Underwater Search and Rescue Device

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Abstract

Third leading cause of unintentional death of total world population is drowning. Mostly, rescue attempts end in failure mainly because of the due to long search time because of the absence of suitable and affordable aid which helps in searching. Current models of underwater drone are used in ocean are not used in local streams. Main disadvantages of the current models are that, they are designed for high cost, complex design etc. In the analysis it was found that the proposed design withstands the operation conditions of an underwater drone. It achieves stable equilibrium in fully merged condition. And it was found that the drone can achieve a speed up to .9m/s in the flow and work comfortably at a depth of 1km by using fiber glass body. The design also allows the installation of more gadgets like sonar and other devices. In the future application or as an extension of the project the drone can be used for many other purposes like under water exploration, useful tool for fishermen etc.

Keywords: Propeller, Stability, Maneuvering

I. INTRODUCTION

We conducted a study on various underwater activities done by humans. It was found that most of these activities either involves direct human involvement or are costly. From these conclusions we thought of a new model of an underwater drone which is both economical and easy to use. The main purpose of this design was initially concentrated for search purposes which in future can be used for rescue operations also, provided, some modifications being done.

In this paper we discussed about a novel model which is most suitable for local streams with low cost and ease of manoeuvring. The design consists of one main propeller for up and down movement and 2 sub propellers providing the front and rotational movement. Each propeller is powered by separate DC geared motor. Proposed body is made up of fibre glass. CATIA is used to design the model and analysis is done with ANSYS. Main parameters of the design are stability, balancing, manoeuvrability and structural strength of the drone.

II. ANALYTICAL METHOD

For designing our drone we assumed some values for its pay load, buoyancy, weight and maximum speed. The aim was to design our drone which satisfies our assumption. The values which we assumed are:
- Pay load of 19.6 N (2 kgf)
- Body weight assumed as 58.8 N (6 kgf)
- Buoyant force assumed as 117.6 N (12 kgf)
- Maximum speed limited to 0.9 m/s

For designing our drone we divided the work into four categories they were, design of body, design of propeller, balancing and stability and electrical and control unit.

A. Design of Body:
While designing our body our aim was to design a body which enhance maneuverability, has optimum strength, good stability, low drag, and good repairability. We have designed such a body. The parts and complete assembly are show below;
B. Propeller Design:
For designing our propeller we first fixed the diameter of our propeller with comparing to body size and the thrust required to propel it. Pitch of our device was calculated from our desired maximum speed. Our propeller is designed to have constant angle of attack throughout the length of blade.

The main propeller helps in vertical motion of the device and the sub motors which rotate mutually opposite direction are use for forward motion and turnings.

![Fig. 1: Shape of Standard Aerofoil](image1)

Standard aerofoil 2032C-il-20-32C AEROFOIL, because it has maximum coefficient of lift is 0.7 at zero angle of attack.

![Fig. 2: Main Propeller Analysis Using MRF](image2)

Ansys Fluent to analyze the propeller. We used Moving Reference Frame (MRF) method to analyze the propeller. MRF method is a method used to analyze rotating bodies. Here the area shown in blue is the velocity inlet and area shown in red is pressure outlet. The condition tested is in still water so the inlet velocity is set to zero. Area shown in Yellow is the reference frame which we analyzed.

C. Balancing and Stability:
1) Fully Submerged Body:
In a fully submerged rigid body, for example a submarine, both centres are always in the same place relative to the body, barring possible shifts in the cargo. If the centre of gravity does not lie directly below the centre of buoyancy, bu is displaced horizontally, for example by rotating the body, the direction of the moment will always tend to turn the body so that the centre of gravity is lowered with respect to the centre of buoyancy. The only stable equilibrium orientation of the body is where the centre of gravity lies vertically below the centre of buoyancy. Any small perturbation away from this orientation will soon be corrected and the body brought back to the equilibrium orientation, assuming of course that dissipative forces (friction) can seep off the energy of the perturbation, for otherwise it will oscillate.

![Fig. 3: Stable Equilibrium Condition](image3)

D. Calculation of Center of Buoyancy:
Center of Buoyancy is the center of the gravity of the volume of water which a volume displaces. Center of buoyancy is found from CATIA by replacing the hollow body to solid body and defining the solid as water. The center of gravity of the obtained shape is the center of buoyancy of the actual volume
E. **Calculation of Centre of Gravity:**
Center of Gravity is the point in a body where the gravitational force may be taken to act. Center of Gravity is found from CATIA directly.

F. **Shaft Axis:**
It is another point where forces acting on the system.
Here from the three results it is clear that center of gravity below the center of buoyancy, which is the actual condition of stable equilibrium in the fully merged condition. Center of gravity and center of buoyancy coincide in same axis and center of buoyancy is 2.7 mm above center of gravity. Also the balancing condition is satisfied in this case. That is if all forces acting in the system pass through the same axis there will not be any unbalanced couples in the system. Center of gravity, shaft axis and center of buoyancy coincide in same axis satisfies the condition. Therefore the system is in stable equilibrium and in a balanced condition.

### III. Results

The analysis of main propeller sub propellers, were done on Ansys Fluent using MRF method. Structural analysis of propellers was also done. The drag was calculated. Structural analysis of body was conducted. Structural analysis of motor casing was also done. The results obtained are mentioned below.

