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Autonomous Underwater Vehicle Thermoelectric Power Generation

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Autonomous underwater vehicles (AUVs) are a vital part of the oceanographer's toolbox, allowing long-term measurements across a range of ocean depths of a number of ocean properties such as salinity, fluorescence, and temperature profile. Buoyancy-based gliding, rather than direct propulsion, dramatically reduces AUV power consumption and allows long-duration missions on the order of months rather than hours or days, allowing large distances to be analyzed or many successive analyses of a certain area without the need for retrieval. Recent versions of these gliders have seen the buoyancy variation system change from electrically powered to thermally powered using phase-change materials, however a significant battery pack is still required to power communications and sensors, with power consumption in the region of 250 mW. The authors propose a novel application of a thermoelectric generation system, utilizing the depth-related variation in oceanic temperature. A thermal energy store provides a temperature differential across which a thermoelectric device can generate from repeated dives, with the primary purpose of extending mission range. The system is modeled in Simulink to analyze the effect of variation in design parameters. The system proves capable of generating all required power for a modern AUV.

Key words: Autonomous, vehicle, AUV, robotic, thermoelectric, harvesting

INTRODUCTION

Subsea exploration and data collection have been routinely carried out by autonomous underwater vehicles (AUVs) for decades, and before that by tethered autonomous buoys. Tasks involving direct interaction with the environment generally require remote operated vehicles (ROVs) or direct manual intervention and so have an easily accessible power supply either on a support vessel or carried on board in sufficient quantity.

AUV mission electronics are generally data logging systems that require little power for their primary tasks, but depending on their method of propulsion they may require significant battery stores for motion. Typical power consumption of conventionally (thruster device) driven AUVs range from 200 W to 2 kW.[1] For some years systems have been created using a buoyancy-based gliding system,[2] where the only power required to move the vehicle is that required to pump a small quantity of oil between two locations to affect buoyancy.

Some gliders take this concept further using purely the volume change in a phase-change material to alter their buoyancy, requiring no electrical power for propulsion.[3] This buoyancy effect allows the glider to both change depth and move forward, diving between the surface and up to 1500 m and at speeds of 30 km/day to 40 km/day.[4] These gliders still require a large battery system to store enough power to use the data logging systems, for guidance, and to operate the few mechanical actuators required to operate the buoyancy and direction control servos if fitted. These power requirements are on the order of watt-hours, but due to the

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