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# Design And Optimization of a Low-Noise and Low-Cavitation Torpedo Using Toroidal Propulsion and Acoustic Coating

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## Abstract
*This project focuses on designing and improving an underwater torpedo to increase its speed, reduce noise, and minimize the chances of being detected. The torpedo is designed with a smooth and streamlined body to lower water resistance and allow for efficient movement. The body shape includes a hollow cylinder and a curved nose to ensure a good balance and stability in water. Instead of a traditional propeller, a toroidal propeller is used because it provides smoother water flow and generates more thrust with less energy loss. An acoustic coating is also applied to the outer surface to help reduce the noise created during movement. The performance of this design is studied using Computational Fluid Dynamics (CFD), which helps analyse water flow, pressure, velocity, and drag around the torpedo. The results show that the design provides stable movement, lower drag, reduced noise, and minimal cavitation. Overall, this study demonstrates that a combination of an improved body shape, advanced propulsion system, and sound-absorbing coating can enhance the efficiency and stealth capabilities of modern underwater torpedoes.*

***Keywords:*** *Underwater Torpedo, CFD, Hydrodynamics, Toroidal Propeller, Cavitation, Acoustic Coating, Noise Reduction.*

## 1. Introduction

An underwater torpedo is a self-powered vehicle that moves through water to reach a target. It is commonly used in naval and defines applications due to its speed and precision. The performance of a torpedo is mainly influenced by its shape, stability, and propulsion system. If the design generates excessive drag or noise, its efficiency will be reduced and it may be easily detected by sonar systems. Therefore, reducing drag, cavitation, and underwater noise is very important. In this project, a low-noise and low cavitation torpedo is designed and analysed. The torpedo has a streamlined body with a parabolic nose that allows smooth water flow. A hollow cylindrical structure is used to maintain proper balance and buoyancy. A toroidal propeller is selected because it generates better thrust with less turbulence than a standard propeller. An acoustic coating is also used to reduce noise during movement. Computational Fluid Dynamics (CFD) is used to study the flow behaviour around the torpedo. The main goal of this project is to improve the efficiency, stability, and stealth capability of underwater vehicles.

### 1.1. Objective of the Study

- To design a streamlined underwater torpedo with improved hydrodynamic performance.
- To reduce drag, cavitation, and noise generated during underwater movement.
- To improve propulsion efficiency by using a toroidal propeller.
- To analyse the torpedo's flow characteristics using Computational Fluid Dynamics (CFD).
- To develop a stable, efficient, and stealthy underwater vehicle for future applications.

## 2. Method

This project follows a step-by-step process to design and analyse a low-noise and low-cavitation underwater torpedo. First, the problems in conventional torpedo designs, such as high drag and noise, are studied through a literature review. Based

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on this study, a better design is developed to improve performance and reduce detection. A 3D model is created using CAD software, and hydrodynamic analysis is conducted to check flow behaviour's design is also evaluated for noise and cavitation effects. Finally, the results are optimized, and the best design is selected to improve underwater performance and efficiency.As shown in Figure 1 Project Methodology Flow Chart

