DESIGN OF MODULAR-BASED UNDERWATER INSPECTION ROBOT

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A report submitted
in fulfillment of the requirements for the degree of
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DECLARATION

"i hereby to declare that this project report entitle design of modular-based underwater inspection robot is written by me and is my own effort except the ideas and summaries which i have clarified their sources."

Signature : ……

Author : KHAIRUL AQIL BIN MOHD YUSOF

Date : MAY 2017

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Design and Innovation).

Signature :.....

Name of Supervisor: Ir. Dr. TAN CHEE FAI

Date : …….

DEDICATION

To my lovely parents, Mr. Mohd Yusof bin Abdullah and Mdm. Wan Hasnah Binti Alang Ibrahim, for theirs uncountable supports. To all my friends, and my housemates, for always provide me with ideas to complete this project. Last but not least my beloved lecturer, Ir. Dr. Tan Chee Fai for guiding and endless help during the preparation of this report.

ABSTRACT

The main purpose of this project is to design a modular-based underwater inspection robot. This project primarily focuses on development of underwater inspection robot within the good design characteristics such as modularity, easy to maintenance, with austhetic value, with the lowest price and etc. The research and development activities have been numerous worldwide. Due to the development of new material, electronic component and other high –tech component, the improvement can be achieved. This project target to produce a more modular design to ease the maintenance work, ease the control system and etc. However, such proposed equipment has for one reason or another not been completely satisfactory. For example, some of the existing underwater inspection robots are very large, complex control system, complex of body structure and therefore expensive to purchase and maintain. Underwater inspection robot with efficiently mechanism will develop through this project and will meet customer requirement where can help people easily maintain and operate the robot.

ABSTRAK

Tujuan utama projek ini adalah untuk mereka bentuk berasaskan modular-pemeriksaan air robot. projek ini terutamanya memberi tumpuan kepada pembangunan pemeriksaan air robot dalam ciri-ciri reka bentuk yang baik seperti mudah untuk melakukan penyelenggaraan, dengan nilai austhetic, dengan harga yang murah dan lain-lain. Dimana aktiviti-aktiviti penyelidikan dan pembangunan telah banyak di jalankan seluruh dunia. Disebabkan oleh penciptaan bahan baru, komponen elektronik dan lain-lain komponen berteknologi tinggi, kemajuan dapat dicapai. Sasaran projek ini ialah untuk menghasilkan reka bentuk yang lebih modular bagi memudahkan kerja penyenggaraan, meringkaskan sistem kawalan dan lain-lain. Walau bagaimanapun, produk yang sedia ada mempunyai reka bentuk yang kurang memuaskan. Sebagai contoh, beberapa robot pemeriksaan air sedia ada mempunyai reka bentuk yang sangat besar, system kawalan yang kompleks, kompleks struktur badan dan oleh itu mahal untuk membeli dan melakukan selenggaraan. Pemeriksa robot yang dicipta dengan mekanisme yang mudah dan cekeap akan dibangunkan melalui projek ini dan akan memenuhi keperluan pelanggan di mana boleh membantu pelanggan untuk mudah menyenggarakan dan mengendalikan robot.

ACKNOWLEDGEMENT

Highest praise to Allah Almighty. Grateful to Him with His will I had successfully finished in preparing this 'Projek Sarjana Muda' thesis.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Underwater inspection robot are very common technology to use for any underwater piping inspection or moreover. This technology had been improved in many time lapses and the improvement is meant to help human power. Basically robots are designed in such way that they remove human intervention from labour intensive and hazardous work environment, sometimes they are also used to explore inaccessible work places which are generally impossible to access by humans. Human ability is very limited to dive deep under the water can give a very high risk to human health. Therefore this technology is made to exceed human ability and surf to deeper underwater for any work of inspection. The underwater inspection robot has its use such as preventive maintenance in a nuclear power plant, underwater pipeline inspection, visual inspection of nuclear reactor internals, underwater welding technology and many more.

Currently, there are many types of underwater inspection robots. There already lots of amazing design of the underwater robot, for example, design of a bio mimetic lobster that mimic the biology or physical of a lobster there also a design of a bio mimetic of an eel and the movement is physically as an eel. Common underwater robots are design that its movement is only by using propeller, also a common track wheeled robot also one of the robot use in the industry. Each of the design may be different but however, it shares the same objective that is to do underwater inspection. This robot is use in different places and environment. Usually the underwater robot use to dive deep into the deep blue sea, however they also been use in to dive into a lake, drain, reservoir and any space that consist of water.

To design an underwater robot there are several important quality and characteristic that must be take care of such as the design issues like mobility, steer ability, turning radius, size and shape adaptability, online adaptability, flexibility, stability, autonomous operation and obstacle avoidance, efficiency at uneven surface, safe operation, material selection, Type of task to be performed according to its environments, retrieval of robot, user friendly navigation and control system, range of operation, quantitative analysis of defects around the environment. The design of underwater robot is best to achieve its objective and it functionality by achieving the important aspect, the design are already good and can be manufacture.

