CERTIFICATION OF APPROVAL

Designing Prototype of Acoustic & Resistivity Transducer

By

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Approved by,

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(Dr. Hilfan Khairy)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

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CERTIFICATION OF ORIGINALITY

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

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MUHAMMAD ASHRAF BIN MOHD FAHARI

Abstract

A seismic wave is acoustic energy transmitted by vibration of rock particles. Low energy waves are approximately elastic, leaving the rock mass unchanged by their passage, but close to a seismic source the rock may be shattered and permanently distorted. Reservoir characterization and monitoring using seismic technology has seen tremendous progress and recognition in recent years. In theory, time-lapse seismology measures the spatial and temporal changes related to reservoir changes and processes and it provide data on whether these changes are large enough to resolve seismically. Other than seismic method, resistivity is one of alternative for geophysicist to characterize and monitoring the reservoir. Seismic and resistivity test normally done in different stages which create errors. This method affect the feasibility during test or experiment thus resulting in wrong interpretation for reservoir characteristic especially while monitoring water flooding. A device is being designed which has the capability to run seismic and resistivity monitoring on reservoir characterization at one time and feasibility will be the focus objective for this research by implementing several experiment with the new device designed. As a result of completing the research project, it expected for author to learn as much possible about geophysics application and able to apply while monitoring the devices. The author will focus on the application of seismic and resistivity test during water flooding monitoring. As the conclusion, implication of findings will be the feasibility of device by applying two geophysics principals which are seismic and resistivity during water flooding monitoring.

Acknowledgement

The authors would like to express his appreciation to the project supervisor, Dr. Hilfan Khairy for the great contribution and supervision in completing the project. The authors also would like to extend his acknowledgement to individuals and organizations who have directly or indirectly contributed to the implementation of the project. Highly appreciated for Universiti Teknologi PETRONAS for providing facilities and sources.

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Chapter 1 : Introduction

1.1 Problem Statement

While presenting laboratory analysis on the effects of water flood on seismic velocity and resistivity, it was found that seismic test and resistivity test cannot be done at one time. Thus, it may create errors while monitoring the laboratory analysis in the process of transferring the core from seismic transducer to resistivity transducer. The errors occurs will effects the detail feasibility study on the relationship between seismic and resistivity data. Finally, it will affect the feasibility study during interpretation on fluid substitution modelling and time-lapse seismic reservoir monitoring.

1.2 Objective

Objective for this project is to design a feasible transducer which provided with acoustic and resistivity transmitter to allow acoustic and resistivity test being carried out at one time using same device. This method is expected to minimise the error occur as much as possible compare to previous method.

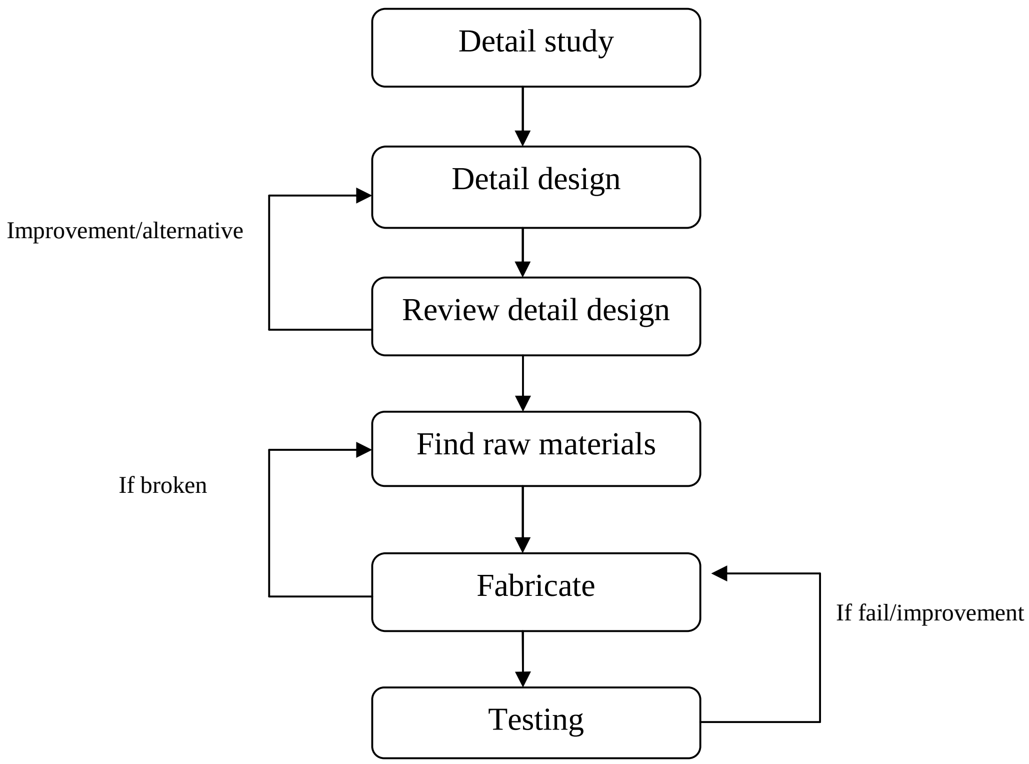
1.3 Scope of Study

To successfully achieve the objective, there are two main stages. Firstly, detail research will be carried out to create good understanding on how transducer for seismic and resistivity work. Then, apply it to make a detail design for fabrication purposes. Throughout the project period, fabrication process will be the major part.

Chapter 2 : Literature Review

Reservoir characterization and monitoring using seismic technology has seen tremendous progress and recognition in recent years. Siesmic method has found successful application in petroleum production assessment, reservoir characterization, and in monitoring enhanced oil recovery (EOR) and production processes. Both the laboratory result and theoretical analysis show that seismic method may succeed in monitoring water floods in some reservoirs under certain condition, while they may fail in others. Thus, it is important to carry out feasibility studies on the implementation of seismic monitoring of water flood processes. Based on the study paper by Wang et al. (1991) present laboratory result on the effects of water flood on seismic, the authors conclude that not every reservoir is suitable for seismic monitoring of water flood. The paper recommends a careful feasibility study has to be carried out before implementing projects of seismic monitoring of water floods. The discussion in this paper include the feasibility of in-situ seismic monitoring of water floods which provided with the effects of reservoir depth and pressure, reservoir temperature, original pore fluids, reservoir lithology, wave frequency and other factors. It conclude that feasibility study should include a thorough understanding in reservoir geology, rock and fluid properties, reservoir parameters, laboratory measurements and theoretical calculations of the effect of water flood on the seismic properties of the reservoir rocks saturation with the reservoir pore fluids and an economic assessment. Another paper by Nur (1989), present a summary of petrophysical basis of 4-D seismology and direct hydrocarbon detection. It summarize that hydrocarbon themselves are responsible for the influence of temperature on the velocity in rock, thus create a basis for true direction detection of hydrocarbons in situ and the monitoring of the recovery of hydrocarbon (EOR) with time through thermal or even other flooding method. This show that water flooding monitoring also can be directed by thermal. Third paper by Wang (1997) discuss the physical basis for the feasibility of time lapse seismic reservoir monitoring (TLSRM). It concludes that several tough challenge still remain although many rock physics issue in time-lapse seismic reservoir monitoring have been worked in the past. One of the challenge that he listed is quantitative interpretation of TLSRM requires large rock physics data sets which are usually costly. Then he discuss about the inversion for reservoir properties especially for customer such as reservoir engineers who may not fully understand velocity/ impedance map. The fourth papaer by Lumley et al. (1997), present procedures for a quick, first order feasibility assessment of a seismic reservoir monitoring project. The authors consider not only the rock and fluid properties that determine the physical feasibility of a 4D project, but also take into account factors such as seismic data quality acquisition repeatability. Based on the paper presented above, this project has greater potential to expand its feasibility for detail laboratory analysis on fluid substitution modelling and time-lapse seismic reservoir monitoring. It also will take a challenge to test a new device which combining seismic and resistivity, thus create another feasibility result for oil and gas field.

Chapter 3 : Methodology



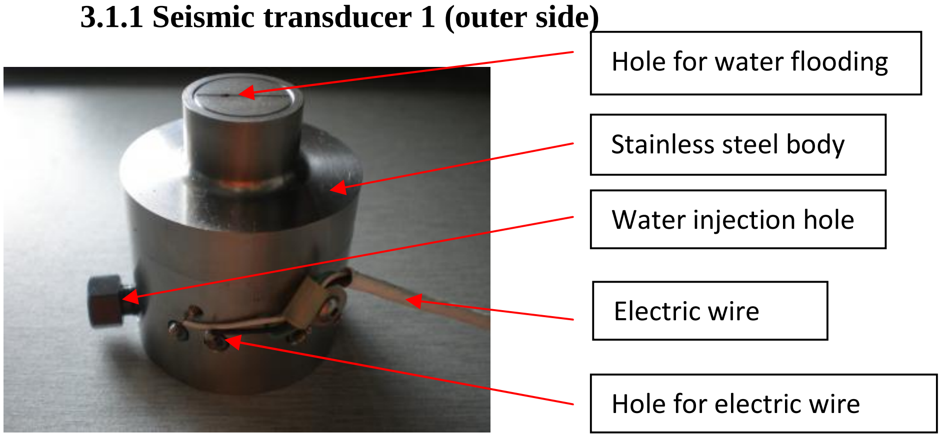
Methodology explanation

1) Detail study on the original design of transducer.
2) Create detail design which fit with the project objective.
3) Review detail design while considering the process used for fabrication and the availability of raw materials in terms of size.
4) Find all raw materials.
5) Start fabricating the transducer based on the detail design prepared.
6) Testing for feasibility such as pressure resistance, compatibility, leakage, etc.

