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Remotely Operated Underwater Glider: Modelling, Fabrication andAnalysis of Depth Control System Using Peripheral Interface Controller (PIC)

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Abstract

Underwater gliders glide by controlling their buoyancy using internal actuators. By altering their buoyancy, vertical motion can be achieved. The characteristic of glider motions consist of upward and downward in a saw tooth pattern, turning and gliding in a vertical motion glides without using thrusters or propellers. This paper investigates the challenges posed by the operation concept and describes in detail a prototype of remotely operated underwater glider (ROG) that was built for initial tests andthe analysis of depth control system using PIC.

1. Introduction

This project is classified as an applied research where the research that been undertaken is to solve practical problems rather than to obtain knowledge for knowledge purpose. The design and fabrication development processes are the research methods used to produce a practical test bed prototype sample that will be used for data collection process.

2. Design Development on ROG Modelling

The glider can be designed in three dimension (3D) by using computer aided software such as MaxSurf. The software enables the user to make any changes or modify the designed model [1].

MaxSurf offers tools for evaluating curvature of the entire surface. All MaxSurf designs are stored in a mutual file structure which is accessed directly by other modules for analysis, construction and performance prediction. Any changes made in MaxSurf will be automatically stream through when the design is opened in other modules. The designs in the database file are very solid and making them ideal for transmission to designers or builders through email.

The flow chart in Figure 1 below shown the immediate of design development process on ROG's body using MaxSurf. The design specifications are determined by the designer such as hull's diameter, thickness of the hull surface and several more. First, the design is modelled in MaxSurf and must encounter all the design specifications. Then, the model will be evaluate using Hydromax module in MaxSurf to get the stability result. Using the MaxSurf surface model will save time and input errors.

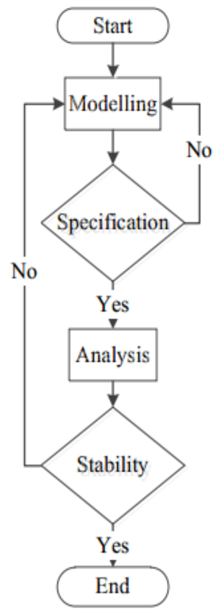


Figure 1: Flow chart of body design process

3. Fabrication Development on ROG's Body

The fabrication process for ROG's body used fibreglass as the foremost material. The fibreglass is a fibre reinforced polymer made of a plastic matrix reinforced by fine fibres of glass. The fibreglass is a lightweight, greatly strong, robust material and less expensive. Its properties are also worthy when compared to metals and it can be easily costumed using moulding processes.

At the first stage of construction, the plug is prepared by using polyvinyl chloride (PVC) pipe according to the design size. The process to shape the plug requires a lot of times as it needs several changesto suits the design specifications. The technique to custom fibreglass require three main items which are polyester resin, catalyst for hardener material and fibreglass cloth.

Firstly, apply the first coat of resin on the plug. This first coat is called the seal coat. Using a foam roller, apply a firm pressure and directional strokes to spread the resin as evenly as possible. Next, cut the fibreglass cloth to the shape needed and attach to the plug. Then, apply another coat of resin which are called the bond coat and fill coat. After the coats were already dried, the coated plug need to be sand in order to be smooth and even. Lastly, a protective agent such as paint need to be applied.

The flow chart in Figure 2 below shown the summary of fabrication development process on ROG's body using fibreglass technique.

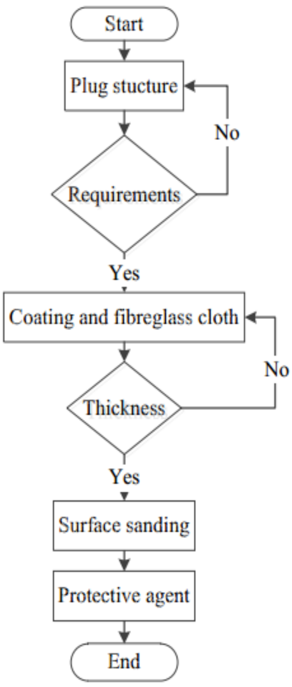


Figure 2: Flow chart of fibreglass technique

4. Result on Modelling and Fabrication of ROG's Body

The ROG designed was enhanced by using MaxSurf software shown in Figure 3. The software enables the variety of dimension and can make any changes if required. Early design, the ROG was small scale of sizes, hence it dimension changed because the material used needs a bigger size to be practically construct [2-4].