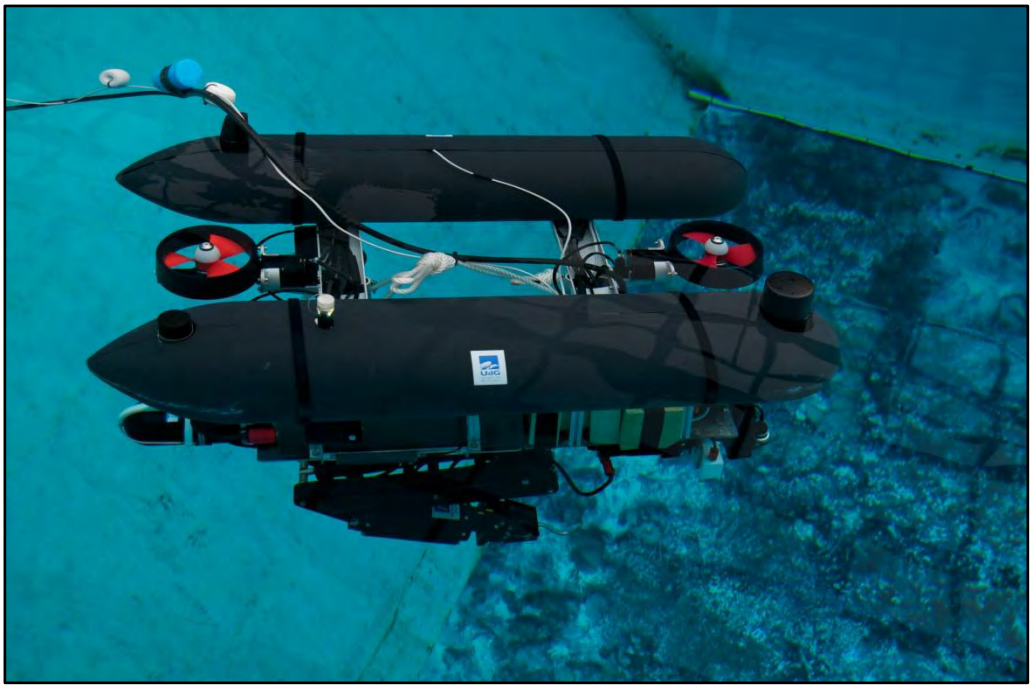

Figure 1.1: Several designs of an underwater inspection robot.
(Source: Success Stories (2014))

1.2 PROBLEM STATEMENT

This present design of underwater robot are commonly design with only one way install and it will has difficulties to maintenance the robot. The work of maintenance is very hard to accomplish because the body design of the robot are very hard to dismantle. The underwater inspection robot had been design with a bigger in size therefore; the mobility of the robot is limited to surf to a smaller region. Control system of underwater vehicles is not easy, mainly due to the non-linear and coupled character of plant equations and also the lack of precise model of underwater vehicles dynamics and parameters, as well as the appearance of environment disturbances.

1.3 OBJECTIVE

The objectives of this project are as follows:

1. To design a modular underwater inspection robot that easy to be operated and manufactured based on the simple design of every important aspect.

1.4 SCOPE OF PROJECT

The scopes of this project are:

1. Focus on designing a modular based underwater inspection robot that are easier to maintenance.
2. To design a more modern and modular inspection robot on the physical appearance.
3. To implement simpler control system based on innovation of existing material and things.

1.5 GENERAL METHODOLOGY

The actions that need to be carried out to achieve the objectives in this project are listed below.

1. Literature review

   Journals, articles, or any materials regarding the project will be reviewed.

2. Conceptual design.

   Study the important characteristic in designing an underwater inspection robot and applying it into the design to improve the present design.

3. Detail drawing.

   The selective design will be combining into a one final design and will be drawn into CAD software which is CATIA. The design will be valued and can be redesign with greater ideas.

4. Analysis and proposed solution

   Analysis will be presented on how to create more modular design of inspection robot that suitable with the modern design and more flexible.

5. Report writing

   A report on this study will be written at the end of the project.

1.6 REPORT FRAMES

This project entitled “Design Of Modular-Based Underwater Inspection Robot” can be divided into five chapters.

Chapter I which is the introduction explains the general information of the underwater inspection robot. The elements that consist in chapter 1 are background of underwater inspection robot, problem statement of the project, scope of projects, objectives of project and report organization.

Chapter II comprises literature review information which includes research of previous project of underwater inspection robot by others. This chapter also includes existing underwater inspection robot in market.

