Energy Transition: The Promise of Desiccant Evaporative Cooling for Net Zero HVAC Onboard Ships

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ABSTRACT

In recent years, there has been increased importance of carbon-neutral technologies and cleaner seas for the maritime world. This is highly relevant across the globe considering that the shipping industry itself forms the 6th largest emitter of CO_2, with HVAC systems contributing to an average annual GHG emissions of 18.2 million carbon dioxide equivalent tons from ships. The IMO also formulated a comprehensive strategy in Jul 2023, which targets net zero GHG emissions by 2050. This would be a major challenge for the air-conditioning industry, considering the high humidity levels at sea.

This research paper therefore describes an integrated desiccant coated M-cycle cooler, with a detailed proof of concept and experimental prototype setup. The experimental setup consists of a channel type heat exchanger, with alternate channels used for dry and wet air passages. The channels are coated with silica gel desiccant on the dry side, which dehumidifies the inlet air. A part of the inlet air is branched in to the wet side using U-type branching and exhaust blowers, where evaporative cooling takes place. This enables simultaneous cooling and dehumidification of air, using a single heat exchanger. Regeneration of the saturated silica gel desiccant is possible through the waste heat of diesel generators, thereby not requiring any electricity consumption, unlike the present system.

Experimental performance analysis reveals that the system dew-point effectiveness increases at higher inlet air temperature and humidity ratio. Higher branching ratio and lower water temperatures also cause an increase in dew-point effectiveness and dehumidification capacity. A maximum of 2.1 kW cooling capacity is achieved at a channel velocity of 3m/s. The experimental results therefore highlight the possibility of using a simultaneous adsorption-evaporation system for compact and eco-friendly air-conditioning applications on-board ships.

System drawings and experimental / fabrication photographs have been provided in the next page for reference.

Keywords: Desiccant coated M-cycle cooler, system performance, regeneration temperature, experimental setup, net zero air-conditioning.

