ANALYSIS OF LIQUID FILM FLOW IN BETWEEN TWO DIFFERENT PLATES

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Report submitted in partial fulfillment of the requirements
for the award of the degree of
Bachelor (Hons.) of Engineering in Manufacturing Engineering

Faculty of Manufacturing Engineering
UNIVERSITI MALAYSIA PAHANG

June 2016

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ACKNOWLEDGEMENTS

My thanks and appreciation to Dr. Nurrina Binti Rosli for persevering with me as my supervisor throughout the time it took me to complete this research. The idea and knowledge that she shared is countless for doing the research. Working with her was one of the most important and formative experiences in my life.

I must acknowledge as well the many friends, colleagues, lecturers and other librarians who assisted, advised, and supported my research and writing efforts over the year. Especially, I need to express my gratitude and deep appreciation to my teammates whose friendship, hospitality, knowledge, and wisdom have supported, enlightened, and entertained me over the many months we works as a team. They have consistently helped me keep perspective on what is important in life and shown me how to deal with reality. I am grateful too for the support and advise from my faculty Administration Staff; The Faculty of Manufacturing Engineering.

Finally, I would like to leave the remaining space to my parents and my siblings as there is no words can describes how big the contribution that they have make in my life and in this project.

ABSTRACTS

In flip chip technology, analysis of underfill flow between chip and substrate are important to prevent the chip from breaking. In other words, the welded solder balls in the packaged chip, underfill epoxy is filled into the gap between a chip and a substrate. It is because to prevent cracks on the solder bump and electrical failure resulting from thermal fatigue. This project focuses on analysis liquid film flow in between two different plates. The filling time will be analyzed to estimate the flow behavior between two parallel plates and flow pattern of liquid to fulfill entire plate. This experimnet uses four different materials which glass, perspex, aluminum and tile with dimension 25mm x 25mm for lower plates. For upper plate is fixed by using glass also with dimension 25mm x 25mm. Software Free Video to JPG Converter used to identify the time taken to fulfill and software Adobe Photoshop to calculate the distance travelled of liquid and to visualize the flow pattern during to fulfill entire plate. Glass-tile present high filling time due to its properties of surface roughness and under 300s of filling time, materials with lowest surface roughness travelled in longest distance.

ABSTRAK

Dalam teknologi cip flip, analisis aliran underfill antara cip dan substrat adalah penting untuk mencegah cip pecah. Dalam erti kata lain, dikimpal bola pateri dalam cip dibungkus, epoxy underfill diisi ke dalam jurang antara cip dan substrat. Ia adalah untuk mengelakkan retak pada benjolan pateri dan kegagalan elektrik yang disebabkan oleh keletihan haba. Projek ini memberi tumpuan kepada analisis cecair mengalir di antara dua plat yang berbeza. Kali pengisian akan dianalisis untuk menganggarkan kelakuan aliran antara dua plat selari dan corak aliran cecair untuk memenuhi keseluruhan plat. experimnet ini menggunakan empat bahan-bahan yang berbeza yang kaca, perspek, aluminium dan jubin dengan dimensi 25mm x 25mm untuk plat yang lebih rendah. Untuk plat atas ditetapkan dengan menggunakan kaca juga dengan dimensi 25mm x 25mm. Software Percuma Video untuk JPG Converter digunakan untuk mengenal pasti masa yang diambil untuk memenuhi dan perisian Adobe Photoshop untuk mengira jarak yang dilalui cecair dan untuk menggambarkan corak aliran semasa untuk memenuhi keseluruhan plat. Kaca jubin hadir masanya pengisian kerana sifat-sifatnya kekasaran permukaan dan di bawah 300-an masa mengisi, bahan-bahan dengan kekasaran permukaan rendah mengembara dalam jarak terpanjang.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

This chapter will discuss about background of study, problem statement and objective. Widely present in our daily life, liquid film flow can be define as motion of a fluid subjected to unbalanced forces or stresses. The motion continues as long as unbalanced forces are applied. For example, in the pouring of water from a pitcher the water velocity is very high over the lip, moderately high approaching the lip, and very low near the bottom of the pitcher. The unbalanced force is gravity, that is, the weight of the tilted water particles near the surface. The flow continues as long as water is available and the pitcher remains tilted. For example, blood circulation which allows the blood flow through entire body and rainy day and water drop and absorb into soil.

In industry of micro-packaging, there are various kinds of method have been used, such as flip-chip technology. It is the strongest interconnection method that use in this industry. Before this, there is another method which had been introduced that is wire bond packaging. Flip-chip technology is actually that use adhesive to stick the chip in board so that the chip is adhesive completely on the board. As s simple definition, it can be seen that the underfill flow is kind of flow in between narrow. It “combines together” between chip and substrate (George Riley, 2000) as shown in Figure 1.1

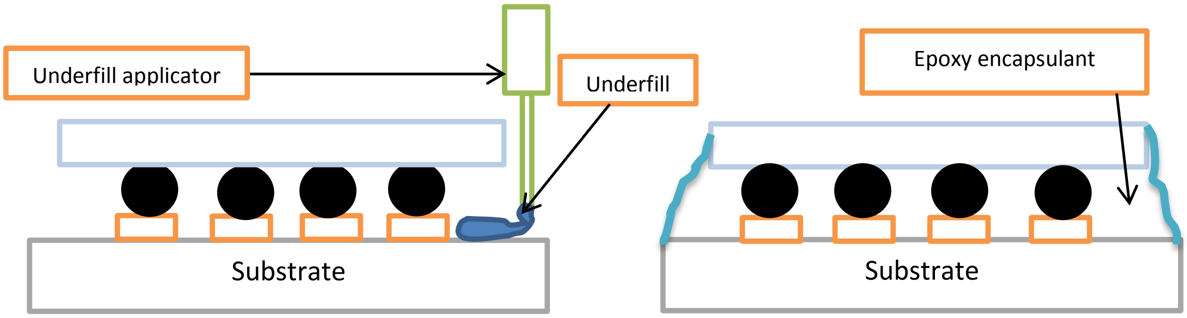


Figure 1.1: Flip-chip assembly

Another method that had been used other that the flip-chip technology in micro-packaging is wire bonding. Generally, wire bonding is a method used to connect a fine wire between an on-chip pad and a substrate pad. According to a definition provided by Smith (2001:23), wire bonding is long conductive wires are connected between a chip and a substrate (Kim, Y. B. and J. Sung, 2013) as shown in figure 1.2.

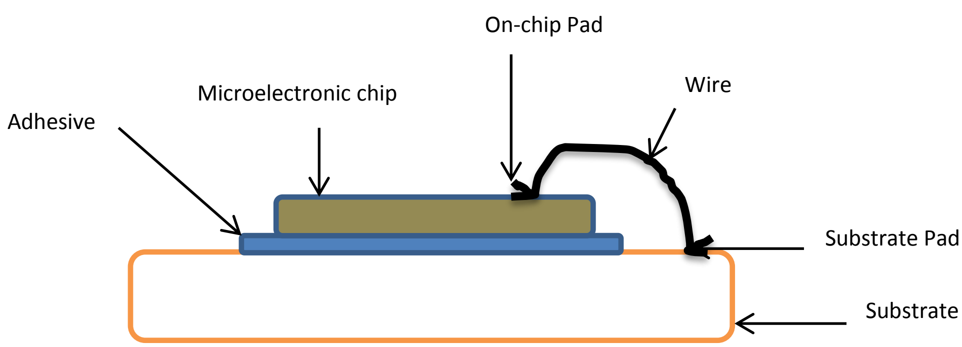


Figure 1.2: Wire Bonding Assembly

The short interconnection in the flip chip technology is more advantageous than the long wire connection for manufacturing thinner and smaller integrated circuit systems. It also possible to improve electrical performance (Kim, Y. B. and J. Sung, 2013). By using a flip chip interconnect process, the chips can be electrically connected in a more compact fashion, better than wire bond that needs some space for a lot of wire. It is because the flip-chip technology uses solder bump that need a little space for its gap height. When compared to a wire connection, the lower inductance of a bump connection will translate into reduce losses and lower power requirements.

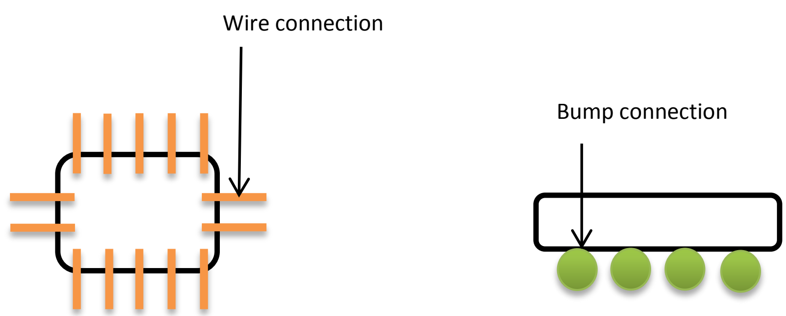


Figure 1.3: Wire connection vs. flip chip bump connection

In flip chip technology, analysis of underfill flow between chip and substrate are important to prevent the chip from breaking. In other words, the welded solder balls in the of packaged chip, underfill epoxy is filled into the gap between a chip and a substrate. It is because to prevent cracks on the solder bump and electrical failure resulting from thermal fatigue. However, a large difference in the thermal expansion coefficient (CTE) between the silicon chip and the organic substrate bring up significant thermal stresses on the interconnections during thermal cycling. Therefore, the underfill epoxy would relax the stresses produce by the CTE mismatch, might as well as reduces the impact and deflection due to substrate. As the results, flip-chip method is much more popular compared to wire bonding method.

In the study of underfill flow behaviour the filling process is must significant process to determine the quality of the flip-chip. One of the important entities to analyse the process the influences of filling time between two plates are:

- Contact angle
- Surface tension
- Gap height
- Viscosity of liquid
- Material of plate
- Size of plate

This project was undertaken as contribution to fundamental knowledge. Thus, to evaluate the purpose of the current study the underfill flow between two plates which influences by different material of plates.

1.2 PROBLEM STATEMENT

The problems to be analyzed in this study are:

- How two different materials plates can lead to the time taken to full-filling the gap between the two plates?
- What is filling pattern of the liquid film upon flowing through the gap?

There are many influence when two different plates when the liquid fluid flow between it. There are surface tension, viscosity, contact angle, gap of height and type of material of plates. In this term that must be take serious because it can influence of time filling to fulfill entire surface of the plate. Each material has different surface roughness. It will be affect the liquid flow in between two plates. However, this project focuses on analysis liquid film flow in between two different plates. It will take the time of liquid to fulfill and analysis that with the influence that can make the time can change and the filling pattern of the liquid film flowing through the gap.