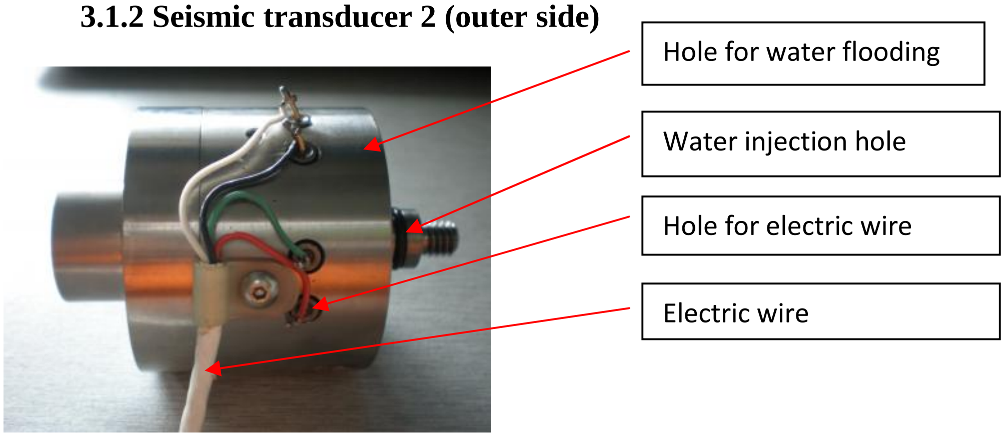
3.1 Phase 1 : Sample

Understanding (function, material used) for each component before designing the combination of seismic and resistivity transducer.

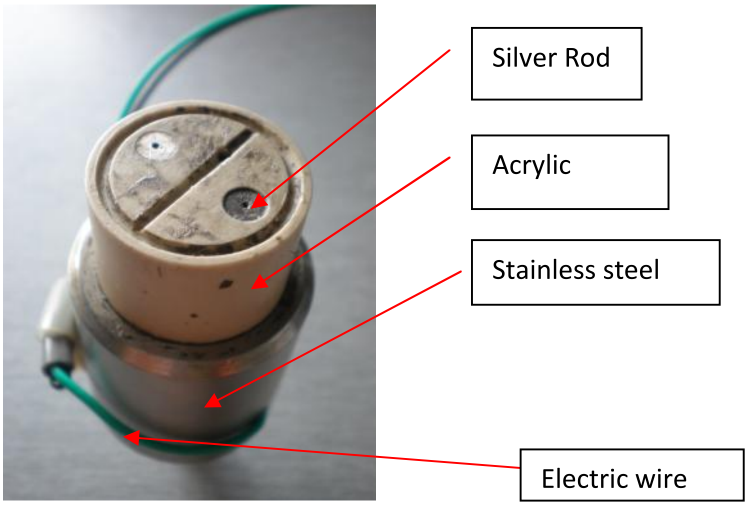
3.1.1 Seismic transducer 1 (outer side)



3.1.2 Seismic transducer 2 (outer side)

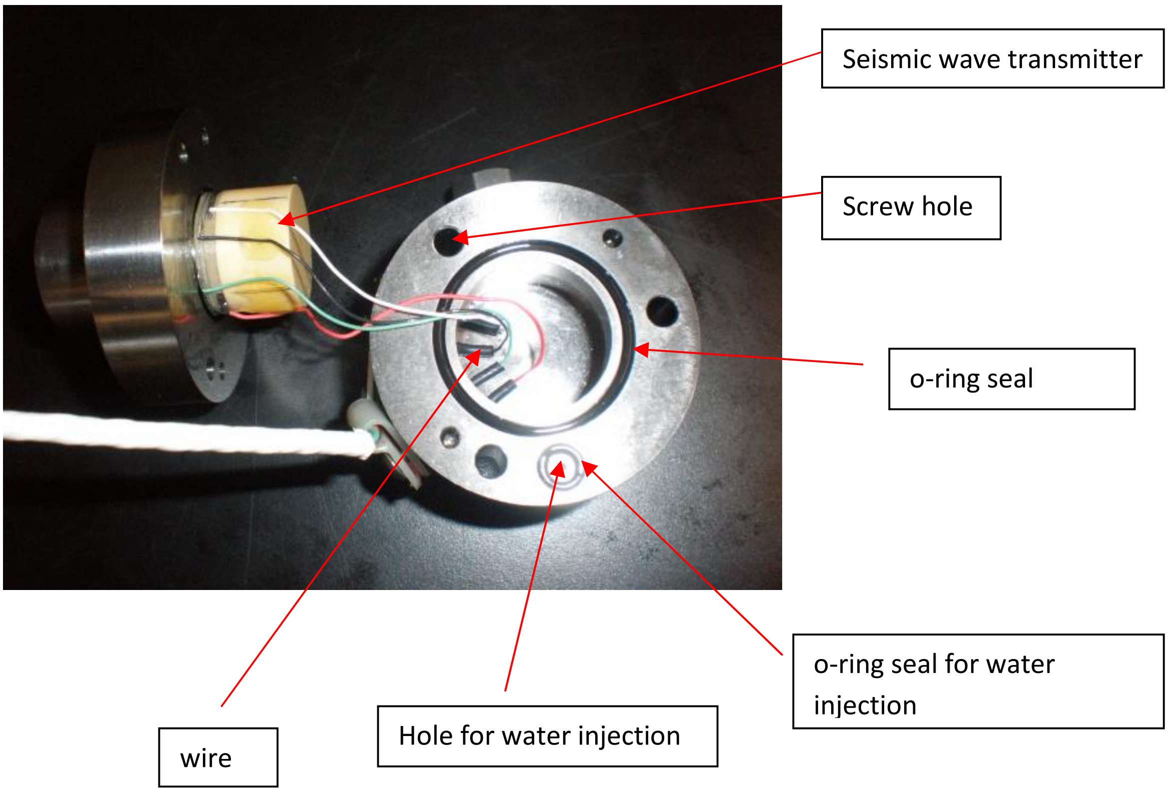


3.1.3 Resistivity transducer



3.1.4 Seismic transducer (inner side)

*inner side of both seismic transducer 1 and seismic transducer 2 are same



3.2 Phase 2 : Drawing sketch

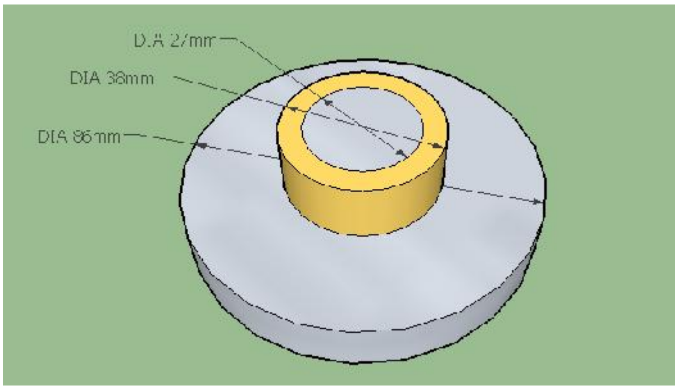
Design and sketch a combination of seismic transducer and resistivity transducer. Provided with new dimension. The drawing sketch for the design is divided to two part which are:

