**SUPERVISOR'S DECLARATION**

I hereby admit that have read this report and from my point of view this report is enough in term of scope and quality for purpose for awarding
Bachelor of Degree in Mechanical Engineering (Thermal-Fluid)

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Date : …...............................

DEVELOPMENT OF SUBMERGE PUMP EXPERIMENTAL RIG TO MEASURE PUMP PERFORMANCE FOR EDUCATIONAL EXPERIMENTATION

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This report is presented to fulfil the requirement to be awarded with
Bachelor of Degree in Mechanical Engineering (Thermal-Fluid)

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JUNE 2012

# STUDENT'S DECLARATION

"I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledge"

| | |
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| Date | : JUNE 2012 |

# DEDICATION

***Special dedication to my beloved parents and all that help me to finish my thesis***

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I would like to express my thankfulness to Allah Almighty for blessing. I have managed to complete this project on time and could submit it to Mechanical Engineering Faculty of Universiti Teknikal Malaysia Melaka (UTeM) to fulfill the requirement of my Bachelor in Mechanical of Thermal-Fluid.

I would like to express my sincere gratitude to my supervisor Mr. Faizil Wasbari for his guidance and support in making this research possible. He has impressed me with his outstanding professional conduct and strong conviction for science.

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I acknowledge my sincere gratitude to my parents and friends for their support help and sacrifice throughout my life. I cannot find the appropriate words that could describe my appreciation for their devotion and faith in my ability to achieve my goals.

**ABSTRACT**

This final year project involves designing and developing an experimental rig to determine performance of a pump. This rig is for an academic purpose only. This is because most of the educational purpose experimental rig is really expensive, weighted and hard to use. This project must overcome all this issues and must well develop. The pump that has chosen for the project is a submersible pump. This is because no such pump has been experimented before at University Teknikal Malaysia Melaka (UTeM) laboratory. The rig was designed based on small scale size to suit with lab oriented. The system then was interpreted into Computational Aided Drawing (CAD) software for detail design and later is simulated in Computational Fluid Dynamics (CFD) software in this case is SolidWorks 2008 and COSMOS FloWorks 2008 for data and result validation. The parameter has been set to 10 l/min to 50 l/min for flow rate, which is used to obtain pressure. Experiment also being run based on the same condition, which pressure is read by the pressure gauge. Then both results were compared and pump output power was obtained. Based on the output power the efficiency of the pump was also being obtained. As for final value for parameter 10 l/min to 50 l/min of flow rate, pump efficiency were obtained from 0.175 to 0.792. In conclusion, the experimental relationship can be defined as; when the flow rate increase, pressure decreases, power output increase and efficiency also increase.

# *ABSTRAK*

Projek tahun akhir ini melibatkan reka bentuk dan pembangunan radas eksperimen untuk menentukan prestasi pam. Radas ini adalah untuk tujuan pendidikan sahaja. Ini adalah kerana kebanyakan radas eksperimen untuk tujuan pendidikan adalah benar-benar mahal, berat dan sukar untuk digunakan. Projek ini mesti mengatasi segala isu-isu ini dan perlu dibangunkan dengan baik. Pam yang akan dipilih untuk projek ini adalah pam yang jenis tenggelam. Ini adalah kerana pam jenis ini belum pernah diuji sebelum di makmal Universiti Teknikal Malaysia Melaka (UTeM). Radas telah direka bentuk berdasarkan saiz sistem paip dan penyambungannya. Sistem akan diolah ke dalam perisian Lukisan Terbantu Komputer untuk direka bentuk secara terperinci dan kemudiannya akan disimulasikan dalam perisian Komputer Dinamik Bendalir untuk data dan pengesahan hasil. Parameter yang ditetapkan adalah 10 l / min hingga 50 l / min bagi kadar aliran yang digunakan untuk mendapatkan tekanan. Eksperimen juga turut dijalankan berdasarkan keadaan tekanan yang sama akan dibaca oleh tolok tekanan. Kemudian kedua-dua keputusan dibandingkan dan kuasa keluaran pam akan diperolehi. Berdasarkan kuasa keluaran, kecekapan pam juga akan diperolehi. Keputusan akhir menunjukkan untuk parameter 10 l / min hingga 50 l / min kadar kecekapan pam adalah dari 0.175 hingga 0.792. Keputusan yang diperoleh juga menunjukkan apabila kadar alir bertambah, tekanan berkurang yang menjadikan kuasa keluaran bertambah yang juga menyebabkan kadar kecekapan bertambah.