1.3 OBJECTIVE

The objectives for this experiment are set as:

- To analyze the time taken for liquid to full-filling the gap between two plates influenced by different materials of plates.
- To visualize the flow pattern of the liquid flow upon flowing through the gap between two plates.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter is presented about literature on flip-chip packaging technology. There are many ways that can get from literature before such as from method that use, using different parameters, use assumption, model and study. According to problem statement, how two different plates influence filling time of liquid to fulfilled entire surface of the plates and how the material of plates effect the liquid flow, this literature will state using different parameters, use assumption, model and study.

2.2 COMPARING THE RESULTS IN PREVIOUS STUDIES

For influence the time taken in different two plates had reported by study using two parallel plates. Objective for this study is to compare result between of simulation and analytical flow front advancement (C.Y. Khor, M.Z. Abdullah, F. Che Ani, 2012). For the simulation, finite volume method-based software (FVM-based software) is use and for the plates are 5mm x 5mm and its fix. It uses different gap heights (5, 10, 15, 20, 25, 30, and 35 μm). After that, create a three-dimensional model as can be seen in figure

2.1, and simulated a non-Newtonian underfill flow by using computational fluid dynamics. The volume of fluid (VOF) model is used to display the flow front advancement of underfill flow for doing simulated.

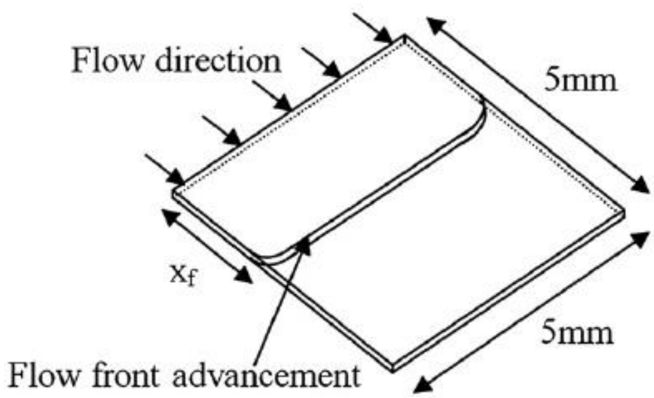


Figure 2.1: Flow direction and flow front advancement in underfill process.

Source: (C.Y. Khor, M.Z. Abdullah, F. Che Ani, 2012)

2.3 DIFFERENT PARAMETERS IN PREVIOUS STUDIES

This study actually more focuses on underfill process for two parallel plates and influence of gap height which a gap height 30 μm was studied in application of flip chip packaging. The gap height also can be influence by the filling time and pressure drop. Also, the solder bumps can be give more big effect on the flow pattern at the melt flow portion. The results of this study which comparison between simulation and analytical results are parallel of both for two parallel plates of underfill flow.

Then, for this study it to discuss in what way to practice flow time testing for underfill flow estimation and material screening (Wang, J., (2005). For this study it will used test pieces made up from glass microscope slide to measure the flow time of some underfill at high temperature. Viscosity, contact angle and surface tension are material properties that influence underfill flow and use Washburn equation to estimate flow times for experimental measured. Empirical and calculated flow times were compared.

Next, there were study that reported to had different underfill materials which consist of epoxy or cyanate ester resins, catalyst, crosslinker, wetting agent, pigment, and fillers. Underfill materials are highly filled with the filler loading ranging from 40% to 70% (J. Wang, 2002). In underfill material processing, fast flow and curing are desired for high throughout. In this study the viscosity, surface tension, and contact angle are key material properties affecting the gap filling process. The underfill materials need to have low viscosity and low contact angle at dispensing temperature in order to maintain and attain fast filling of time taken for them to fulfil the gap in between surfaces. In this study, it not state what kind of material that it used for this study but it take as influences of time to fulfill process even this is for underfill material but for material of plates the influence also same. It also go through detail for material which Due to curing of an underfill material at dispensing temperature, the viscosity increases with time, make the complicates for underfill flow process. The rheological behavior of several underfill materials was experimentally studied. In the other hand, those underfill materials shows strong temperature dependence in viscosity before the curing. The dynamic time sweep test was using to test dependent viscosity and curing of underfill materials. Also the study investigated the effects of viscosity and curing behavior of underfill materials on underfill material processing. The material with a shorter gel time had more unstable viscosity at room temperature, and hence longer pot life. The experimental methods were planned to calculate the surface tension and the contact angle of underfills at temperatures over 100 C. As results, the contact angle for underfill on a substrate was time dependent. This meant the interaction between underfill and substrate affects not only gap filling, yet also filleting. Besides that, the study also contains the effect of surface energies of flip-chip substrates on wetting angles. Experiment results showed that for the same underfill, the higher the surface energy of substrate, the better the filleting.

After that, for this study to investigate experiment about influence of first velocity on the liquid film thickness which in accelerated flows under adiabatic condition (Y.J. Youn, K. Muramatsu, Y. Han, N. Shikazono, 2015). Device that uses to measure the initial liquid film thickness is laser focus displacement meter and use water, ethanol, FC-40 are used as working fluids and circular tube with inner diameter of 1 mm was used for the test tube. When the flow is accelerated from small initial velocities under small Bond number condition, initial liquid film thickness is identical to that of steady flow at small capillary numbers, and then deviates from the steady condition and eventually follows that of accelerated flow from zero initial velocity as capillary number is increased. When the flow is accelerated from large initial velocities, initial liquid film thickness deviates from the steady condition earlier and starts to follow that of accelerated flow from zero initial velocity as capillary number is increased. It is found that the initial flow velocity cannot be neglected in accelerated flows especially at large initial flow velocities and at large Bond numbers. Finally, an empirical correlation is proposed for the initial liquid film thickness of accelerated flows that accounts for the initial flow velocities. Based on this study, the material that using for micro tube is suitable for water, ethanol and FC-40 for liquid to flow. According to problem statement, for the material in this study is suitable for liquid flow because of thermal. So, the material can make liquid flow stable and fast to flow it.

Capillary tubes are extensively used in several cooling applications like refrigeration, electronic cooling etc. Local pressure variation in adiabatic straight capillary tube (mini channel) is studied experimentally and numerically with R134a as the working fluid. Experiments are performed on two straight capillary tubes (S.D. Deodhar, H. B. Kothadia, K.N. Iyer, S.V. Prabhu, 2015). It is found that the diameter is the most sensitive design parameter of the capillary tube. Experiments are performed on five helically coiled capillary tubes to quantify the effect of pitch and curvature of helically coiled capillary tube on the pressure drop. Non dimensionalized factor to account coiling of capillary tube is derived to calculate mass flow rate in helically coiled capillary tubes. Flow visualization in adiabatic capillary tube confirms the bubbly nature of two phase flow. Numerical and experimental investigations in diabatic capillary tube suggest that the use of positive displacement pump and choking at the exit of the channel ensures flow stability. From this experiment, it use capillary tube use and it suitable for liquid flow but it different.

Silver nanowires (AgNWs), as one-dimensional nanostructured materials, possess high aspect ratio and intrinsically high thermal conductivity. However, AgNWs are difficult to disperse homogeneously in epoxy resin, and their high electrical conductivity also limits their applications for electronic packaging. Herein, silica-coated silver nanowires (AgNWs@SiO2) were synthesized by a flexible sol–gel method and then incorporated into epoxy. The less stiff silica intermediate nanolayer on AgNWs not only alleviated the mismatch between AgNWs and epoxy, but also enhanced their interfacial interaction. Hence, the thermal conductivity of an epoxy/AgNWs@SiO2 composite with 4 vol.% filler loading was increased to 1.03 W/mK from 0.19 W/mK of neat epoxy compared to 0.57 W/mK of an epoxy/AgNWs composite with identical nanowire loading. Simultaneously, the insulating silica nanolayer effectively avoided formation of an electrically conductive network of AgNWs in epoxy, leading to high electrical insulation of the composite. AgNWs@SiO2 nanowires with core–shell structure also improved the dielectric properties of epoxy. In addition, these composites possessed a viscosity suitable for the underfill process in electronic packaging. From this study types of underfill also can be influence of time taken which the mixture of liquid that can make liquid flow slowly.

This study investigated the dynamic variations of flow and meniscus during underfill process using flow visualization techniques to understand physics of capillary flows (Lee, S. H., S.Jaeyong, 2010). For the quantitative flow visualization, a high speed micro particle image velocimetry (lPIV) was applied to a transparent flip chip specimen with arrayed bump structure. As an underfill liquid, glycerin was filled into the flip chip specimen by capillary action. The present visualization technique offers time-varying movement of meniscus and phase locked velocity fields frozen to the meniscus position.

To observe the dynamic contact angle between parallel plates, an in situ measurement technique was developed in the present study. Then, the filling time was compared with analytical models. From this experiment, it was found that the meniscus velocity and the contact angle vary in-phase according to the position of meniscus. The phase-locked velocity fields show velocity gradients on the meniscus surface which gives rise to the breakdown of equilibrium contact angle. Consequently, the detailed filling time has different behavior from the analytical models.

2.4 USING MODELS IN PREVIOUS STUDIES

A modified Hele–Shaw flow model, that considered the flow resistance in both the thickness direction and the restrictions between solder bumps, was used (Young, W.-B., 2003). This model estimated the flow resistance induced by the chip and substrate as well as the solder bumps. A capillary force model, depending on the direction of filling flow, for full array solder bumps was proposed to study the anisotropic behavior of the underfill flow. The capillary force was formulated based on quadrilateral arrangement of solder bumps. It was found that the capillary action is not the same for different directions. In the 458 direction, enhancement of the capillary flow was noticed for a bump pitch within a critical value. The edge preferential flow during the underfill experiment could be attributed to the anisotropic behaviour of the capillary action. Analysis of the design criteria for the contact line jump effect was also performed. The analysis will provide guidelines for the design of the solder bump arrangement with better underfill efficiency. The solder bump influence the time taken to fulfill.

On top of that, it is interesting to note that in all cases of this study, underfill process is really give a huge advancement in the flip-chip packaging because of its great impact on the reliability of electronic devices. The analytical model is required to perform for control the underfill dispensing. Surprisingly, Washburn model was found to use in order to predicts the flow of fluid viscosity in the flip-chip underfill process which driven by capillary forces (Wan, J. W., D.J. Bergstorm, 2008). Regrettably, some studies have shown the drawbacks of model which does not match the measured results. Perhaps this is the most serious disadvantage of this method due to the neglect of the characteristics such as solder bump resistance and non-Newtonian behavior of underfills. Even though, there are some underfill flow models that have been established by considering these characteristics, yet still there is no sufficient account for such a mismatch from the literature. The study experimentally proven that limitation may existed in Washburn model. It was validated that the underfill fluid used in flip-chip packaging performed a complex non-Newtonian behaviour. Indeed, Washburn model only applicable to the Newtonian fluid in this setting. Another contribution of the study is the provision of measured data on a test bed which was built upon using the off-the-shelf components; which mean the data can be used by other researchers to confirm their theoretical judgments.

