DECLARATION

"I declare that I have read this thesis and according to my opinion, this thesis is enough to fulfill the purpose for award of the Bachelor's Degree in Mechanical (Thermal Fluids) Engineering from the aspects of the scope and quality."

Signature	:..
Name of Supervisor	: **EN MD ISA BIN ALI**
Date	: 30/5/06

DESIGNING AND TEST A VISCOMETER

NORAZLIN BINTI ABD JALIL

Thesis submitted as a partial fulfillment of the requirement for the degree of Bachelor in Mechanical (Thermal fluids) Engineering

Faculty of Mechanical Engineering
KOLEJ UNIVERSITI TEKNIKAL KEBANGSAAN MALAYSIA

May 2006

DECLARATION

"I hereby declared that this thesis entitle **DESIGNING AND TEST VISCOMETER** is my original work and the result of my own research expect for quotation and summaries, each one of which I have clearly stated its source.

Signature : ....

Name of Candidate : **NORAZLIN BINTI ABD JALIL**

Date : 16 MAY 2006

Special dedicated to…
My beloved mother and father, family, members.
Thanks for everything
Alhamdulillah

ACKNOWLEDGEMENT

All the praise to Allah the Al-Mighty for His blessings and benevolence, that this project has been successfully completed. By the Grace of Him and His knowledge that He granted to me, I have been able to write this humble report to the completion.

With sincere gratitude and appreciation, I would like to thank my supervisor, En Md Isa bin Ali for his valuable guidance and encouragement throughout the accomplishment of this project. All his advices and ideas have contributed to the success of this project. It's been an honor for me to be working under supervision of such a great person like him.

I would like to express appreciation to Mr. Zulkarnain Abdul Latiff for being a very helpful and advisor and also for all technicians for spending their valuable time to assisting me till the end of this project.

To my beloved father, mother and all my family, thanks for all your affectionate caring, and above all your sacrifices and prayers, moral and material support accorded to me until successful completion of this project.

Last but not least, I am happy to thank my fellow friends and individual who is directly or indirectly contributed to this project. Thank you very much. May Allah bless all of you.

ABSTRACT

The viscosity of the fluids can be define by calculated the data or by using the apparatus such as the viscometer. Viscosity can divide into two categories which are the kinematics and dynamic viscosity but in this research the dynamic viscosity is chosen. The viscosity can be determined by the measure of the internal friction of fluids. Viscosity is a principal parameter when any flow measurement of fluids, such as liquids, semi solids, gases and even solids are made. The viscometer is the device that used to measure the viscosity. There have are few types of viscometer such as the rotating drum viscometer, the capillary tube viscometer, falling ball viscometer and so on. The all concept of the viscometer is same but the application is different. In this research the rotating drum viscometer is chosen to define the value of the viscosity of the fluids and do the comparison of the existence the data. New design of the viscometer creates with the same concept and application of the existence viscometer in the market. The experiment was done to the new design of the rotating drum viscometer to compare the value of the viscosity. The positive and negative of the methods were discussed and the best methods to define the value of viscosity were proposed.

ABSTRAK

Nilai kelikatan sesuatu bendalir boleh ditentukan melalui pengiraan atau menggunakan alatan pengukuran kelikatan bendalir. Kelikatan boleh dibahagi kepada dua jenis iaitu kelikatan kinematik dan kelikatan dinamik tetapi di dalam kajian yang dilakukan kelikatan dinamik dipilih. Kelikatan bendalir boleh ditentukan dengan mengira geseran dalaman sesuatu bendalir. Kelikatan adalah prinsip parameter dimana pada semua pergerakan pengukuran bendalir umpamanya cecair, pepejal separa, gas dan pepejal. Viscometer adalah alatan yang digunakan untuk mengukur kelikatan bendalir. Terdapat pelbagai jenis viscometer di pasaran yang digunakan untuk mengukur kelikatan bendalir antaranya viscometer jenis drum berputar, penjatuhan bebola dan sebagainya. Kesemua alatan ini mempunyai konsep pengendalian yang sama tetapi penggunaannya yang berbeza dalam mendapatkan nilai kelikatan. Di dalam kajian ini, viscometer jenis drum berputar dipilih untuk mencari nilai kelikatan bendalir dan membuat perbandingan data dengan nilai kelikatan yang sedia ada. Suatu rekabentuk yang baru dengan konsep dan penggunaan yang sama dengan viscometer yang sedia ada di pasaran dicipta. Ujikaji dijalankan ke atas rekabentuk yang baru bagi membezakan dan membuat perbandingan data kelikatan bendalir yang sedia ada. Kebaikan dan keburukan kaedah yang digunakan turut dibincangkan dan kaedah yang terbaik turut dicadangkan bagi memperbaiki kajian ini.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

