INTERFACE REGION LEVEL MEASUREMENT

By

MOHAMAD ASHRAF BIN MOHAMAD JAPRI

FINAL REPORT

Submitted to the Department of Electrical & Electronic Engineering
in Partial Fulfilment of the Requirements
for the Degree
Bachelor of Engineering (Hons)
(Electrical & Electronic Engineering)

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CERTIFICATION OF APPROVAL

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Approved:

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Mrs Zazilah May
Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

January 2013

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 acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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MOHAMAD ASHRAF BIN MOHAMD JAPRI

ABSTRACT

This progress report is intended for final year project under Electrical & Electronic Engineering Department which provide the introduction that consist of background study, problem statement, objectives of this project and theory are also stated within the introduction part. In order to ensure correct operation of the plant or equipment involved, it require careful control of liquid level in many processes involving the storage, movement or processing of liquids. In order to maintain a smooth operation and to provide a quality product to consumer, it's a vital for an operator to emphasize a mutual measurement to identifying the interface level between two media with different specific of gravity either liquid or solid in the same tank or vessel, such as oil and water or water and sand.

These methods are also extensively being used in chemical industries and petrochemical plant. This paper aims to tackle the weaknesses of the current system in terms of costly and complex equipment's, high maintenance cost, instability and inability to control and monitor from remote location. It describes how the innovative interface level control system can be characterized as an event-based system, where every control actions are primarily deliberated compared to the events formed by instabilities from surrounding elements.

This project report offers a costs-saving solution with low maintenance required, as well as producing a great performance results. This system eliminates the over-dependability of the industry on human workforce. The system will continuously measure, control and monitor two of the most important parameters, interface liquid level and total level, as the quality and ability of process are highly affected by these factors.

Through refer the separating funnel method, a mixture of liquid will be shaken and then left it until becomes steady again. Liquid with heavier density around 1 or above such as water will goes to the bottom while on the other hand, the liquid with lighter density less than 1 like oil will floating above.

When a two liquids that differ in term of density mixing together in the end it will separate and resulting in a “clear” interface that will be easier to detect. On some cases an emulsion or “rag” layer will exist between the two liquids. In some cases, it may be necessary to measure the thickness of the upper layer.

Basically, the products will separate due to a difference in the specific gravity of the products. Even though this difference is enough to cause the product to separate, it may be too small in term of thickness on a difference of which to base an interface measurement.

To achieve the objectives, a differential pressure transmitter being used to measure the interface level base on density of each liquid in a wet - leg closed tank. It is important that the level be large enough to create a reasonable measurement differential pressure between the two specific gravity extremes. Interface applications typically result in a small non-zero based span. Size the transmitter appropriately to cover this span. To increase the span, either the level (distance between taps) must be larger or the specific gravity difference of the two fluids must be greater.

Furthermore, using a wet leg system can also create errors if the fluid does not stay at a constant height or density. As a conclusion, this project can consider as a new solution to overcome the reliability in term of accuracy of level measurement in industry. With the humblest salutation and gratitude, hopefully the reader will gain some useful information and positive benefits from it.

Throughout the report, authors also justify a detail literature review. Include also the project methodology that will be explained regarding the Project Flow Chart and also the project activities. At the end of the report, author highlighted the expected result if all the modeling and calculation are correct.

As a conclusion, this project can consider as a new solution to overcome the reliability in term of accuracy of level measurement in industry. With the humblest salutation and gratitude, hopefully the reader will gain some useful information and positive benefits from it.

ACKNOWLEDGEMENTS

Praise to Allah for giving me hope and will to do the development and simulation work with enthusiasm and joy. Without His help, I will not be able to make it a reality the completion of this final year project that was made possible by the valuable assistance I received from many people.

There are also people who I would like to express my appreciation that has contributed directly or indirectly to this work. I am grateful to Ms Zazilah May, my supervisor and Ir. Dr. Idris bin Ismail as my co-supervisor who really acts as my inspiration of the project. They guidance, encouragement, helps and supervision has made this work proceeded successfully. They highly cooperation in giving ideas and time for this project really made me aware that I have to complete my work as “perfect” as I can.

My appreciation would also goes to Dr. Nasreen Badruddin, Dr. Nordin bin Saad, Miss Noor Hazrin, Mr.Azhar and also for Electrical lab technician department for their help in contributing ideas and advice and also to the UTP librarian for helping me finding the journals related to the project. In other words, huge thanks to everyone for helping me out when I have problems and questions. It is to them that I owe my deepest gratitude in making this final year project a success.

I have learnt a lot of valuable things while working this project. I realize that learning theoretical is never the same when it comes to practice. I also learned it is very important to know how to work as part of the team especially when working with others in term of personal communication skills.

Finally, it is a pleasure to thank my family for their understanding, and friends for their consideration and also to the Electrical & Electronic Engineering Department for providing this golden opportunity for me to perform this final year project.

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1. DP – Differential Pressure
2. ρ - Density
3. M – mass
4. V – Volume
5. GWR – Guided Wave Radar
6. HP – High Pressure
7. LP – Low Pressure

CHAPTER 1

INTRODUCTION

1.1 Background of Study

In order to ensure correct operation of the plant or equipment involved, it require careful control of liquid level in many processes involving the storage, movement or processing of liquids. In order to maintain a smooth operation and to provide a quality product to consumer, it's a vital for an operator to emphasize a mutual measurement to identifying the interface level between two media with different specific of gravity either liquid or solid in the same tank or vessel, such as oil and water or water and sand. These methods are also extensively being used in chemical industries and petrochemical plant.

Through refer the separating funnel method, a mixture of liquid will be shaken and then left it until becomes steady again. Liquid with heavier density around 1 or above such as water will goes to the bottom while on the other hand, the liquid with lighter density less than 1 like oil will floating above.

In addition, some situations include multiple interfaces between more than two products, or the interfaces between a liquid and a solid. The unalike density or specific gravity of the two different liquids means the lower density liquid will float on top of the higher density liquid[1]. When a two liquids that differ in term of density mixing together in the end it will separate and resulting in a "clear" interface that will be easier to detect. On some cases an emulsion or "rag" layer will exist between the two liquids. In some cases, it may be necessary to measure the thickness of the upper layer[1]

Basically, the products will separate due to a difference in the specific gravity of the products. Even though this difference is enough to cause the product to separate, it may be too small in term of thickness on a difference of which to base an interface measurement.

To take countermeasures against that, the research project was organized by the author to understand the behavior of interfacial tension and method to figure out the measuring equipment. These studies are mostly based on the experimental result and by discussing with industrial engineer that is expert in this field

1.2 Problem Statement

1.2.1 Problem Identification

To observe the behavior an interface level region between two different density media in a tank and how to measure the level of interface region. Obviously if consider a normal process in refinery that does not want any mixture of liquid that still contain water from tank to enter the distillation process. Once an operator detect where the interface between two liquid occur, the next phase are to separate off the top crude, leaving only the water to be processed separately.

1.2.2 Significant of Project

In petroleum and chemical industry, measurement and control of oil-water interface level are very important process parameter.[2] Accuracy is very important here because any oil in the water means product losses, and any water in the oil requires extra processing [1]. This is also applying to other process product. In a process sometimes it may require to separating two different products by using separator method that base on density or specific gravity if the product are liquid and it is crucial to make sure that none of the product are blend together when goes to distillation process. In some applications, because of miscibility of liquid that can mix or dissolve in all proportions make the separation may not be quite as obvious, such as ethanol in water, methanol, diesel and green diesel. While petrol and diesel would mix since both are based on hydrocarbon.