This experiment that use high-speed video camera to get images of the flow close the pipe wall in extremely dispersed oil-water flow which 12 m long straight acrylic pipe, with 26 mm of internal diameter, using mineral oil (828 kg/m^3 of density and 220 cP of viscosity) and tap water. Dispersed oil–water flow was studied in a 12 m long horizontal acrylic pipe, with 26 mm of internal diameter, using mineral oil (828 kg/m3 of density and 220 cP of viscosity) and tap water. So that, at the pipeline it was design and set up visualization for that significant. The method applied according to get images of the flow then, use application of digital images to get the film thickness near the wall clearly. The algorithms were suggested to measure the film thickness that sensed at the top and bottom of the pipe at extremely turbulent oil-water flow which a pre-processing improvement algorithm and a combined segmentation algorithm. For the result of this experiment the combined method better than the traditional techniques to obtain digital images of thickness near the wall.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter will describe the materials, tools and equipment that used to analyze filling time of liquid in between two plates and to study the effect different material of plates to the liquid flow pattern. This experimental provide information about the size of plates, gap height in between two plates, material of plates, types of liquid that will use, viscosity of liquid and temperature . It is because can influence the time taken to fulfill in the plates. In this experiment, method that used is injection. It use syringe to inject the liquid into the plates. This experiment will use three types of plates, so it will be use the same person to inject the liquid into the plates to become constant when injections occur in different plates. This experiment also, make in room temperature. For the time we take three time for each different plate. Finally, digital camera will used to capture the picture of liquid flow pattern.

3.2 APPARATUS

There are many apparatus that must have when this experiment does. There are

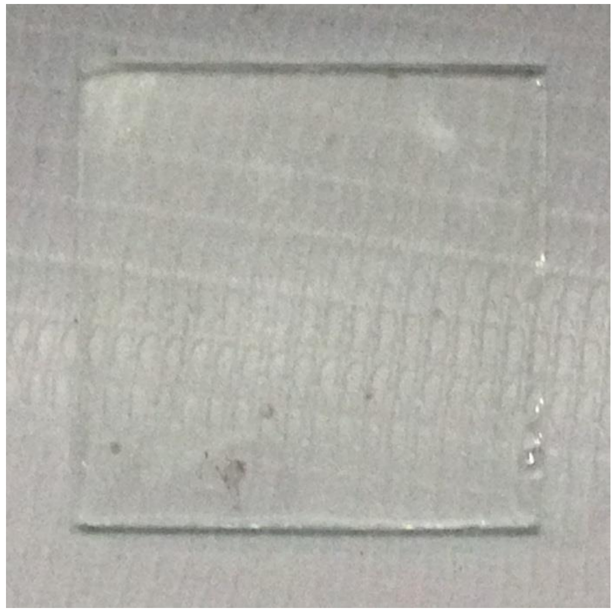


Figure 3.1: Glass

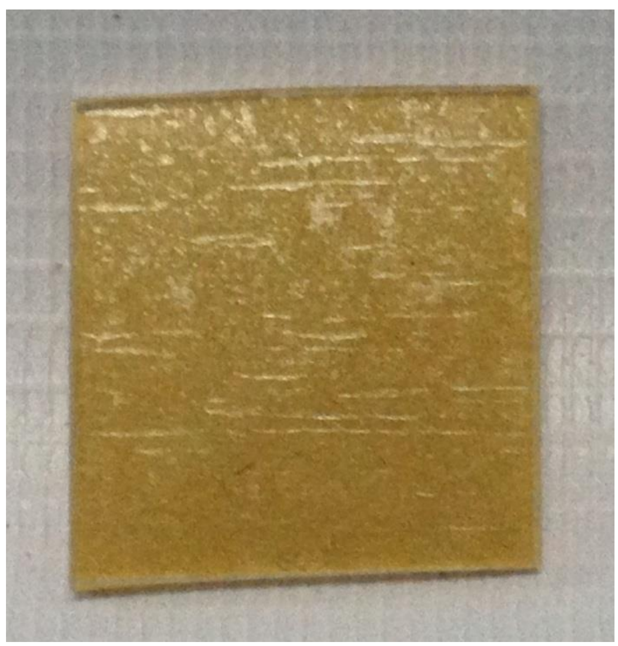


Figure 3.2: Perspex

Figure 3.3: Aluminum

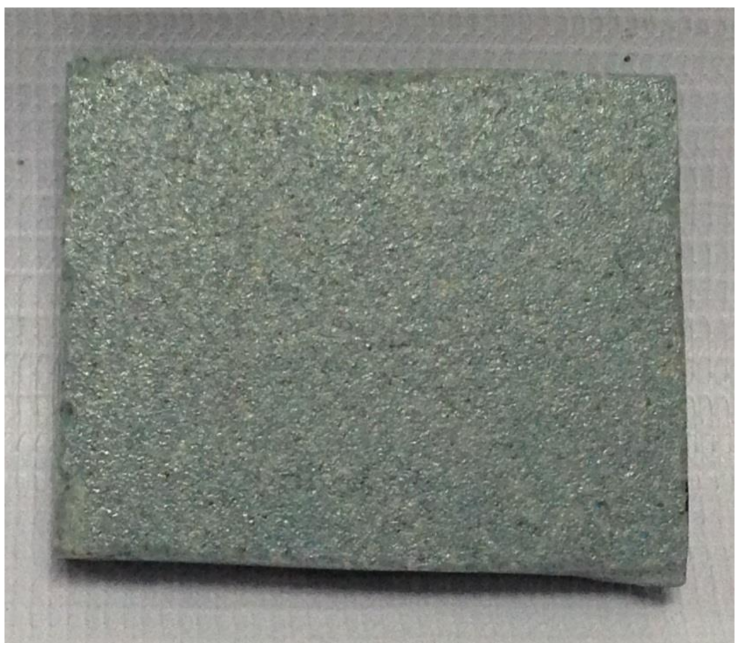


Figure 3.4: Tile

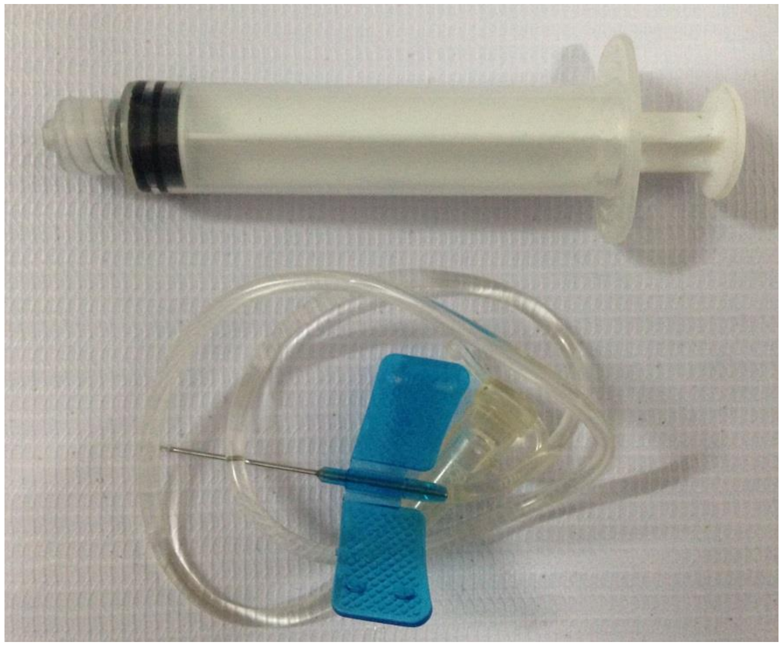


Figure 3.5: 5ml syringe disposable syringe

Figure 3.6: Flashlight

Figure 3.7: Tripod

Figure 3.8: Detergent (viscosity 800cSt)

Figure 3.9: Ricoh CX4 camera

Table 3.1: Specifications of Ricoh CX4

Item		specification
No. of Effective Pixels (Camera)		Approximately 10.00 million pixels
Image Sensor		½.3-inch CMOS (total pixels: approx. 10.60 million pixels)
Lens	**Focal length**	f=4.9-52.5mm (Equivalent to 28-300mm for 35mm film cameras. With Step Zoom set, focal lengths can be fixed at eight steps: 28mm, 35mm, 50mm, 85mm, 105mm, 135mm, 200mm, and 300mm)
	F-aperture	F3.5 (Wide) – F5.6 (Telephoto)
	Shooting Distance	Normal shooting: Approx. 30cm – infinity (Wide), approx. 1.5m – infinity (Telephoto) (from the front of the lens) Macro: Approx. 1 cm – infinity (Wide), approx. 28 cm – infinity (Telephoto), approx. 1 cm – infinity (Zoom Macro) (from the front of the lens)
	Lens Construction	10 elements in 7 groups (aspheric lens: 4 elements and 5 surfaces)
Zoom Magnification		Optical: 10.7x zoom (equivalent to 28-300 mm focal length for 35 mm cameras) Digital: 4.8x up to 51.4x (equivalent to 1440 mm) when used with optical zoom Auto Resize: 5.7x [*1] up to 61.0x [*1] (equivalent to 1710 mm) when used with optical zoom
ISO Sensitivity (Standard Output Sensitivity)		AUTO, ISO100-3200
Monitor		3.0-inch TransparentLCD (approx. 920,000 dots)
Recording Media		SD memory card

	SDHC memory card
Recording File Format	JPEG
Shutter Speed	8, 4, 2, 1 – 1/2000 sec.
Power Supply	Rechargeable Battery: DB-100 x1
Interface	USB 2.0 (High-Speed USB) Mini-B, Mass storage compatible [*8]/ AV Out 1.0Vp-p (75Ω)

Figure 3.10: Software Free Video to JPG Converter

Figure 3.11: Software Adobe Photoshop

3.3 EXPERIMENT CONDITION

In this experiment, the parameter had decided to do this experiment.

