DESIGN A BALLAST TANK FOR DEPTH CONTROL UNDERWATER VEHICLE

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Bachelor of Mechatronic Engineering

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"I hereby declared that I have read through this report entitle "Design a Ballast Tank for Depth Control Underwater Vehicle" and found that it has comply the partial fulfilment for awarding the Bachelor of Mechatronic Engineering."

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A report submitted in partial fulfilment of requirements for Bachelor of Mechatronic Engineering.

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2012

I declare that this report entitle “Design a Ballast Tank for Depth Control Underwater Vehicle” is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ……

Name : Muhamad Fauzi Bin Ab Latip

Date :…….....

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ABSTRACT

In underwater vehicle industry, ballast tank is important to allow the vehicle to dive and float back. This project describes a design and development of ballast tank. The project is to show one of its operation principles which are it can submerge underwater and rise back up using remote control. For deep Underwater Vehicle (UV) the most important part is that ballast tank. Without this, there is not possibility that the vehicle can submerged more depth. This project is developing a prototype of ballast tank which are attached to Remotely Operated Vehicle (ROV) to demonstrate the basic operation of ballast tank as well as it operation in the water. Most of the ROV implement static dive using thrusters. Thus, the purpose of this project is to develop a low cost of ballast tank that implement static dive concept. In Underwater Vehicles, ballast tanks are used to let the ROV to submerge, water being taken in to change the UV's buoyancy and let it to submerge. When the ROV rise up, water is exhale out from the tanks by water pump, and UV becomes positively buoyant again, letting it to move up to the surface.

ABSTRAK

Dalam industri kenderaan di bawah air, tangki balast adalah penting untuk membolehkan kenderaan untuk menyelam dan timbul kembali ke permukaan. Projek ini menerangkan rekabentuk dan pembangunan tangki balast. Projek ini adalah untuk menunjukkan salah satu daripada prinsip-prinsip operasi tangki balast di mana ia boleh menyelam di dalam air dan naik semula dengan menggunakan alat kawalan jauh. Untuk kenderaan dalam air yang dalam, bahagian yang paling penting adalah tangki balast. Tanpa tangki balast, amat sukar kenderaan itu untuk tenggelam lebih dalam. Projek ini adalah untuk membangunkan prototaip tangki balast yang digabungkan bersama dengan kenderaan kendalian dari jauh untuk menunjukkan operasi asas tangki balast semasa di dalam air. Kebanyakkan kenderaan kendalian dari jauh yang menyelam statik hanya menggunakan "thruster". Oleh itu, tujuan projek ini adalah untuk membangunkan satu projek kos rendah mereka tangki balast yang melaksanakan konsep menyelam statik. Dalam kenderaan dalam air, tangki balast digunakan untuk membolehkan kenderaan kendalian dari jauh tenggelam, air yang masuk telah mengubah keapungan kenderaan dalam air, dan membolehkan ia untuk menyelam. Apabila kenderaan kendalian dari jauh hendak timbul di permukaan, air ditolak keluar dari tangki menggunakan pam air dan kenderaan dalam air akan menjadi daya apungan positif dan ia akan naik semula ke permukaan air.

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CHAPTER 1

INTRODUCTION

This chapter describes the project overview, problem statement, project objectives, and project scope. Problem statement explains about engineering issues for this project. The project objective is the description of the expected result and goal of this project. Project scope explains about the limitations and boundaries on this project.

1.1 Project Overview

This project is about implementation of ballast tank on Remotely Operated Vehicle (ROV). This project is developing a prototype of ballast tank which are attached to ROV to demonstrate the basic operation of ballast tank as well as it operation in the water. The project is to show one of its operation principles which are it can submerge underwater and rise back up using remote control.

1.2 Problem Statement

Since thousand years ago, human tried to find ways to make their work easier. Thus, variety of techniques and inventions are created to reduce the human work. Nowadays, underwater is one of the popular sectors that human tried to explore. So that to reduce the risks to human life, underwater vehicles are the best choice over human divers because that vehicle can go down to greater depth and are able to stay there for the longer time. Underwater vehicles are used in the water for particular purpose. Remotely Operated Vehicle is the one type of underwater vehicle. It has much type of operations and involves many shapes. The main purpose of ROV is to replace the people is working in the underwater industry. Meanwhile the main obstacle in development of underwater vehicles is target of depth, control and stability in underwater. For deep underwater vehicle the most important one is that ballast tank. Without this, there is not possibility that the vehicle can submerged more depth. Thrusters only can submerge in a shallow water depends on speed of motor and weight of underwater vehicle. So ballast tank is introduced to underwater vehicle to submerge more deep. To ascertain its buoyancy, the underwater vehicle has ballast tank, which can be exchange provided with water or air. When the underwater vehicle is rise up, the ballast tank is provided with air and the underwater vehicle overall density is less than of the nearby water. When submerged, the ballast tank is filling up with water and the air in the ballast tank is vented from the underwater vehicle until its overall density is more than nearby water and the underwater vehicle start to sink. The problems with existing ballast tank system of ROV from international researches are typically too expensive and more complex system. It is because their body structure of ballast tank is made from good material, used higher technology system and totally waterproof, so that their price higher compared with local research. Other than that, researches from local from final year students of Universiti Teknologi Malaysia (UTM), their ballast tank project cannot fully function. The major problem thing that happen is the leaking of their ballast tank that makes it submerges and cannot rise again. This happen because the use of hardware that is not suitable to cover from high pressure. Besides that, they used syringes