1.3 Objectives

To measure the interphase region level that containing two different media or having two different densities in a vessel. Thus need to determine a higher long-term stability and low-maintenance of measuring equipment that also are very reliable.

1.4 Relevancy of Study

A research project to figure out a reliable interface level measuring instrumentation in term of safety and maintenance free to indicate or control an interface between two different liquid. Moreover, each of the immiscible liquid is having a different dielectric constant.

1.5 Scope of Study

In this study, research is focus on the behavior of interface level in a vessel base on liquid gravity density, temperature and type of liquid. A comparison between existed level measurement equipment / method also being stressed by author.

1.6 Feasibility of Project

This project is an extended study over two semesters for the fulfillment of FYP I and FYP II courses. The followings are the aim of the project for the first four months (FYP I):

- Literature review on the topic.
- Preparation of the methodologies of reliability interface level measurement.

After the completion of FYP I, identifying the measurement equipment and data analysis would be conducted within the remaining four months (FYP II), the experiments that will be conducted for FYP II. The estimated project cost will be within the budget allowed by the university.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

When do research about liquid characteristic, one must consider its surface tension and interfacial tension effect. Both these effects take place due to the unbalanced of intermolecular forces between the liquid or solutions molecules. In a certain event such as, forming of droplets, immiscibility of liquids, capillary action, soap bubbles, and tears of wine and even the floating of the water strider are based on the observation form of surface tension and interfacial tension effects in the day to day life. Through deep understanding on both effects, humankind is able to mix an emulsion mixture to create something useful.

2.2 Surface Tension

Effects of liquid droplets form spheres and meniscus effects in capillaries are act of decrease the free energy of the system from surface tension. Every molecule in the central parts of the liquid has exactly same amount of force pulling it to every side[3].

2.2.1 Surface tension values of various interfaces liquid table[4].

No.	Liquid	Interface	Temperature	Surface tension, y in (mN/m)
1.	Water	Air	20C	72.86
2.	Water	Air	21.5C	72.75
3.	Water	Air	25C	71.99
4.	Ethanol	Air	20C	22.39
5.	Ethanol	Air	30C	21.55
6.	Mercury	Air	20C	486.5
7.	Benzene	Air	20C	28.88
8.	Octane	Air	20C	21.62
9.	Liquid Nitrogen	Air	-196	8.85
10.	Acetic Acid (40.1%)	Water	30	40.68
11.	Ethanol (40%)	Water	25	29.63
12.	Acetone	Air	20	23.7

Table 1 **:** Liquid interface against the temperature and surface tension.

2.3 Interfacial Tension

Interfacial tensions are well known as a term when to study about immiscible liquids those incapable of mixing reside within the same vessel and each having a different dielectric constant. Moreover, surface tension also applies the same theory. Interfaces are most commonly found in the diverse separation processes that are essential to every industry[5]. Mostly are wide use in separation recovers additives, catalysts or any solvent extracts impurities and routes media into different processing channels.

The only difference between interfacial tension and surface tension is that interfacial tension base on the liquid to liquid interface while surface tensions are toward the liquid to air interface. When immiscible liquids that meets along the interface layer, they will undergo some amount of emulsification

Difference between surface tension and interfacial tension

The main difference between these two is the places where it occurs. Surface tension is defined to a single liquid surface, whereas the interfacial tension is defined to the interface of two immiscible liquids. Surface tension is essentially a derivation of interfacial tension where force from the second surface is negligible or zero.

To avoid confusion to the reader there are differences between interface detection and interface level detection such as explanation below:

I. Interface Detection

- An extensively method when comes to the flow through pipeline and also for fuel distribution to help identify, isolate and store multiple fuel products
- A standard procedure in the pipeline industry but recent developments of reformulated gasoline, low sulfur fuels, and unique-blends fuels have created a renewed emphasis on interface detection. Thus, improvement on interface detecting technology and improved in interface detecting procedures need to be complete in order to meet this challenge.

II. Interface Level Detection

- Basically it refers to product detection inside a storage vessel.

2.4 Air-Water Interface surface shape

Base on the '*Young-Laplace equation*' any air-water shape of the interface can be identified and measured due to the phenomenon of wall tension or surface tension. The pressure differences on the shape of the liquid surface are somehow related with the Young–Laplace formula and it is crucial when come to understand the static capillary surfaces.

It is a statement of normal stress balance for static fluids meeting at an interface, where the interface is treated as a surface (zero thickness)[6] :

$$\begin{aligned} \Delta p &= -\gamma \nabla \cdot \hat{n} \\ &= 2\gamma H \\ &= \gamma \left(\frac{1}{R_1} + \frac{1}{R_2} \right) \end{aligned}$$

The main purpose to familiarize these equations are considered as important when use to explain the energy required to create an emulsion in a liquid.

To form the small, highly curved droplets of an emulsion, extra energy is required to overcome the large pressure that results from their small radius.[6]

2.5 Emulsions & Emulsification

When a two liquid that in contact or mix together and both are have a non – zero interfacial tension know as immiscible. Hence, emulsion occurs when an immiscible liquid that mix up with other immiscible liquid usually different material with different density it will create one layer that dispersed each other. This project the author specifically used oil in water emulsion (O/W).

Most emulsions are in a '*metastable state'* which are a kind of temporary energy trap [8]. It is the immiscible liquid condition when combine together.

Furthermore, emulsions have numerous applications in consumer products usage itself such as in pharmaceuticals, foods production, cosmetics industry and etc. On the other hand, in industrial usage emulsion mainly being used in oil & gas industry, mining, petrochemical industries, and production engineering. While in construction industries, the emulsion theory being implemented when to produce cement from a combination of sand with water to make stable structure.

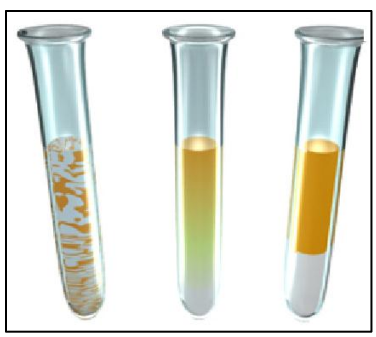


Figure 1: Emulsion

No.	Oil in water Emulsion (O/W)	Water in oil Emulsion (W/O)
1	Water is the dispersion medium and oil is the dispersed phase	Oil is the dispersion medium and water is the dispersed phase
2	They are non-greasy and easily removable from the skin surface	They are greasy and not water washable
3	They are used externally to provide cooling effect e.g. vanishing cream	They are used externally to prevent evaporation of moisture from the surface of skin e.g. Cold cream
4	Water soluble drugs are more quickly released from o/w emulsions	Oil soluble drugs are more quickly released from w/o emulsions
5	They are preferred for formulations meant for internal use as bitter taste of oils can be masked.	They are preferred for formulations meant for external use like creams.
6	O/W emulsions give a positive conductivity test as water is the external phase which is a good conductor of electricity.	W/O emulsions go not give a positive conductivity test as oil is the external phase which is a poor conductor of electricity.

