Thermal Gradient Energy Harvester

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INTRODUCTION

What's a profiling float? *Oceanographic instruments that collect subsurface data, and sink/float in the ocean by changing its buoyancy. An Argo Float is an example*

- ***Drawback:*** *Currently, Argo floats are powered by four lithium battery packs - a third of this power is used by the buoyancy pump alone*
- ***Aim:*** *Design a conceptual engine to replace a buoyancy pump with one that harvests the ocean's thermal gradient, the temperature gradient between the ocean's warmer surface and colder depths*
- ***Why:*** *This work will help gain a viable renewable energy source for powering an unmanned, long-term data collecting device*

PROBLEM STATEMENT

➢ To improve thermal-to-hydraulic efficiency of a phase change material (PCM) engine to be a practical option for increasing the lifespan of Argo Floats

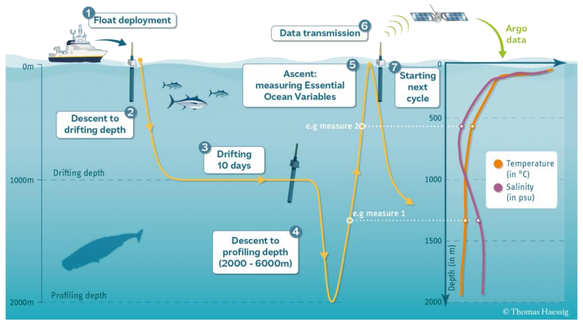

Figure 1: An Argo Float's typical profile [1]

CORE FUNCTIONS

An engine to change the buoyancy of a float to move vertically in the ocean

Secondary Functions

- *Withstand changing pressures of the ocean*
- *Designed for 150 cycles (go up/down)*
- *Operate in ocean temperature range 5-25 ° C*

DESIGN AND DEVELOPMENT

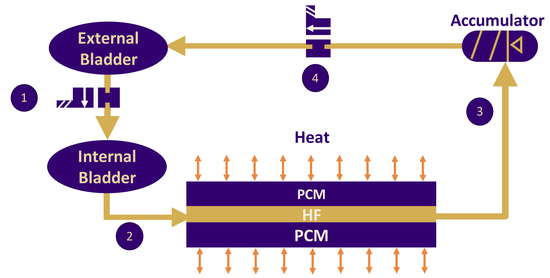

Figure 2: Flow Diagram of PCM Engine

Engine Concept Idea [2]

1. ***Float Descends:*** *Solenoid value opens, Hydraulic Fluid (HF) moves from External Bladder (EB) to Internal Bladder (IB)*
2. ***Water Temperature decreases & PCM solidifies:*** *PCM takes HF from the IB*
3. ***Float Ascends:*** *Solenoid valve opens, Accumulator pushes HF into EB*
4. ***Water temperature increases & PCM melts:*** *PCM pushes HF into Accumulator*

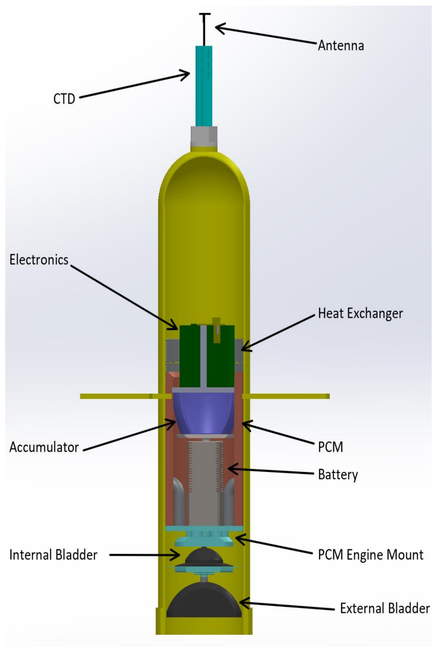

Figure 3: CAD Model of PCM Engine Argo Float

PCM Engine Model

- *Used ARGO float design as starting point*
- *Replaced hydraulic pump assembly with PCM engine*

Key differences

- *Engine does not rely on battery power, extra capacity can be used for additional sensors*
- *More internal volume may be available for more sensors*

RESULTS / VALIDATION

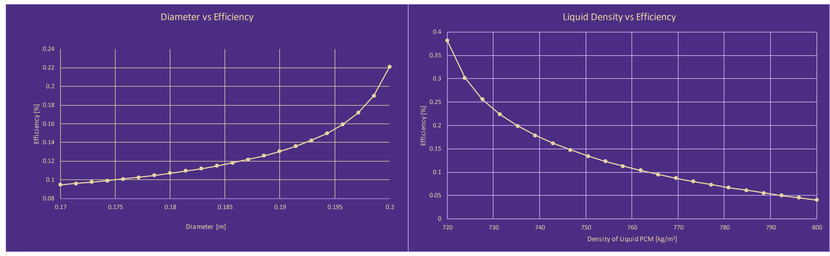

Figure 4: Plots of Efficiency vs. Liquid Density of PCM (hexadecane) and Outer Diameter of PCM Hull

We created a simplified MATLAB model of our system to analyze it. We created scripts to find optimal parameters for the system and understand how the system's parameters effects efficiency

- ***Plots*** *of parameters affecting efficiency*
- ***Sensitivity analysis*** *of parameters in hopes to double the current efficiency of 0.33%*
- ***Optimizer*** *to determine the most optimal geometric and material parameters*

CONCLUSION & FUTURE WORK

- ***Strengths****: Configurability*
- ***Weaknesses****: No physical model*
- ***Next stages of development:*** *Build a tabletop prototype to confirm results found in analysis*
- ***Modifications:*** *Electrical power used by sensors and frictional head losses through pipes and valves were not considered*
- ***Application:*** *Work can be used in any field that requires information about the water deep underneath the ocean surface*

Acknowledgements

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Citations: [1] "How do floats work," Argo. [Online]. Available: https://argo.ucsd.edu/how-do-floats-work/. [2] Y. Yang, Y. Wang, Z. Ma, and S. Wang, "A thermal engine for underwater glider driven by Ocean Thermal Energy," Applied Thermal Engineering, vol. 99, pp. 455–464, Jan. 2016.