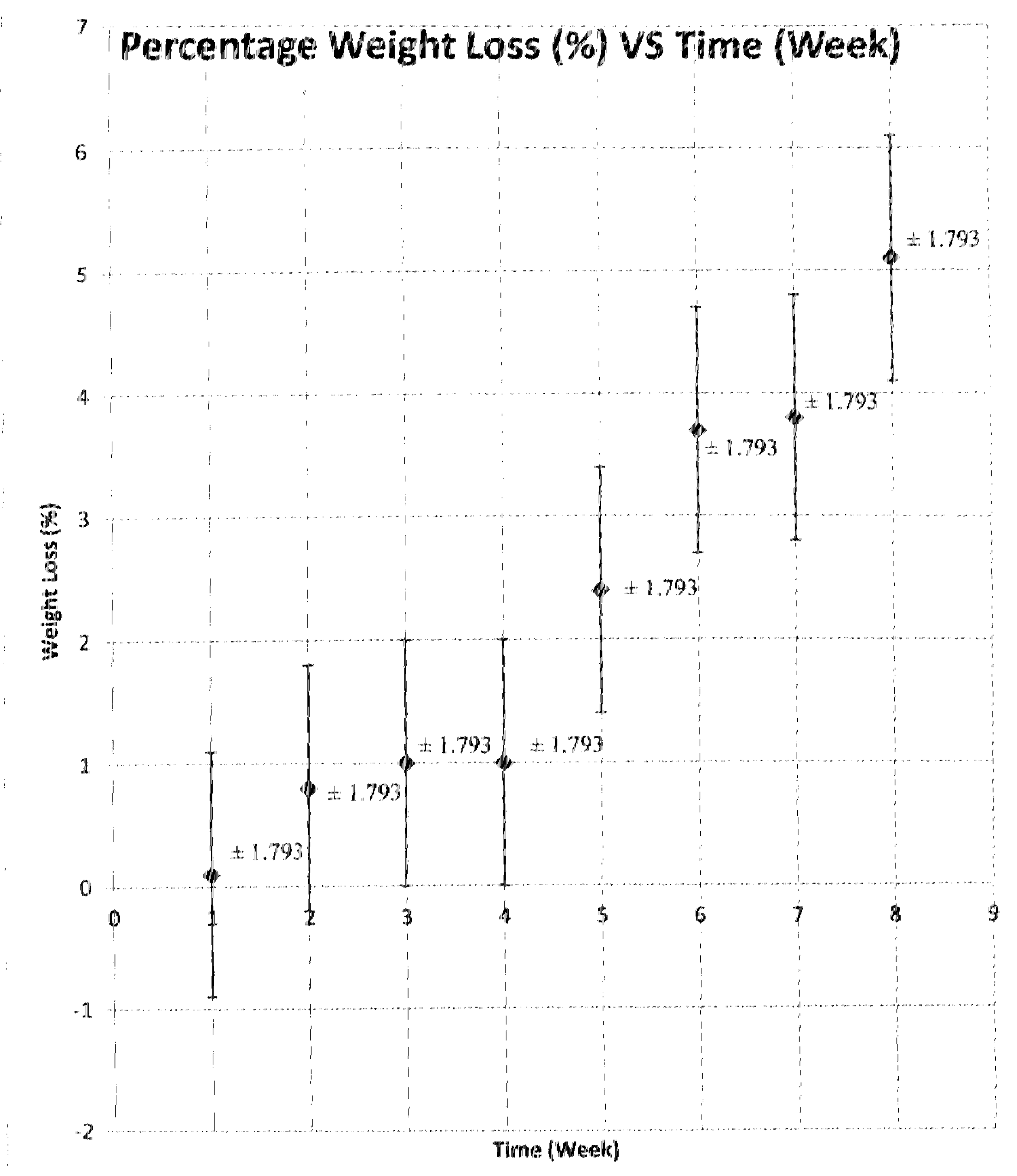

Figure 22: Graph Percentage Weigh Loss (%) vs Time (Week)

Below is the picture taken using metallurgical optical microscope for sample 1 for every weeks.