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# LIST OF ABBREAVIATION

| | | |
|---|---|---|
| CFD | = | Computational Fluid Dynamics |
| kPa | = | Kilopascal |
| m | = | Meter |
| l | = | Liter |
| s | = | second |
| min | = | minute |
| ft | = | Feet |
| Re | = | Reynolds Number |
| f | = | Friction Coefficient |
| $H_L$ | = | Head losses |
| W | = | Watt |
| Me | = | mechanical efficiency |
| $D_f$ | = | transmission loss |
| N | = | Revolution per minute |
| Rpm | = | Revolution per minute |
| $Q_A$ | = | Flow rate actual |
| $Q_T$ | = | Flow rate theoretical |
| $T_T$ | = | Torque theoretical |
| $T_A$ | = | Torque actual |

# CHAPTER 1

# INTRODUCTION

## 1.1 Background

A device that is used to move fluid such as liquid and gases is called pump. It can also move mixture and slurries. It converts mechanical energy into hydraulics energy. Pump cans categories into two types; dynamic (non-positive displacement pumps) and positive displacement pump. Under this category, submersible pump is one of the pumps that exists and will be the main subject. Submersible pumps use a motor that is designed to operate submerges in the pump fluid. (Michael volk, p.e, 2005) It is a pump that can be submerged in the liquid (water).The electric motor delivers a mechanical energy to the pump which next creates a partial vacuum at its inlet and into the pump. Later, the fluid will be pushed up to the hydraulic system. Pumps may be used in a wide variety of applications, including domestic water, wash down and irrigation. The pump is used for many types of application such as; a single stage submersible pump is used for sewage and slurry pumping, drainage, and in industrial pumping. As for multiple stages, submersible pump is lowered down a borehole and used for water extraction or in water wells.

## 1.2 Objective

- To find the relationship between pump output power with flow rate changes
- To find the relationship between various pressure changes with submersible pump efficiency

## 1.3 Scope

- Literature review
- Design submersible pump experimental rig
- Development of a submersible pump experimental rig
- Run and conduct experiments for test rig
- Validate results with CFD software

## 1.4 Problem statement

The study was conducted to obtain the efficiency of pump that will be used for an educational purpose. Most of the study involves the centrifugal and other normal pump. There are no studies that have been done to obtain submersible pump performance in University Teknikal Malaysia Melaka (UTeM). When consider the educational field, another thing that involves is the rig itself. The experimental rig is used as the base that will hold the experiment apparatus. A decision needs to be made either using a dry or wet type motor of pumps. A few common issues that always come are the size of the rig, cost, and maintenance because the rig will be used by the student in the future. It is necessary to create a rig that can be operating with minimum supervision. It also needs to develop a rig with the lowest cost as possible. Common experimental rig is considered too costly, fixed and hard to modify. So the new rig will be able to be much better, which is lighter, smaller, and moveable and can be disassembled. This is important for future modification. The experiment will show the benefit and efficiency of submersible pump and it performance.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Fluid power

The technology that deals with the generation, control, and transmission of power, using pressurized fluids is called fluid power. Fluid power is being used to push, pull regulate, or drive virtually all the machines of modern industry. It is almost impossible to find a manufactured product that hasn't been "fluid-powered" in any stage of its creation. In the liquid state, fluid power is called as hydraulics while the gas state it is called pneumatics. Hydraulics systems use liquids such as petroleum oils, synthetic oils and water while pneumatics uses air as the gas medium because air is very abundant and can be released into atmosphere after being used. An earlier hydraulics system used water as it was already available. However, due to certain water properties such as the freezing point, not good as lubricant and tendency to rust metal make it less favorable compare to hydraulics oil. Even so, due to environmental concerns, water has been research to improve its properties by adding additive to use in hydraulics system.

