

UNIVERSITI MALAYSIA PAHANG

DECLARATION OF THESIS AND COPYRIGHT

Author's Full Name : AZWAN BIN AIRUDDIN
Identification Card No : 930413-03-5027
Title : STUDY OF LIQUID CONTACT ANGLE IN
DIFFERENT SOLID SURFACES
Academic Session : 2015/2016

I declare that this thesis is classified as:

- CONFIDENTIAL** (Contains confidential information under the Official Secret Act 1972)
- RESTRICTED** (Contains restricted information as specified by the organization where research was done)*
- OPEN ACCESS** I agree that my thesis to be published as online open access (Full text)

I acknowledge that Universiti Malaysia Pahang reserve the right as follows:

1. The Thesis is the Property of University Malaysia Pahang.
2. The Library of University Malaysia Pahang has the right to make copies for the purpose of research only.
3. The Library has the right to make copies of the thesis for academic exchange.

Certified by:

(Author's Signature)

AZWAN BIN AIRUDDIN

(Supervisor's Signature)

DR NURRINA BINTI ROSLI

Date: _____

Date: _____

STUDY OF LIQUID CONTACT ANGLE IN DIFFERENT SOLID SURFACES

AZWAN BIN AIRUDDIN

Report submitted in partial fulfillment of the requirements
for the award of the degree of
Bachelor of Engineering in Manufacturing Engineering

Faculty of Manufacturing Engineering

UNIVERSITI MALAYSIA PAHANG

June 2016

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering in manufacturing.

Signature :

Name of supervisor : DR NURRINA BINTI ROSLI

Position : SENIOR LECTURER

Date : 7JUNE 2016

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotation and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

Signature :
Name : AZWAN BIN AIRUDDIN
ID Number : FA12042
Date : 7 JUNE 2016

TABLE OF CONTENTS

	Page
SUPERVISOR'S DECLARATION	i
STUDENT'S DECLARATION	ii
ACKNOWLEDGEMENTS	iii
ABSTRACT	iv
ABSTRAK	v
TABLE OF CONTENTS	vi
LIST OF TABLES	viii
LIST OF FIGURES	ix

CHAPTER 1 INTRODUCTION

1.1	Introduction	1
1.2	Problem statement	4
1.3	Objectives of the research	4

CHAPTER 2 LITERATURE REVIEW

2.1	Introduction	5
2.2	methods of finding liquid contact angles	9
2.2.1	Tilting plate method	9
2.2.2	Wilhelmy plate method	10
2.2.3	Telescope-goniometer	10

2.2.4	Capillary tube	11
2.2.5	Capillary penetration method for powders and granules	12
2.2.6	Sessile drop method	12

CHAPTER 3 METHODOLOGY

3.1	Introduction	13
3.1.1	Step for sessile drop method	14
3.1.2	Adobe photoshop	15
3.2	Experimental condition	18
3.2.1	Aluminium	19
3.2.2	Perspex	20
3.2.3	Mild steel	21
3.2.4	Wood	22
3.2.5	Camera	23
3.3	Experiment setup	25
3.4	Flow chart of research activity	27
3.5	Experiment flow process	28

CHAPTER 4 RESULT AND DISCUSSION

4.1	Liquid contact angle result	29
4.2	Liquid shape result	36

CHAPTER 5 CONCLUSION

5.1	Conclusion	46
5.2	Recommendations	47

References		i
-------------------	--	----------

Appendices		ii
-------------------	--	-----------

LIST OF TABLES

Table No.	Title	Page
3.1	Experiment condition use in experiment	18
3.2	Specification review of Nokia Lumia 1020	24
4.1	Data measurement of contact angle for aluminum	31
4.2	Data measurement of contact angle for perspex	32
4.3	Data measurement of contact angle for mild steel	33
4.4	Data measurement of contact angle for wood	34
4.5	Average data of contact angle measurement	35
4.6	Data measurement of wettability of aluminum	37
4.7	Data measurement of wettability of perspex	38
4.8	Data measurement of wettability of mild steel	39
4.9	Data measurement of wettability of wood	40
4.10	Data of wettability on different material drop from 14mm height	41