#### A. CFD Analysis of Main Propeller:

For the analysis of main propeller results are calculated at 2000rpm using MRF method. The main propeller CFD analysis is shown below.

![Fig. 8: Velocity Stream Line](image)

It was found that no vortex was formed. This indicates that the design of propeller is safe. The pressure contour of the main propeller is also shown below.

![Fig. 9: Front View of Pressure Contour](image)

From the pressure contour it is clear that pressure acts on back side. In our design the main propeller is used to sink the device. So more pressure will act on back side.

The main results obtained from MRF analysis of main propeller is given below.

- Main propeller thrust calculated from MRF method is 221.29607 N.
- Main propeller torque calculated from MRF method is 3.8204994 Nm.
- No vortex formation has been observed.
B. **CFD Analysis of Sub Propeller:**

CFD analysis on sub propellers were done and the pressure contour obtained is given below.

![Pressure Contour of Sub Propellers](image)

The following results were obtained from the analysis:
- Sub propeller thrust calculated from MRF method is 24.009969 N
- Sub propeller torque calculated from MRF method is 0.589641 Nm
- No vortex formation has been observed

C. **Structural Analysis of Propellers:**

Structural analysis of propeller was done and it is seen that aluminium alloy with a yield strength of $2.8 \times 10^8$ N/m$^2$ is the best suited material for propeller. By giving a load of 250N, the FOS for main propeller obtained was 1.125. The maximum force generated was found to be 221.29 N from the force report of the main propeller but in the structural analysis of the propeller a load greater than the maximum is applied so that it can accommodate any additional force acting on the system. The FOS will be greater than 1.125 if the load applied was 221.29 N.

![Stress Analysis of Main Propeller](image)

It can be seen that the stress is distributed equally and so the design is safe. For the sub propeller we gave a load of 25N and we got a FOS of 8.

![The Stress Analysis of Sub Propeller](image)

It can be seen that the stress is distributed equally on propeller and so that the design is safe.
D. 3.4 Drag Calculation of Propeller:
The vertical drag and transverse drag was calculated at a speed of .9 m/s. The maximum vertical drag was found to be equal to 48.429 N. The vortex flow was minimum.

![Pressure Contour of Vertical Drag](image)

The maximum transverse drag was found to be 5.49 N from CFD analysis. It was also found that the vortex formation is minimum. Pressure contour obtained is given below.

![Pressure Contour of Horizontal Drag](image)

The structural analysis of body was conducted and the following results were obtained.
- Base structure Aluminium with yield strength of 9.5x10⁷ N/m².
- Body cover fiberglass of Polyester and Chopped Strand Mat Laminated 30% E- glass with yield strength of 10x 10⁷ N/m².
- Pressure loaded is 1MPa which is approximately equal to the pressure at one kilometre depth.

E. Deformation Analysis:
1) Base Structure Alone:
From the results, it is seen that a deformation of 8mm will happen to the base structure at one kilometre depth. This is an undesired condition since the thickness of our material is 3cm only.

![Pressure Contour When Base Structure Alone](image)

F. Body Cover Alone:
From this graph it is seen that at a depth of 1km a deformation of 3mm will occur to body cover. This is also not desirable.
G. Combination of Base Structure and Body Cover:
It is seen that 0.9 mm deformation will occur to this combination at a depth of one kilometre. It is a safe condition. Combination gives only total deformation of 0.9 mm which can be assumed to be safe as 0.9 mm deformation cannot produce a crack on 3 mm thick body cover.

H. 3.8 Structural Analysis of Motor Casing:
Structural analysis of motor casing was done. The deformation graph obtained is given below.

The results obtained are given below.
- Material used is polyethylene of yield strength with $2.5 \times 10^7$ N/m².
  With load of 250 N we get a FOS of 8.22.

IV. CONCLUSION

Stability of a fully merged body depends upon the relative position of the center of gravity and center of buoyancy. Here in this model we get center of gravity below the center of buoyancy, which is the actual condition of stable equilibrium in the fully merged condition. Center of gravity and center of buoyancy coincide in same axis and center of buoyancy is 2.7 mm above center of gravity. Also the balancing condition is satisfied in this case. That is if all forces acting in the system pass through the same axis there will not be any unbalanced couples in the system. Center of gravity, shaft axis and center of buoyancy coincide in same axis satisfies the condition.

Normal speed of current under water devices like spray glider as small as 23 cm/s and normal divers of international standards are about 0.7 m/s. In this novel model designed from results it shows that it can achieve a speed up to 0.9 m/s for both vertical and transverse motion.
The analysis was conducted at depth of 1 km from the surface of the water for analysing the structural strength of the main frame, body cover, main and the sub propeller and motor casing. CFD analysis shows body can withstand up to pressure of one kilometer depth.

Drag for both vertical and transverse motion has been calculated and found to be less than that of the thrust actually given by the propeller. So the motion is not greatly disturbed by the drag force acting. Also vertical drag found to be less than that of the transverse drag because of the reason that exposed area on the transverse face.

V. FUTURE SCOPE

(1) Base model containing wired control which can be improvised to wireless model.
(2) An improvised model can be used for rescuing purposes without a diver also.
(3) Use various devices such as SONAR to help in missions.
(4) Further improvisation in the design or addition of gadgets can make device work for other application efficiently.
(5) It can be used in defence systems, under water construction, underwater exploration etc.

REFERENCES