as their type of ballast tank system and it is a poor system because is not efficient way to do this project because it can suck only a few amount of water. Other problem in their project is it have leakage at the combination point because they using more than one hardware to construct the ballast tank. If this project can develop the ballast tank which are can perform the basic operation of ballast tank as well as it operation in the water with a low cost and simple construction of ballast tank system, this will be the good news for the ROV developer.

1.3 Project Objective

As important as the other part, the project objective must be clearly defined so that the direction of the project always keeps in track. After clearly understand the problem statements, the purpose of this project is restricted to one major objective that hopefully can be achieved throughout project completion. The main objective of this ballast tank is:

- To design ballast tank that can be submerged underwater and rise back to the surface.
- To construct and control the ballast tank using water pump.
- To study performance of ballast tank in lab pool and swimming pool.

1.4 Project Scope and Limitation

In order to achieve the objectives of this project, there are several scopes and limitation that had been outlined. The scope of this project includes:

- Should be operating in underwater which the depth is below than 5 meter.
- The main source of power supply was come from the battery 12 V.
- To implement a suitable ballast tank for static diving of the ROV.
- To produce a low cost and simple construction system of ballast tank that can be operating in lab pool and swimming pool.

CHAPTER 2

LITERATURE REVIEW

In this chapter, a review of previous research project that are related of this project will be discussed. This kind of surveys done as one of the tools to have some ideas on how this project works based on other achievement and also to think about the advantages of proposed solution. This may help in problem solving skills and options required for design and develop the ballast tank.

2.1 Diving Technology

The dynamic and static diving is the ways to submerge. Dynamic diving boats always have positive buoyancy and they are submarines that inherently float. Meanwhile static diving submarines dive by allowing water into ballast tanks by altering their buoyancy. The boats start sinking when the buoyancy changed from positive to negative. These boats called static diving when its do not require speed. The main ballast tanks will fill up with water and then it will submerge. Then the buoyancy is completely changed with the trim tanks. Once underwater, the depth is controlled by the hydroplanes [1].

2.2 Static Diving

The main ballast tanks (MBT) can change the buoyancy of submarine by allowing water into it. They can be placed in different ways, which are inside the pressure hull, outside the pressure hull and in between the outer hull and the pressure hull [1].

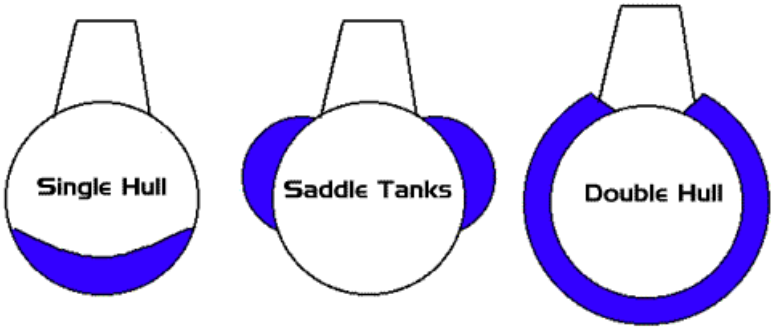

Figure 2.1 : The different locations of the main ballast tank [1].

To empty and fill, the MBT have two different ways. To rise up, the MBT are wholly filled with air and the MBT are closed on top of main vent valves. Meanwhile the ballast tanks are opened on top of vent valves to allow air get away from the MBT when to submerge.

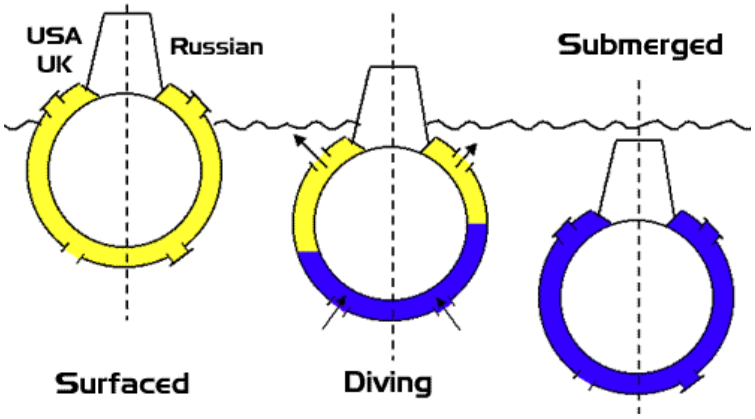

Figure 2.2 : The flooding of the main ballast tank [1].

To rise up, the pressure air was forced out by the water in the tank meanwhile to submerge more deep, high pressure air will uses to overcome the water pressure.

