Design Analysis of Remotely Amphibian Vehicle (RAV) –Underwater Drone

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***Abstract*— This project is mainly focusing on the conceptual design and design analysis of the Remotely Amphibian Vehicle (RAV). RAV is considered as an underwater drone or vehicle that can operate autonomously or remotely controlled by a user. The term “amphibian” is referring to a vehicle that is capable of functioning in dual environments, which is in aerial and aquatic. In order to meet that purpose, the ability of flying and submerging are implemented into this RAV. This innovation mends to assist and help human in aquatic operation as well as aerial activity. However, this is still a very recent concept with numbers of limitation and challenge. Challenges like transition in medium has limited and affected the performance of the vehicle in terms of flying capability or submerging ability. Available model in the market is either robust in flying such as quadcopters but imperfect in submerging and vice versa. Hence, this research is to study and analysis of the conceptual design a remote control amphibian vehicle that can fly and submerge models. In order to overcome the challenge mentioned above, denser material is preferable for body frame fabrication. Besides, a body design with low volume is recommended to achieve a better performance in transition medium. To judge the performance of the conceptual design, a series of simulations using SolidWorks will be carried out. At the end of this project, the design will be used to development a remotely amphibian vehicle that operate robustly in two mediums.**

***Index Terms*— Design Analysis; Remotely Amphibian Vehicle; Solidwork.**

I. INTRODUCTION

At this ever-changing era, the technology of robotics is undeniably getting more and more advanced from day to day. The usage of remote control robot and unmanned drone can be easily found at every corner of modern country. A leading country like America has already started to utilize the capability of robot and drone to aid in their daily routine [1-3]. Other than daily routine, this promising technology is being applied on medical field as well. For an instance, a Dutch engineer had designed an unmanned drone, called Ambulance Drone [4]. This drone has built in webcam and loudspeaker which allow remote doctors to monitor the situation of the victim and instruct the people to help the victim at incident spot [5-7].

Knowing that drone comes in very handy in many situations, a lot of engineering experts have already started to design and improve the performance and functionality of drone to a better level until what we see today. One of the famous type of drone can be seen today is Unmanned Underwater Vehicles (UUV). Unmanned underwater vehicle is a kind of drone which is able to operate underwater remotely controlled by human. A drone with this capability gives a big hand to the related field to carry out some dangerous mission underwater. There are two categories under this UUV drone, which are Remotely Operated Underwater Vehicles (ROVs) and Autonomous Underwater Vehicles (AUVs) [8-10]. The difference between these two categories is that ROVs works based on operator command while AUVs operates independently of the operator’s command. The ROV is widely used by the underwater researcher to gather some info and data under the sea. Besides, it is also being used for the seabed cleaning purpose.

Seeing that this tech brings a lot of advantages, field experts start coming up with idea applying flying capability to the drone so that it can viable in the aerial as well as in aquatic. Therefore, the term of Remotely Amphibian Vehicle (RAV) starts being used to refer to drone that able to navigate and operate in two different mediums, which is in the aerial and aquatic. In order to let the vehicle to travel in more than two mediums, there are quite a few limitations and challenges faced by most engineers during their design stage. Engineers need to solve those limitations such as the design of the body, waterproof issue, thrust required to move the body in both medium and controller issues, so that the vehicle can function well in both mediums. However, experts managed to eliminate and overcome one by one until now what we can find in the market. As this idea is still very recent, not much prototype can be found in the market or being used for any practical application yet.

In order to keep pace with the technology, this idea has been brought into University Teknikal Malaysia Melaka for development purpose. This development includes design and fabrication of the hull of the vehicle, controller design and also thruster design [11-18]. In year 2014, UTeM has successfully developed an unmanned amphibian vehicle which able to navigate in vertical direction in both mediums. It was a big breakthrough for the vehicle [16]. The vehicle succeeded in sealing the crucial part from water invasion and designing the suitable propellers for the usage in both mediums [17-18]. This project has not only gained the attention of the university, but also the concern from engineering field and to be believed that this project will be carried forward by other final year students to continue the development.

II. METHODOLOGY

Based on the study of the earlier literature review, an amphibious vehicle have to take consider of two working mediums, which are aerial and aquatic. In order to develop a functional RAV, all these body parts and electrical components used have to be sure able to function under these mediums. As stated, this vehicle has to go in aerial as well as aquatic. The vehicle has to perform the capability of navigating in both mediums. By utilizing the four thrusters, the vehicle is able to ascend or descend. The level of ascending and descending is manipulated by changing the rotation speed of the thrusters [19-23]. During aerial, the working concept of the thrusters is more or less the same as a common quad copter [24]. By changing the rotation speed of the thrusters, the vehicle will be able to perform the yaw, pitch and roll movement. The lifting force and the torque produced by these four thrusters can be adjusted to get a better experience of flying [25-29].