Chapter III present the methodology of the project. This chapter is discussing the method used throughout the development of underwater inspection robot. It started with the section identifying customer needs using interview method. Concept selection method and software use to generate the design also had been explained in this chapter. The steps involve in the process of develop underwater inspection robot are described in detail in this chapter.

Chapter IV present the conceptual design of underwater inspection robot. This chapter show 4 new concept designs and explanation of each concept. Besides, 3D modelling drawing and part number also include in this chapter. Other element include in this chapter are the design analysis using CATIA Structural Analysis software, ANSYS workbench and manufacturing process flow of the product.

Chapter V The project is concluded with Chapter V which discusses the conclusion and recommendation of the project based on the objective and the relationship with problem statement presented in Chapter I

CHAPTER II

LITERATURE REVIEW

2.1 INTRODUCTION

The purpose of this chapter is to collect the information from the journal, book article and internet web pages that are related to the project. Basically, this chapter has been divided into two sections. Firstly, is the information about the inspection robot and secondly on the modular design of the inspection robot. Usually, inspection robot are build and use for inspecting some area that are human are unable to reach with its own human power because human were designed with its own limitation. For example, human body cannot withstand the high pressure area nor small area such as in pipes and deep sea, therefore inspection robot can overcome the human limitation.

Figure 2.1: Traditional ways in inspecting underwater area.

(Source: Divingms, (2014)

2.2 INSPECTION ROBOT

A great part of existing literature studies by Junichi, Mineo, Takashi and Osamu (1985) state that the main purpose of robot is to carry out underwater inspecting works instead of divers. However, the efficiency and safety of underwater activity are not sufficient because underwater conditions consist of dangerous environment. Increasing risks and lower working efficiency of port construction work at deeper sea area and shortage of divers will make the situation worse. Therefore, to build up robot are necessary to overcome the problem.

Robotic are currently been build and designed in such way so that they can intervention from dangerous and hazardous work environment, they also used to explore inaccessibility area which are hardly impossible to access by human (Ankit Nayak, 2014). Loius (2000) had state that over 1000 robotic uninhabited undersea are presently in regular operation worldwide and most are commercial remotely operated vehicles (ROVs) and inspection robots designed to perform subsea inspection, survey, construction, and repairing operation at modest depths. This robotic creation helps to minimize the human power and help to avoid any dangerous environment that can affect the human health.

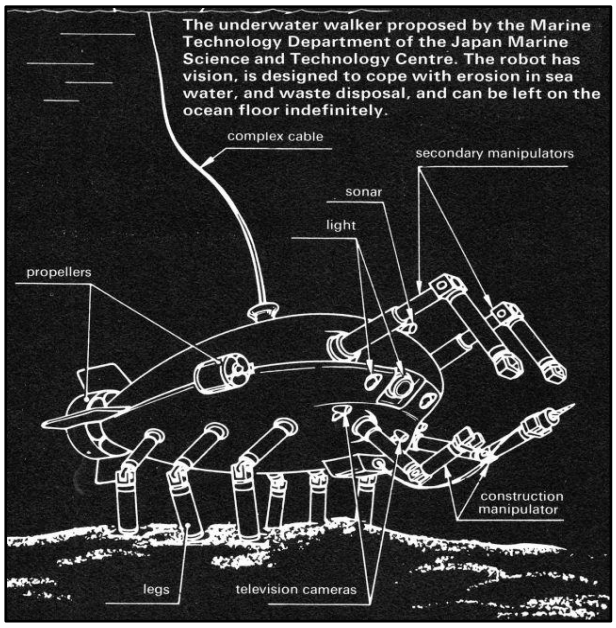

Figure 2.2: An early concept of inspection robot.

(Source: Jasia Riechardt (1978))

2.3 MATERIAL

Braga (2014) stated that most other underwater robot gets their buoyancy from a material called syntactic foam. This composite material filled hollow microscopic glass bubbles. These bubbles lower the material's density and making it buoyant. Putting anything underwater requires a delicate balance between buoyancy and weight. Maintaining that balance become more difficult the deeper its goes. The deeper its goes, the stronger syntactic foam has to be withstanding the increasing pressure, and adding strength also adds size and weight. To increase efficiency is to reduce the weight of buoyant material, the investigation continue to find another material. Ceramics, it turns out are five times stronger than steel when compress, but weigh about third as much. By using small ceramic spheres, it could theoretically enable a robot to carry more weight by using a lighter buoyant material with the same buoyancy as syntactic foam. Though ceramic is cheap and well-understood, its use as a replacement for syntactic foam is not tested yet.

Figure 2.3: Syntactic foam block machined robot's body.

(Source: Braga (2014))

Inspection robot need to dive while maintaining a safety factor of 1.5, and additionally figure out which material would allow it to achieve this goal with the best

cost. The different materials will be tested according to the size of the pressure vessel. It is to be noted that this is a simplified version of the actual model, which will be used as a preliminary test in order to understand the effects of hydrostatic pressures on an object under water Martos, Abreu, Gonzalez and Tremante (2013).

