Simon Fraser University
Laboratory of Alternative Energy Conversion (LAEC)

SFU Surrey campus
New program: Sustainable Energy Engineering

- Program launch in 2019
- 320 undergraduate and 100 graduate students

Now Hiring!

Sustainable Manufacturing, Clean Power Generation, Smart Cities, Transportation, Cleantech, Renewable Energy, Sustainable Food and Water Solutions
Sorption chillers (systems, low pressure evaporators, heat exchangers, materials)

Thermal energy storage

Fuel cells (CL, GDL, transport phenomena, ex-situ testing of thermal conductivity and gas diffusivity of thin films)

Power electronics cooling (e.g. light electric vehicle battery changers)

Greenhouses (sustainable temperature and humidity control, upcoming installation of small solar thermal and PV)

District heating

Graphite heat sinks, heat exchangers, and thermal interface materials

Heat and humidity recovery modules for building ventilation

Dehumidification

Atmospheric water harvesting

Waste heat recovery

Thermal management of batteries
The Lab
Sorbent materials

Composite sorbent coated on graphite substrate for heat transfer test

Sorbent for “VENTIREG” cold climate ventilation heat and humidity recovery tests

CaCl₂ composite sorbent for dehumidification

Sorbent on heat exchangers for sorption chiller tests: Z02 coating, Z02 pellets, empty heat exchanger and CaCl₂ composite
Material characterization

- Salt, silica gel, binders and thermally conductive additives are combined to create sorbents for a range of applications.
- Water vapor sorption (isotherms, heat of adsorption), pore structure, thermal properties (dry & wet), and pressure-jump sorption dynamics.

"Hot disk" sensor
Heat flow meter test sorbent pellets

Composite "A3"
Sylobead B127 silica gel
Z02
Lab-scale sorption chiller

Lab-scale sorption chiller with two sorber beds (1,2), condenser (3), CALPE evaporator (4), valves, sensors and heating/cooling (H/C) circulators.

**Z02 Coating (0.8 kg per HEx, 10 min cycle)**
SCP = 472 ± 8 W/kg, COP = 0.27

**Z02 Pellets (1.97 kg per HEx, 15 min cycle)**
SCP = 130 ± 10 W/kg, COP = 0.28
Capillary-assisted low pressure evaporator

- Water-based sorption systems operate at low pressure and require thin film evaporators
- Developed low pressure evaporators and custom-built apparatus for measuring their heat transfer performance
- Developed method to determine porosity and surface roughness of metal coatings

<table>
<thead>
<tr>
<th>Evaporator Type</th>
<th>Cooling Power</th>
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<tbody>
<tr>
<td>Porous copper evaporator</td>
<td>0.3 kW/kg</td>
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<tr>
<td>Sintered aluminum evaporator</td>
<td>1.2 kW/kg</td>
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Thermal spray porous copper coating on finned tube heat exchanger

Direct metal sintering of finned aluminum microtube heat exchanger
Manufacturing heat sinks and heat exchangers from natural flake graphite

Low cost Material

Roll embossing (mass production)

Light weight

Good cooling performance

Corrosion resistant

Graphite heat sink had comparable performance to aluminum + TIM
Greenhouse Research Collaboration

Three year project (2017-2018):

- Assess energy consumption of local greenhouses
- Model greenhouse climate control
- Test energy efficient climate control systems in a research greenhouse compartment
The LAEC has developed new composite sorbents, adsorber beds, capillary-assisted low pressure evaporators and a modular lab-scale sorption chiller.

Future research includes:

- Lab-scale single chamber sorption chiller
- Sorber bed heat transfer modeling
- Composite sorbents
- Compact capillary-assisted evaporators
- Graphite heat exchangers
- Testing systems for sustainable temperature and humidity control in greenhouses

Thanks
Extra slides
J. M. Cullen, et al., “Reducing energy demand”,
The food cold-chain

World population: 7.3 billion

Food losses due to lack of refrigeration: 25%

Projected population: 8.5 billion by 2030

Developed countries:
627 refrigerators per 1000 people

Developing countries:
70 refrigerators per 1000 people

How much power would be required to provide cold storage to this portion of the world population?

Sorption Chiller: Comparison of AQSOA™ FAM-Z02 sorbent coatings and pellets

Operating conditions: $T_{\text{evap}} = 15 \, ^\circ\text{C}$, $T_{\text{cond}} = T_{\text{ads}} = 30 \, ^\circ\text{C}$, and $T_{\text{des}} = 90 \, ^\circ\text{C}$

Z02 coating 0.8 kg per HEx  
Z02 pellets 1.97 kg per HEx

Heat transfer measured at the evaporator

$$Q_{\text{evap}} = \int_0^\tau m c_p (T_{\text{in}} - T_{\text{out}}) dt$$

Coefficient of performance

$$COP = \frac{Q_{\text{evap}}}{Q_{\text{heat}}}$$

Specific cooling power

$$SCP = \frac{Q_{\text{evap}}}{(m_{\text{ads}} \cdot t_{\text{cycle}})}$$

Volumetric cooling power

$$VSCP = \frac{Q_{\text{evap}}}{(V_{\text{ads}} \cdot t_{\text{cycle}})}$$
Manufacture of heat sinks from natural graphite sheets

Heat transfer in the base limited by the low thermal conductivity and sheet-to-sheet contact resistance.

Optimal geometry for a graphite heat sink will differ from metal.