a) head

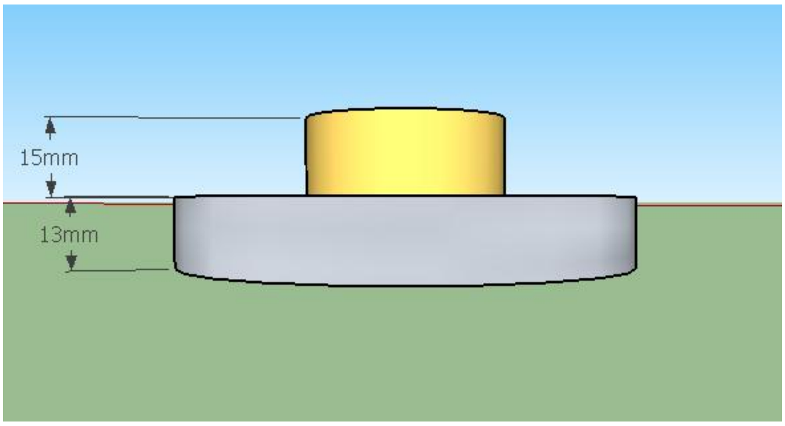
b) body

3.2.1 Head

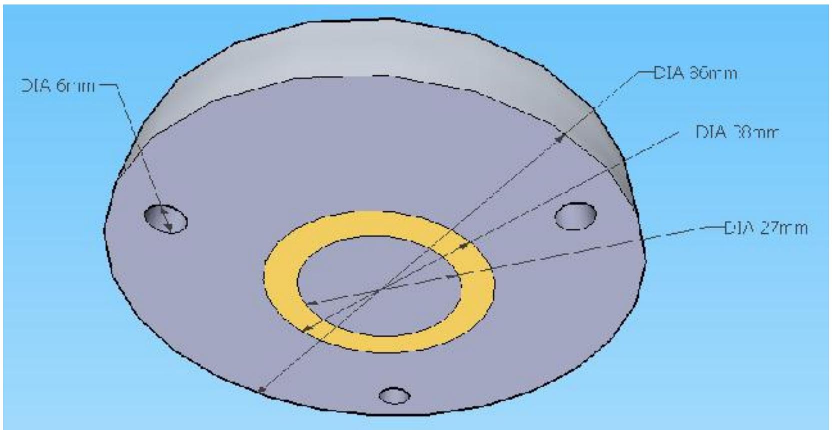
Top view



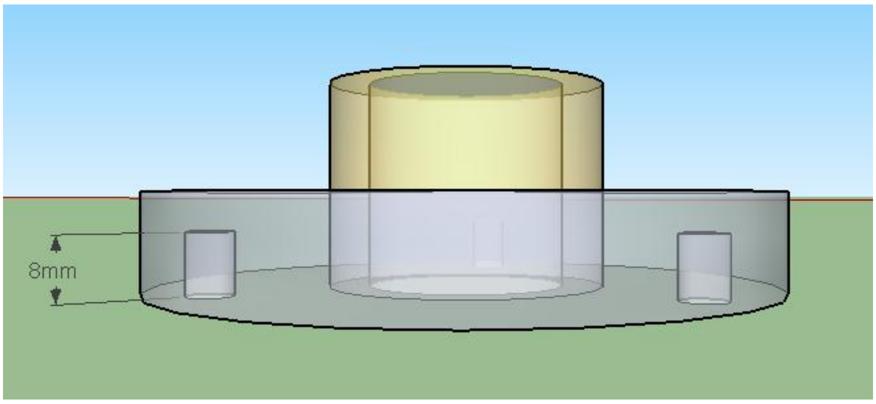
Side view



Bottom view

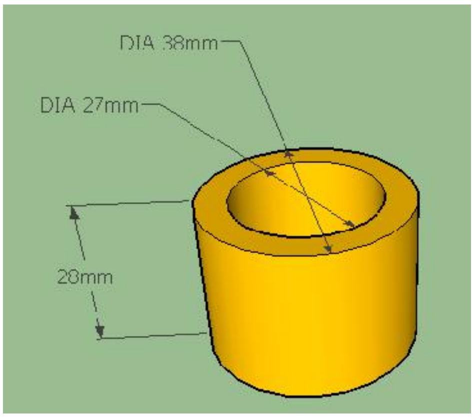


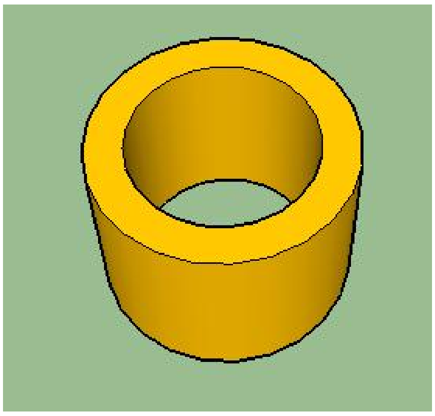
X-ray view



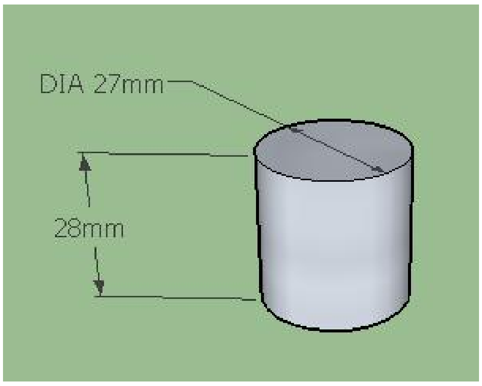
Components of head:

1) Acrylic

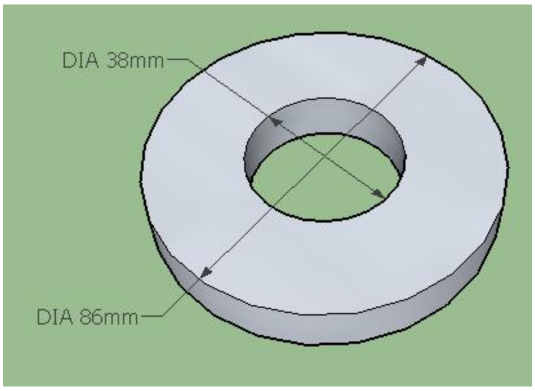


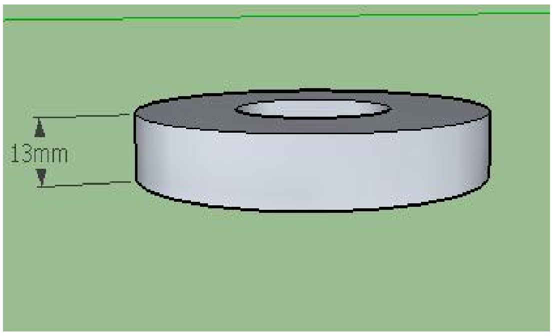


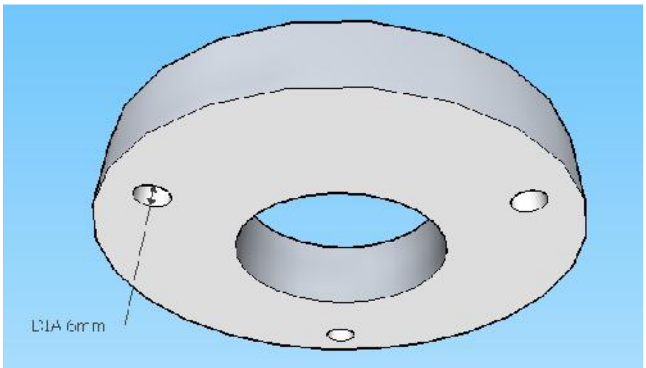
2) Stainless steel 1

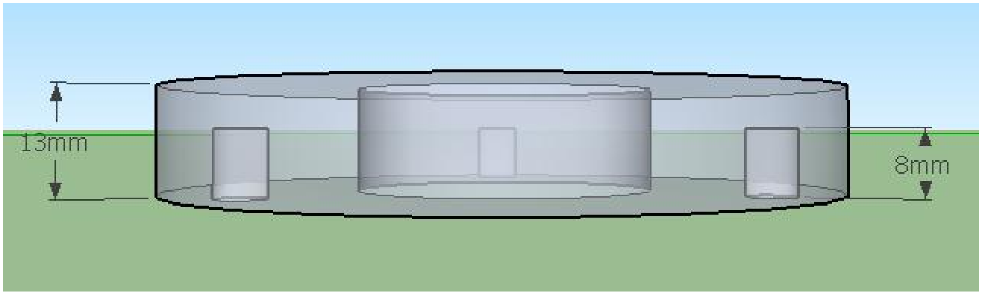


3) Stainless steel 2



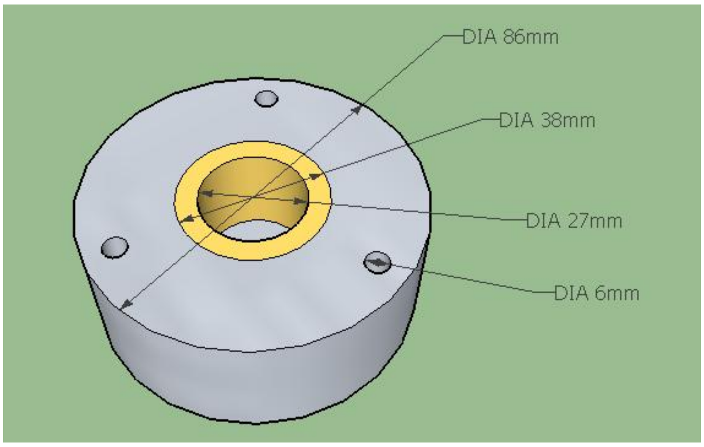




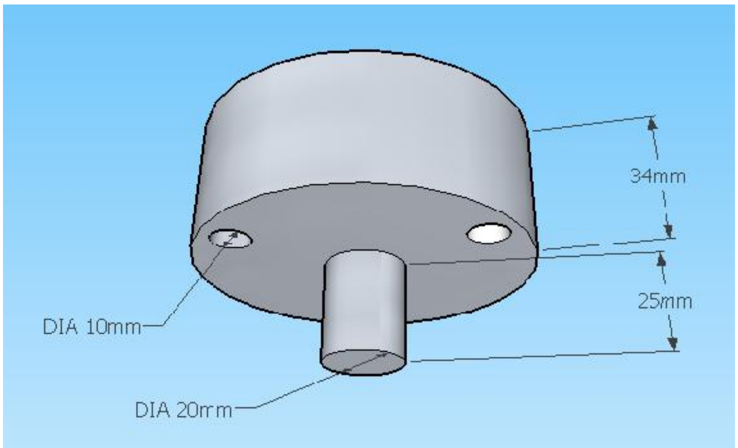


3.2.2 Body 1

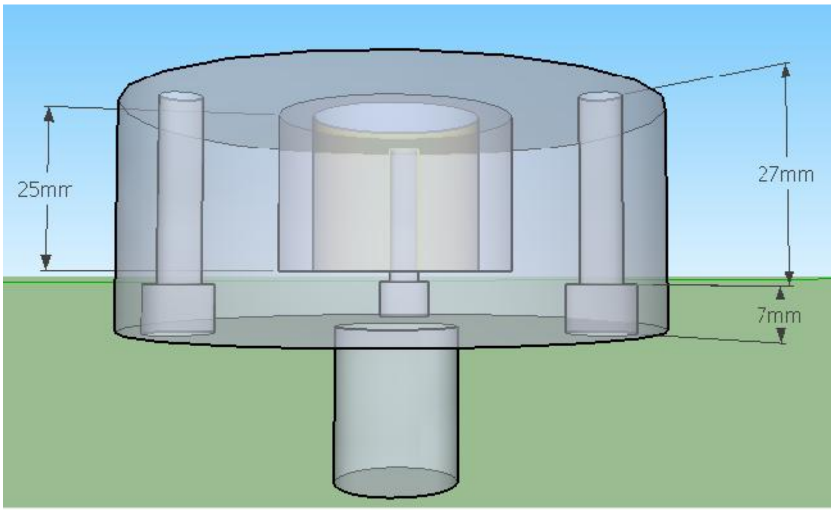
Top view



Bottom view

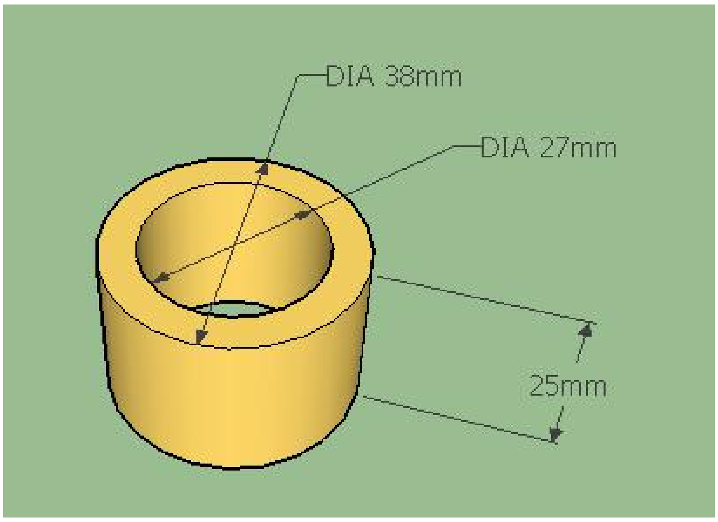


X-ray view



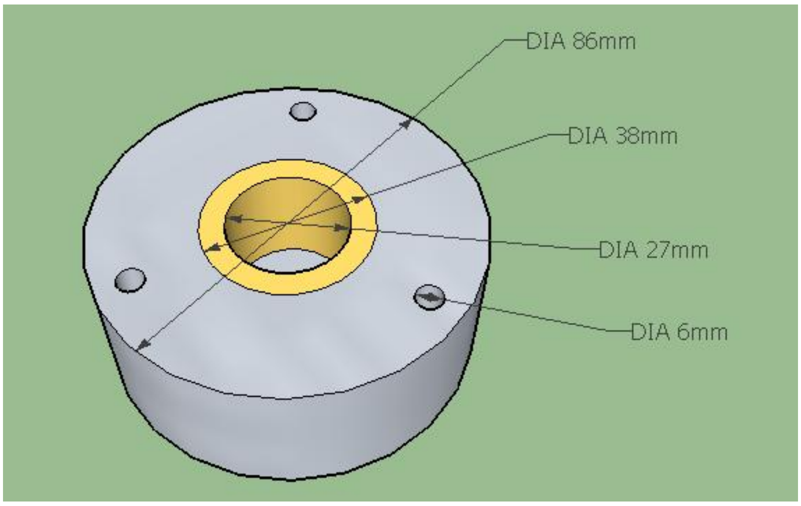
Component of Body 1:

1) Acrylic cylinder

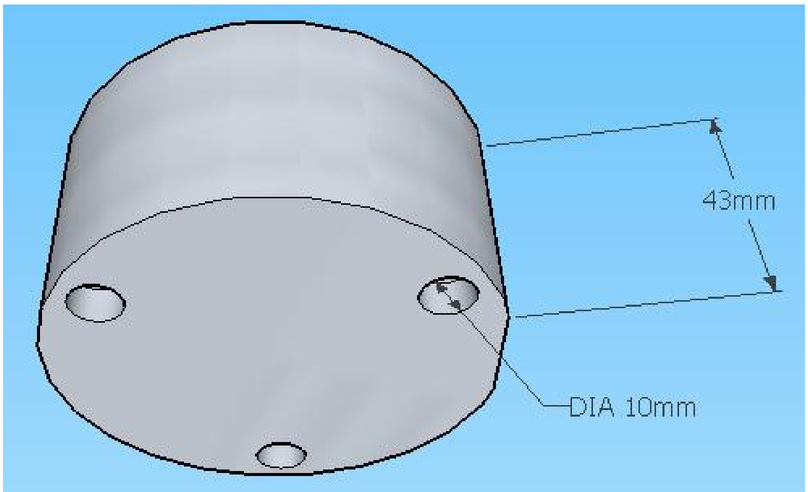


3.2.3 Body 2

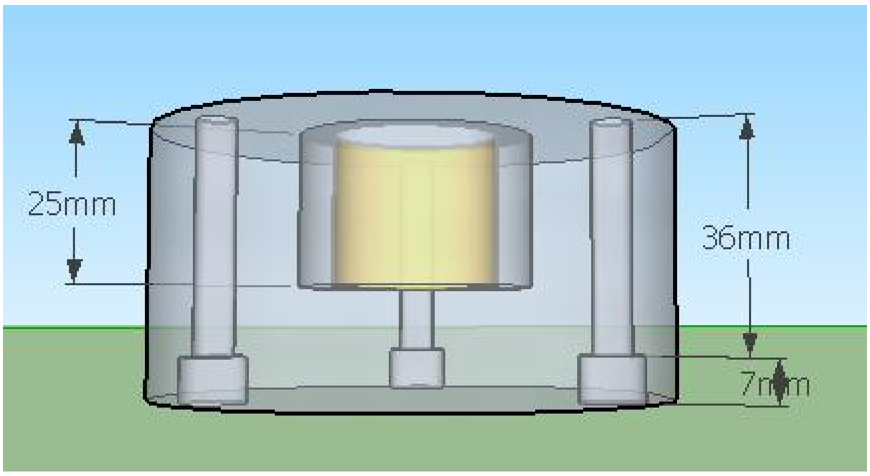
Top view



Bottom view

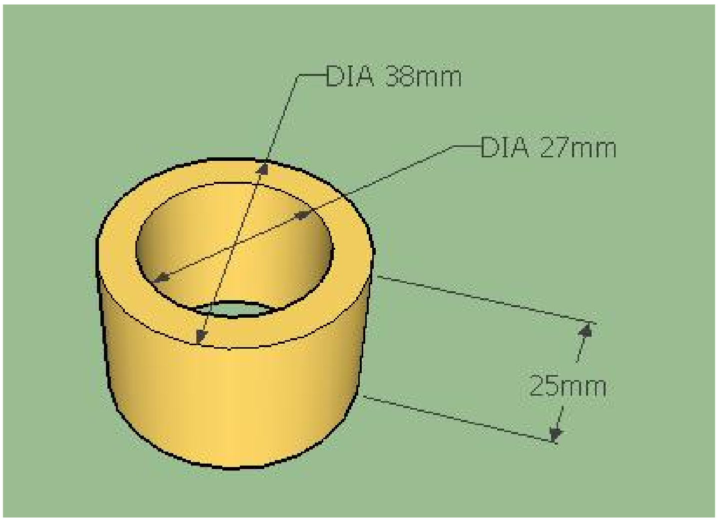


X-ray view



Component of body 2:

1) Acrylic cylinder



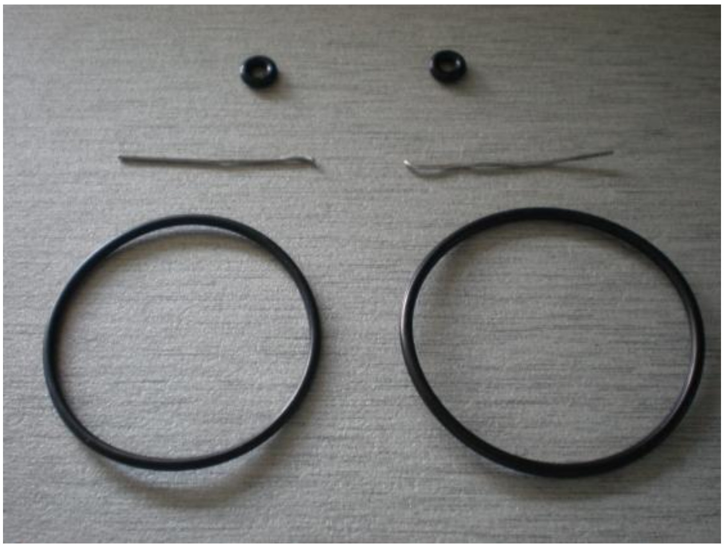
3.3 Phase 3 : Raw Materials

Raw materials for fabricating purposes. The fabricating process is done at the foundary workshop in Pusing, Perak.