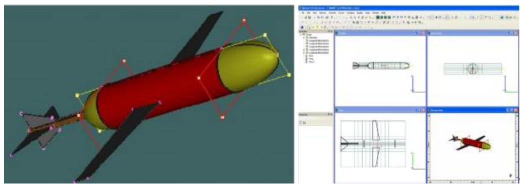


Figure 3: ROG's model using MaxSurf [2-3]

After several adjustments have been made to meets the requirement, the construction of the ROG begins with using fibreglass as the main material. At the first stage of construction, the plug is built by using polyvinyl chloride (PVC) pipe according to the hull size. The process to build the plug shown in Figure 4 which requires two weeks as it needs several adjustments to suits the design specification [2-4]

Figure 4: ROG's body under construction [2-3]

The Figure 5 shows the finishing product as the actual model of the ROG and the Table 1 shows the dimension of the ROG.

Figure 5: The finished prototype of ROG [2-4]

Table 1 Dimension of ROG's body [2-4]

Dimension	Unit
Hull length	0.82 meters
Hull diameter	0.34 meters
Wing spa	0.30 meters
Tail length	0.23meters
Tail fin	0.12 meters
Weight	3.50 kilograms

5. Fabrication Development on Depth Controller Circuit

A pressure sensor named MPX4250 is used as a research technique to measure the depth which produce small voltage when the depth increases. The depth controller will receive feedbacks from the sensor which installed in the glider's body for decision making. The MPX4250 needs supply voltage in between 4.85 to 5.35 volts to operate. The MPX4250 is a low cost and capable to measure maximum pressure of 36.3 psi or about 2.47 atm. At the sea level, the surrounding pressure due to open air is 14.7 psi or 1 atm and for every 10 meters of depth under sea surface, the pressure increases about 1 atm. The absolute pressure at 10 meters underwater is about 2 atm or 29.4 psi. The research techniques to fabricate the depth controller circuit are draw printed circuit board (PCB) layout, etching, drilling and soldering components. The PCB layout can be draw manually or by using software aid such as EAGLE PCB and Proteus. The result of controller fabrication is shown in Figure 6. The Figure 6 a) shows the circuit layout for the controller that been design using EAGLE PCB software while Figure 6 b) shows the etching process using suitable chemical. The Figure 6 c) show the assembling process of electronic component and Figure 6 d) shows the complete product of the controller circuit [3-4].

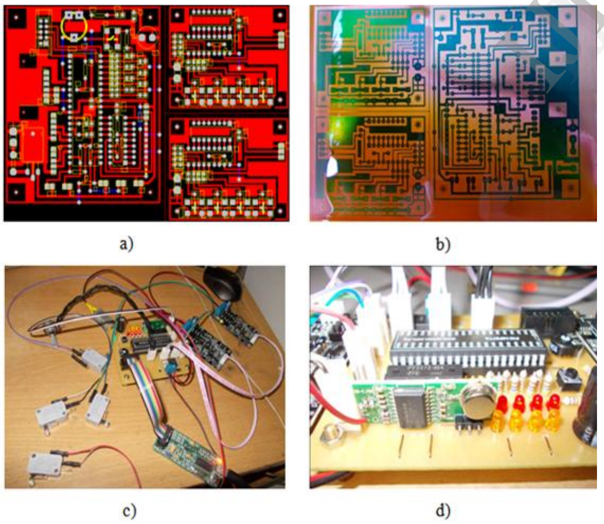


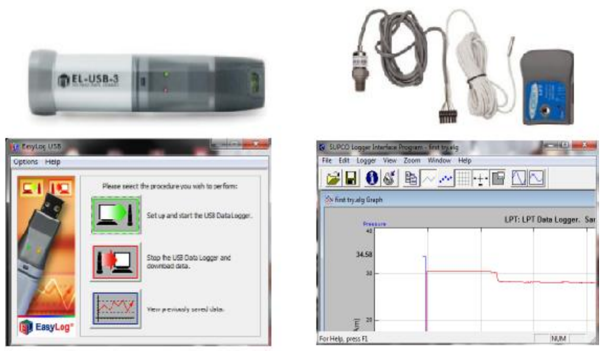
Figure 6: Fabrication of controller circuit

6. Research Technique for Data Collection and Analysis

A proper data collection process is necessary to guarantee that data that were gathered are both defined and accurate. The process delivers both a reference point from which to measure and in certain cases a target on what to develop. The controlled experiment is used as the research technique for data collection process. The technique focus on the sea trial of the remotely operated glider (ROG) at UniKL MIMET's slipway which is shown in Figure 7 below with the depth of between 6 to 8 meters.