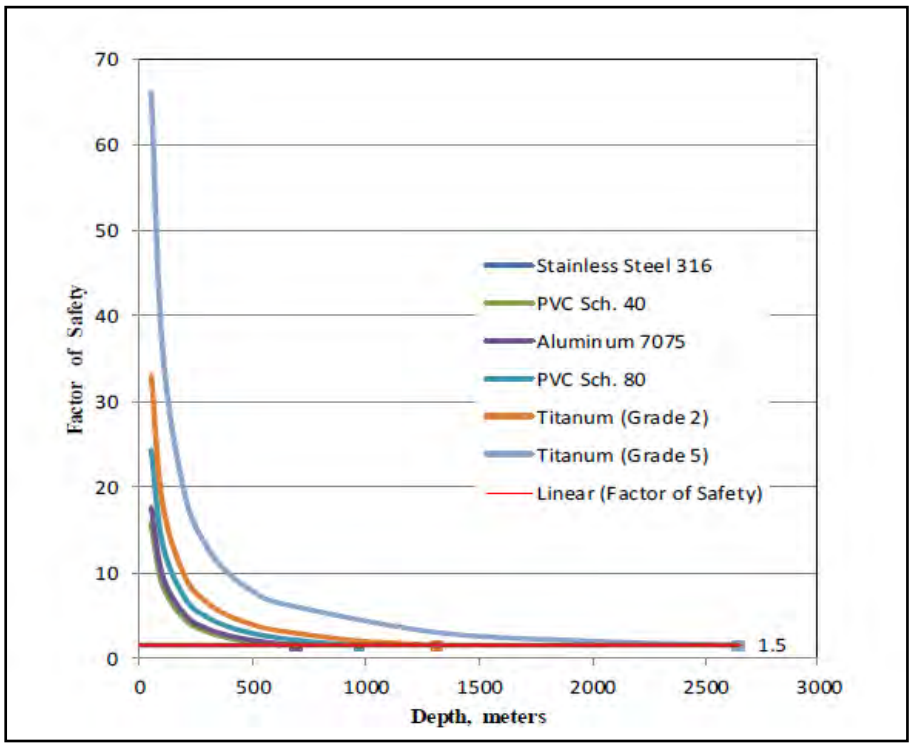

Figure 2.4: Factor of safety graph in comparison to depth.
(Source: Martos, Abreu, Gonzalez and Tremante (2013)).

Table 2.1: Factor of Safety at each Depth.

PVC Sch. 40		Stainless Steel 316		Aluminum 7075		PVC Sch. 80		Titanium (Grade 2)		Titanium (Grade 5)	
Depth	FoS	Depth	FoS	Depth	FoS	Depth	FoS	Depth	FoS	Depth	FoS
50m	15.817	50m	15.887	50m	17.634	50m	24.403	50m	33.093	50m	66.199
100m	8.636	100m	8.675	100m	9.628	100m	13.324	100m	18.069	100m	36.145
200m	4.526	200m	4.546	200m	5.046	200m	6.983	200m	9.47	200m	18.944
300m	3.067	300m	3.08	300m	3.419	300m	4.732	300m	6.416	300m	12.835
400m	2.319	400m	2.329	400m	2.586	400m	3.578	400m	4.852	400m	9.706
500m	1.864	500m	1.873	500m	2.079	500m	2.876	500m	3.901	500m	7.803
600m	1.559	600m	1.565	600m	1.738	600m	2.405	600m	3.261	600m	6.524
610m	1.534	610m	1.541	650m	1.606	770m	1.881	900m	2.186	1300m	3.038
620m	1.509	620m	1.516	690m	1.515	900m	1.612	1100m	1.793	2000m	1.98
624m	1.499	627m	1.499	697m	1.499	969m	1.499	1317m	1.499	2644m	1.499

(Source: Martos, Abreu, Gonzalez and Tremante (2013)).

A typical underwater robot tends to use aluminium, polycarbonate (PC), and polyoxymethylene (POM) for shallow water. While for deep sea underwater robot, high strength steel, titanium and composites material are considered. Steel is commonly used because of its high tensile strength and low cost. The surface steel need to be treat because it had the potential for corrosion and rusting phenomenon. Stainless steel is typically used for hydraulic, pneumatic and fasteners but it is difficult to machine and weld. The aluminium alloy is lightweight and has high strength and reasonable with a non magnetic system. Since it is vulnerable to corrosion, surface treatment also needed. Titanium alloy has very high strength-to-weight ratio, excellent corrosion resistance without any surface treatment, low electric conductivity, and no magnetic field distortion (Siciliano and Khatib, 2016).