Table 3.2: Experiment condition

Test plate	Glass plate (25 mm x 25mm) Aluminum plate (25mm x 25mm) Tile plate (25mm x 25mm) Perspex plate (25mm x 25mm)
Test fluid	Detergent Viscosity: 800cSt
Gap height	Type: double-side tape Thickness: 50 µm Area: 4mm x 4mm (approximately)
Syringe	5ml
Frame rates	30 f.p.s provided by Ricoh CX4
Light source	Single LED

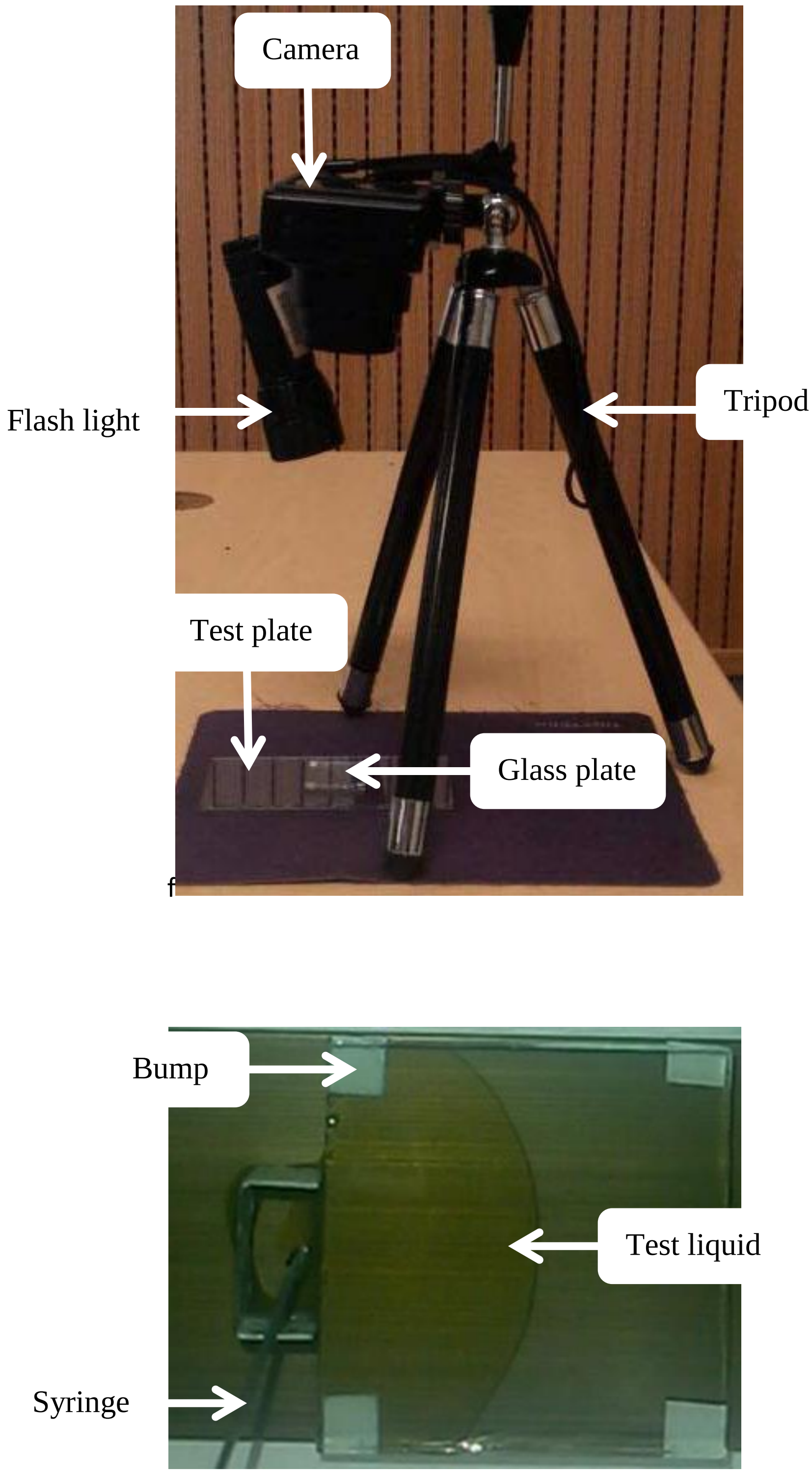


Figure 3.12: Experimental Setup

3.4 METHODOLOGY

In this methodology will description about procedure of experiment and software that involved in this experiment.

3.4.1 PROCEDURE OF EXPERIMENT

The steps are as below:

1) Setup all apparatus which use glass and glass and gap height is 50 µm.
2) Use syringe to suck the detergent.
3) Inject the liquid at pitch of plate.
4) The time taken is recorded.
5) Experiment is repeated with different material of plates.
6) Sample image processing and analysis.

3.4.2 HOW TO USE THE SOFTWARE FOR ANALYSIS

In this experiment had use two software, there are Free Video to JPG Converter and Adobe Photoshop.

For software Free Video to JPG Converter use collects data for time to fulfill. The steps are below:

1) Open software Free Video to JPG Converter.

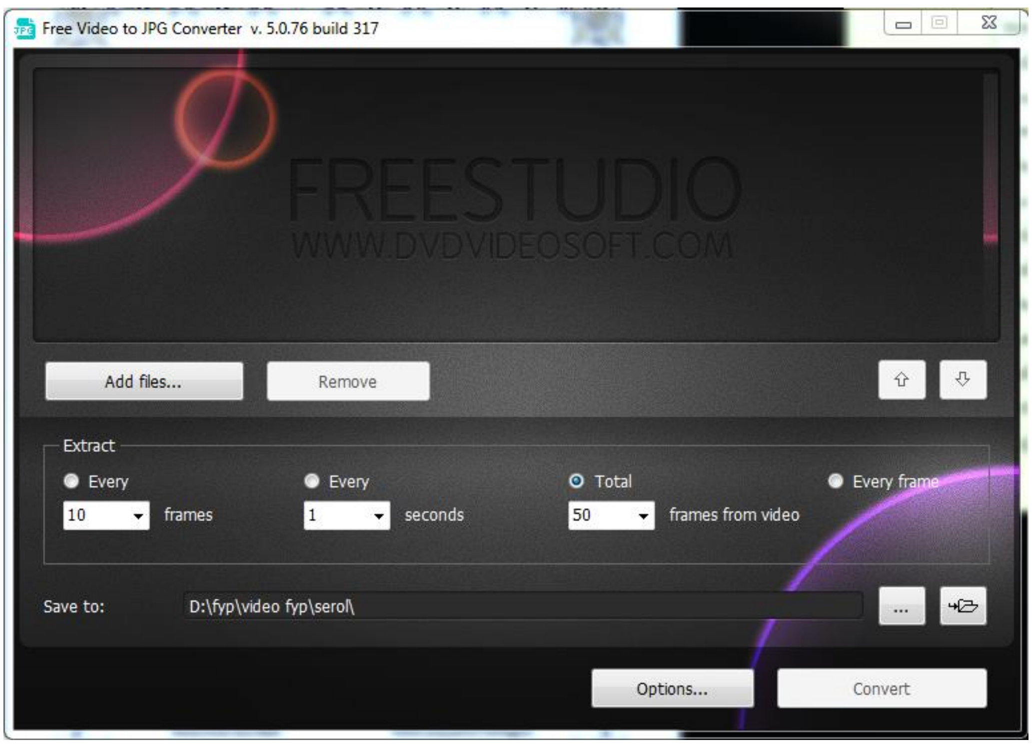


Figure 3.13: Interface of Free Video to JPG Converter software

2) Click 'Add files' to choose video that had taken for experiment

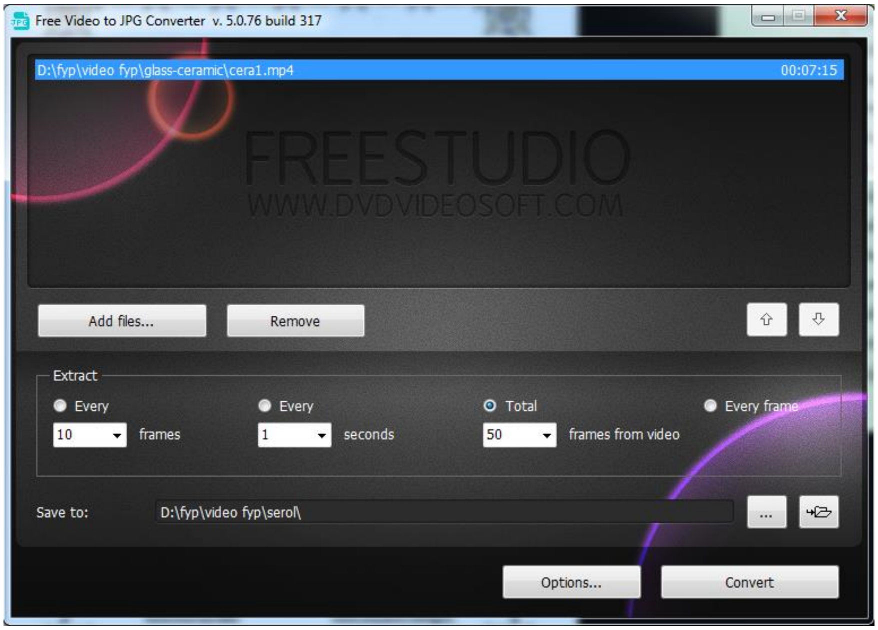


Figure 3.14: After choose the video

3) Click 'Every frame' on the right side.

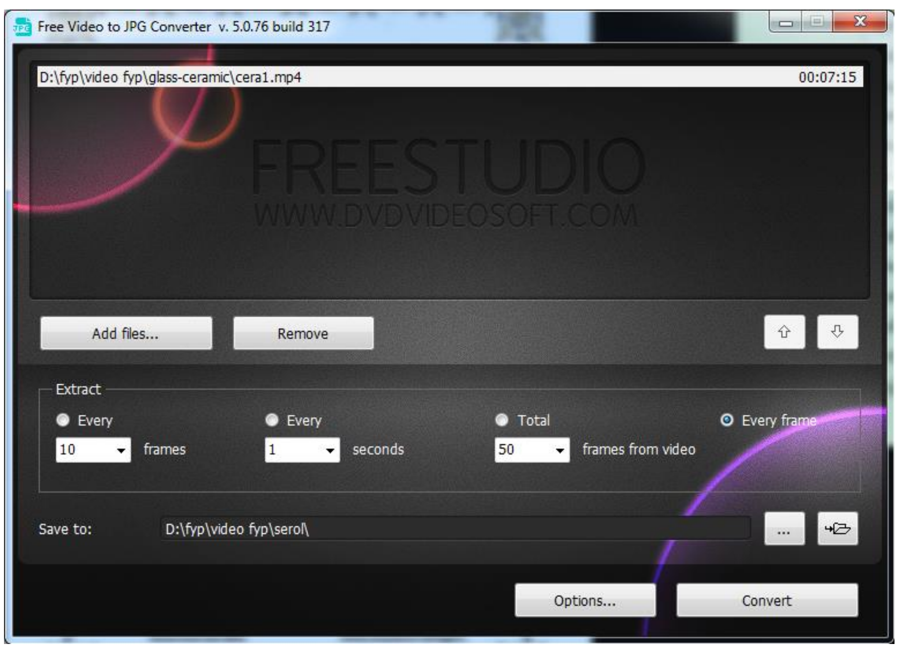


Figure 3.15: After click 'Every frame'

4) Create new folder by click '…' on the right side
5) Lastly, click 'Convert' to convert the video

The steps calculation for get time to fulfill:

1) Choose and record the number of picture that first liquid touch the gap of plate and set as 0s

