OAK RIDGE National Laboratory | BUILDING TECHNOLOGIES RESEARCH AND INTEGRATION CENTER

Novel Heat Exchanger Design Based on Porous Materials (CRADA Baltimore Air Coil)

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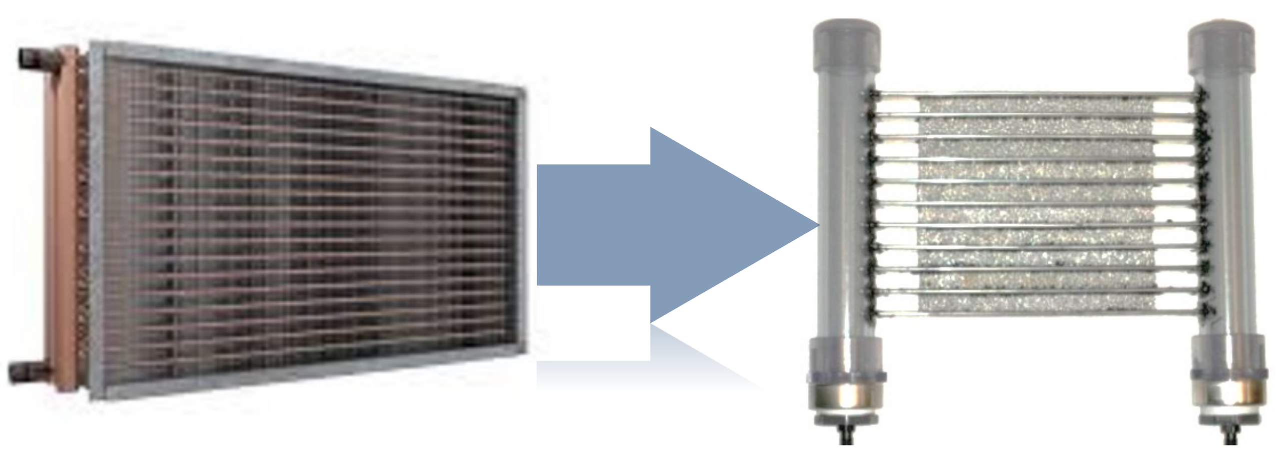
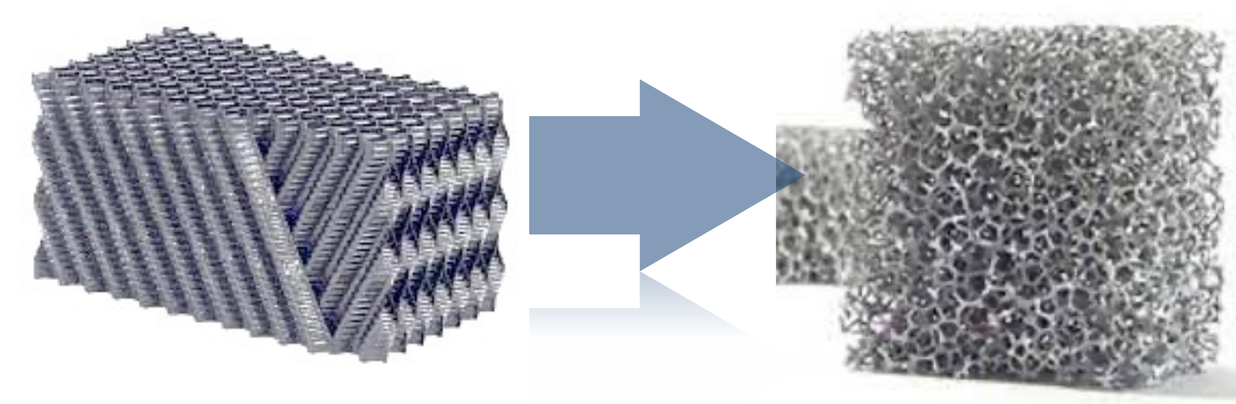
Summary Statement

The evaporative cooling process has been successfully deployed in multiple energy conversion processes, such as power generation, process cooling, HVAC, and commercial and industrial refrigeration

- Packing media is key to the performance of direct and indirect evaporative coolers:
  - Increase in surface area and residence time
  - Enhancement of flow mixing—increased heat and mass transfer
  - Conventional technologies rely on *nonmetallic* structures
  - Carry-over is unavoidable owing to structure (5%–10% loss owing to carry-over)
- A novel heat exchanger design based on porous materials is a next-generation hybrid solution for direct/indirect evaporative cooling processes