Table 2: Difference between o/w and w/o emulsions

2.6 Liquid Density

To understanding liquid density one must acknowledge the mass per unit volume of a material. The symbol, ρ (the lower case Greek letter rho) are the most habitually being used in mathematic when to defined mass that divided by volume:

$$\rho = \frac{m}{V},$$

Density of liquid is identified as *ρ*, while *m* is the mass, plus *V* is the volume of liquid in a tank. It is an important perception that different materials basically have different liquid densities when comes to buoyancy, purity and packaging

Normally a smaller amount of dense liquid will float above on other more dense liquids if they do not mix. If any liquid density such as oil that are less than water, it will floating above the water and hence when the liquid are heavier than water's such as sea water that contain salt, it will goes below the water.

In some cases density is conveyed as the dimensionless quantities specific gravity or relative density, in which case it is expressed in multiples of the density of some other standard material, usually water or air/gas. (For example, a specific gravity less than one mean that the substance floats in water.)[7]

Temperature and pressure varies can affect mass density of liquid. Example when pressure increases it will decrease the volume of the liquid and therefore increase its density On the other hand if temperature increasing it will decrease its density by increasing the volume of that liquid.

2.7 Interface level Detection

Surrounding condition could cause a major effect to the measuring technology transmitter. Change in humid such as temperature and pressure could also change the media properties. Hence, it will produce unsatisfied and unreliable result. To avoid this problems an engineer must monitor the process conditions all the time.

Traditional displacer or differential pressures (DP) transmitter that operate base on the different densities of the media [10], for example are very sensitive when sudden transformation in process pressure and temperature varies. Especially when measuring a liquid medium, by increasing the temperature it will increase the volume or the liquid mass. Hence, the density will decrease and vice versa.

Similarly, build-up and scaling on the sensing elements is another factor that affects mechanical systems with moving parts [10].

When using differential pressure (DP) transmitter, some measuring method need to consider the correct procedures either to use ‘wet leg calibration’ or ‘dry leg calibration’.

By taken this into account, it can extend the life cycle of the equipment and also reduce cost during the commissioning.

2.7.1 Mechanical Systems

Mechanical transmitter system involves a direct contact and indirect contact with the subject base on application. Even though these equipment's still reliable for a wide range application, thus when comparing with electronic base system, that are more favor compare to mechanical system. Electronic system has an advantage over mechanical system as following:

•***Capital costs***:

Although there are cost advantages on the smaller and simpler measuring applications, on larger and more complicated requirements, mechanical systems can cost up to three times more than electronic solutions.

•***Poor dynamics***:

When interface measurement is between two products with small differences in specific gravity, or where the span of interface change is small (small dynamic), mechanical systems cannot offer a high enough measurement resolution.

•***Poor flexibility***:

If either the media changes or the density changes at any time, the complete mechanical design has to be resized and the construction modified.

•***Poor reliability***:

Sedimentation or scaling and corrosion on the mechanical parts not only influences accuracy but can lead to the complete failure of the system.

•***High maintenance***:

Today, plants run with lean engineering resources and maintenance-intensive systems only add to operational costs.

2.7.1.1 Type of electrical & electronic base level transmitter.

No	Type	Measure method	Detail	Cost
1	Differential Pressure (DP)	Different densities	Accuracy of the DP method unreliable	Effective
2	Capacitive Probe	Dielectric changes	Dielectric changes – the capacitive changes	Fair
3	Radiometric	Gamma Ray	Use only on harsh condition, high temp. & pressure.	High
4	Guided Wave Radar	High-frequency radar (electromagnetic)	Base on radar impulse that reflected by the medium surface.	Fair