LIST OF FIGURES

Figure No.	Title	Page
1.1	Definition of contact angle	2
1.2	Description of Young 's modulus	3
2.1	Description of hydrophobic surface	7
2.2	Description of hydrophilicity surface	8
2.3	Description of super-hydrophobic	8
2.4	Tilting plate method	9
2.5	Wilhelmy plate method illustration	10
2.6	Illustration of telescope-goniometer	11
2.7	Capillary tube illustration	11
3.1	Schematic view of experimental setup	13
3.2	Adobe photoshop software review	15
3.3	Right triangle definition	16
3.4	Illustration of calculating liquid contact angle in adobe photoshop	17
3.5	Aluminum plate	19
3.6	Perspex plate	20
3.7	Mild steel plate	21
3.8	Wood plate	22
3.9	Nokia Lumia 1020 smartphone	23
3.10	Experiment setup for contact angle measurement	25
3.11	Experiment setup for liquid shape measurement drop from 140mm	26
4.1	Liquid contact angles for different material	42
4.2	Diameter of spreading liquid for different material	43

STUDY OF LIQUID CONTACT ANGLE IN DIFFERENT SOLID SURFACES

AZWAN BIN AIRUDDIN

Report submitted in partial fulfillment of the requirements
for the award of the degree of
Bachelor of Engineering in Manufacturing Engineering

Faculty of Manufacturing Engineering

UNIVERSITI MALAYSIA PAHANG

June 2016

ABSTRACT

The purpose of this study is to analyse the contact angle on different material of solid surfaces and to analyse the liquid drop shape on different material. The materials used include aluminium, Perspex, mild steel and wood. There are many methods have done to find contact angle. In this study, sessile drop is used to find contact angle as it is easy to apply. Then adobe Photoshop software is used to process the image and measure the contact angle and diameter of spreading liquid on different solid materials. From this study shown that Perspex has higher contact angle then aluminium and mild steel and wood has low contact angle reading. For the wettability wood state the highest result compare to other solid materials used. The low contact angle result the high wettability and high reading of contact angle has low surface free energy.

ABSTRAK

Tujuan kajian ini adalah untuk menganalisis sudut sentuh cecair pada bahan yang berbeza daripada permukaan pepejal dan untuk menganalisis bentuk titikan cecair pada bahan yang berbeza. Bahan-bahan yang digunakan termasuk aluminium, perspek, keluli lembut dan kayu. Terdapat banyak kaedah telah dilakukan untuk mencari sudut sentuh cecair. Dalam kajian ini, kaedah sessile drop digunakan untuk mencari sudut kenalan kerana ia adalah mudah untuk memohon. Maka perisian adobe Photoshop digunakan untuk memproses imej dan mengukur sudut sentuh cecair dan diameter menyebarkan cecair pada bahan-bahan pepejal yang berbeza. Daripada kajian ini menunjukkan bahawa perspek mempunyai sudut sentuh cecair lebih tinggi maka aluminium dan keluli lembut dan kayu mempunyai bacaan sudut sentuh yang rendah. Bagi kayu mempunyai kebolehasahan yang paling tinggi berbanding dengan bahan-bahan pepejal lain yang digunakan. sudut sentuh yang rendah menyebabkan kebolehasahan yang tinggi dan bacaan tinggi sudut kenalan mempunyai tenaga bebas permukaan rendah.

CHAPTER 1

PROJECT BACKGROUND

1.1 Introduction

In nature, rain drop on surfaces is the clear example to discuss the significant of liquid's contact angle. The application are also present in our lungs, we can see the flow of liquid that covered with membranes and also the film of tears of the cornea in our eyes. The term of contact angle is defined as a droplet of liquid that is in contact with the surface of material as shown in figure 1.1. Then, the angles will be measured between the surface and the liquid form on the material surfaces. Nowadays, the contact angle measurement is significantly applied in various industrial fields, such as microfluidics, spraying, printing, and coating.

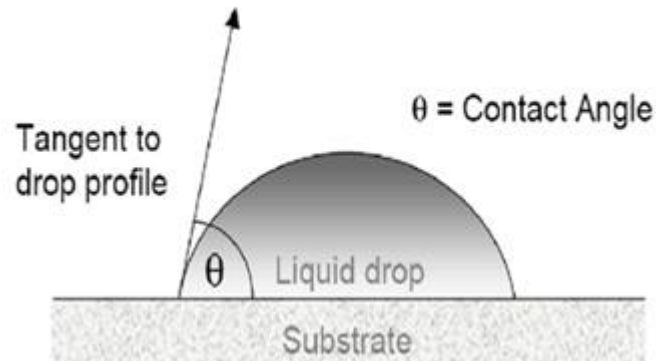


Figure 1.1: Definition of contact angle

Source: (Rudawska et al. 2009; Zhao et al, 2004).