1) Stainless steel

2) Acrylic

3) pin, o-ring



3.4 Phase 4 : Engineering drawing

Additional engineering drawing for references (also requested by workshop)

3.4.1 Body 1

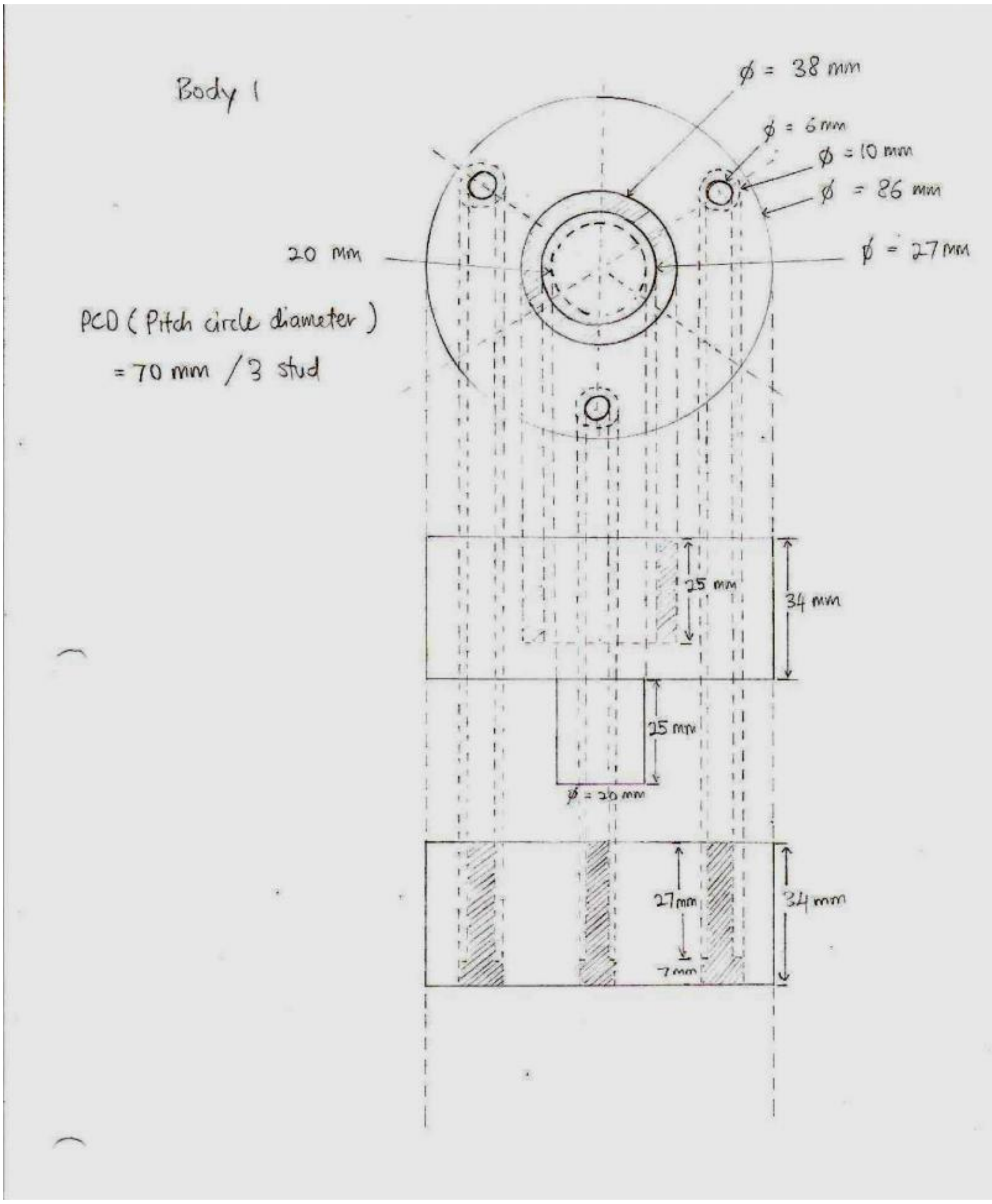


Figure 1 : Body 1 drawing sketch

3.4.2 Body 2

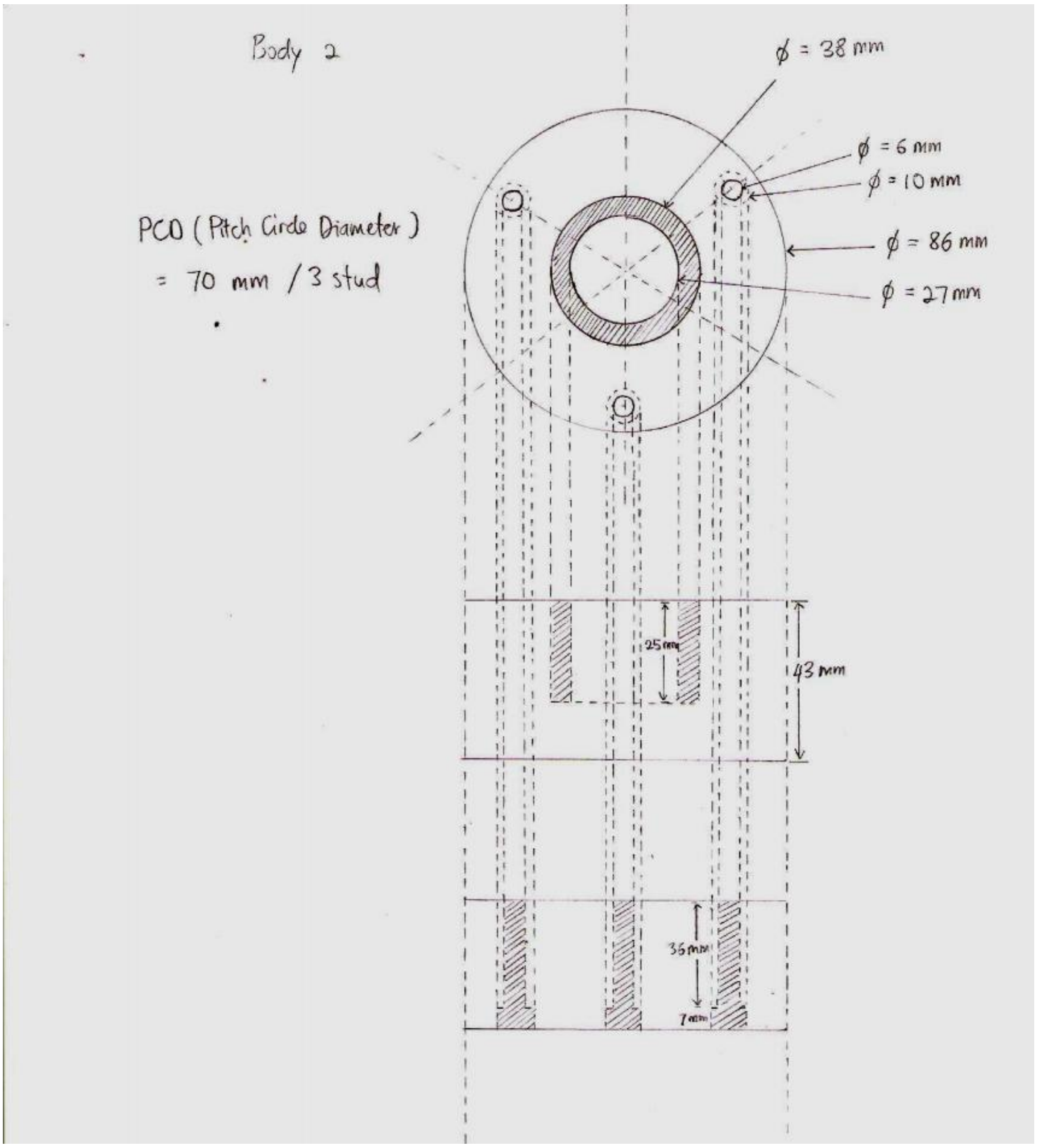


Figure 2: Body 2 drawing sketch

4.0 Findings of the project

a) List of fabrication phases and brief explanation

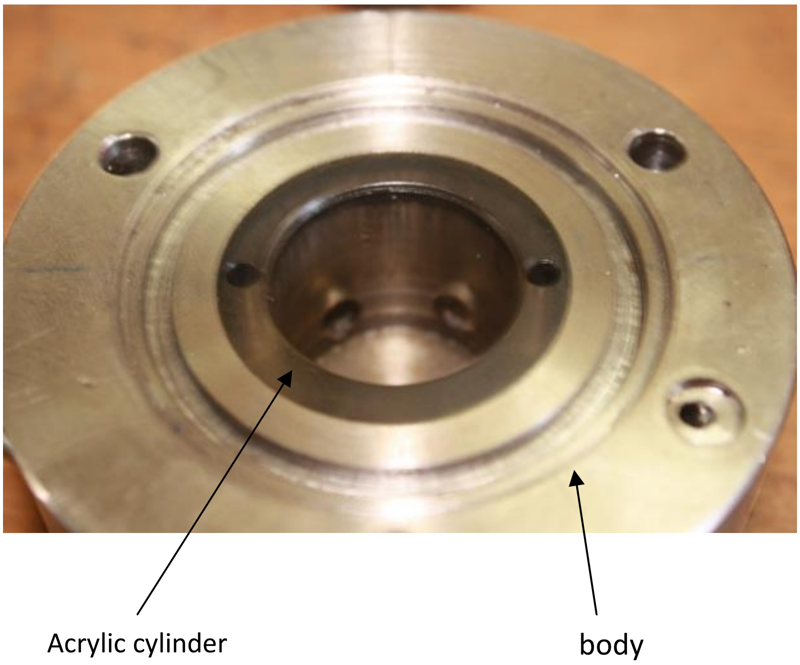
b) Problems encountered and solution

c) Further improvement and planning

4.1 List of Fabrication Phases

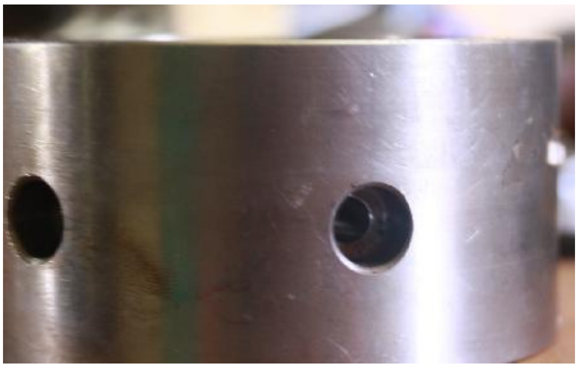
4.1.1 Acrylic cylinder installation

- Involve two body (1 & 2)
- Need modification because of limited space available for o-ring.
- Need o-ring to prevent oil enter to center of body.
- Each cylinder have slightly different dimension (please refer to 3.2.2 and 3.2.3)
- O-ring (ID = 38 mm, OD = 42 mm, thickness = 2 mm)