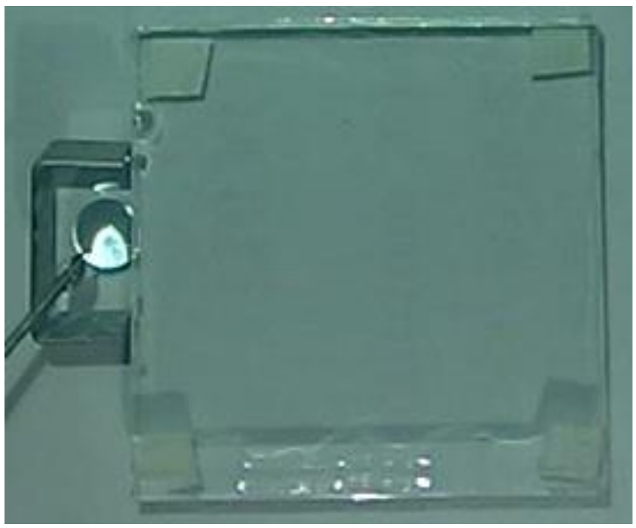


Figure 3.16: Liquid touch at gap plate

2) Choose and record the number of picture that had full-filling

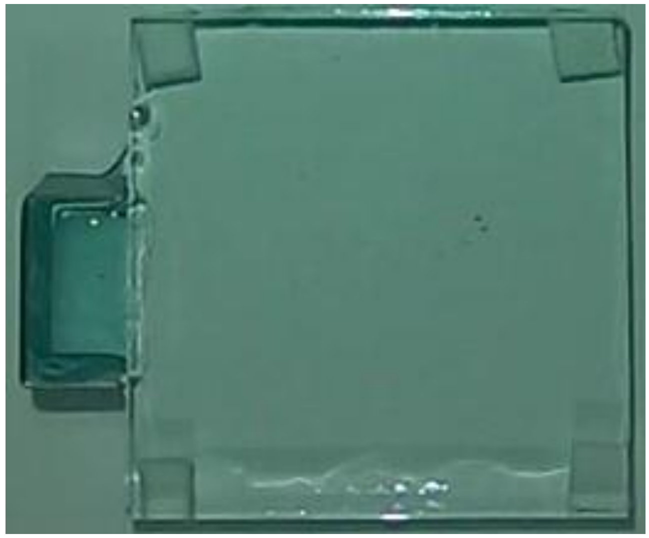


Figure 3.17: Liquid that full-filling entire plate

3) Calculation

No. of picture at 0s	No. of picture at fulfilling	Different
419	9499	9080

$$9080 \times \frac{1}{30} = 302.67$$

The final answer is 302.67s. Repeat this calculation for 3 times every each material and get average.

For software Adobe Photoshop use collects data for distance travelled and flow pattern. The steps are below:

1) Choose the number of picture by using calculation

From result of time filling

No. of picture at 0s	No. of picture at fulfilling	Different	Time
419	9499	9080	302.67

Different	Time (s)
9080	302.67
x	300

Calculated,

$$\frac{300}{302.67} \times 9080 = 9000$$

After that sum of the answer with no of picture at zero to know number of picture at 300s

$$9000 + 419 = 9419$$

2) Choose number of picture from the folder
3) Open the picture that had chosen in Adobe Photoshop

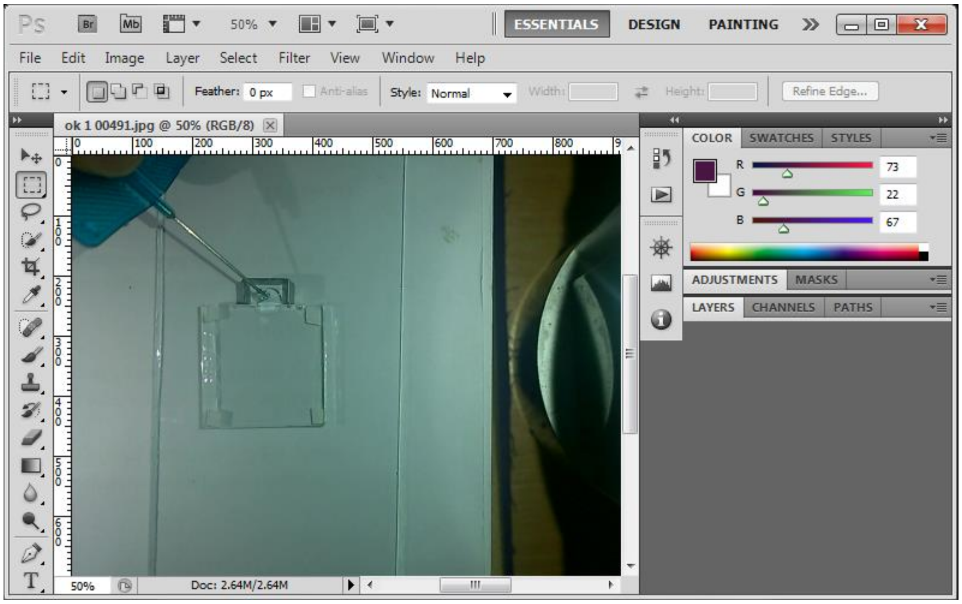


Figure 3.18: Picture had chosen in Adobe Photoshop

4) Crop the picture by select area that wants to crop, click ‘image’ and choose crop

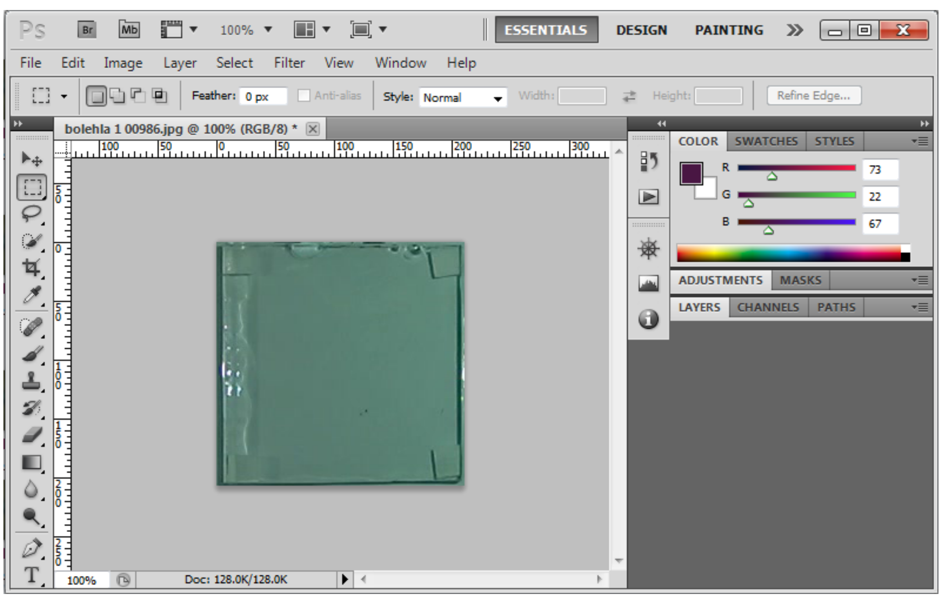


Figure 3.19: Picture after crop

5) Press ‘F8’

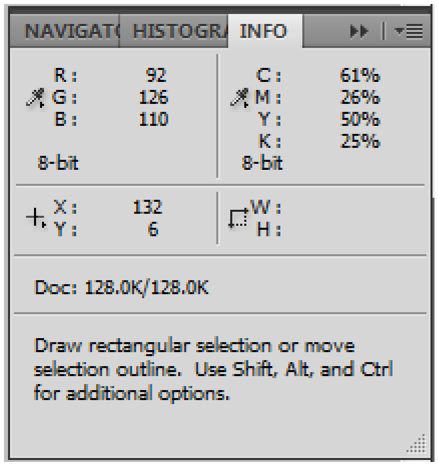


Figure 3.20: Information of coordinate

6) Select right click at the scale and choose pixel

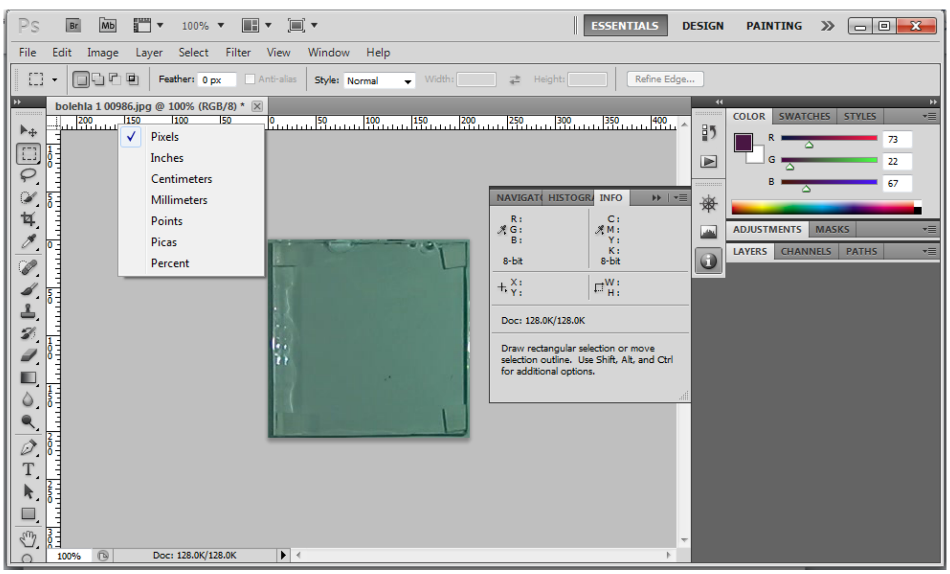


Figure 3.21: Change to pixel

7) Select area of whole picture then look at information of coordinate

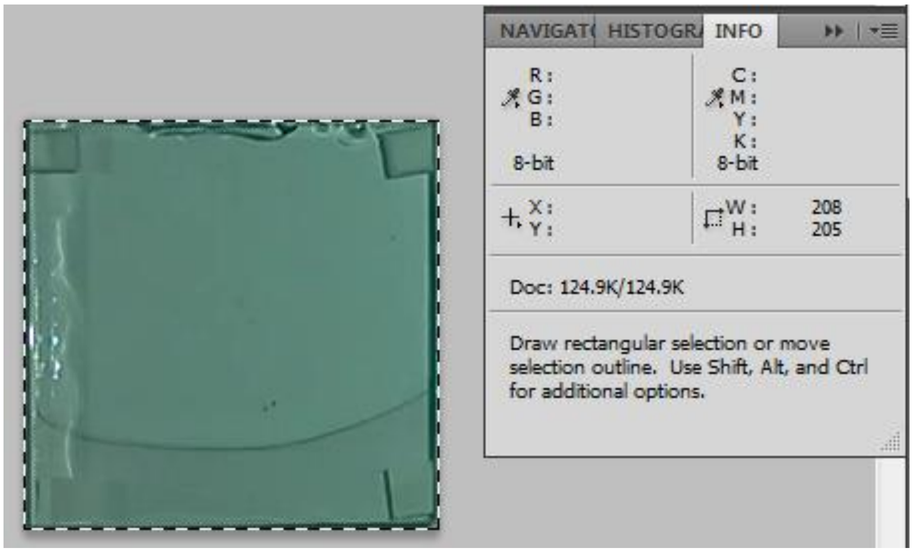


Figure 3.22: Information of coordinate after select area of whole picture

8) Value of W divided by 2 because want to state 12.5mm to calculate the distance travelled