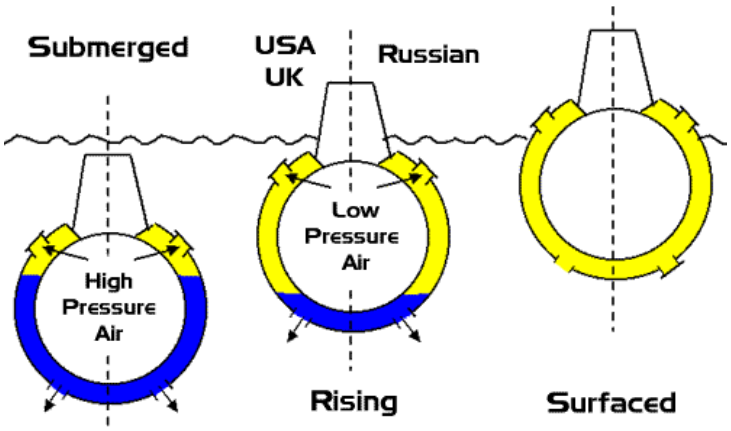

Figure 2.3 : The blowing of the main ballast tank [1].

2.3 Dynamic Diving

Perhaps the simplest form of diving technology is the dynamic diver. This has no functional ballast system at all, but rather uses its dive planes to "push" it under the surface of the water [3]. The hydroplanes control the depth of the submarine when it trimmed to neutral buoyancy. By using the hydroplanes, the submarine requires a speed to make a force on tilted planes. To maintain the submarine at the required depth, the fore hydroplanes are used exclusively because it more accurate to control the depth and at that location the bow mounted further from centre of gravity [1].

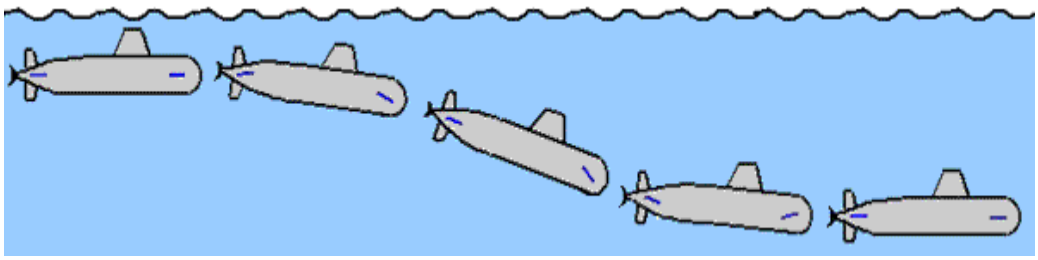

Figure 2.4 : The fore and aft dive planes are used during a submerge [1].

Highly nonlinear systems of equations with unsure difficulties coefficients and disturbances described the dynamics of UV are difficult to measure [10]. During the submerge process the aft hydro planes must in the neutral position meanwhile the hydroplanes is controlled by dive. To get the certain depth the aft planes are moved down and the fore planes up to level off. The fore planes are sustaining the depth by slow the speed. The hydroplanes usually control the depth for the most UV [11].

2.4 Types of Ballast Tank

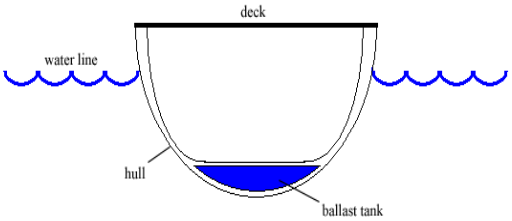

Figure 2.5 : Ballast tank

The ballast tank is a partition inside a boat or ship that holds water. Ballast tank is used to stabilize the ship when the ship begin to move [2]. There are many types of alternative for the ballast tank concept that can be applied to the submarine which are:

(a) Vented ballast tank
(b) Flexible ballast tank
(c) Pressure ballast tank
(d) Piston ballast tank
(e) Membrane ballast tank
(f) Bellow ballast tank
(g) Gas operated ballast tank
(h) Compressed air ballast tank

All the details about the types of ballast tank are summarized in Table 2.1.

2.4.1 Vented Ballast Tank.

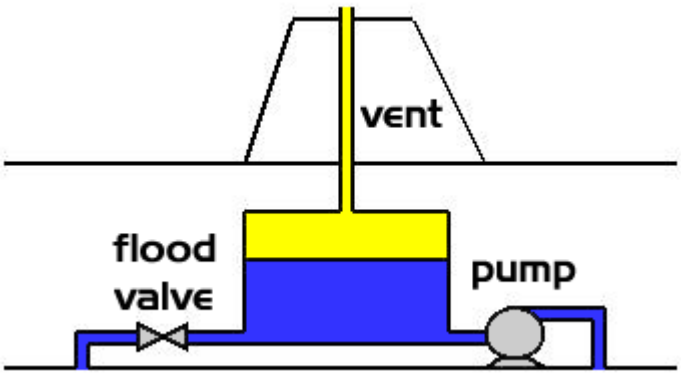

Figure 2.6 : Vented ballast tank [1]