Fluid system consists of two types: fluid transportation and fluid power. Fluid transportation is used to deliver or transport of a fluid from a location to another. As for examples are pumping stations for resident's water supply, cross country gas line, petroleum fuel pump at the offshore rig and many more and fluid power systems are designed to perform work such at factories and manufacturing process. This is done by pressurized fluid onto operating cylinder or fluid motor (actuators). Then the actuators provide muscle to do desire works as shown in Figure 2.1. Others control components also needed to control the output power of the muscle.

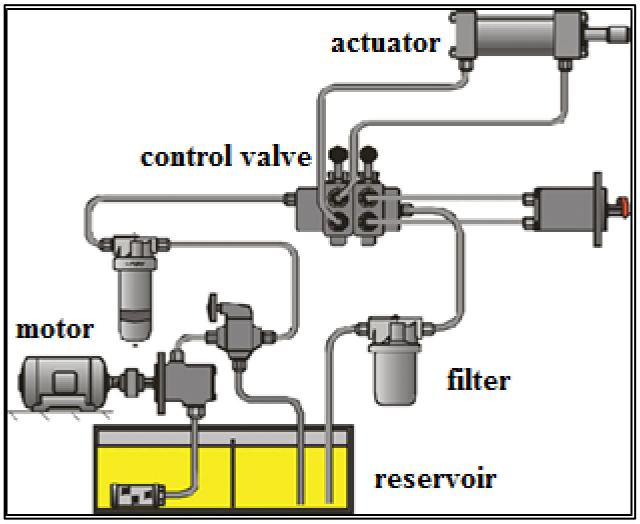


Figure 2.1 Hydraulic systems that using fluid power concept
*(http://www.mobilehydraulictips.com)*

## 2.2 Hydraulic fluid

The most important thing in a hydraulic system is hydraulic fluids. The chosen fluid will give a big effect to the system itself based on its performance and life. It is important to use a clean hydraulic fluid and high quality in order to archive efficient hydraulic system operation.

These are the functions for hydraulic fluid:

- Can transmit power
- Be a lubricant for the moving parts
- Can seal clearance between mating parts
- Can transfer heat
- Can be pressurized

Other than above, good lubricity, ideal viscosity, chemical stability, low cost, and many other properties are needed to become an excellent hydraulic fluid. So a laboratory analysis is needed to get the best hydraulic fluid for certain operation. Lots of hydraulic fluid has been rejected due to contamination effect. So research has been done to use water for primary hydraulic fluid.

## 2.3 Hydraulic pump

Pump is always considered the heart of a hydraulic system converts mechanical energy to hydraulic energy. The mechanical energy is delivered to the pump via mover named motor. Pump creates a partial vacuum at the inlet due to mechanical action. This allows atmosphere pressure to force fluid to the pipe inlet to the pump, and then it is pushed into the hydraulic system. Pump can be divided into few categories based on the prime mover inside it. The size varies and also it powers. The application to use will be the one to determine which type of pump suit it. Each pump is attached with motor either via gear, shaft or belting system. So rather than just focusing on pump performance it is important to choose the best motor to operate with the pump. Two major type of pump classification is explained briefly in next page.

### 2.3.1 Pump types and system

The pumps are divided into five overall groups: Circulation pumps, pressure boosting and fluid transport, water supply pumps, industrial pumps and wastewater pumps. Each group will use different type of pump based on application.

- Circulation pumps are used for circulation of water in example for heating, cooling and air-conditioning systems as well as domestic hot-water systems. The water in a domestic hot-water system is left to circulate in the pipes. The reason is to prevent a long wait for hot water when the tap is opened.

- For pressure boosting pump are used for increasing the pressure of cold water and as condensate pumps for steam boilers system. The pumps are designed to handle fluids with small particles such as sand.