Roman

C	Absolute gas velocity
$_{p}C$	Specific heat capacity at constant pressure
dt	
d	Ordinary differential with time
dx	
d	Ordinary differential with the length in x-axis direction
dy	
d	Ordinary differential with the length in y-axis direction
dz	
d	Ordinary differential with the length in z-axis direction
e	Deformation
$_{x}F$	Momentum interaction between the fluid and the dispersed phase
h C_pT,	Enthalpy
$\cdot m$	Mass flow rate
P	Pressure
R	Radius
T	Temperature
$_{j}U$	Fluid velocity components in the j_{th} direction
$_{i}U$	Fluid velocity components in the i_{th} direction
$_{\theta}v$	Tangential velocity
$_{r}v$	Radial velocity
v	Velocity
xv	
$_{j}x$	Distance in the j_{th} direction

Greek

λ	Second viscosity
μ	Dynamic fluid viscosity
$_{zx}\sigma$	Stress for plane in *z*-axis and direction in *x*-axis
$_{yx}\sigma$	Stress for plane in *y*-axis and direction in *x*-axis
$_{xx}\sigma$	Stress for plane in *x*-axis and direction in *x*-axis
$_{xy}\sigma$	Stress tensor
τ	Shear stress
δx	Length difference in *x*-axis direction
δy	Length difference in *y*-axis direction
δz	Length difference in *z*-axis direction
ϑ	Turbulent velocity
ω	Angular velocity

CHAPTER 1

INDTRODUCTION

A fluid at rest cannot resist shearing forces and if such forces act on a fluid which is in contact with a solid boundary. Viscosity is a principal parameter when any flow measurements of fluids, such as liquids, semi-solids, gases and even solids are made. Brookfield deals with liquids and semi-solids. Viscosity measurements are made in conjunction with product quality and efficiency. Anyone involved with flow characterization, in research or development, quality control or fluid transfer, at one time or another gets involved with some type of viscosity measurement.

Many manufacturers now regard viscometers as a crucial part of their research, development, and process control programs. They know that viscosity measurements are often the quickest, most accurate and most reliable way to analyze some of the most important factors affecting product performance.

Rheological relationships help us to understand the fluids we are working with so that we can either know how they are behaving or force them to behave according to our needs.

There are many different techniques for measuring viscosity, each suitable to specific circumstances and materials. The selection of the right viscometer from the scores of instruments available to meet the need of any application is a difficult proposition. Today's instruments vary from the simple to the complex: from counting the seconds for a liquid to drain off a stick to very sophisticated automatic recording and controlling equipment.

1.1 Objectives

1.1.1 To design a new simple approach of viscosity meter.

1.1.2 To fabricate a new viscometer comparing to the existence viscometer in the market.

1.1.3 To identify the limitation of the existence viscometer in market.

1.2 Project Scope

1.2.1 To establish problem definition, objective and methodology

1.2.2 To design by using the suitable software likes Solidwork and test the new design of viscometer that fabricate.

1.2.3 Doing compression of result that have with the existing viscometer result.

1.2.4 Data collection from the experiment that we done.

1.3 Problem Statement

As we know in the market there is too many of viscometer that have but the usage of it very limited. Other than that, the design of the existence viscometer is not user friendly to the consumer. The usage of various type of viscometer not only inconvenient for the user also the desired value of liquid viscosity measurement is obtained using difficult method.