Table 3: Level transmitter powered by electrical system

i. Differential Pressure *(DP)*

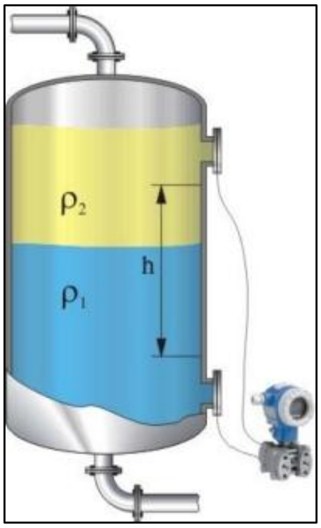


Figure 2: Interface measurement using differential pressure

ii. Capacitive Probes

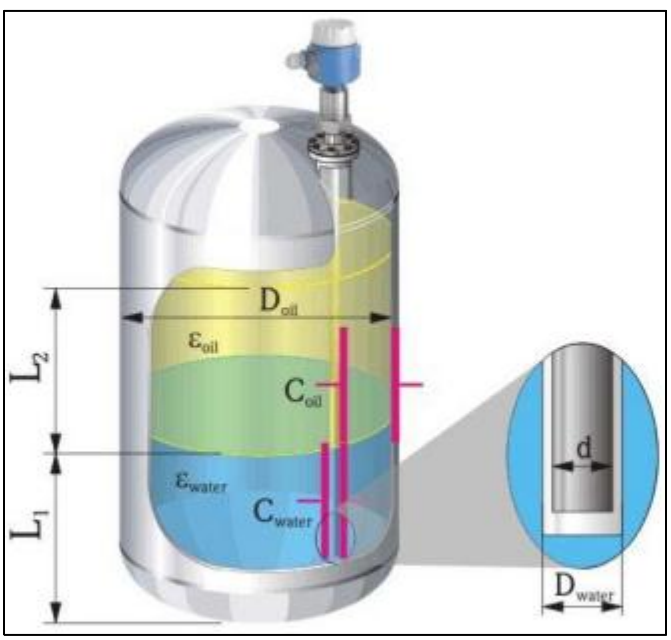


Figure 3: Interface measurement using capacitive probes

iii. Radiometric Measurement

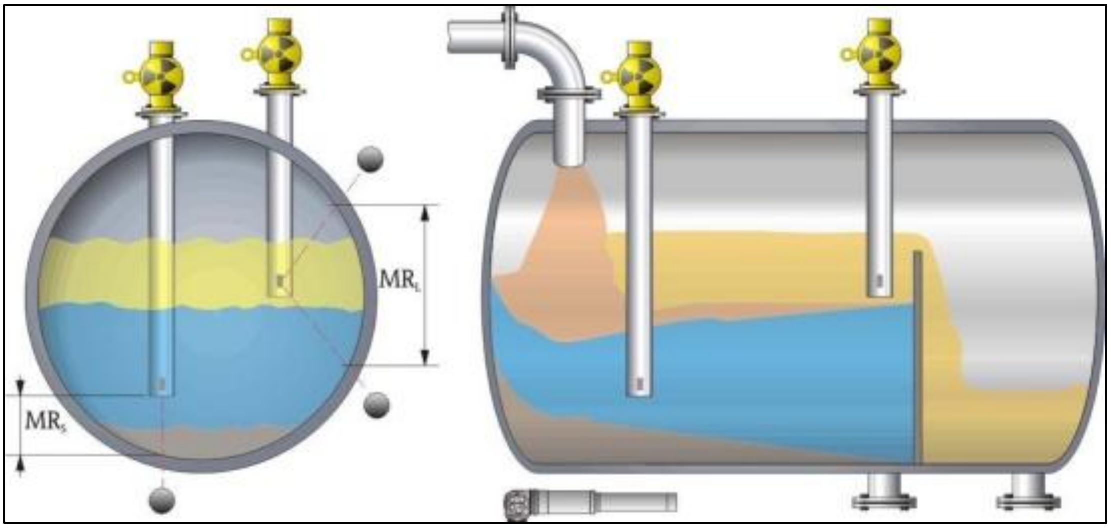


Figure 4: Interface measurement in a separator using radiometric systems

iv. Guided Wave Radar

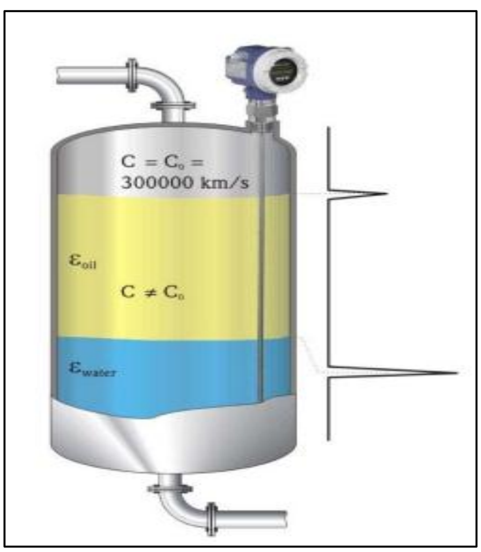


Figure 5: Interface measurement using guided radar.

2.8 Static Pressure of Level

Employs conventional industrial instruments which is actuated by changes in hydrostatic pressure head of the liquid as the level changes.

This head is the “weight” of liquid above a reference level or line. Head is often expressed in terms of pressure or level height.

Measurement of pressure due to liquid head can be translated to level height above the line by the following basic relationship

$$h = P/\rho g$$

where h=height or level

P=pressure due to hydrostatic head

ρ=density of the liquid

g=acceleration due to gravity

- For the readings to be accurate the density have to be constant.
- The accuracy will be affected for e.g., temperature variations is sufficient to cause changes in the density of the liquid.

2.9 Differential Pressure Level Measurement

Differential pressure level sensors or Differential pressure transmitters are probably the most widely employed devices for the purpose of level detection. Using DP for level is really an inferential measurement. A DP is used to transmit the head pressure that the diaphragm senses due to the height of the material in the vessel multiplied by a density variable.

2.9.1 Level Detection Using Differential Pressure

Differential pressure level measurement technique makes use of a differential pressure detector which is installed at the bottom of the tank whose level is to be detected. The liquid inside the tank creates pressure which is comparatively higher than the reference atmospheric pressure. This pressure comparison is performed via the Differential pressure detector. A standard differential pressure transmitter connected to an open tank is shown in the figure below:

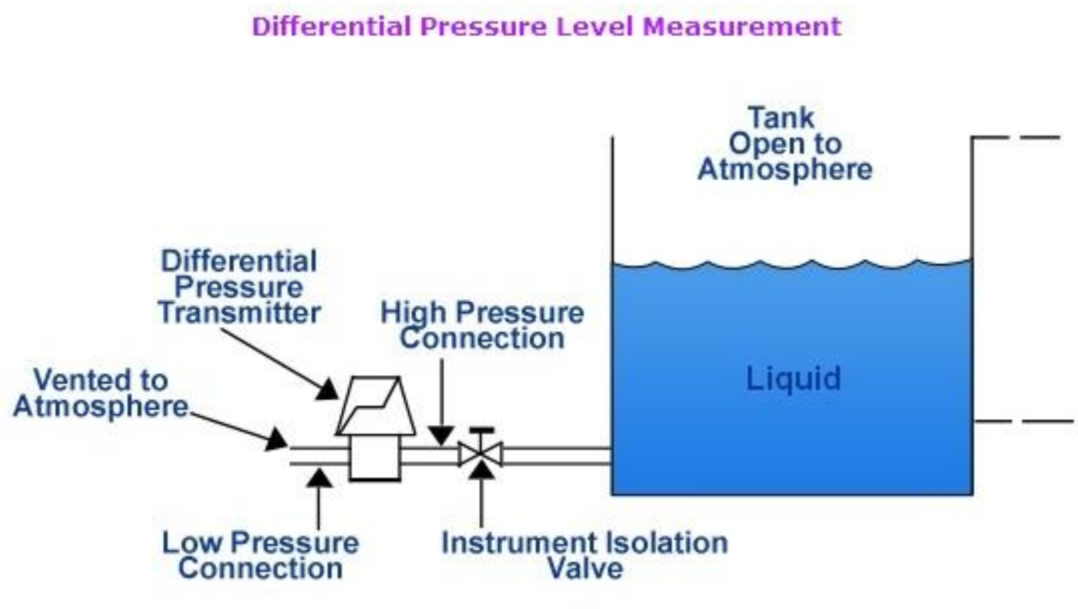


Figure 6: DP Level Measurement

In case of open tanks i.e. tanks which are open to the atmosphere, only high pressure ends of the DP transmitter is needed to be connected whereas the low pressure end of the DP transmitter is expelled into the atmosphere.

Hence, the differential pressure happens to be the hydrostatic head or weight of the fluid contained in the tank.

The highest level detected by the differential pressure transmitter usually depends upon the maximum height of fluid above the transmitter, whereas the lowest level detected is based upon the position where the transmitter is attached to the tank or vessel.

Now, in cases where tanks or vessels are not open to the atmosphere i.e. in pressurized tanks, both the high and low pressure ends of the differential pressure detector are required to be connected. These tanks are entirely covered in order to avoid release of vapors or steam outside. Due to this, the liquid inside the tank gets pressurized.

2.9.2 Dry Leg

The weight of the vapors found above the fluid in the tank is considered to be insignificant whereas, the pressure in the vapor area is quite considerable; hence it cannot be disregarded and usually transmitted to the low pressure end of the differential pressure cell. This type of pressure connection is known as a dry leg. It is primarily used in situations where liquid vapors are non-corrosive, non-plugging, and have low condensation rates at ordinary working temperatures. A dry leg enables the d/p cell to compensate for the pressure pushing down on the liquid's surface, in the same way as the effect of barometric pressure is canceled out in open tanks. It is recommended to maintain a dry reference leg since buildup of condensate or other fluids have tendency to introduce errors in the level measurement results. A typical closed tank dry reference leg is shown in the figure below:

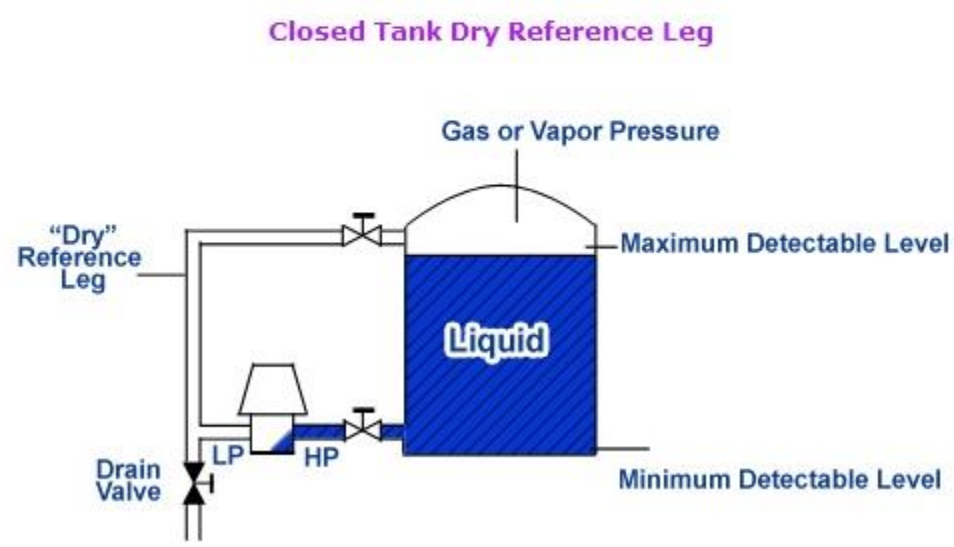


Figure 7: Closed Tank Dry Reference Leg

2.9.3 Wet Leg

In situations where the vapors of the process fluid tend to condense at standard ambient temperatures or happen to be corrosive and unsteady, the reference leg can not be kept dry. It must be then filled with an inert liquid to produce a wet reference leg. For a wet reference leg, it is always suggested that the chosen filling liquid must have a low thermal expansion rate. In case of wet reference legs following two factors should be carefully noted:

1. The specific gravity of the filling liquid and the height of the reference column are required to be correctly evaluated. Besides, the differential pressure cell ought to be lowered corresponding to the hydrostatic head of the same column.
2. A sight flow indicator should be mounted above the wet leg in order to get visual indication of the height of the reference leg.

A typical closed tank wet reference leg is shown in the figure below :

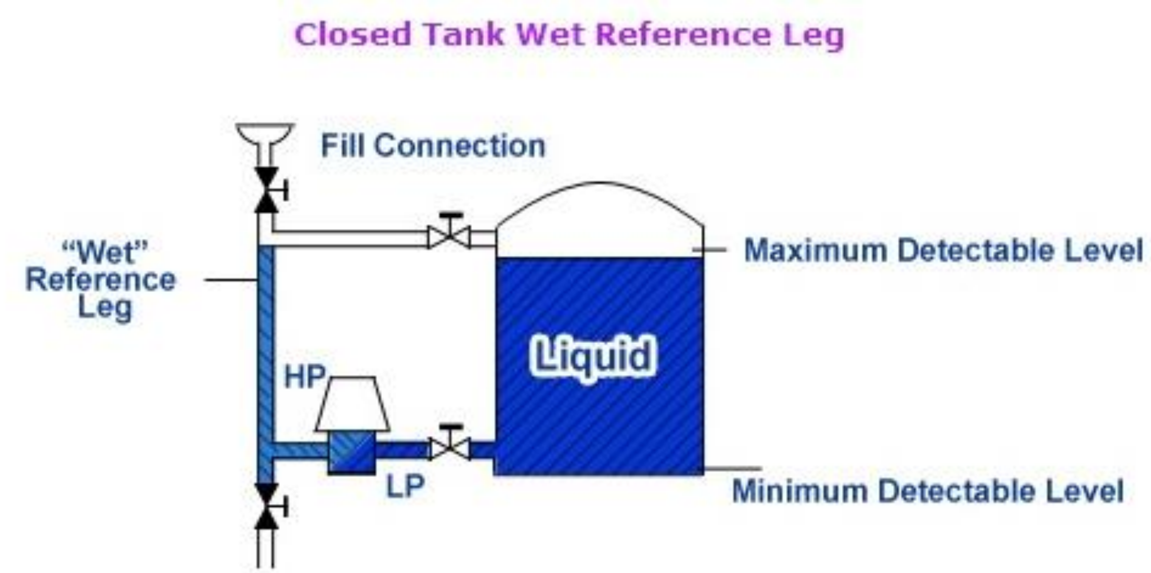


Figure 8 : Closed Tank Wet Reference Leg

2.9.4 Advantages of Differential Pressure

Following are the major advantages associated with techniques of level measurement using differential pressure.

- Differential pressure based level sensors can be easily mounted or retrofitted to the surface of the vessel.
- To carry out maintenance and testing, these sensors can be provided with block valves for isolating them carefully from the process liquid.
- They can be easily applied in level measurement applications such as total level in separator vessels where other level measurement devices are not feasible owing to the extensive changes in material formation experienced in the upper state.

2.9.5 Disadvantage of Differential Pressure

Use of differential pressure transmitters includes few drawbacks too, which are mentioned below:

- Errors can get introduced in the measurements if the density of the process fluid varies because of reasons such as temperature variations or change of process. Hence, the density of the process must always be maintained constant in order to get accurate results.
- Differential pressure transmitter works well with clean liquids only. Besides, it necessitates two vessel penetrations for its operation, out of which one is installed near the vessel base where leakage happens.
- Their use is always avoided with liquids such as paper pulp stock since they result in solidification upon rise in their concentrations.

CHAPTER 3

METHODOLOGY

3.1 First stage: Research of Topic

Better understanding of the topic is very important. The past findings by other researchers that are related to the topic have to be analyzed and studied to uncover new ways to improve the works of others. Reliable information from journals, books and articles that are available online or in the library are vital regarding this research

3.2 Project Flow Chart

3.3 Project Activities and Key Milestones

Several targets have been set for the FYP I. Table 3 show the project activities and key milestones for FYP I.

FYP 1															
NO	**Description**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1	Topic Selection														
2	Research & Literature review														
3	Study on suitable software or simulation for interface measurement														
4	Extended proposal submission														
5	Extended proposal defense														
6	Comparison against capacitance & GWR														
7	Submission of interim report														
8	Interim report														

FYP 2																		
NO	**Description**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
1	Project Work Continues																	
2	Selection of level measurement method																	
3	Equipment Verification																	
4	Design Model																	
5	Progress Report																	
6	Result Evaluation																	
7	Pre-EDX																	
8	Draft Report																	
9	Final Report																	
10	Viva																	