- Water supply pump is divided into section either be submerged in a reservoir or can be placed on the ground surface. The conditions in the water-supply system make heavy demands towards domestic supply and mining.

- Industrial pumps can, be used everywhere in the industry and this in a very broad section of systems, which handle many different types of fluids. Strict environmental and safety requirements and procedure are needed on pumps, which must handle corrosive, toxic or explosive fluids.

- Waste water pumps are used for pumping contaminated water, solid in sewage plants and industrial systems. The pumps are constructed in a certain way which making it possible to pump fluids with a high content of solid particles

### 2.3.2 Dynamic pump

Generally used for low pressures, high-volume flow applications and type of pump is the little use in the fluid power field. Maximum capacity is around 250-300 psi. Primarily used for transporting fluid to many places. The most common type is centrifugal and axial flow pumps. These pumps are not commonly used due to it has great deal clearance between the rotating and stationary element. It does not have been self-priming unlike positive displacement pumps. This is because the large clearance space does not allow suction pressure to occur in the inlet when the first pump is turned on. So if the fluid being pumped from a reservoir located below the pump, priming needed. Priming is the pre-filling of the inlet pipe and pump housing with fluid so that the pump can initially draw in fluid and pump it efficiently. Although the dynamic pump provides smooth continuous flow, their output flow rate is reduced as resistance to flow increased. Figure 2.2 shows an example of an axial flow pump.

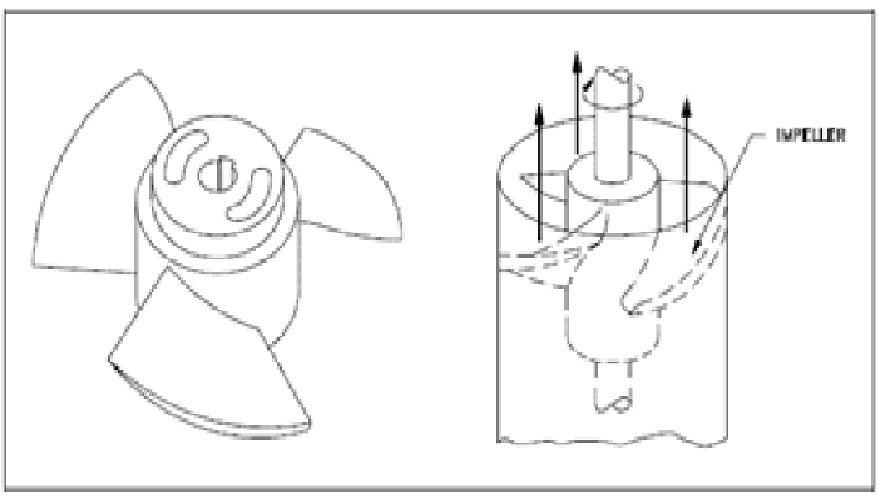


Figure 2.2 Axial flow pumps

*(http://mech-details.blogspot.com/2009/12/classification-of-centrifugal-pumps.html)*

### 2.3.3 Centrifugal pump

Centrifugal pumps are dynamic pump's category. Energy is transferred to the liquid by a disk with curved vanes rotating about a shaft called the impeller. The fluid flows from the inlet to the impeller center and out along its blades as shown in Figure 2.3 and 2.4. The centrifugal force hereby increases the fluid velocity and consequently, also the kinetic energy is transformed to pressure.