1.4 Summarize Activity

By refers the Gantt chart, all the activity is contributed from first week till week fifteen. Start from choose title for PSM, student had been choose the title but the committee of PSM can decide the title that can give to the student. After get the title, the entire student had been given the briefing about the PSM 1. The next activity understands objective and project scope. The purpose of this activity is to give an illustration about what have to do in this semester. From week four to week seven the activity that I've done is study about the types and the method about viscometer such as;

- Benefit and purpose of viscometer in industry
- The basic problem solving technique
- The process capability
- How the design (by using solid work software)
- How to fabricate and the material that use.
- The manufacturing process that provided to fabricate it
- The methods that used to conduct the experiment (calculate the value of viscosity)

After finish the activity, prepare the draft of report. The contents of this report are introduction, literature review, methodology and conclusion.

CHAPTER 2

LITERATURE REVIEW

Viscosity is a principal parameter when any flow measurements of fluids, such as liquids, semi-solids, gases and even solids are made. Brookfield deals with liquids and semi-solids. Viscosity measurements are made in conjunction with product quality and efficiency. Anyone involved with flow characterization, in research or development, quality control or fluid transfer, at one time or another gets involved with some type of viscosity measurement.

Many manufacturers now regard viscometers as a crucial part of their research, development, and process control programs. They know that viscosity measurements are often the quickest, most accurate and most reliable way to analyze some of the most important factors affecting product performance.

Rheological relationships help us to understand the fluids we are working with so that we can either know how they are behaving or force them to behave according to our needs. There are many different techniques for measuring viscosity, each suitable to specific circumstances and materials. The selection of the right viscometer from the scores of instruments available to meet the need of any application is a difficult proposition.

2.1 Work Done

2.1.1 Objective

- Determine the viscosity of Newtonian fluids in a capillary viscometer at different temperatures.
- Characterize the rheological behavior of a fluid (e.g. Newtonian, shear thinning, shear thickening) in terms of shear stress - shear rate relationship from the data collected in a rotational viscometer.

2.1.2 Theory

Newton's law of viscosity and the various models for non-Newtonian fluids have been covered in 06-152, Transport Processes I. The capillary viscometer is based on laminar flow in a circular tube and the rotational viscometer has the fluid flowing tangentially between a rotating cylinder and a concentric stationary cup. For laminar flow of Newtonian and non-Newtonian fluids in a circular tube, see 06-152 lecture notes and pages 35 and 369 in Denn. Bird, Stewart, and Lightfoot, *Transport Phenomena;* Wiley, 1960 (Example 3.5-1 pp. 94-96) present a discussion of tangential flow between two concentric rotating cylinders for Newtonian fluids; they also discuss the theory of the cone and plate viscometer, pp98ff. One can extend the analysis in the example to non-Newtonian fluids to find an analogous relationship between torque and angular velocity to characterize the rheological behavior of such a fluid.

An equation of the Arrhenius type[1] characterizes the temperature dependence of viscosity of liquids

$$\mu = A\exp(E/RT) \quad (1)$$

where μ = Newtonian viscosity of liquid

E = "Activation energy" for viscosity

T = absolute temperature

R = Gas constant

2.1.3 Viscometer

There are two viscometers for this experiment. The Cannon-Fenske viscometer (also denoted capillary viscometer) to study variation of viscosity with temperature. Each group will also use the Stormer viscometer to complete the experiment. Interested groups can also use a cone and plate viscometer after consulting with the instructor.

Cannon-Fenske Viscometer

In the Cannon-Fenske viscometer (Fig. 1), one measures the time for a known volume of fluid to flow through the capillary. One can then relate this efflux time, which is inversely proportional to the volumetric flow rate, through the equation for velocity distribution for laminar flow in a circular tube to viscosity

Model	Ident Code	Calibration constant *a*, cSt/s
50	I606	0.00383
100	I682	0.0142
150	M103	0.0320
150	M104	0.0319
150	M547	0.0293
200	M26	0.110
200	C60	0.109
300	I285	0.263
300	I285	0.263
350	R152	0.485
350	Q145	0.465
400	T820	1.097
400	L720	1.315

Table 2.1: Cannon Viscometer Calibration Data

Table 2.1 lists approximate values for *a*. *Each viscometer will have a slightly different calibration; hence, you should always check the information provided with the one you are using.* The second term on the right, *b/t* is the "kinetic energy correction," accounting for the fact that energy is imparted to speed up the fluid as it goes from the reservoir to the capillary. For a well-designed viscometer, this correction is negligible for $t > 60$ s.