Figure 7: UniKL MIMET's slipway

The ROG is programmed to operate at 3 meters depth. Two electronic data logger, Voltage Universal Serial Bus (USB) logger and SUPCO LPT logger shown in Figure 8 were used to obtain the real time data from the experiment such as voltage, pressure and temperature. These electronic data logger can log the data for a long time and the data can be transfer to the computer through the computer USB port for analysis process. Characteristics analysis of data sample are used for data analysis process and assessed through basic statistics of important variables, line plots, correlations and comparison.



a) Voltage Universal Serial Bus (USB) logger

b) SUPCO LPT logger

Figure 8: Voltage Universal Serial Bus (USB) logger and SUPCO LPT logger

7. PIC Programming

The program can be develop using C or Assembly language. Before the programming process started, the programmer need to specify all the design requirements and parameters that involved such as inputs and outputs parameters. A programmer also need to verify the type of inputs parameters whether analogue or digital. This action is important for the PIC to communicate with real simulation. The PIC programming process can be done using MPLAB IDE shown in Figure 9 below which is an open source software.

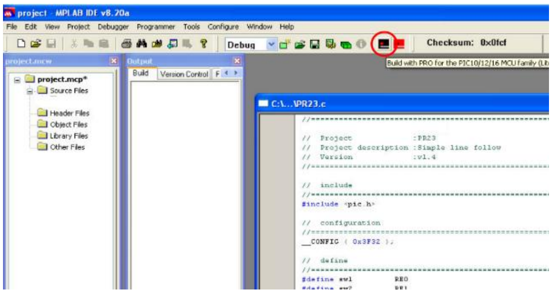


Figure 9: MPLAB IDE

The flow chart shown in Figure 10 described the programming sequence processes to control the ballast tank operation in order to get the require depth [6-7].

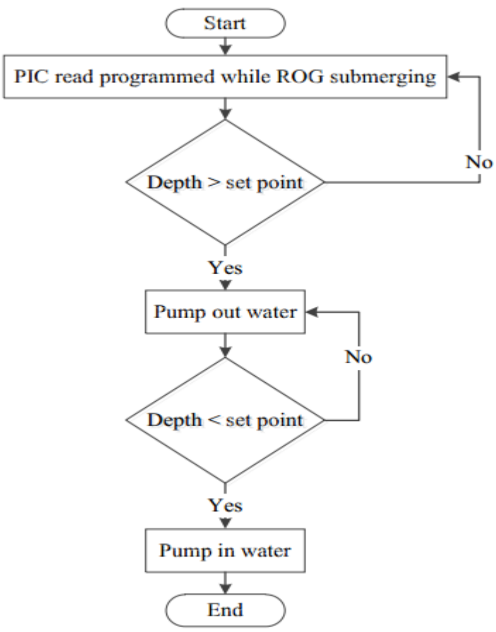


Figure 10: The flowchart of PIC programming process

8. Data Collection and Analysis

The table 2 shows the relation between output voltage from sensor MPX4250, underwater depth and underwater absolute pressure.

Table 2. Table data of voltage, depth and pressure

Voltage (volt)	Depth (meter)	Pressure (kPascal)
1.9	0.0	103.4
2.1	1.0	113.3
2.3	2.0	123.2
2.5	3.0	133.1
2.7	4.0	143.0
2.9	5.0	152.9

The result for experiment for 3 meters desired depth is shown in Figure 11. The depth control using PIC is able to control the desired depth which using the output voltage of MPX4250 as the reference for the desired depth.

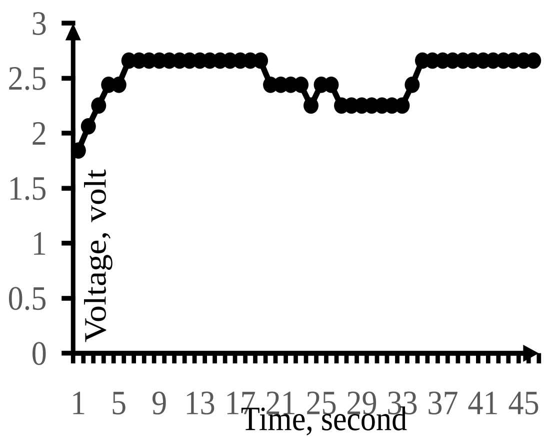


Figure 11. Experiment data for 3 meters desired depth

9. Conclusion

In conclusion, a practical body of underwater glider that was produced can be used to test the performance of depth control system and advanced control algorithm.The automatic depth control system using PIC was developed as a research tool for conducting research in the underwater robotics applications.

10. Acknowledgments

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