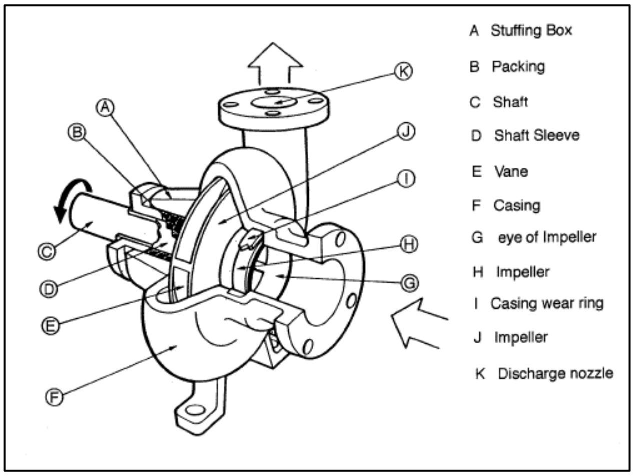


Figure 2.3 Centrifugal flow pumps

*(http://www.lightmypump.com/pump_glossary.htm)*

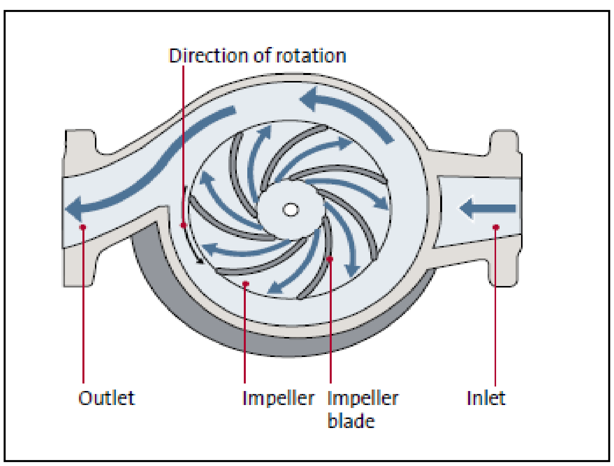


Figure 2.4 Fluid flows in pump

*(Grundfus Research and Technology. (2010) The centrifugal pump)*

The impeller transfer it kinetic energy to the fluid by means of its shape and high rotational velocity. The pressure head difference between the inlet and the outlet, where Total Head produced by the pump, is proportional to the impeller speed and diameter. So, to obtain a higher head, the rotational speed of the impeller or the impeller diameter can be increased.

#### 2.3.3.1 Impeller

The rotating impeller transfer energy to the fluid there by increasing pressure and velocity. Then fluid is sucked into the impeller eye and flows through the impeller channels formed by the blades between the shroud and hub as shown in Figure 2.5. The design of the impeller depends on the needed for pressure, flow and type of application. The impeller is considered primary component determining the pump performance. Pump's variants design and performance are often created only by modifying the impeller.

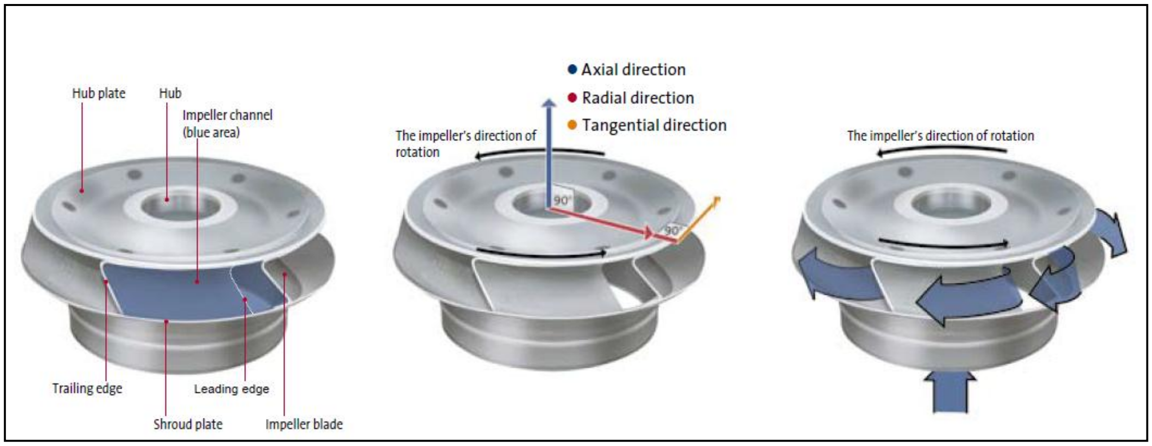


Figure 2.5 Impeller function and component

*(Grundfus Research and Technology, (2010), The centrifugal pump)*