Replacement of conventional heat exchanger with novel design

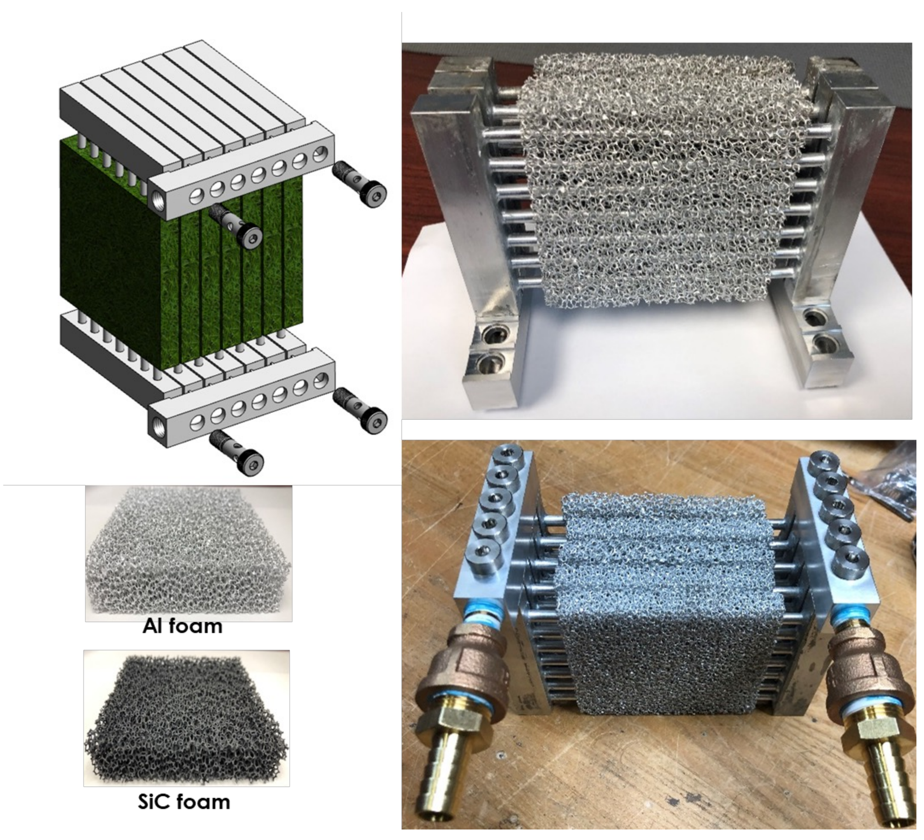


Deployment of fill material with large surface area

Current Research

Prototype development

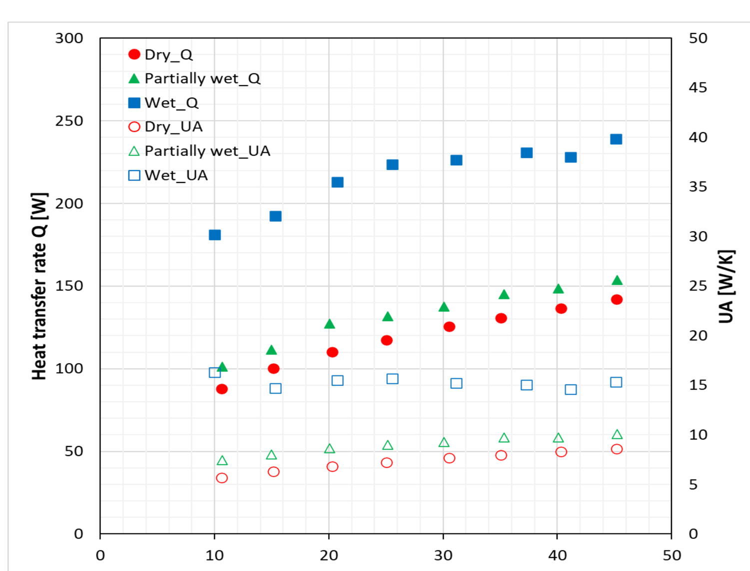
- Foam-and-tube heat exchanger
- Flexible capacity