3.4 Expected Result (FYP 1)

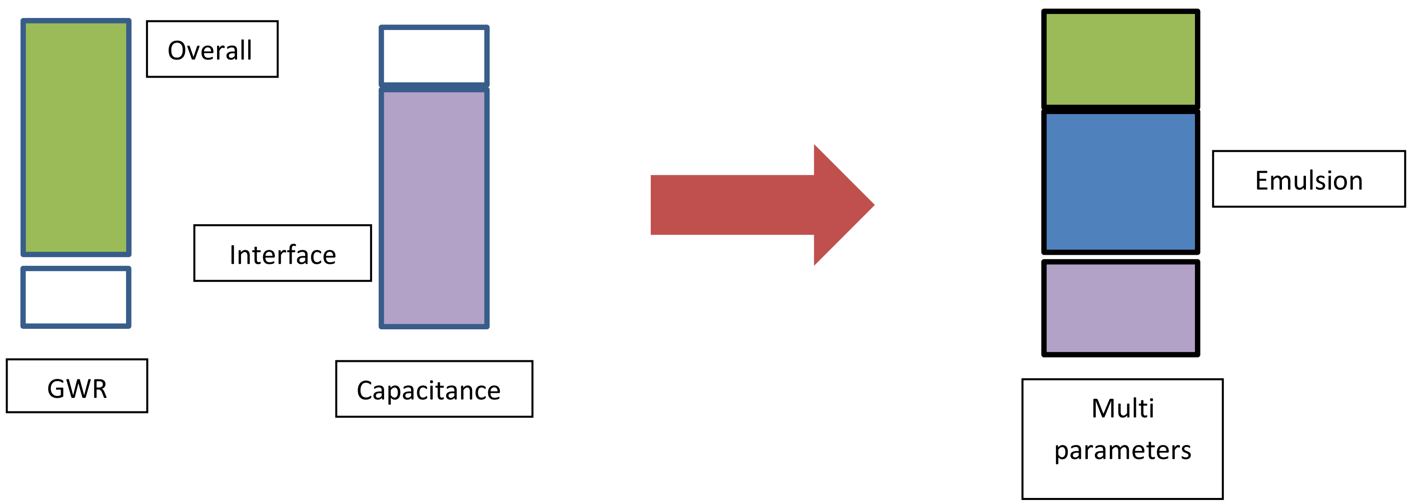


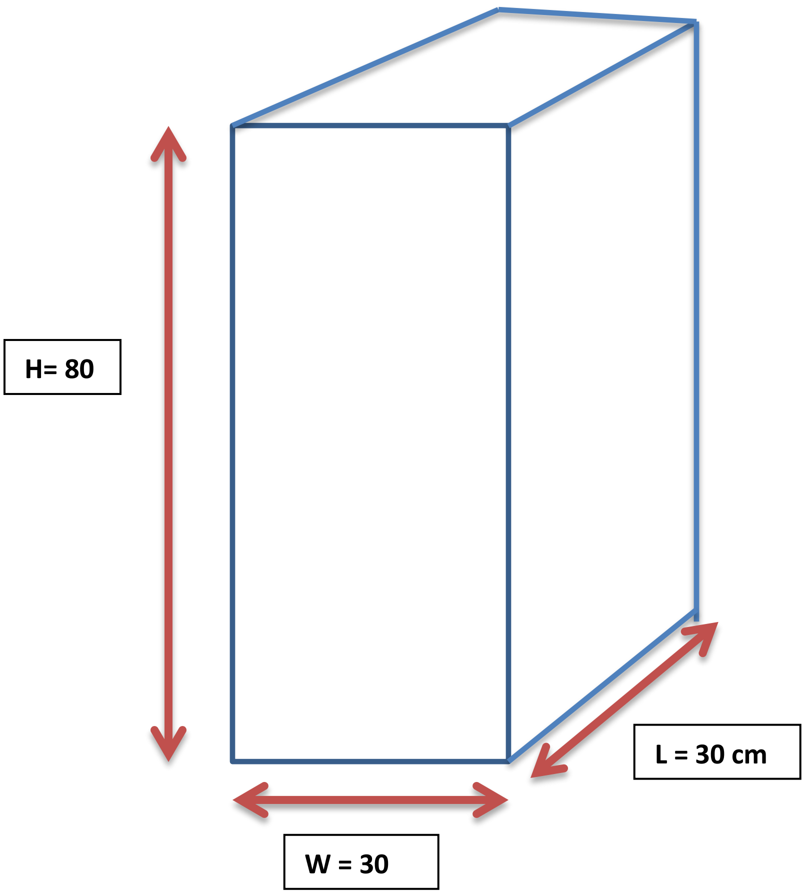
Figure 9 : Outcome from combination between GWR and Capacitance

Base on figure above show an expected outcome when the designing model accomplishes to measure the interface level. Basically will be designing by using MatLAB to create the Simulink. Simulink as a main software for this project to generate the graph and expected result.

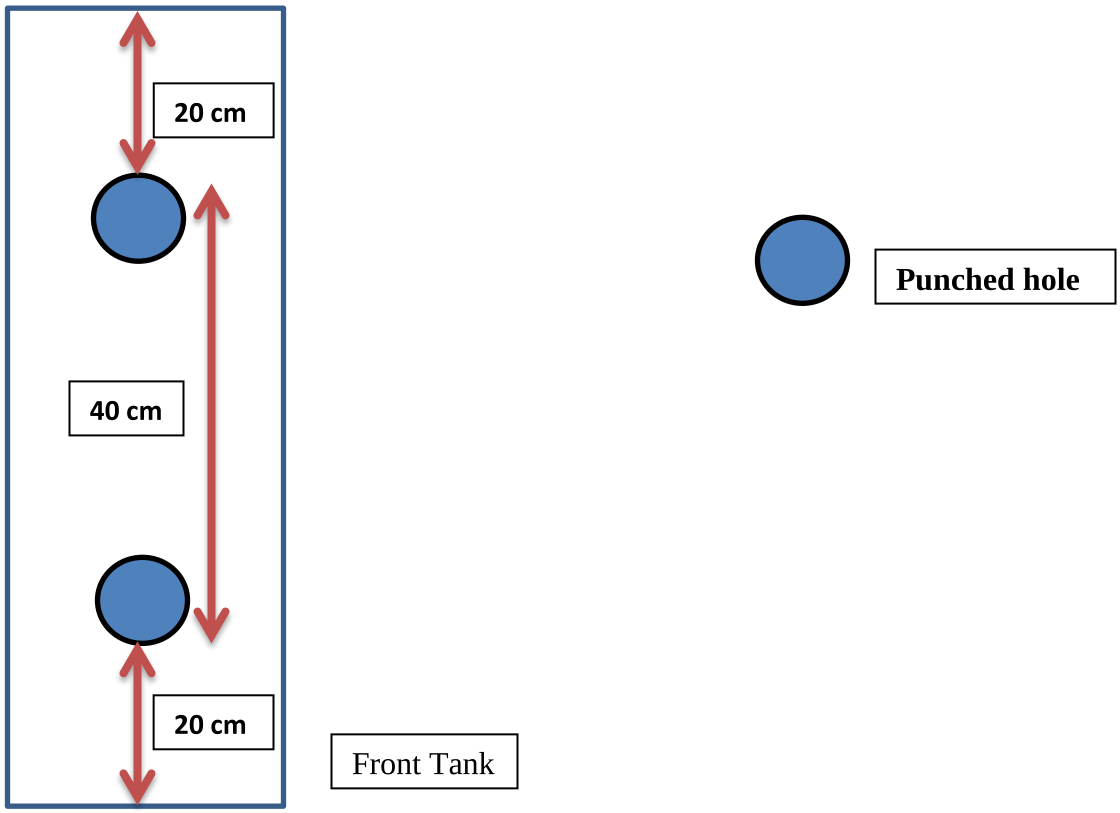
All the project activities of modeling, simulation and energy efficiency calculation is expected to be done during the FYP 2 period. For FYP 1, only research and preparation is done.