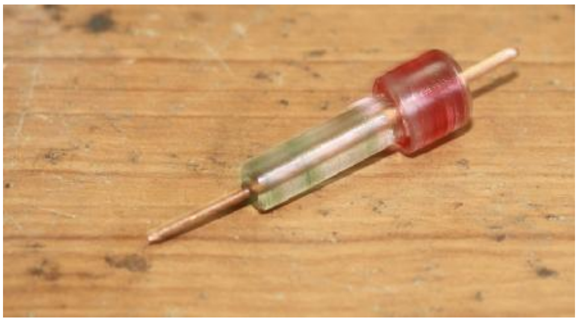
4.1.2 Copper pin installation

- One of the most important phases.
- Need to design for high pressure resistance (> 1000 psi) and ensure there is no contact between copper rod and stainless steel (body).
- In order to meet these two characteristic, after doing study and discussion, it was decided to use acrylic as a medium to ensure no contact between copper rod and body and able to prevent leakage of high pressure hydraulic around the body.
- The installation method involve tight compression to pressurize the copper rod and silicon for leakage resistance.



a) Hole for copper pin installation

b) Copper pin installed



c) Copper pin with

d) Copper pin obtain from cable

Drawing sketch for copper pin installation :

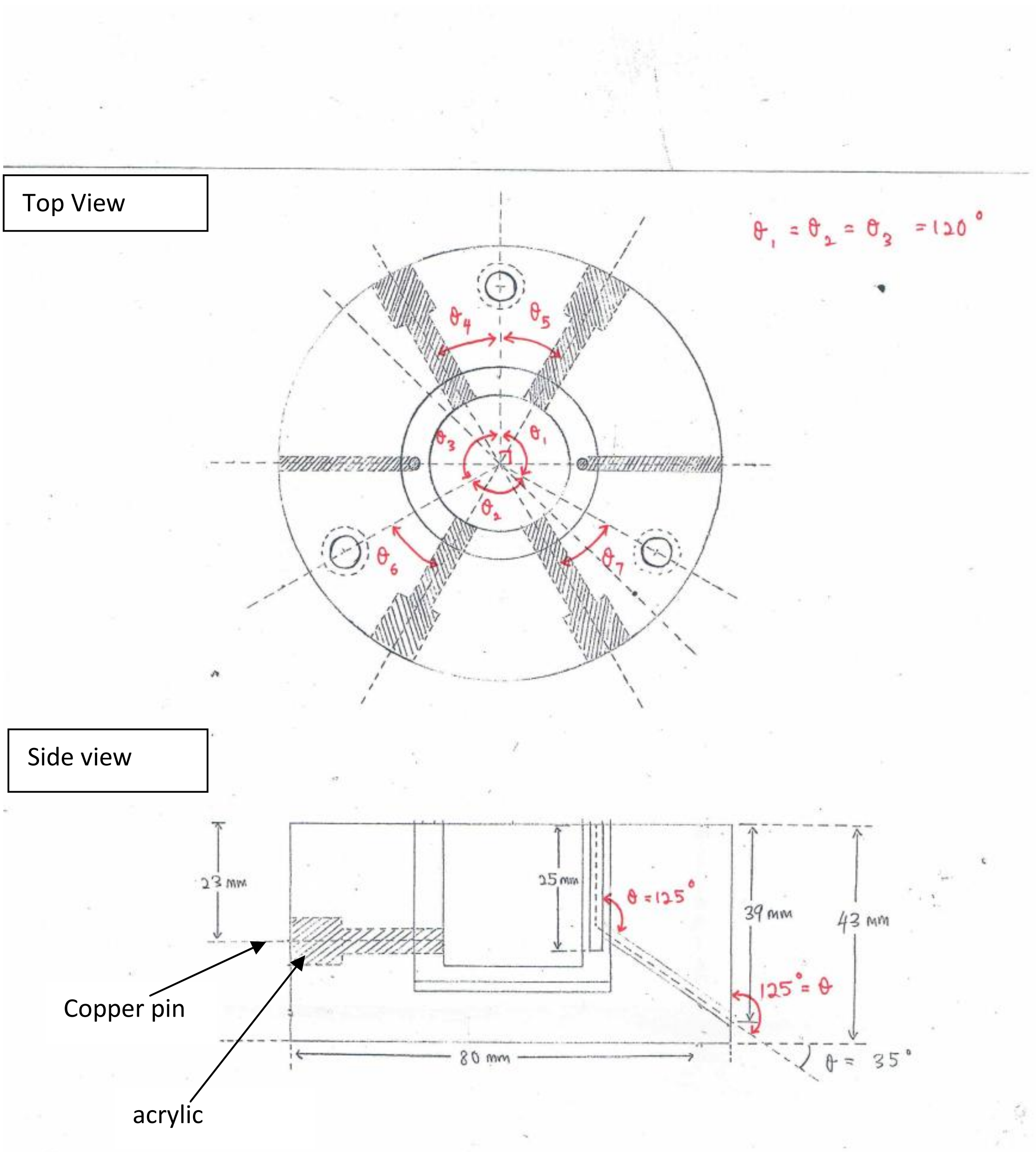


Figure 3: Drawing sketch for copper pin

4.1.3 Drilling for water hole injection

- Diameter for water hole injection is 1.5 mm.

- The phase need different angle while drilling due to limited space.

- Please refer to the drawing sketch below:

a) Head

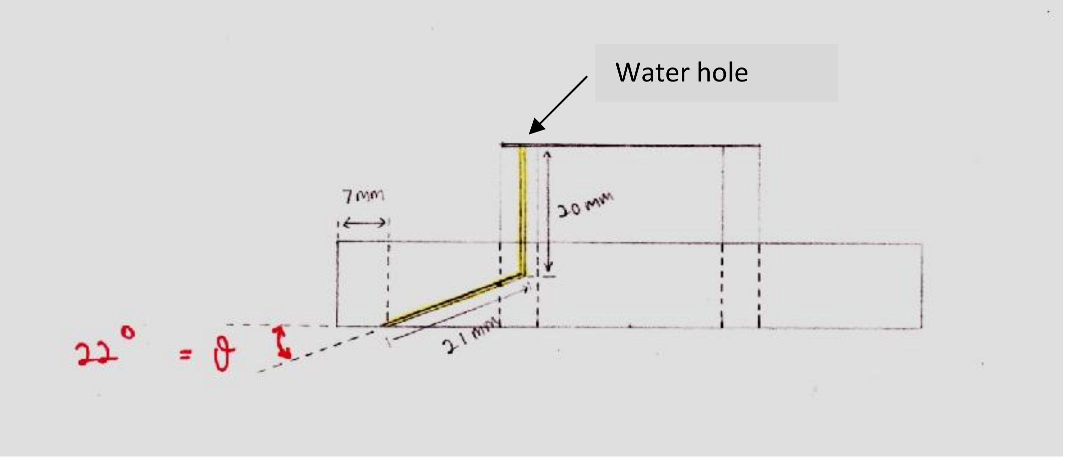


Figure 4: Drawing sketch for water hole (head 1 and 2)

b) Body1

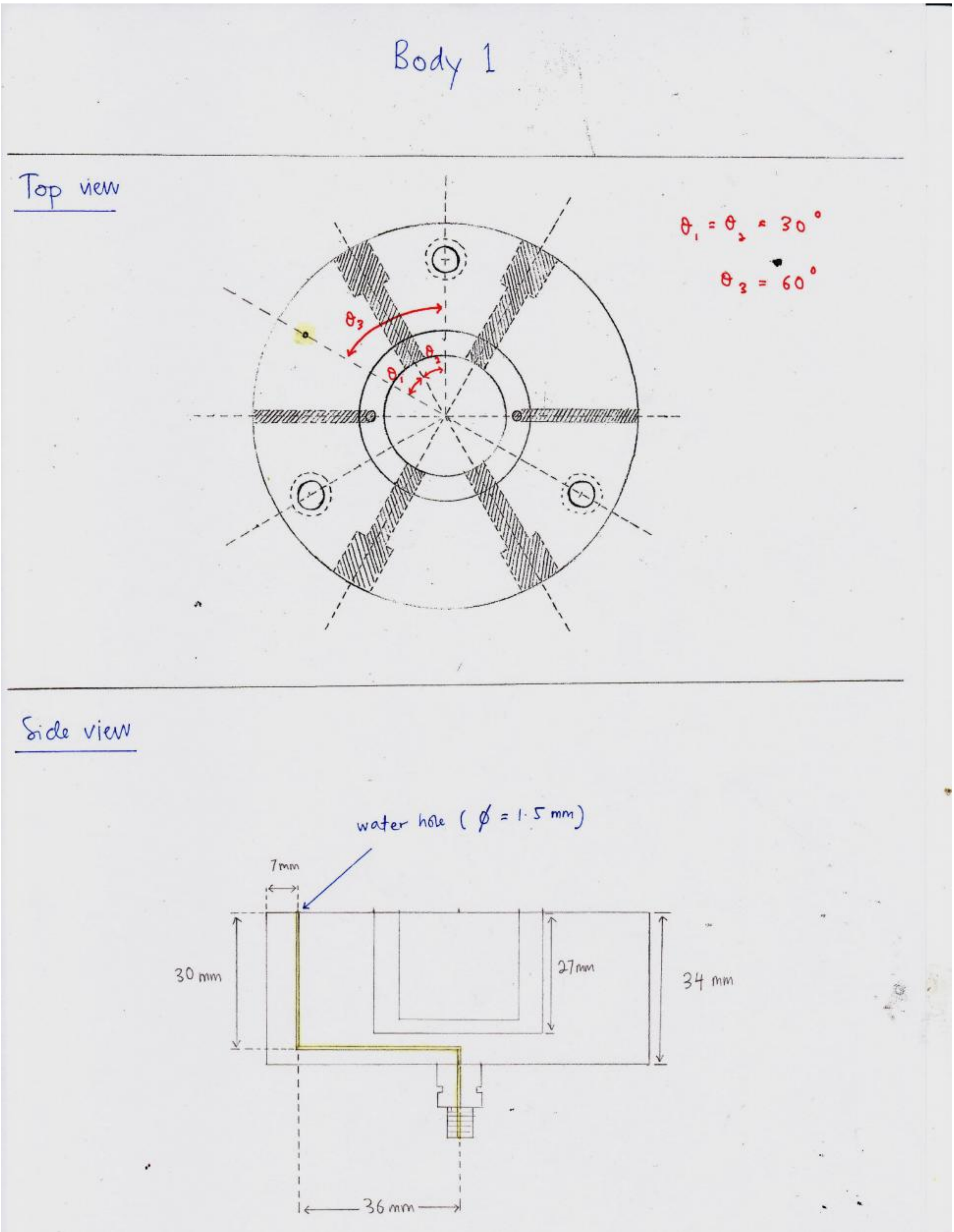


Figure 5: Drawing sketch for water hole (body 1)