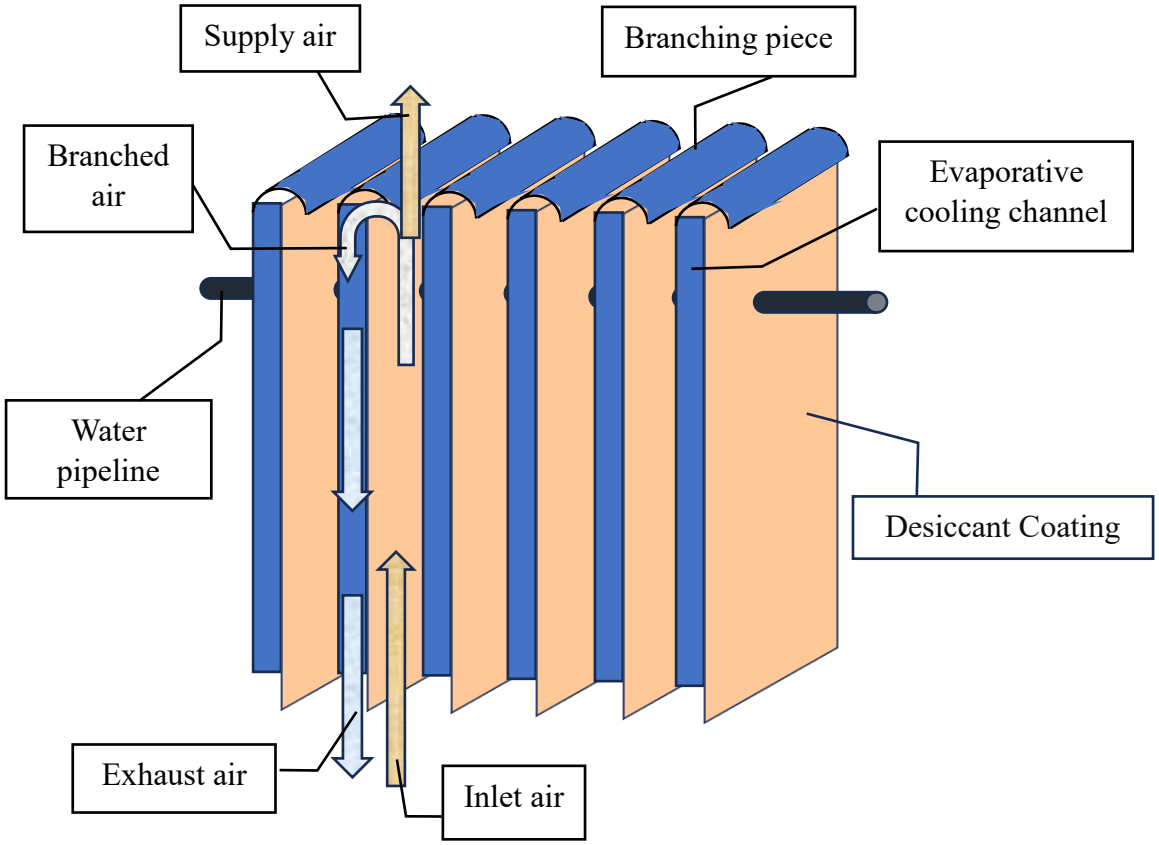

Fig. 1. Schematic of system

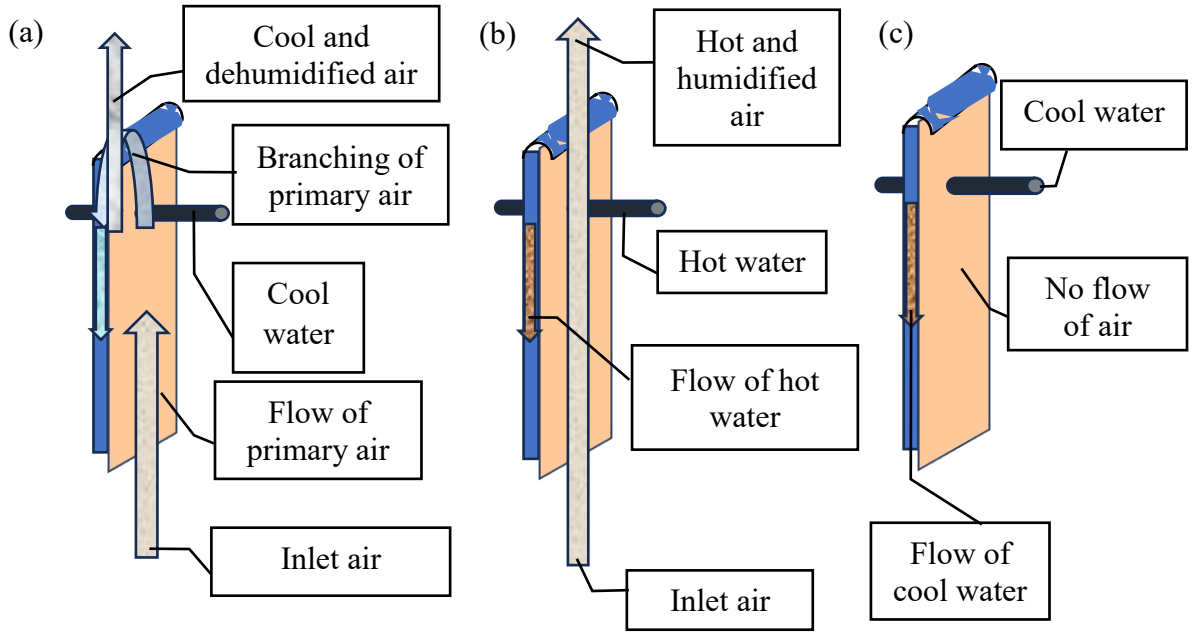

Fig. 2. Working principle in (a) DD (b) Regeneration and (c) Cooling stages