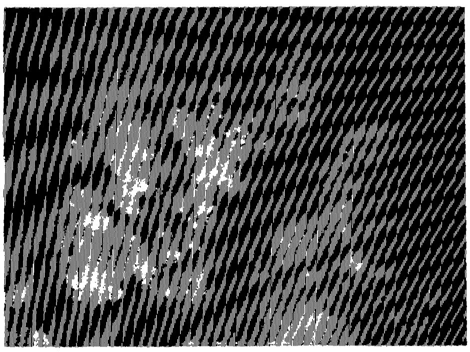

Figure 23: Week 1

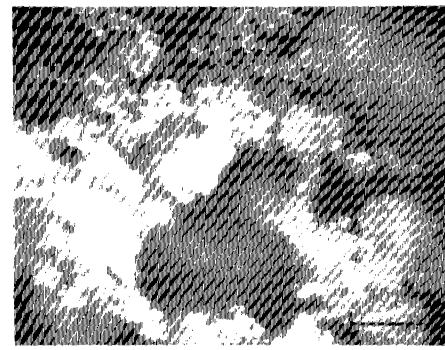

Figure 24: Week 2

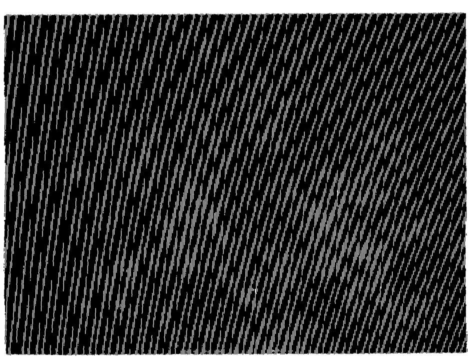

Figure 25: Week 3

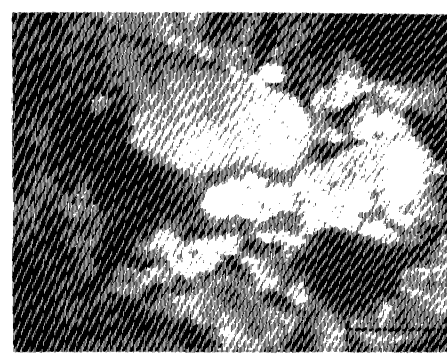

Figure 26: Week 4

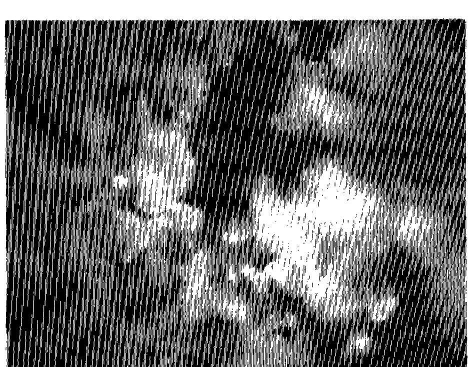

Figure 27: Week 5

Figure 28: Week 6

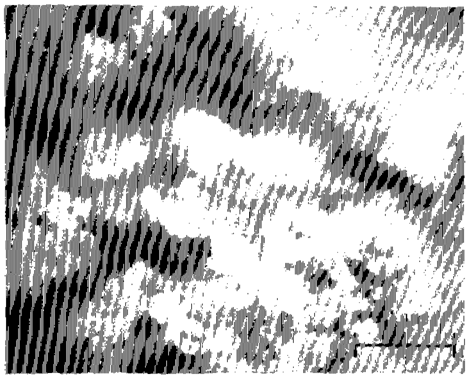

Figure 29: Week 7

Figure 30: Week 8

Based on the results shown, there are several factors that affect the surface of the rubber stopper. When it were placed at the open space, first factor that will degrade the rubber stopper were Ultra Violet (UV) which also called as photochemical reaction. This photochemical reaction was based on chemical reaction in the light form which produces energy to be absorbed. Direct sunlight is the source of this factor. It will create the transient excited states whose the properties differed greatly compared to the original molecules. These will create a new chemical which may undergo a lot of molecules structural effects.

For the second factor, the rubber stopper seemed to face the hydrolysis reaction. Based on the data, the weight of the stopper decreases from week to week. Hydrolysis reaction gives the meaning of water reaction which a molecule is divided into two parts by the addition of a molecule of water. One fragment of the parent molecule gains a hydrogen ion (H^+) from the additional water molecule. The hydroxyl group (OH^-) were the other group that remaining.

For the third factor, the oxidation seems to take part to the rubber stopper material. The rubber does the chemical reaction in which the oxidation numbers of the atoms are changed. In this process the rubber molecule, atom, or ion loses electrons to an oxidant. The oxidized substance increases in positive valence. This reaction always occurs together as part of the oxidation-reduction reaction. The reduced substance gains electrons and thereby decreases in positive valence.

For the fourth factor, the mechanical reaction that called erosion also takes part in degrading the rubber stopper surface. Although it does not seem to give the big effects to the rubber but it contribute to the rubber surface crazing. There are lot of particles in the air which we cannot see such as the small sand, the abrasive particles and others thing. When we put the sample at the open space, the wind will carry all of the small things around together that will flow on the surface of the rubber. This will degrade the rubber surface.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Based on the schedule and progress of the project, the project currently on the right track, as all activities are meet the target of schedule and key milestone. Now the experiment was done and the data collected had been shown. Therefore, based on the data collected, the experiment seems to be successful. As a conclusions, this experiment were proven that the rubber stopper will degrade when it were placed at the open environment. There were a graph which shown the results after 8 weeks the rubber stopper had been placed at total outdoor environmental exposure. This will help the researcher and inventer to do more research on this environment.

Anyway, the experiment seems can be repaired and enhance in many ways. First, the number of samples can be doubled and place at many places in one area. By doing this, the data can be more accurate as the average of every samples were being taken count. The conditions of every places also may gives different effect to the rubber rather than just putting it at one place only.

Therefore more detailed study should be done especially in the discussion on the effect of the rubber material. This is because there are many factors that did not being discussed which may affect the rubber material and taking part in degrading the rubber material. Lot of reading needs to be done on polymer degradation.

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