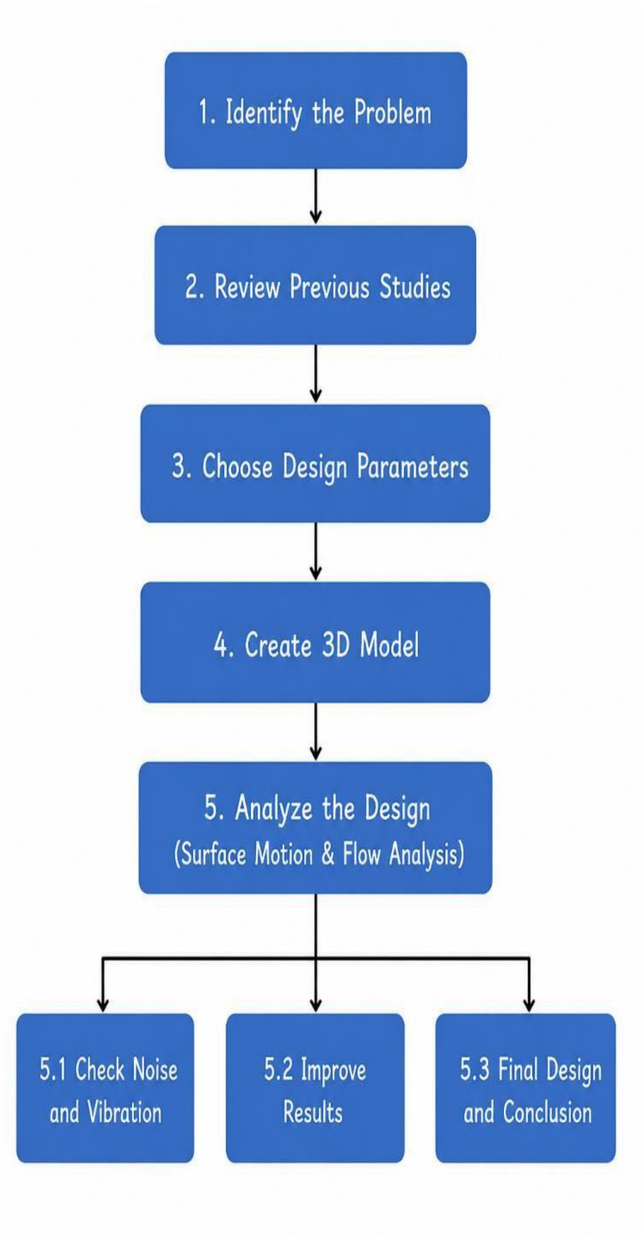


**Figure 1 Project Methodology Flow Chart**

## 2.1.Geometric design

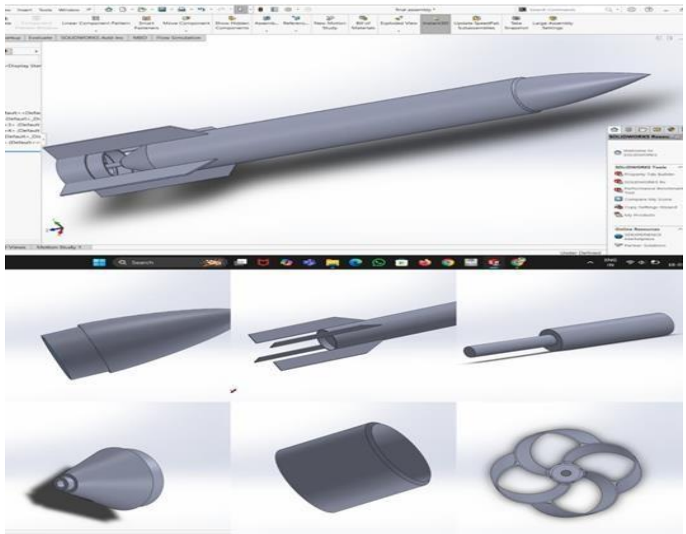

**Figure 2 Full Torpedo Body**

This design is based on the principle of allowing flow to pass through the design as freely as possible while also providing an internal mechanism that helps sustain the flow. The design is simple and functional, with three main parts: a front nose, a long cylindrical section, and the rear part, which helps in locomotion and stability.As shown in Figure 2 Full Torpedo Body.

## 3. Analysis

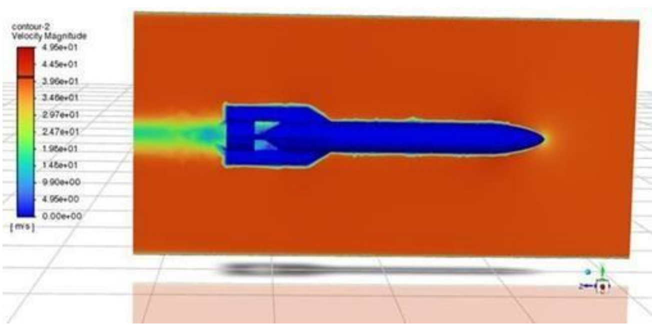


**Figure 3 Velocity Magnitude**

This design uses a toroidal fan as the main propulsion system and is located within the cylindrical section of the system. This type of fan is shaped like a ring, rather than having individual blades like a typical propeller.As shown in Figure 4 Propeller and Noise

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Performance.

**Table 1 Design Parameters for an Underwater Torpedo**

| Parameter | Symbol | | Value | Unit |
|---|---|---|---|---|
| Length | L | | 1.15 | m |
| Diameter | D | | 0.13 | m |
| Velocity Range | V | | 15 – 20 | m/s |
| Flow Type | – | | Subso nic | – |
| Fluid | – | | Wate r | – |
| Propulsion | – | Counter-rotating toroidal propeller | | – |

## 4. Result

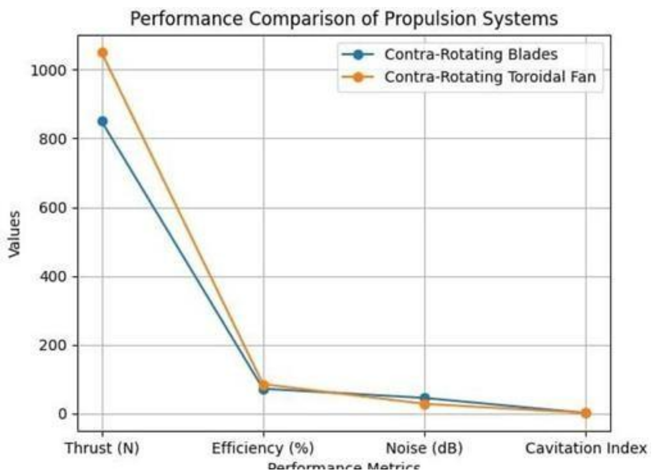


**Figure 4 Propeller and Noise Performance**

The calculated cavitation number is greater than the critical limit, ensuring safe operation under the given conditions. The use of a counter-rotating toroidal propeller further improves thrust and reduces turbulence in the wake region.

### 4.1.Discussion

The CFD analysis shows that the proposed torpedo design performs well under underwater conditions. The streamlined body helps reduce water resistance and allows for smooth flow around the torpedo. The pressure and velocity distributions indicate stable movement with lower drag.

## Conclusion

In this project, a modified torpedo design is developed to address some of the major issues zazmain goal of this work is to reduce noise and avoid cavitation, as both of these factors can lower performance and make the torpedo easier to detect. In modern underwater systems, maintaining good efficiency while also keeping the system quiet is very important. From this study, it is clear that the shape of the torpedo plays a significant role in its performance. By designing the body with a smooth and streamlined profile, the flow of water around the torpedo becomes more stable. This helps lower resistance and allows the torpedo to move faster with less energy loss.

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