Hydrogen Fueled Inspection Submarine

TEAM Design Term 241 - Team 33 - Dr. Naveed Iqbal

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Introduction

The inspection of underwater structures, particularly pipes and tanks, is a critical task in various industries. Traditional methods often involve shutting down operations, leading to significant downtime and economic losses. Additionally, manual inspections can be dangerous and time-consuming. To address these challenges, the Submarine inspection concept is proposed. This device will be capable of inspecting underwater structures for corrosion without the need for shutdown, providing a safer, more efficient, and cost-effective solution, provided that it is powered by green hydrogen which is a renewable energy source.

Problem Statement

- Safety Risks: Human divers face significant safety hazards, including exposure to toxic substances, confined spaces, and underwater conditions.
- Efficiency Limitations: Traditional inspection methods can be time-consuming and labor-intensive, especially for large-scale infrastructure.
- Data Accuracy: Manual inspections and ROVs may have limitations in collecting accurate and comprehensive data, leading to potential oversights or misdiagnoses.
- Cost: The cost of traditional inspections can be high, particularly for complex or remote infrastructure.
- Environmental Impact: The use of chemicals and equipment associated with traditional inspections can have negative environmental consequences

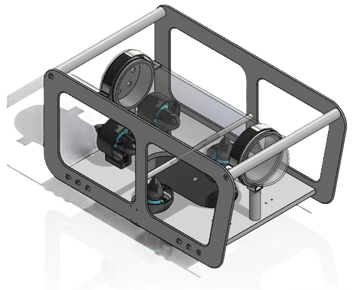
Specifications / Constraints

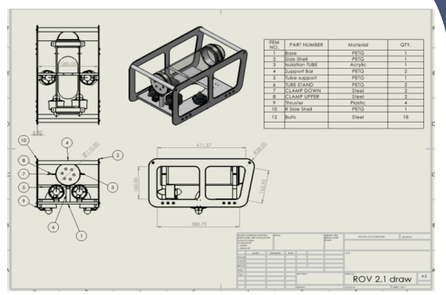
Target Specifications	Constraints
Materials must be resistant to corrosion from saltwater and capable of pressure at 20 meters depth	440mm x 364mm x 248mm (L x W x H)
Ecofriendly materials and charging system	15 kg
Tube sizes = 1/4 and 1/8 inch.	Polyethylene terephthalate glycol (PETG), stainless steel for critical components Acrylic for Electrical Housing and isolation
The coverage area should be at least 1.5 Km^2	Camera Features: Adjustable tilt and zoom, waterproof housing
PEM voltage supply of 12 V	Limited hydrogen production

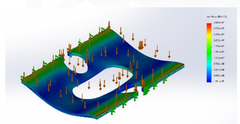
Project Impact

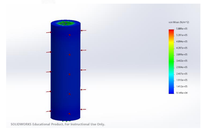
Impact Type	Justification
Environmental	Using green hydrogen fuel cell to generate electricity which is a type of renewable energy that contributes to reduce the carbon emission.
Economical	Saving labor cost in inspection applications where the submarine can replace the labors salary with its fixed operating and maintenance cost
Health and Safety	Using inspection technology will contribute to lowering the probability of human labor inspectors which promotes safety.

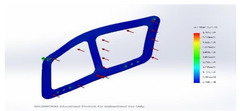
Submarine Design

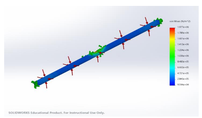




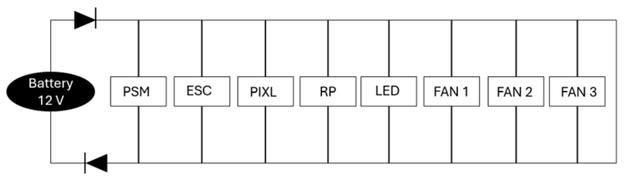


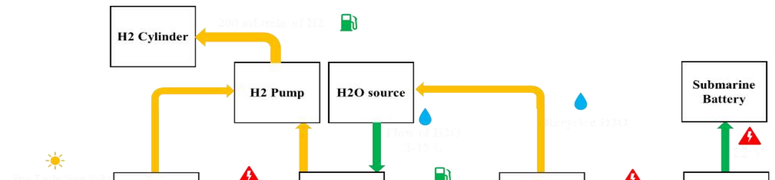






Power System





- Chemical Equation:

Anode Side:

$$2H_2O_{(l)} \longrightarrow \frac{1}{2}O_{2\,(g)} + 2H^+_{(aq)} + 2e^-$$

Cathode Side:

$$2H^+_{(aq)} + 2e^- \longrightarrow 2H_{2\,(g)}$$

Overall:

$$2H_2O_{(l)} \xrightarrow{V} \frac{1}{2}O_{2\,(g)} + 2H_{(g)}$$

Chemical Equation:

Anode Side:

$$H_{2\ (g)} \longrightarrow 2H^+_{(g)} + 2e^-$$

Cathode Side:

$$2H^+_{(g)} + \frac{1}{2}O_{2\,(g)} + 2e^- \longrightarrow H_2O_{(l)}$$

Overall:

$$O_{2\,(g)} + H_{2\ (g)} \longrightarrow H_2O_{(l)}$$

Important Calculations

Drag Force Calculation:

$$F_d = 0.5 \times \rho \times v^2 \times A \times C_d$$

$$F_d = 0.5 \times 1000 \times 0.5^2 \times 0.5 \times 0.2$$

$$F_d = 12.5\ N$$

$$F_b = v \times n \times g$$

$$F_b = 0.002872 \times 1000 \times 9.81 = 28.21\ N$$

Net Force Calculation:

$$F_{net} = 5 \times 9.81 - 28.21 = 20.84\ (downward)$$

Total voltage= 10 V | Total current = 3.2

Total loads = 8

voltage for each load = 12 (Parallel Connections)

Current for each load = average of 0.4 A, as the daffier and total max of 3.2 A

Water Required Calculation for PEM Electrolyzer:

Electrolysis Reaction:
$2H_2O \rightarrow 2H_2 + O_2$

Hydrogen flow rate = 800 mL/min
At STP: 1 mol H_2 = 22.4 L
Moles of H_2 = 800 / 22400 = 0.0357 mol/min

From reaction: 2 mol H_2O → 2 mol H_2
Moles of water required = 0.0357 mol/min

Mass of water = 0.0357 × 18 = 0.6426 g/min
Volume of water = 0.6426 g/min ≈ 0.643 mL/min

Final Answer:
Water required = 0.643 mL/min

Future Improvement

- Adding more water testing sensors.
- Making the submarine self-inspected.
- Integrating a testing sample room for further water analysis.
- Increasing the hydrogen production rate.
- Making use of the vented oxygen waste.

Conclusion

In conclusion, the project is aimed to solve the issue that is related to water tank inspection and operators' safety. Implementing an intelligent submarine system reduces reliance on manual labor, leading to significant cost savings in operational expenses, in addition to minimizing carbon footprint due to green hydrogen utilization, contributing to environmental sustainability, and integrating AI-driven submarine inspection with centralized data processing which ensure effectiveness.