3.5 Wet- Leg Tank Design.

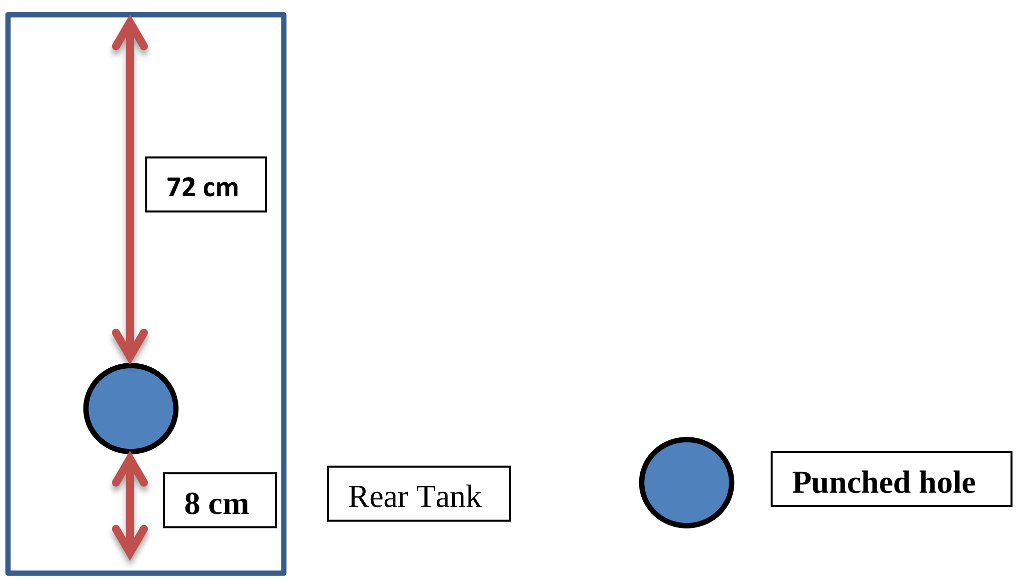
1. Propose design for rectangular shape.



2. Punched hole location at side of the tank for fitting the wet-leg PVC piping



3. Drainage location that located at the bottom of the tank.



CHAPTER 4

RESULT AND DISCUSSION

In term of availability of equipment and cheaper compare to Guided wave radar (GWR), the author selects to use Differential Pressure (DP) Transmitter as the main tool to measure the interface level between two liquids. Differential pressure are easier to use and very dependable compare to others transmitter. Even though the liquid characteristic being change or got some contamination, as long it doesn't directly affect the density of the liquid the Differential Pressure are really suitable.

4.1 Differential Pressure Transmitter for Interface measurement

To make an interface measurement and for reliable result, the overall level must be half full of the tank or in another way it can be fill up above the low pressure tap at all times. It is important that the level be large enough to create a reasonable DP between the two specific gravity extremes.[11]

4.1.1 Calculation of Interface Level Measurement

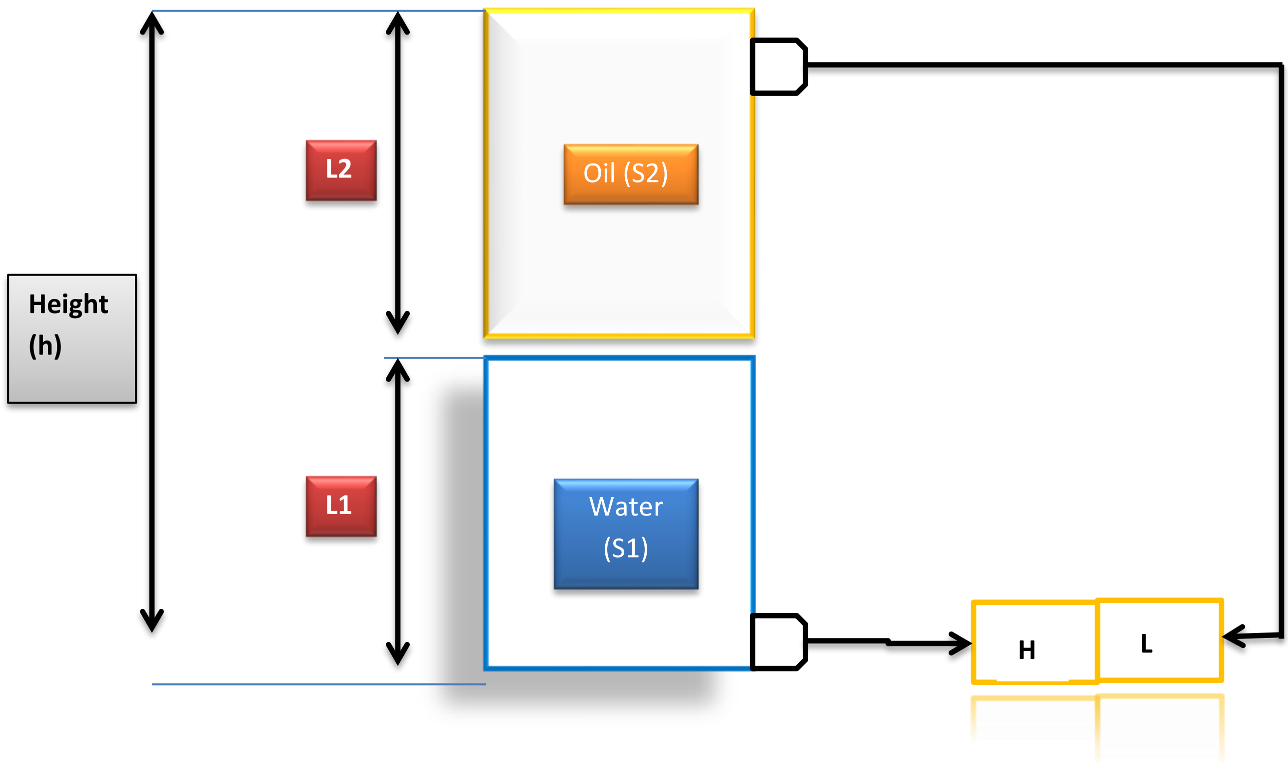


Figure 10 : Differential Pressure System

Total tank height, h = 80 cm

Cooking Oil density = 0.8

Water density = 1.0

Liquid ratio, Sf = 0.8 / 1.0

= 0.8

I. Low Pressure Side :

HP = L2S2 + dSf

LP = dSf + hSf

4mA DP = HP - LP

= L2S2 – hSf [Lighter Fluid]

= (80cm) * (0.8) – (80cm) * (0.8)

= 0%

- Lower pressure side or min limits is 0% at 4 mA Dp.

II. High Pressure Side :

HP = L1S1 + dSf

LP = dSf + hSf

20mA DP = HP - LP

= LS1 – hSf [Heavier Fluid]

= (80cm) * (1.0) – (80cm) * (0.8)

= 79 – 64

= 15%

- High pressure side or max limits is 15% at 20 mA Dp.