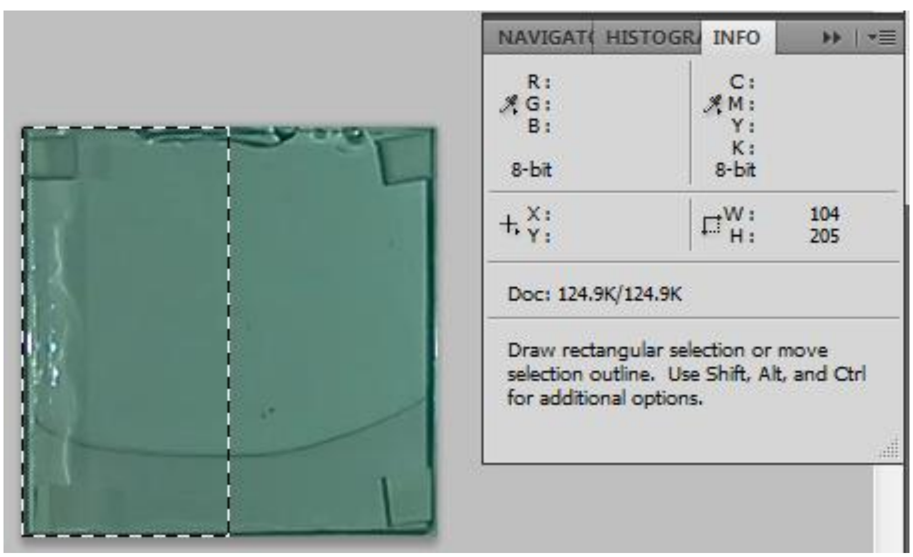


Figure 3.23: Value of W divide by two

9) Move the value of H until touch the curve of liquid flow

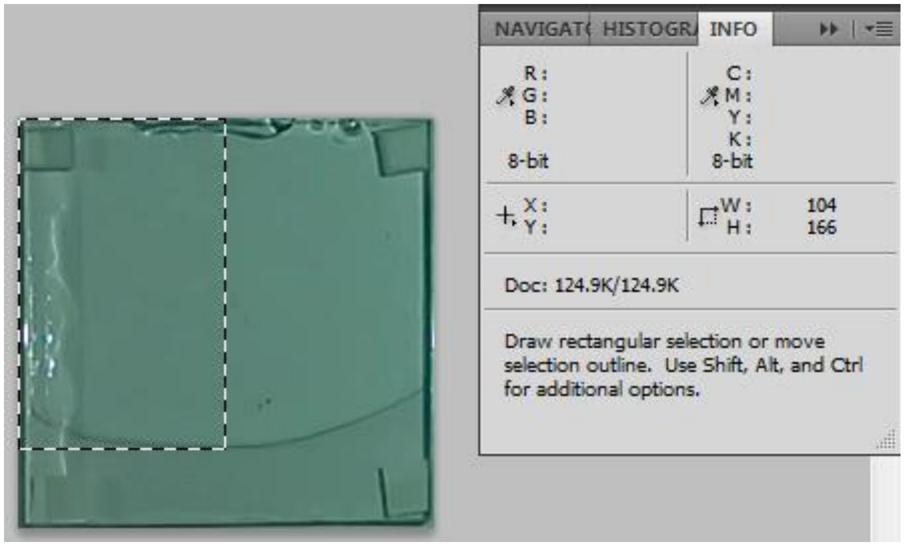


Figure 3.24: Move the value of H

10) Calculate

Pixel	Distance (mm)
205	25
166	x

$$\frac{166}{205} \times 25 = 20.24$$

The distance travelled for this picture is 20.24mm

11) Repeat this calculation for another materials and get the average

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

This chapter is about the result or outcome obtains from the experiment. It include the time to fulfill, distance travelled of liquid and volume of liquid and which syringe that suitable to use for doing this experiment. The explanation of the result and discussion of the result will provide in this chapter also.

4.2 TIME FILLING

For this result, related to first objective to analyze the time taken for liquid to full-filling the gap between two plates influenced by different materials of plates. The time was taken by using software Free Video to JPG Converter and recorded as result before plot into the graph. The tables below show the result of time filling.

Table 4.1: Result of different number of picture for glass-glass in frame

	No. of picture at 0s	No. of picture at fulfilling	Different
Reading 1	508	12150	11642
Reading 2	705	11525	10820
Reading 3	443	11227	10784

Table 4.2: Result of time taken to fulfill for glass-glass after calculated in second.

Reading	Time (s)
Reading 1	388
Reading 2	360.67
Reading 3	359.47
Average	369.38

Table 4.3: Result of different number of picture for glass-perspex in frame

	No. of picture at 0s	No. of picture at fulfilling	Different
Reading 1	597	13001	12403
Reading 2	491	12279	11787
Reading 3	705	11525	10820

Table 4.4: Result of time taken to fulfill for glass-perspex after calculated in second.

Reading	**Time (s)**
Reading 1	413.43
Reading 2	392.9
Reading 3	360.67
Average	389

Table 4.5: Result of different number of picture for glass-aluminum in frame

	No. of picture at 0s	**No. of picture at fulfilling**	**Different**
Reading 1	391	12785	12394
Reading 2	705	12809	12104
Reading 3	521	12285	11764

Table 4.6: Result of time taken to fulfill for glass-aluminum after calculated in second.

Reading	**Time (s)**
Reading 1	413.43
Reading 2	403.47
Reading 3	392.13
Average	400.91

Table 4.7: Result of different number of picture for glass-tile in frame

	No. of picture at 0s	**No. of picture at fulfilling**	**Different**
Reading 1	635	18371	17737
Reading 2	560	15960	15401
Reading 3	453	12860	12407

Table 4.8: Result of time taken to fulfill for glass-tile after calculated in second.

Reading	**Time (s)**
Reading 1	591.23
Reading 2	513.37
Reading 3	410.57
Average	505.06

All data had recorded into the table. In the table had number of picture at 0s, number of picture at fulfilling and different of picture. This experiment was taken three times and gets the average from that because the data get from experiment not accurate for each material.

Result from the table show highest average time is glass-tile with 505.06s followed by lowest average time is glass-glass with 369.38

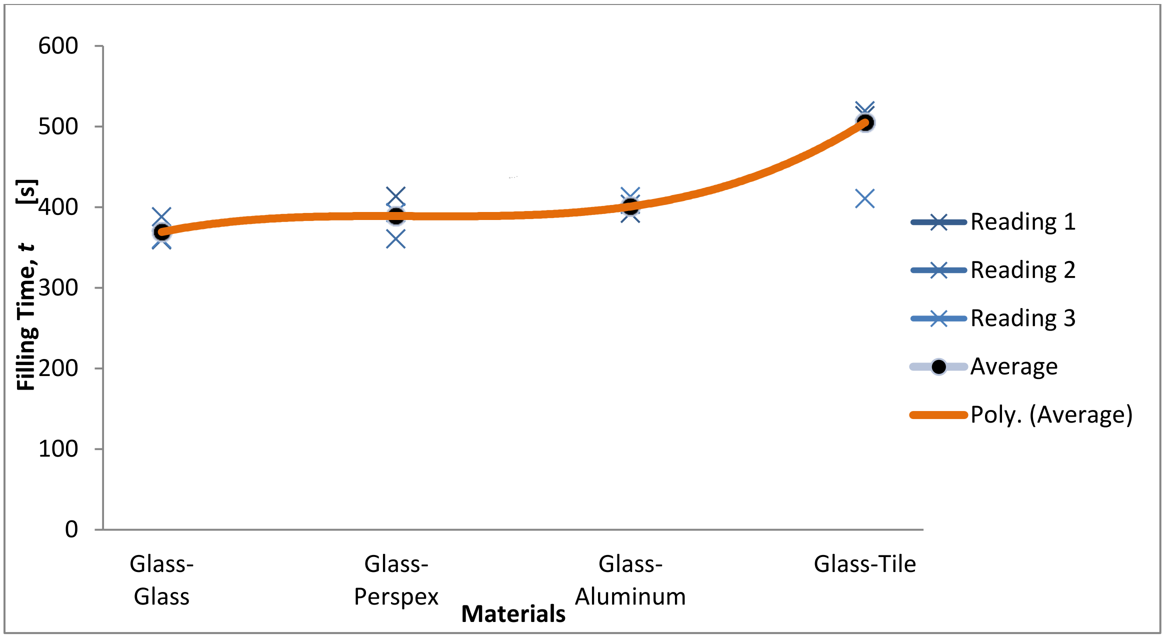


Figure 4.1: Graph of filling time taken for different material plates

Figure 4.1 shows the graph of filling time taken for different material plates. Data get from this experiment not accurate. Many influences that occur while doing this experiment. One of them is pressure of liquid. Even doing this experiment had many times, the time taken also not accurate because the pressure of liquid given by manually or use by hand.

The pressure is really giving impact to time filling when the pressure are not stable. If not maintain the pressure of liquid during the experiment, the filling time will be fast or slow. During start at gap height, the pressure was high and during almost to fulfill the pressure of the liquid slowly. That's why the pressure of liquid not consistent and influence of filling time to fulfill.

The materials not cleanly very well also can effect on time filling. Maybe dust or foreign object can prevent or can make the liquid flow slowly to fulfill entire plate, the flow pattern will not like u-shape and effect on distance travelled.

Glass-glass presents the highest time filling and glass-tile presents the lowest time filling because of properties of material which is surface roughness.

Table 4.9: Surface roughness of materials in Ra

material	Glass-glass	Glass-perspex	Glass-aluminum	Glass-tile
Reading 1	0.061	0.125	1.145	2.974
Reading 2	0.054	0.042	0.231	3.956
Reading 3	0.053	0.058	0.790	4.945
Average	0.056	0.075	0.722	3.958

Table 4.9 shows surface roughness of materials in Ra. Using surface roughness tester machine in lab, take three times for surface roughness and get the average for accurate reading.

Related to the result, glass-glass is lowest surface roughness presents highest time filling to entire plate.

4.3 DISTANCE TRAVELLED

For this result, the time was fixed the time which is 300s for calculate the distance travelled. This results also needed because to get more sturdy related to result of time taken. The distance travelled calculated by using software Adobe Photoshop. The table below shows the result of distance travelled after analysis by using software Adobe Photoshop.