c) Body 2

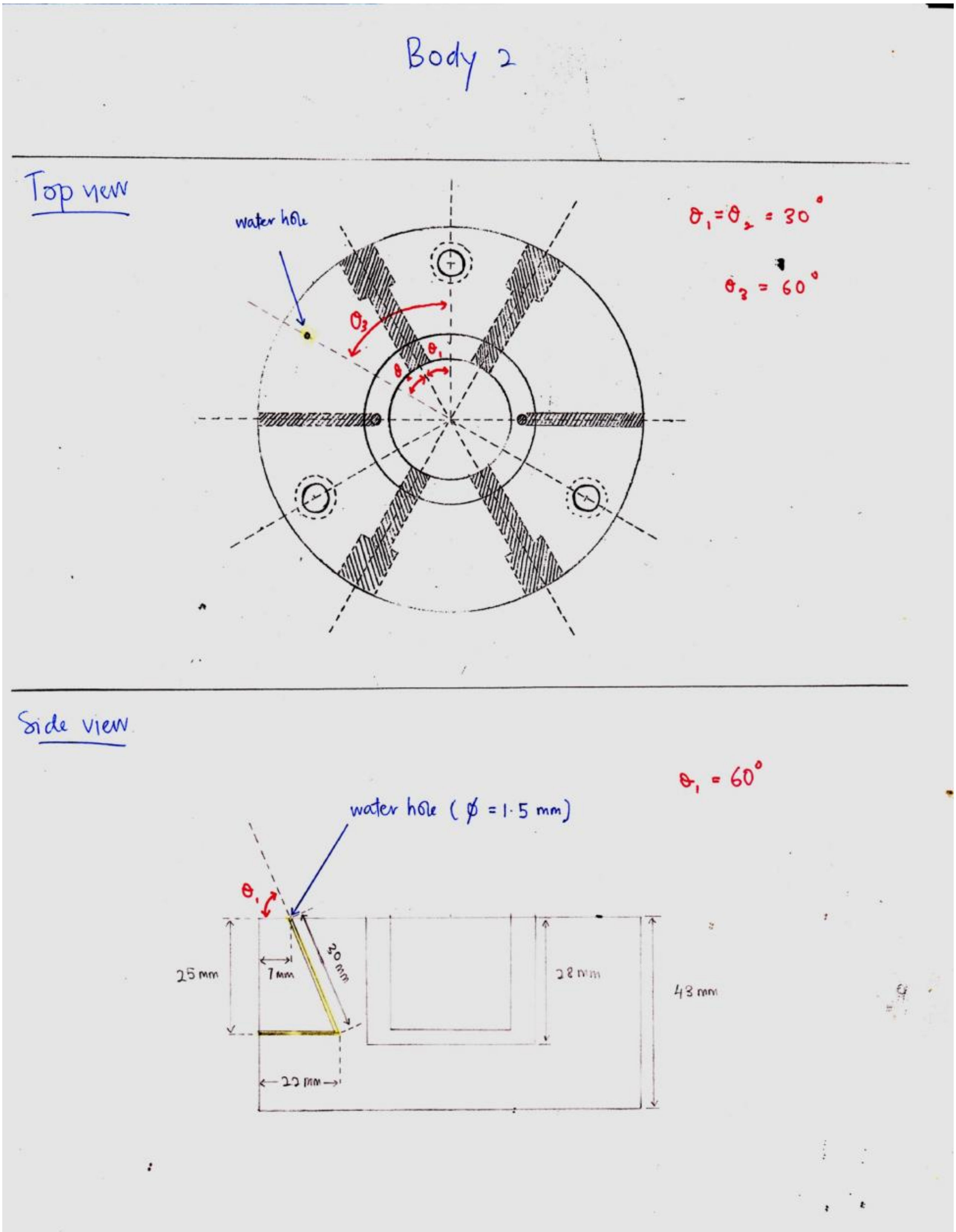
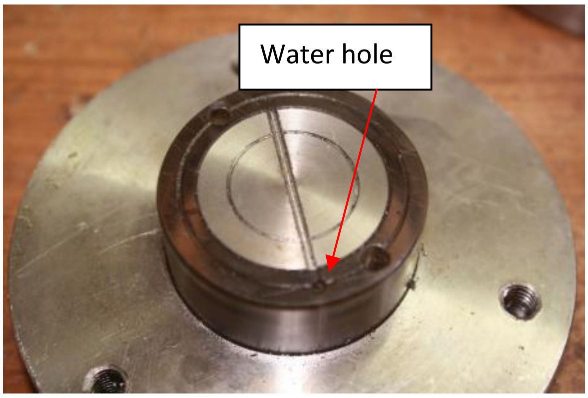
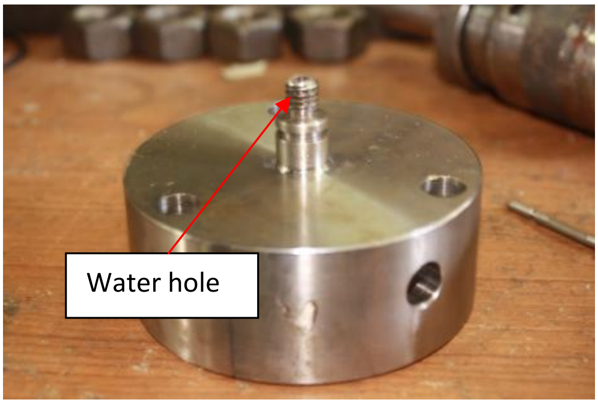


Figure 6: Drawing sketch for water hole (body 2)



a) Head 1 and 2

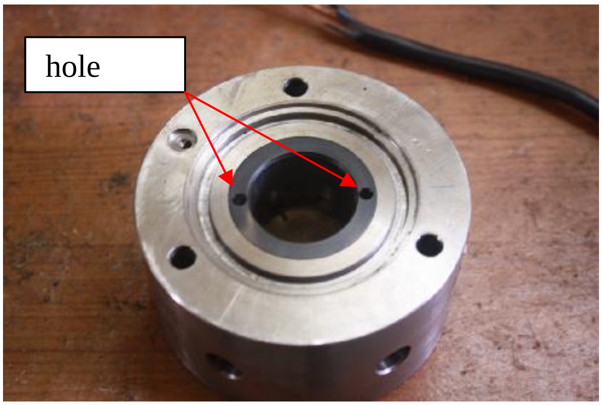


b) Body 1

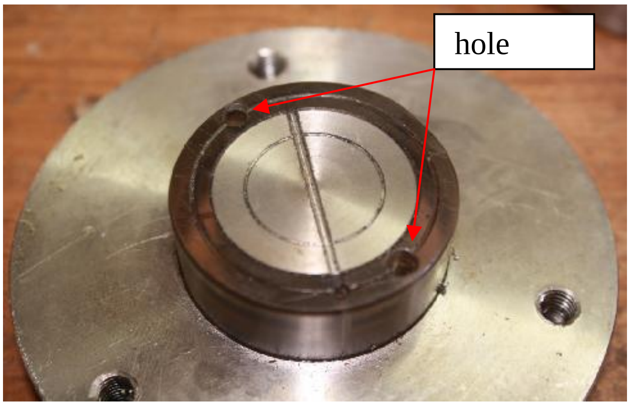
c) Body 2

4.1.4 Resistivity rod installation

- It is called resistivity rod because the rod is working for resistivity monitoring.
- The type of rod is steel.
- During installation, we need to ensure there is no leakage for hydraulic oil entering to the center of body.
- The installation will fail if there is leakage.



a) Hole for resistivity rod (body)



b) Hole for resistivity rod (head)

c) resistivity rod (steel)

d) resistivity rod install in head

4.2 Problems encountered and solutions

4.2.1 Raw material and tool

- Raw materials include copper rod, silver rod and o-ring.
- For **copper rod**, it is hard to find the only material in market unless the bigger size, however we able to find it in cable which consist of several copper rod.

-For **silver rod**, it is use as resistivity rod and only need small size (diameter = 2.5 mm). Due to difficulty to find it, we decide to use steel rod as alternative.

-For **o-ring**, we need various sizes for o-ring during the installation of acrylic cylinder and head. Because of its elasticity characteristics, we need to choose the most suitable size in order to avoid it from breaks during installation. Sometimes, we need to repeat the process because the size is not suitable enough.