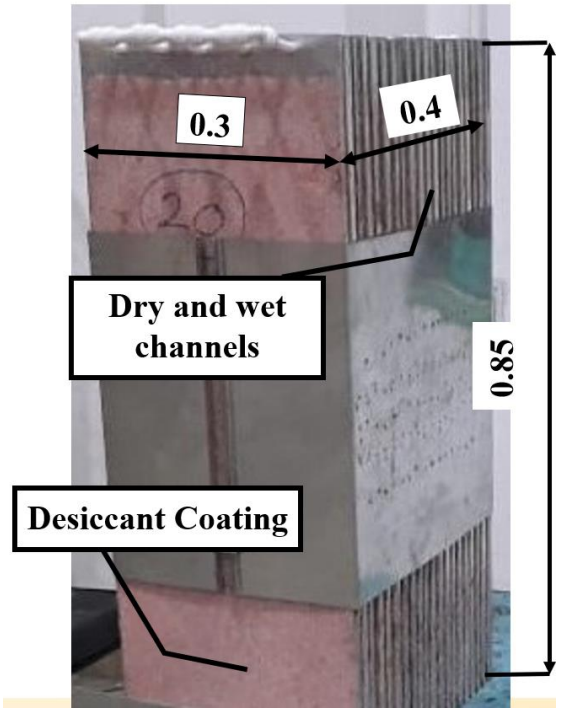

Fig. 3. Fabricated system (a) assembly and (b) ducting

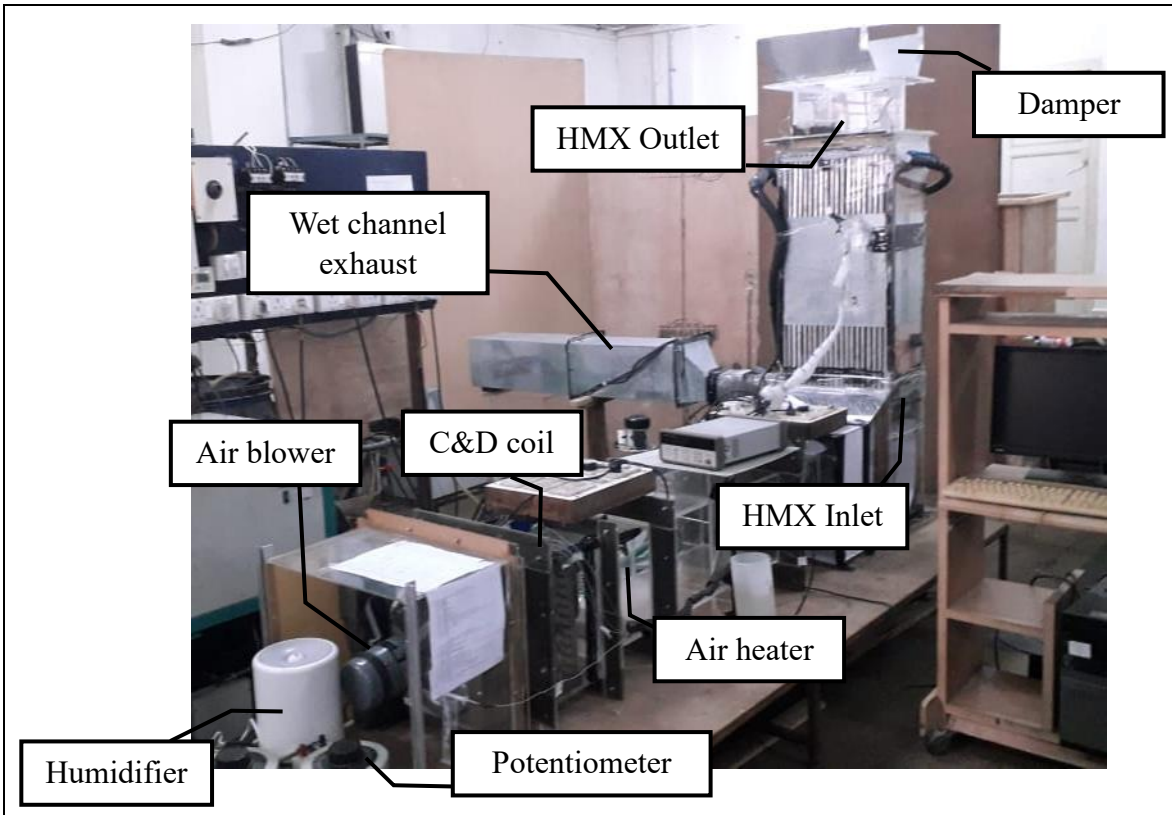

Fig. 4. Experimental setup