Table 4.10: Result of distance travelled at 300s

	Glass-glass	**Glass-perspex**	**Glass-aluminum**	**Glass-tile**
Reading 1	22.32	20	21.14	18.42
Reading 2	21.14	22.31	21.1	16.42
Reading 3	22.31	21.46	20.59	21.63
Average	21.95	21.25	20.94	18.82

Table 4.10 shows result of distance travelled at 300s. Data had recorded by three reading and average to get accurate result after using software Adobe Photoshop. From this table, plat the graph for get clearly results.

The longest average of distance travelled is glass-glass with 21.95mm followed by glass-tile which is the shortest average of distance travelled is 18.82mm.

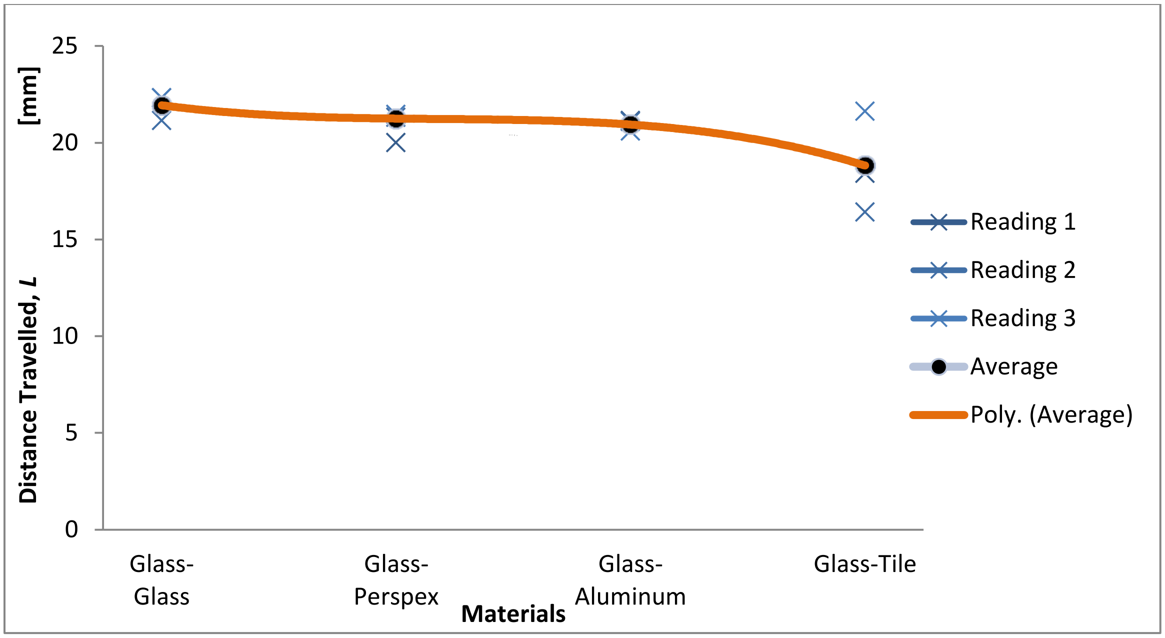


Figure 4.2: Graph of distance travelled by different material plates when the time is 300s

Figure 4.2 shows Graph of distance travelled by different material plates when the time is 300s. The time 300s had been fixed for this result because the results of filling time, no time at 300s had fulfill for each materials even the average time. So that, 300s is the suitable to calculate the distance travelled.

The data for glass-tile different so far because the flow pattern when calculate in software Adobe Photoshop not consistent like u-shape when the liquid almost to fulfill. The calculation take middle of the plate, so if the flow pattern was irregular shape will influence of calculation for the distance travelled.

Glass-tile presents lowest distance travelled because of the time filling for glass-tile is lowest. The liquid slowly flow because of highest surface roughness value. Glass-glass presents highest distance travelled because of the time filling for glass-tile is highest. Lowest surface roughness value can make liquid flow fastest.

4.4 FLOW PATTERN

This result is related to second objective which is to visualize the flow pattern of the liquid flow upon flowing through the gap between two plates. In this result also will show the flow pattern of liquid from zero to fulfill. Many shapes that will be visualize from that and explain cause of that. The tables below show the results of flow pattern each material.

Table 4.11: Flow pattern for glass-glass

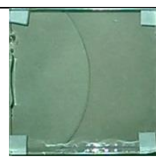
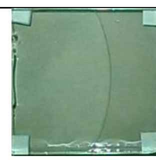
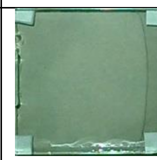
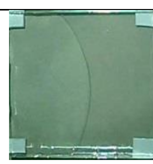
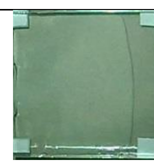
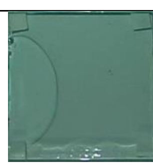
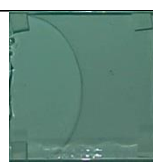
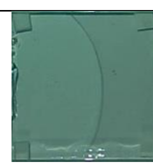
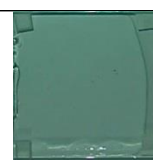
Time(s)	64.67	129.34	194.01	258.68	323.35	388
Reading 1						
Reading 2						
Reading 3						

Table 4.12: Flow pattern for glass-perspex

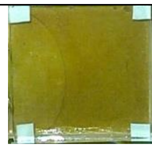
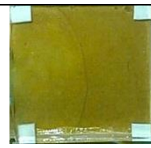
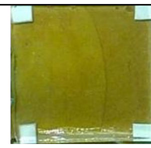
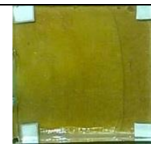
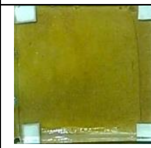
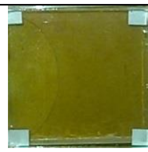
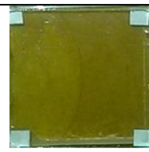
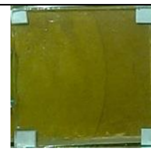
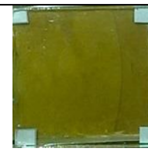
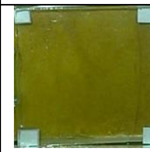
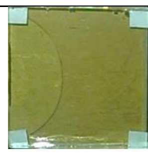
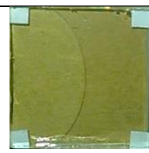
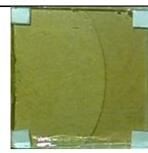
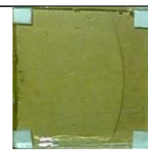
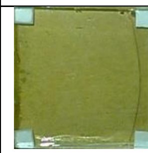
Time(s)	68.91	137.82	206.73	275.64	344.55	413.13
Reading 1						
Reading 2						
Reading 3						

Table 4.13: Flow pattern for glass-aluminum

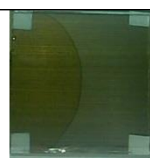
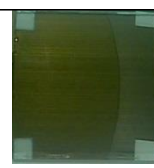
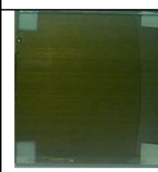
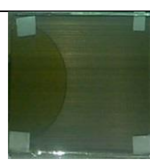
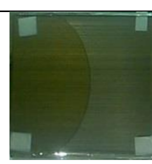
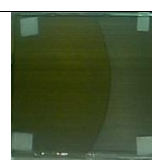
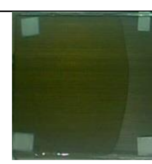
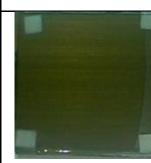
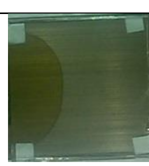
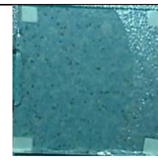
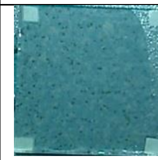
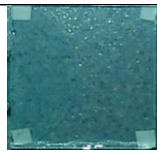
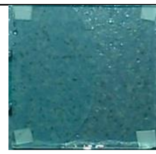
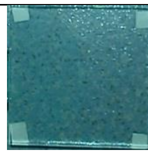
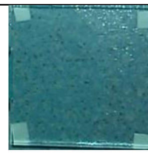
Time(s)	68.91	137.82	206.73	275.64	344.55	413.43
Reading 1						
Reading 2						
Reading 3						

Table 4.14: Flow pattern for glass-tile

Time(s)	**98.54**	**197.08**	**295.62**	**394.16**	**492.7**	**591.23**
Reading 1						
Reading 2						
Reading 3						

From table 4.11 until 4.14 show the flow pattern of glass-glass, glass-perspex, glass-aluminum and glass-tile. In this result, some flow patterns not maintain the u-shape. There are many influences for flow pattern not like u-shape.

One of them is the surface of material not clean very well. From that, the flow pattern not like u-shape or irregular shape because of prevent by dust or something else. Not maintain the pressure of liquid during experiment also affect for flow pattern because the pattern will moved u shape into left or right side. The angle of plate also influenced the flow pattern and the affect is same.

Bubble in liquid before inject also can effect flow pattern. Not just flow pattern but time filling and distance travelled also can affect. When the bubble in flow pattern will show the flow pattern not fulfill. This flow pattern cannot be taken and labeled as error result. Bumps arrangement also influenced the flow pattern and affect when the liquid want to move on the edge.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

In this chapter will conclude experiment that had been finish from beginning to get the results and analysis data. Additionally, some recommendation will be in this chapter to improve this experiment to get accurate results.

5.2 CONCLUSION

As conclusion, all the objectives of the research ‘Analysis of Liquid Film Flow In Between Two Different Plates’ are achieved. The materials can get easily from around environment and measure the surface roughness by using surface roughness tester machine.

Glass-tile presents highest filling time due to its properties of surface roughness. For glass-glass presents lowest filling time because of surface roughness is lowest. For make this result perfect distance travelled had shown.

Under 300s of filling time, material with lowest surface roughness travelled in longest distance. Premiere result is volume to fulfill entire plate is suitable use for 3ml syringe because can use many time not many time to refill the liquid in syringe.

5.2 RECOMMENDATION

Use the high speed camera to get clear video and has a big lighting source while doing this experiment because if not using lighting source effect of the video is shadow. When the video has shadow will affect the flow pattern and confuse to calculate the distance travelled through cannot get the accurate results.

Must has a pressure machine to pressure the liquid while want to start the experiment. The pressure of liquid also affects the time to fulfill if the pressure not consistent. The liquid mixture by dye color to ensure the liquid appearance clearly when take video while doing experiment. To get the result sturdy must has comparison with experiment result and simulation result using suitable software to improve.

