N232-107: Shipboard Carbon Capture and Storage

ADDITIONAL INFORMATION
N/A

TECHNOLOGY AREAS:
Materials

MODERNIZATION PRIORITIES:
General Warfighting Requirements (GWR)

KEYWORDS:
climate; carbon capture; combustion, absorption, membrane separation

OBJECTIVE:
Develop and demonstrate methods to capture carbon dioxide emissions from a ship's exhaust and store it onboard until it can be offloaded.

DESCRIPTION:
The Department of the Navy's recently released strategy, Climate Action 2030 [Ref 1], established aggressive targets to reduce Department-wide emissions of greenhouse gases. Despite recent advances in energy efficient technology, the Navy is still heavily reliant on fossil fuels for propulsion and power generation on its ships and aircraft, with surface ships consuming more than 12 million barrels of marine diesel annually. Achieving net zero emissions will require a combination of approaches including alternative fuels, increased hybridization, and direct carbon capture both on installations and at-sea. The latter requires adaptation of stationary carbon capture technology for shipboard application. A number of post-combustion carbon captures technologies have been employed in terrestrial power plants, with chemical adsorption being the most mature. Exhaust gas is first cooled, passed through a filter, and then reacted with the absorbent, typically an amine-based solvent, to separate carbon dioxide before the exhaust is released to the atmosphere. The absorbent then goes through a regeneration process in which the CO_2 is released by heating, and the absorbent is recycled to the absorption process. In addition to requiring large machinery, the solvents are toxic and can degrade in the presence of other components common to a marine exhaust. Adsorption of CO_2 into a solid matrix can alleviate the need for such solvents, but is less selective as absorption. Membrane separation systems are potentially more compact and efficient, but long-term durability has not been demonstrated. Another challenge is shipboard storage of the captured CO_2. Storage in gaseous form is often not practical due to space requirements and conversion to liquid or solid require significant power.
Innovative research is sought to develop compact approaches to capture and store carbon directly from shipboard exhaust, while minimizing impact to current ship systems. Systems resulting in a net reduction in carbon emissions greater than 75% are sought, while minimizing impact on efficiency. Net carbon reduction includes extra emissions from power needed to run the system. The most common propulsion system used in Navy surface combatants is F76 fueled LM2500 gas turbines that produce up to 150 lbs/s of 1050 °F exhaust. The system must be able to store at least two weeks' worth of removed carbon for transfer during ship refueling. Storing captured CO_2 as a liquid or solid (dry ice) has significant volumetric advantage, but requires additional power. Possible alternatives such as liquid mixtures or mineral carbonization could be evaluated.

PHASE I:
Develop an innovative, compact, and energy efficient approach to capture and store carbon dioxide from post-combustion exhaust from a gas turbine engine typical of Navy surface combatants. Analyze the size, weight, and power consumption of complete system. Perform an initial estimate of system cost.

PHASE II:
Demonstrate a working prototype of the system sized at least 1/50th of an LM2500 exhaust at full power. Experimentally validate the unit's performance over a variety of exhaust conditions. Assess operational impacts of proposed technology. Complete a cost and scalability analysis of full-scale system.

PHASE III DUAL USE APPLICATIONS:

Optimize the concept design for manufacturability, performance, and military requirements using the knowledge gained during Phases I and II. Perform a detailed integration study for installation on a Navy surface combatant. Develop a commercialization strategy for dual use on commercial maritime vessels.

The system could be used in commercial maritime vessels.

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