Until now it is increasingly hard to ignore the role of contact angle measurement. Therefore, many studies and researches associate with the contact angle. The first approach has been done on the measurement of contact angle is done between 13 June 1773 to 10 May 1829 by Thomas Young. His research was focused on treating the contact angle of a liquid with a surface as the mechanical equilibrium of a drop resting on a plane solid surface under the control of three surface tensions. The research leads to the equation of Young's equation as shown in Eq. (1.0)

$$\cos \theta_e = \frac{\gamma_{sv} - \gamma_{sl}}{\gamma_{lv}} \quad (1.0)$$

Where, γ_{sv} is surface tension at interface of the solid and vapour phase, γ_{sl} is surface tension at interface of solid and liquid phase while γ_{lv} is surface tension at interface of the liquid and vapour phase as described in figure 1.2.

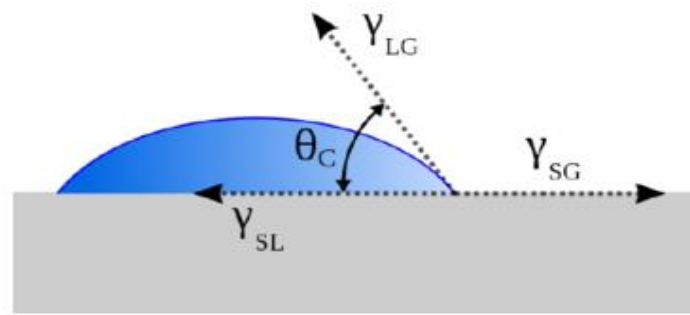


Figure 1.2: Description of Young's modulus

Source: (Rudawska et al. 2009; Zhao et al, 2004).

There are many factors that cause the differences of contact angle of liquid. Among them, the surface material that contact with the liquid droplet has become the main factor. As we know, the surface of material is not always in the because of the properties aspects. That is the different materials have different properties such as roughness, hardness, tensile, and so on. Thus in this study, four different types of material will be which are glass, wood, plastic and stainless steel.

REFERENCES

This thesis is prepared based on the following references;

- Chen, H., Tang, T., & Amirfazli, A. (2015). Effect of contact angle hysteresis on breakage of a liquid bridge. *The European Physical Journal Special Topics*, 224(2), 277-288. doi:10.1140/epjst/e2015-02359-1
- Das, A. K., & Das, P. K. (2010). Equilibrium shape and contact angle of sessile drops of different volumes—Computation by SPH and its further improvement by DI. *Chemical Engineering Science*, 65(13), 4027-4037. doi:10.1016/j.ces.2010.03.043
- Grundke, K., Pöschel, K., Synytska, A., Frenzel, R., Drechsler, A., Nitschke, M., . . . Welzel, P. B. (2015). Experimental studies of contact angle hysteresis phenomena on polymer surfaces — Toward the understanding and control of wettability for different applications. *Advances in Colloid and Interface Science*, 222, 350-376. doi:10.1016/j.cis.2014.10.012
- Jaroslawn Drelich, Emil Chibowski, Dennis Desheng Meng, & Konrad Terpilowski (2011) *Hydrophilic and Superhydrophilic Surfaces and Materials*. *Soft matter*, 7(21), 9804-9828
- Kubiak, K. J., Wilson, M. C. T., Mathia, T. G., & Carval, P. (2011). Wettability versus roughness of engineering surfaces. *Wear*, 271(3-4), 523-528. doi:10.1016/j.wear.2010.03.029
- Schuster, J. M., Schvezov, C. E., & Rosenberger, M. R. (2015). Influence of Experimental Variables on the Measure of Contact Angle in Metals Using the Sessile Drop Method. *Procedia Materials Science*, 8, 742-751. doi:10.1016/j.mspro.2015.04.131
- Yuan, Y., & Lee, T. R. (2013). Contact Angle and Wetting Properties. 51, 3-34. doi:10.1007/978-3-642-34243-1_1
- Zhou, X. B., & Hosson, J. T. M. D. (1995). Influence of surface roughness on the wetting angle. *AG Groningen, The Netherlands*, 10, 9.