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Developing Compact Capture Technology for Removal of CO_2 from NL Offshore Oil and Gas Production Facilities

Prepared by:

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in collaboration with

C-CORE

Aker Solutions Canada

and

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PROJECT SUMMARY OF RESULTS AND ACHEIVEMENTS

This project is organized with two partners working with M. A. Procense Inc. (MAPI), namely the Centre for Cold Ocean Resources (C-CORE), and Aker Solutions. The scope was broadened to include particle separation with the assistance of an academic consultant, Dr. Vlasta Masek

It is a comprehensive investigation into the use of supersonic nozzles in carbon capture from exhaust flue gases from machinery burning hydrocarbon fuels. The main objective of this project is to optimize the design and performance of the nozzle for offshore applications in which weight and footprint are at a premium. The MAPI and C-CORE part of the project explores nozzle design alternatives through a combination of computational fluid dynamics (CFD) simulations and physical experiments in a laboratory set up at C-CORE.

The experimental and CFD part of the project consisted of the following:

- An extensive literature review on supersonic nozzles for different applications.
- Experimental and CFD simulations were compared with existing, and 3D printed supersonic nozzles to validate the literature.
- CFD exploration of alternative nozzle designs to achieve low temperatures. Lower temperatures allow the formation of CO_2 particles that may be extracted from the main gas flow using centrifugal acceleration, thus, enhancing CO_2 separation.
- Four nozzles were designed, simulated using CFD, and tested in the laboratory.
- Advanced instrumentation was utilized to measure several pertinent variables including, pressure, mass flow rate, temperature, particle size, particle count, flow velocity, as well as particle imaging.
- Separation rates were determined for different particle sizes using CFD simulations.
- Particle size frequency distributions were established to validate experimental CO_2 separation rates with those found for different particle sizes using CFD.
- Several important discoveries were made during the project including:
    - Significant sensitivity of the separation rates for smaller particles in relation to the throat size of the nozzle.
    - The length of the straight part of the nozzle is imperative to ensure adequate residence time for CO_2 droplets and particles to become sufficiently large for separation through the nozzle bend and into the CO_2 extraction exit.
- Work was also done at the end of this phase in preparation for the next phase of the project

MAPI and Aker Solutions looked at the possible implementation of this technology as a retrofit on an offshore floating production storage and offloading (FPSO) vessel. The expertise and experience of Aker Solutions was employed for comprehensively gathering all preliminary information for this work. Their work investigated the following:

- The additional equipment needed to get the flue gases to the desired condition for injection into a bank of supersonic nozzles.
- Existing energy sources on the platform useable for driving necessary equipment.
- Space requirements and means of connecting to existing systems.
- Added weight needed for the equipment and additional structure for the retrofit.
- Estimation of costs associated with the retrofit and its operation.

This information can be used as a starting point for an industrial implementation in which there would be implications for:

- FPSO vessel stability and trim.
- Necessity for permanent ballast.
- Reduction in maximum produced oil storage capacity.
- FPSO vessel longitudinal strength considerations through likely needed modifications to oil storage tank filling and offloading patterns.

The scope was broadened to include particle separation with the assistance of an academic consultant, Dr. Masek. Dr. Masek and his associates provided valuable insight in use of electromagnetic separation of charged particles. These results were organized and presented.

This first phase of the project has more than exceeded expectations in creating the basis for this technology to achieve more than competitive performance both on a technical and an economic basis. The path forward to creating an efficient nozzle design which achieves separation rates well over 90%, and possibly close to 100%, is seen as more than feasible in the next phase. These outcomes render the project on track for proto-typing and commercialization stages. It has also been shown that the retrofit on the existing offshore facility investigated in this project (example offshore FPSO) could be challenging. For land-based facilities a retrofit would be possible, but the cost would depend on the design and layout of the facility. Implementation on a new facility offshore or onshore would be the easiest, however, retrofits of existing facilities will likely be the primary market initially.

PROJECT COST INFORMATION

Natural Resources Canada’s Emission Reduction Fund, Offshore RD&D program, provided $1,445,465 to complete this project.