III. To determine the interface of mixture of fluids :

$$I = \frac{DP - LCV}{Span}$$

LCV = lower calibrated value

4.1.2 Interface measurement shown graphically

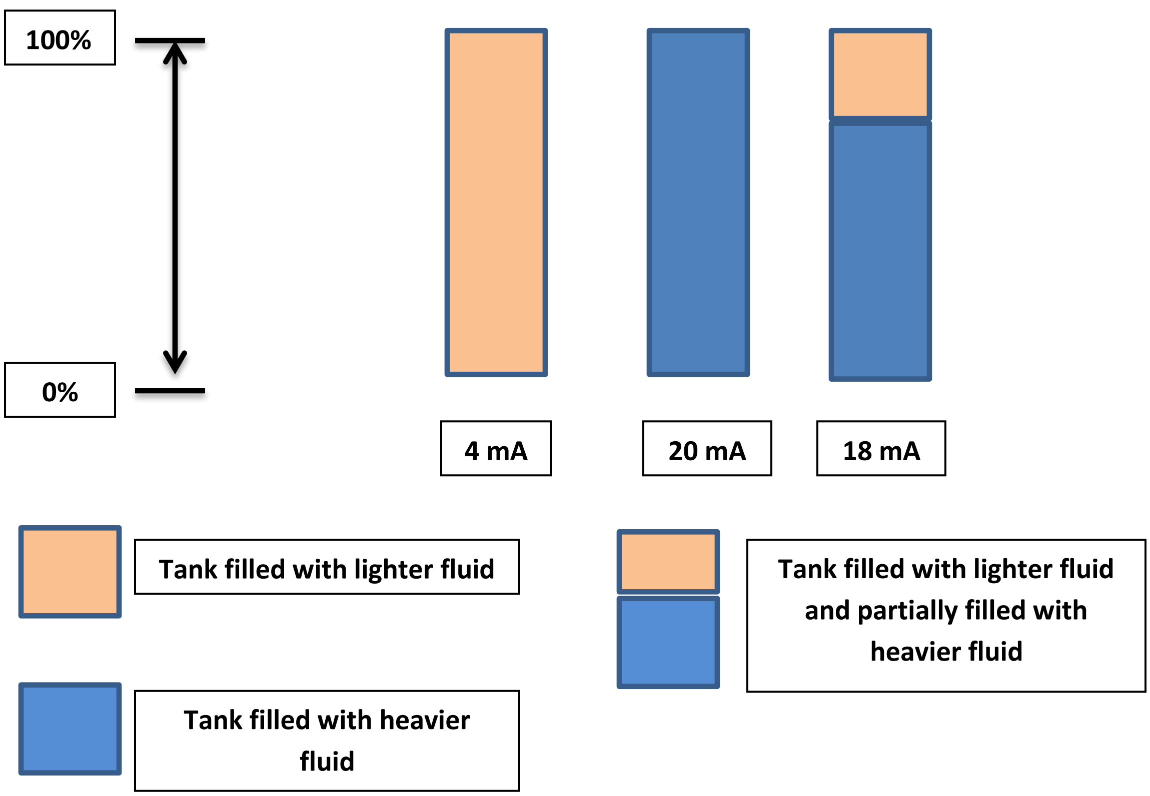


Figure 11 : Interface Measurement

4.2 Improvement Strategies

Overall, the model structure still has errors. Improvement can be done to make it more robust for the model in predicting the output. Various improvements strategies can be implemented that include:

- Upper tap must be covered at all times.
- Increase the span, either the tap height must differ or difference of the two liquid density are greater

CHAPTER 5

CONCLUSION AND RECOMMENDATION

The past findings by other researchers that are related to the this researched topic from reliable information from journals, books and articles that are available online or in the library are vital regarding the relevancy of this topic research. The methodologies that have been properly set up can be used to study the measurement interface region level accuracy of the equipment. After the completion of FYP I, selection of suitable and reliable equipment and data analysis would be conducted within the remaining four months (FYP II), the experiments that will be conducted for FYP II.

There is no universal technology that covers all interface applications, highlighting the importance of the correct selection to provide best performance with optimized of ownership. It is know that liquid level does not have any particular value when comes to level measurement dissimilar to the pressure and temperature. Moreover, it is always being relative to certain reference point such as the liquid density, specific gravity and temperature.

Commissioning the Differential Pressure transmitter that can measure the interface level indicated that this project meet the primary objective.

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10 Interface Level Detection - what to consider

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14 Marques, L.C.C et al. (2004) A New Technique to Solve Gas Hydrate Problems in Subsea Christmas Trees

APPENDICES

Figure 12 : A clear interface between two different types of liquids.

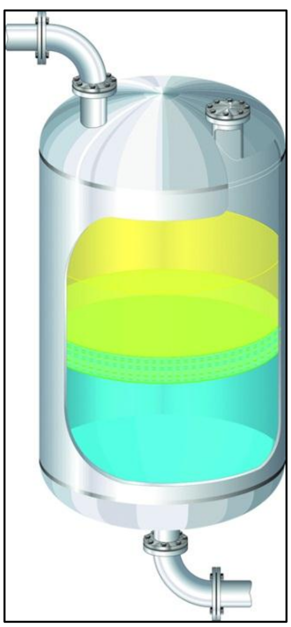

Figure 13: An emulsion or ‘rag layer’ occur between two liquids. It’s differ by liquid density characteristic.

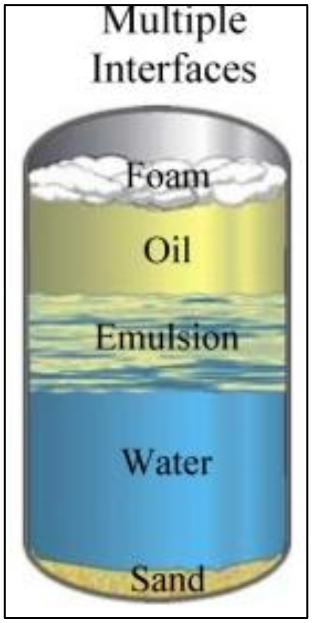

Figure 14: A multiple interfaces

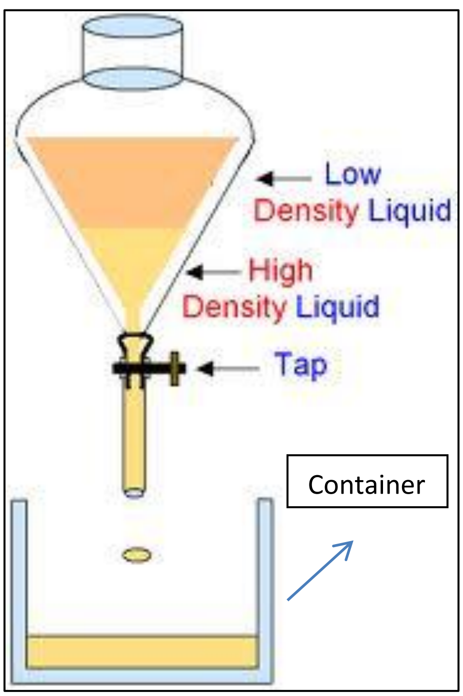

Figure 15: A Separating Funnel with different density of liquid

Liquid	Temperature - t - (^oC)	Density - ρ - (kg/m^3)
Acetic Acid	25	1049
Acetone	25	784.6
Acetonitrile	20	782
Alcohol, ethyl (ethanol)	25	785.1
Alcohol, methyl (methanol)	25	786.5
Alcohol, propyl	25	800.0
Ammonia (aqua)	25	823.5
Aniline	25	1019
Automobile oils	15	880 - 940
Beer (varies)	10	1010
Benzene	25	873.8
Benzil	15	1230
Brine	15	1230
Bromine	25	3120
Soya bean oil	15	924 - 928
Stearic Acid	25	891
Sulfuric Acid 95%onc.	20	1839
Sulfurus acid	-20	1490
Sugar solution 68 brix	15	1338
Sunflower oil	20	920
Styrene	25	903
Terpinene	25	847
Tetrahydrofuran	20	888
Toluene	20	867
Trichlor ethylene	20	1470
Triethylamine	20	728
Trifluoroacetic Acid	20	1489
Turpentine	25	868.2
Water, heavy	11.6	1105
Water - pure	4	1000
Water - sea	77^oF	1022

Table 4: List of liquid density respect to temperature

Figure 16: Yokogawa High – Low Differential pressure transmitter.

Figure 17: 250 ohm, Decade Resistance Box Model 1041.

- To convert the 4-20mA analog signal from the HART to a 1-5 volt.

Figure 18: HART Communicator