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APPENDICES

GANTT CHART FOR FYP1

PROJECT ACTIVITIES		**W1**	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	**W8**	**W9**	**W10**	**W11**	**W12**	**W13**	**W14**
FYP briefing	P														
	A														
Verify the project objective and problem statement	P														
	A														
Literature search (book/journal)	P														
	A														
Refining chapter 1	P														
	A														
Submit draft chapter 1	P														
	A														
Redefined chapter 1	P														
	A														
Submit draft chapter 2	P														
	A														
Submit milestone 1	P														
	A														
Submit draft chapter 3	P														
	A														
Presentation of final year project 1	P														
	A														
Redefined chapter 1,2,3	P														
	A														
Submission of final year project report 1	P														
	A														

GANTT CHART FOR FYP2

PROJECT ACTIVITIES		**W1**	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	**W8**	**W9**	**W10**	**W11**	**W12**	**W13**	**W14**	**W15**	**W16**
Experiment	P																
	A																
Analysis and interpreting result	P																
	A																
Discussion	P																
	A																
Submit draft chapter 4	P																
	A																
Redefined chapter 4	P																
	A																
Conclusion and recommendation	P																
	A																
Submit draft poster	P																
	A																
FYP 2 presentation	P																
	A																
Submit draft chapter 5	P																
	A																
Redefined chapter 1, 2, 3, 4, and 5	P																
	A																
Submission of final year project report	P																
	A																

SURFACE ROUGHNESS OF TILE


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Tilt = Straight
C.F.R. = 300

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Rz = 21. 063µm
Pt = 25. 638µm

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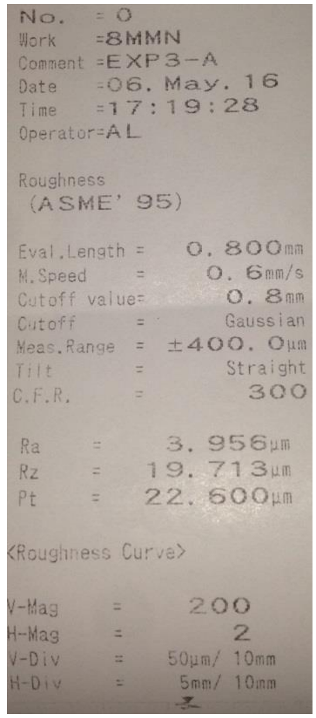
V-Div = 50µm/ 10mm
H-Div = 5mm/ 10mm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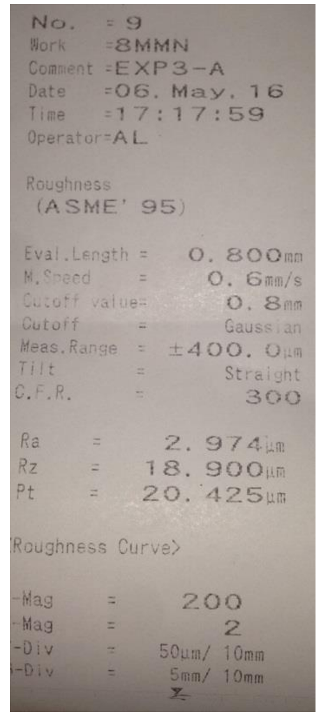
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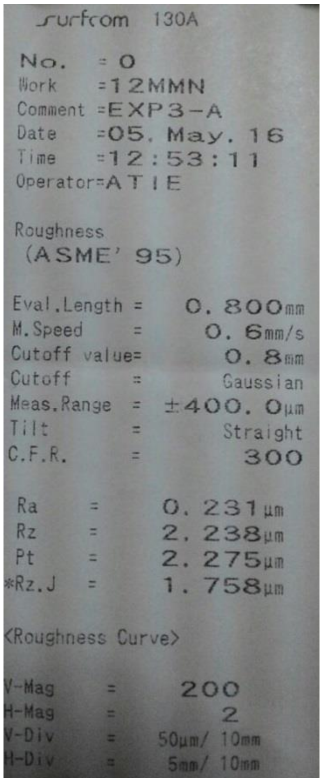

surfcom 130A

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Pt = 2. 275µm
*Rz.J = 1. 758µm

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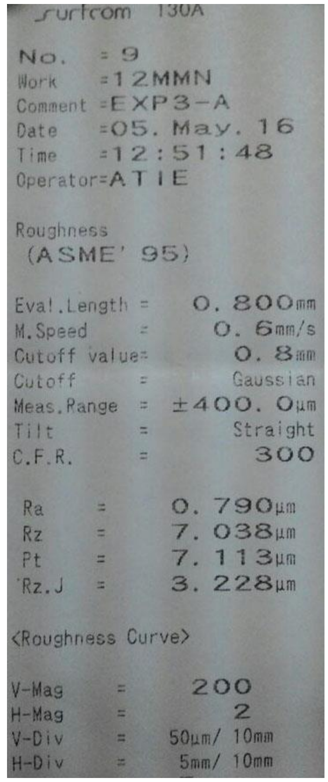
H-Div = 5mm/ 10mm



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Ra = 0. 790µm
Rz = 7. 038µm
Pt = 7. 113µm
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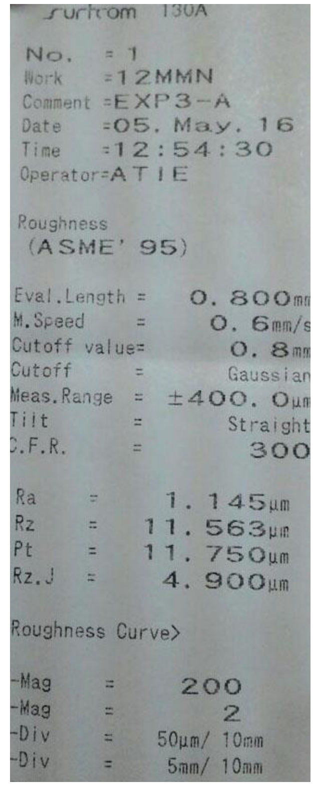
H-Div = 5mm/ 10mm



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Ra = 1. 145µm
Rz = 11. 563µm
Pt = 11. 750µm
Rz.J = 4. 900µm

Roughness Curve>

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-Div = 50µm/ 10mm
-Div = 5mm/ 10mm

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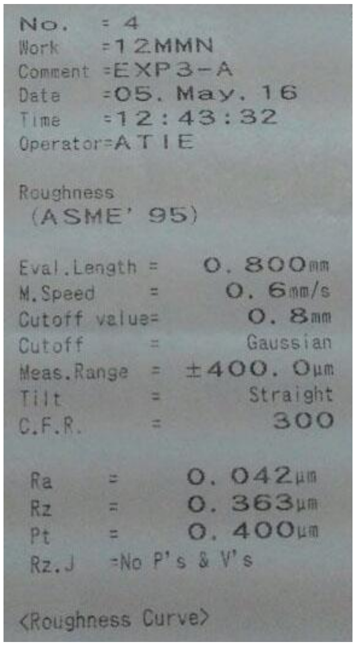
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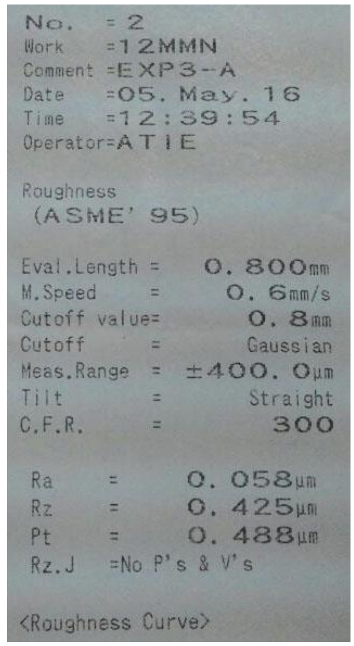
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Cutoff value= 0. 8mm
Cutoff = Gaussian
Meas.Range = ±400. 0µm
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Ra = 0. 058µm
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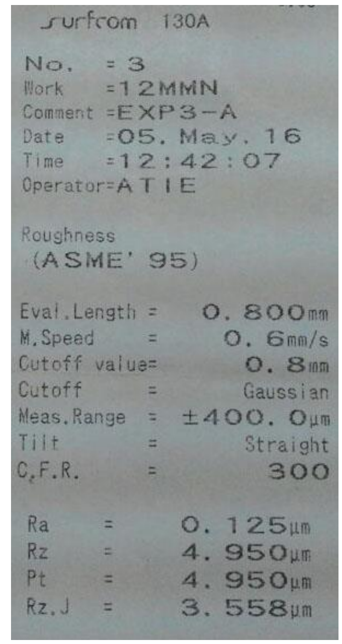
<Roughness Curve>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Cutoff = Gaussian
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Ra = 0. 125µm
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Rz.J = 3. 558µm

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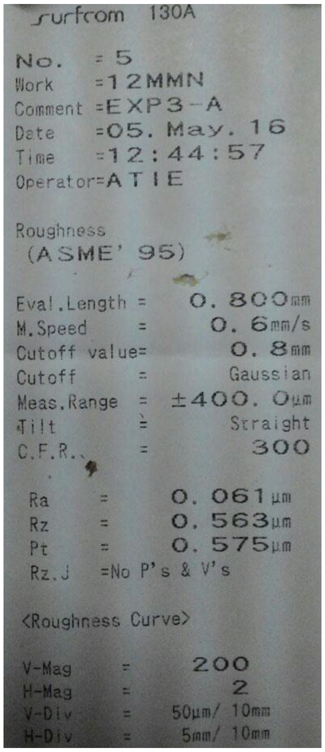

surfcom 130A

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Ra = 0. 061µm
Rz = 0. 563µm
Pt = 0. 575µm
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<Roughness Curve>

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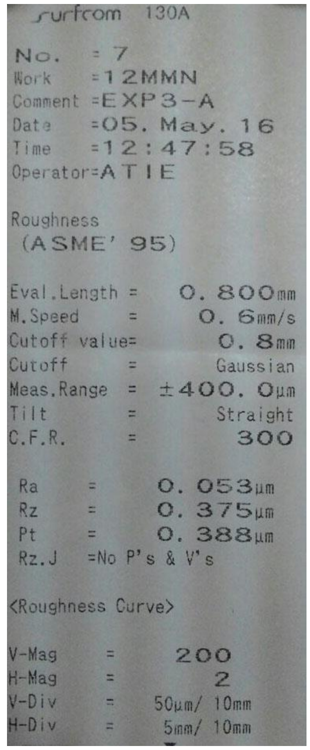
H-Div = 5mm/ 10mm



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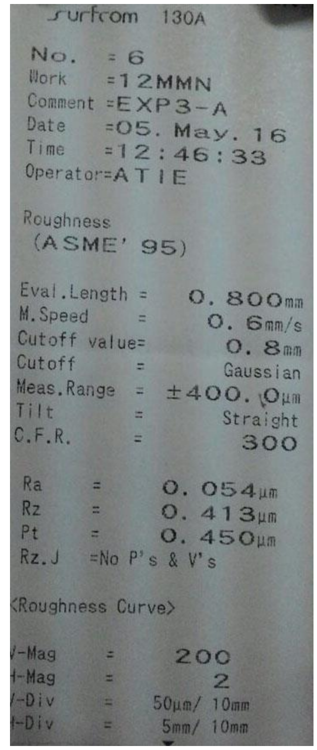

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