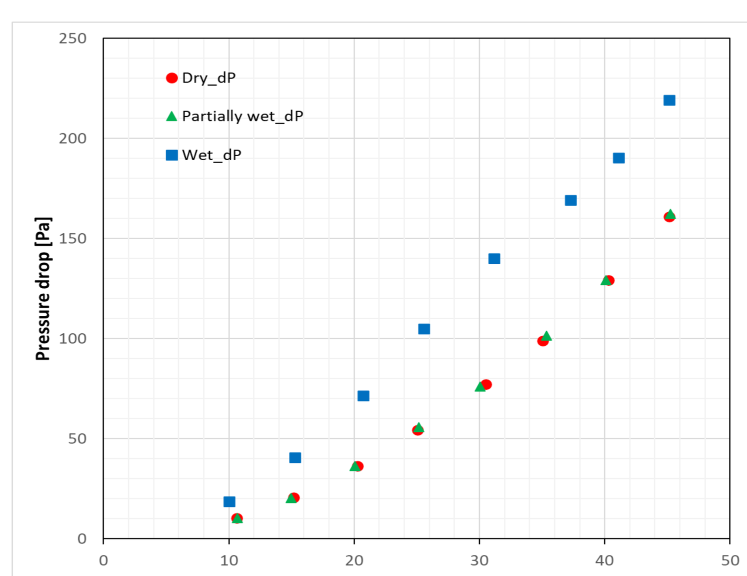


Thermal-hydraulic performance

- An open-loop wind tunnel in an environmental chamber
- Test conditions:

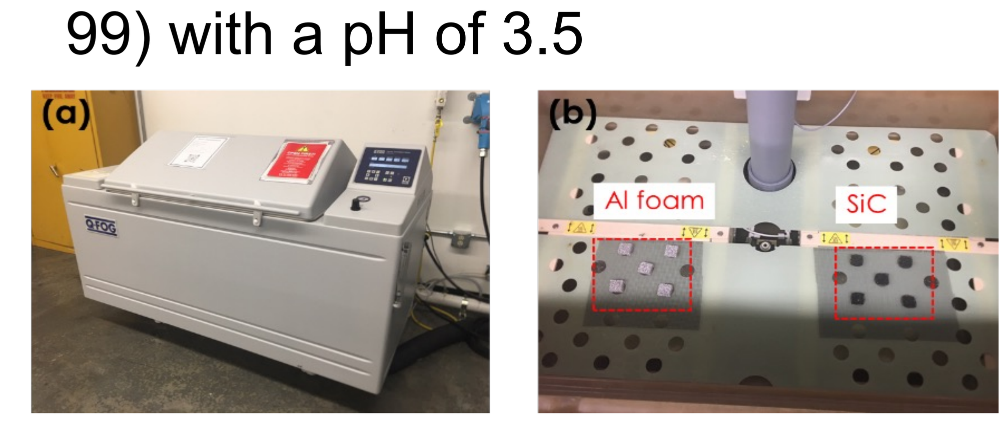
Conditions	Dry	Partially wet	Fully wet
Dry-bulb temperature of the air at the inlet [°C]	19°C	27°C	27°C
Relative humidity of the air at the inlet [-]	35%	45%	70%
Inlet water temperature[°C]	39°C	7.5°C	7.5°C
Mass flow rate of the water at the inlet [kg/min]	0.9	0.67	1.5





Durability assessment

- Cyclic corrosion test using Q-fog CRH600 tester
- ASTM G85 standard
- Synthetic seawater (ASTM D1141-99) with a pH of 3.5



Al foam before test (g)	Al foam after test (g)	Mass change (%)	SiC before test (g)	SiC after test (g)	Mass change (%)
1.798	1.783	-0.83	1.4913	1.489	-0.15
1.826	1.802	-1.31	1.6464	1.638	-0.51
1.727	1.712	-0.87	1.6115	1.608	-0.22
1.847	1.833	-0.76	1.6085	1.607	-0.09
1.773	1.76	-0.73	1.4438	1.442	-0.12
Average		-0.90			-0.22

Future Research

- Development of large-scale heat exchanger prototypes
- Durability assessment under field operating conditions
- Development of cost model and life cycle cost analysis
- Risk mitigation strategy for scaled-up solutions
- Field deployment and performance analysis over an extended period

Project Impact

- Ultracompact infrastructure to control the air temperature (>30% reduction in size)
- At least 30% reduction in water usage for competing capacity
- At least 50 Mt emissions reduction owing to improved performance
- At least 800 TBtu energy savings in air-conditioning technologies