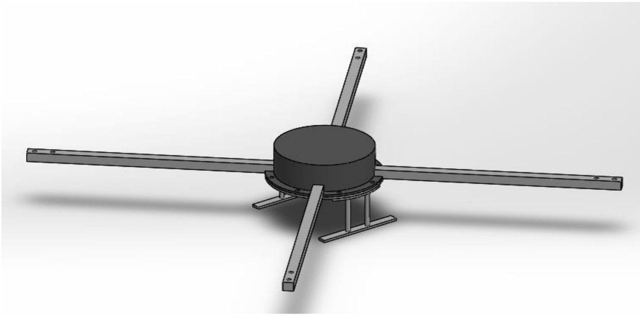


Figure 1: Design of RAV prototype

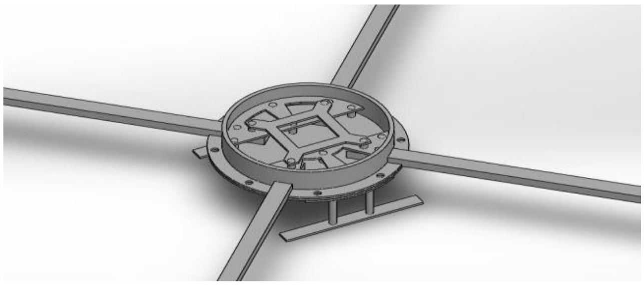


Figure 2: Inner Look of RAV prototype

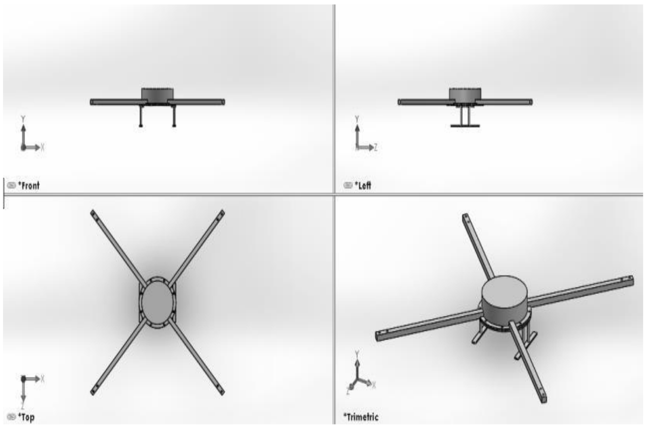


Figure 3: Isometric View of RAV prototype

In this part paper will discuss about the part of software which is sketching and drafting the project prototype by using computer-aid software. Based on the study of literature review, the design of the prototype has to be low in volume so that easy to transition in mediums. In order to study the outcome, several simulations will be carried out and discuss in later chapter. Other than that, the ability of withstand water pressure of the body will be simulated at this section.

During the development of this prototype, software part is playing a very important role. Design a body frame for a quad-copter is easy, but design a body frame for one to perform better in transition in mediums is very challenging. By using the computer aided drawing software, SolidWorks, the design of the body frame can be tested with many different simulations. MCAD Solid Work, also known as Mechanical Computer Aided Design SolidWorks is a mechanical design automation application that takes advantage of Microsoft Windows graphical user interface. This software makes it possible for designers to quickly sketch out ideas, experiment with features and dimensions and produce models and detailed drawings. Generally, SolidWorks software is a solid modeler that utilizes a parametric feature-based approach to create models and assemblies. At this stage, the first drafting of prototype has already done by using the Solid Work software. It is a very challenging practice when the prototype needs to meet the requirement and against the problem statement earlier. As shown in Figure 1 is the draft of prototype first done by using SolidWorks. Figure 2 shows the details of the design of the inner part of the prototype.

This draft is comprised of many other parts such as base platform, skids, rods, top cover and so on. Every part of the draft is drawn part by part. After getting all the part done, assembly feature is used to assemble and combine all these small parts into one complete draft as shown in the Figure 3. The center of gravity also can be found using this software as shown in 4.

III. RESULTS AND DISCUSSION

The part shown in Figure 5 (a) and (b) is simulated and test by using the analysis feature in SolidWorks. The simulation is done by using several types of material. In the following, the results of simulation will be concluded and tabulated in Table 1. There are two types of results being recorded, which are the result of stress and displacement.