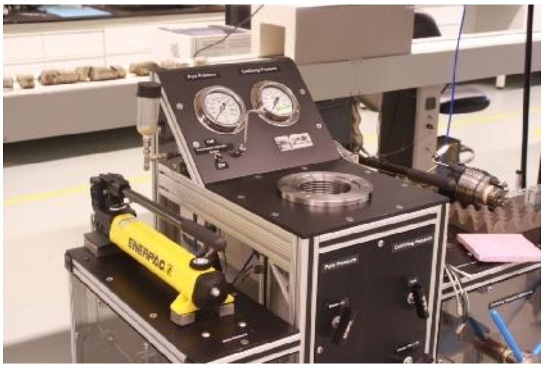
4.2.2 Copper Pin Installation

- Copper pin installation need us to consider about pressure and leakage resistance.

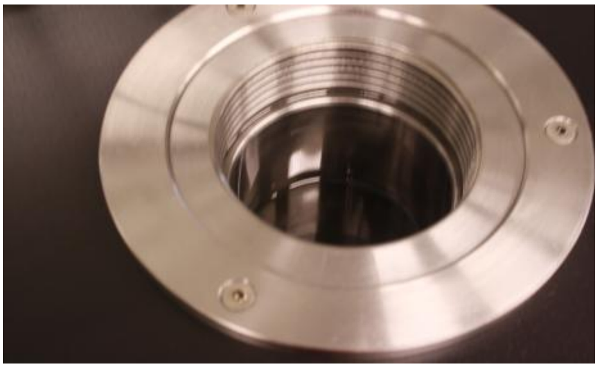
- Each body consist of 4 copper rods and 8 copper rods need to be installed.

- For the first trial, one copper rod had been installed and tested in lab for its feasibilities.

- The testing showed that the installation method is working properly as it meets the characteristic which to sustain pressure and leakage.



a) Pressure compartment control tool



b) Pressure compartment contains hydraulic for pressure and liquid resistance testing

4.2.3 Drilling for water hole injection

- The problem for this matter is the driller.
- At least, we need driller with minimum length of 45mm (diameter 1.5mm) to drill the hole.
- The only available in the workshop is the driller (diameter 1.5 mm) with length of 25mm.
- We need to find another long series of driller in market for further progress.

4.3 Recommendation

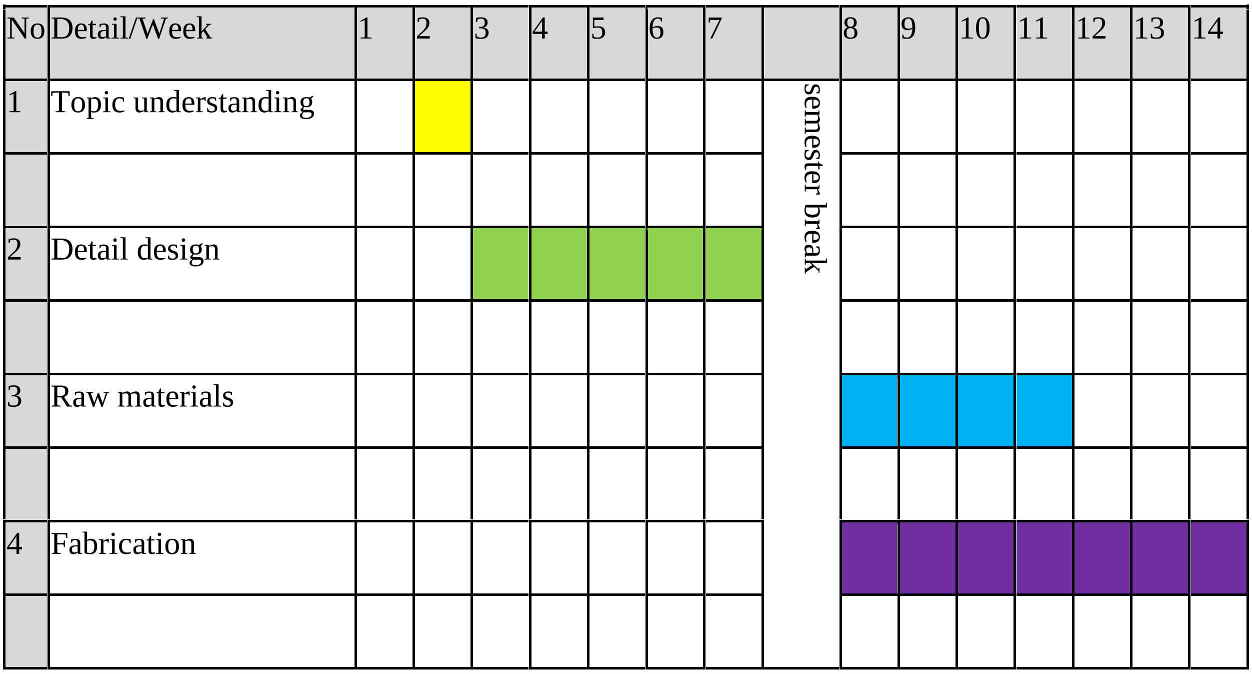
1. Create duration forecast for each phases and get justification from the supervisor and technician to ensure that the project can be completed right at the time given.

2. Indentify every single raw materials needed and find it from various sources. Use all the facilities and raw materials provided in UTP to reduce time consuming and costs.

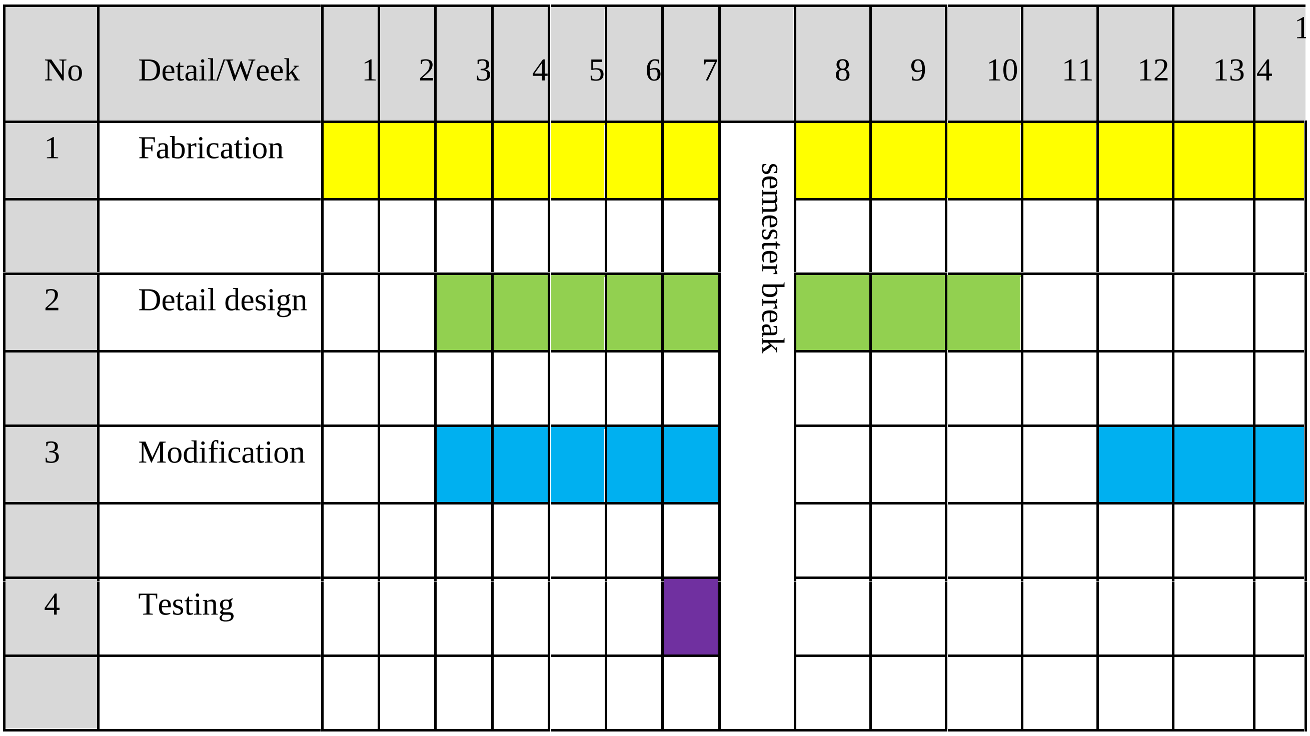
3. Help the technician to find by our self for any tools or raw materials for quicker progress.Respond as soon as possible for any problems.

Gant chart

a) Final Year Project 1



b) Final Year Project 2



Tools

1) Lathe machine
2) Driller
3) Drill chuck
4) Hydraulic pressure compartment
5) Google sketchUp 8 (software)

Conclusion

The aim of this project is to fabricate the acoustic and resistivity transducer . in order to complete as planned, this project need to be monitored carefully on fabrication process to avoid mistakes which are not able to be corrected unless start again form the first part. This project really need close understanding on how the device functioning, which one is the best design, how fabrication process being done, what are the limitation during fabrication, where to find to suitable raw materials, how to cater with schedule planned provided dealing with unexpected progress and skill need in communication with technician during monitoring the fabrication. All of these things need to be combined and execute in the best way as possible. The transducer fabrication process was done until the final stage and was handed over to the supervisor.

References

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3. Wang, Z., 1997, Feasibility of time-lapse seismic reservoir monitoring (TLSRM).

4. Lumley, D., Behrens, R., and wang, Z., 1997, Assessing the technical risk of a 4-d seismic project.

Appendix

I. Foundry details