Table 1
Simulation Result

Type of Material	Stress $\left(\frac{N}{m^2}\right)$		Displacement (mm)	
	Min	Max	Min	Max
Aluminium Alloy	3.39	13766.96	0	18.65
Steel Alloy	1.11	13943.22	0	6.14

Based on the result stated in Table 1, both fabrication materials show a good capability of withstanding pressures. An amount of 500N of force is applied on the platform during the simulation. Turns out both the materials show a very similar value of pressure they can endure. The maximum stress both platforms can withstand is around 13.8KPa. This is considered a very positive outcome. This has fulfilled the objective of creating a vehicle which better in transition in medium with a good pressure withstands capability.

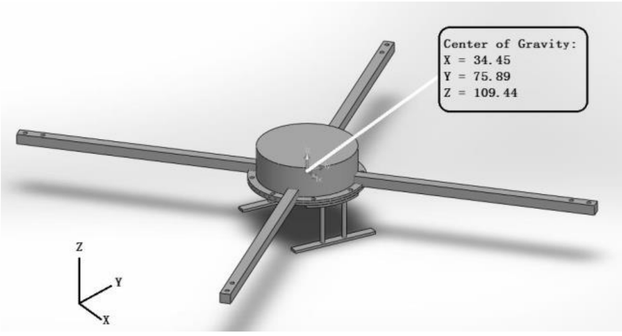
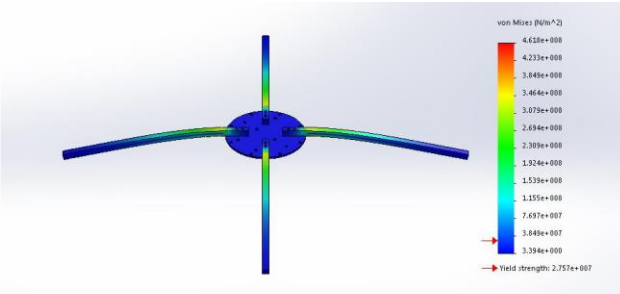
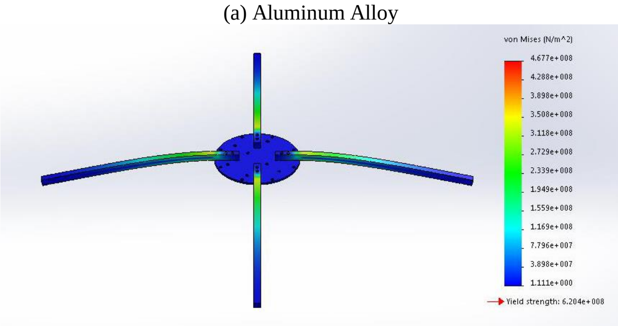


Figure 4: Center of Gravity



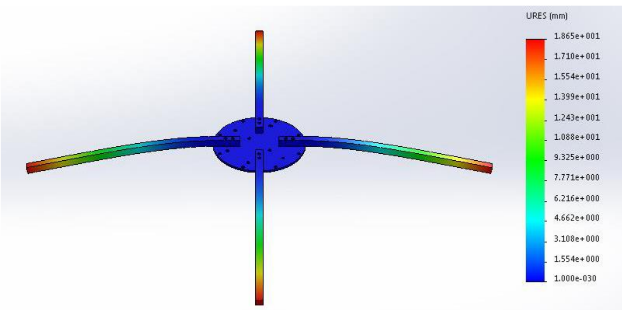
(a) Aluminum Alloy



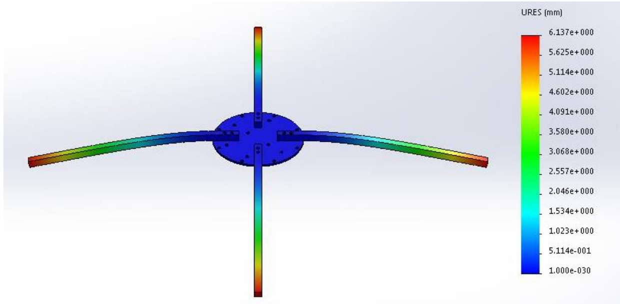
(b) Steel Alloy

Figure 5: Stress Test

From the result included in Figure 6(a) and (b), both materials show different value of displacement when force is applied. During the simulation, an amount of 500N of force is applied to both materials. Aluminum alloy shows a value of 18.65mm in displacement, while steel alloy shows a value of 6.14mm. Both value of displacement shown are as expected and in range. Results show that they have fulfilled the objective like the stress test. In comparison, steel alloy is more preferable to be used as it has a lower value of displacement than aluminum alloy. The simulation is done on the complete assembled prototype. In order to study the air and water flow of the external of the prototype, a complete set of prototype is preferable.



(a) Aluminum Alloy



(b) Steel Alloy

Figure 6: Displacement Test

The results of the simulation are as shown in Figure 7 and Figure 8. The simulation of air flow, which the prototype is flying upward, is stated in the first table. Simulation of water flow, which the prototype is submerging downward, is stated in the Figure 8.

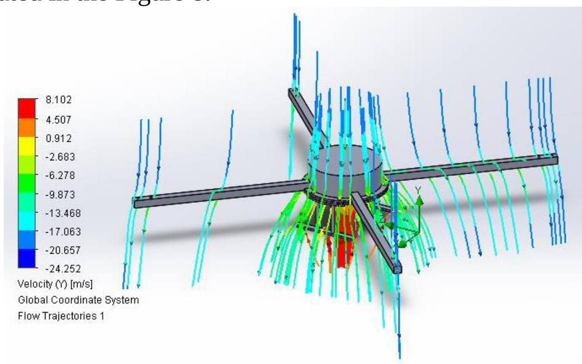


Figure 7: Displacement Test Prototype is flying upward

Based on the result included in Figure 7, the vehicle is moving upward. Hence, the air flow will be traveled from upside to downside. The blue indication is representing the air flow faced by the body. The air resistance faced by the body is very small as the air flow through the body smoothly. The result is as expected and in range. This can help to improve the movement speed of the vehicle as stated in earlier objective.

From the result stated in Figure 8, the vehicle is descending downward. Thus, the water flow is traveling from downside to upside. The orange, yellow and green indications represent the water flow faced by the body. In aquatic, water creates a larger resistant than air. The body of the vehicle faced larger water resistant when travelling in aquatic. The water flow is not as smooth as in aerial. Nonetheless, the result shown is still in range and as expected. The movement speed of the vehicle only can be sure after the experiment of speed performance. At this stage, the result is still accepted and in range.

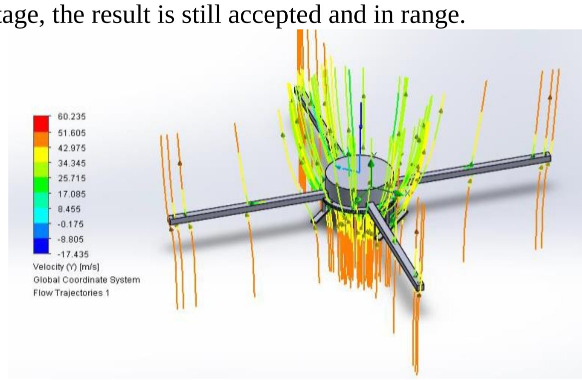


Figure 8: Prototype is submerging downward

IV. CONCLUSION

As conclusion, in order to shorten the time taken for transition in mediums, a volume of a body has to be lower and the density of the body has to be higher to reach a point where the buoyant force acted on that body is the smallest. Time taken will be shortened if the buoyant force acted on the body reduces to the smallest. Thus, the design of the body frame is aimed to be smaller in size and fabricated by using denser materials. In the study of movement speed of the vehicle in both mediums, the mechanism and body frame design are taken into consideration. To enable a better movement speed, the resistances faced by the body have to be minimized. Larger surface area of the vehicle, the bigger the resistance acted on the body. In order to minimize the resistance, the body frame is designed in a cylindrical shape which contribute to resistant minimization and also capable of withstanding pressure. Besides, concept of the quad-copter is implemented, which is compact in size and less resistant acted upon it. At this stage, the prototype is almost complete in design concept and planning. Some virtual experiment, test and simulation have been carried out to testify. By using the software, simulation of stress test and flow test have shown that the architectural design has fulfilled the objective of the project. At the end of this project, the design will be used to development a remotely amphibian vehicle that operate robustly in two mediums.

ACKNOWLEDGMENT

We wish to express our gratitude to honorable University, Universiti Teknikal Malaysia Melaka (UTeM) Special appreciation and gratitude to especially Faculty of Electrical Engineering, Faculty of Technology Engineering, and Centre of Research and Innovation Management (CRIM), for supporting this research under Short Term Grant PJP/2015/FTK(19C)/ S01437.

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