OAK RIDGE National Laboratory | BUILDING TECHNOLOGIES RESEARCH AND INTEGRATION CENTER

Analysis of Frost Formation and Novel Defrost Techniques for Commercial Refrigeration Applications

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Problem Statements and Objectives

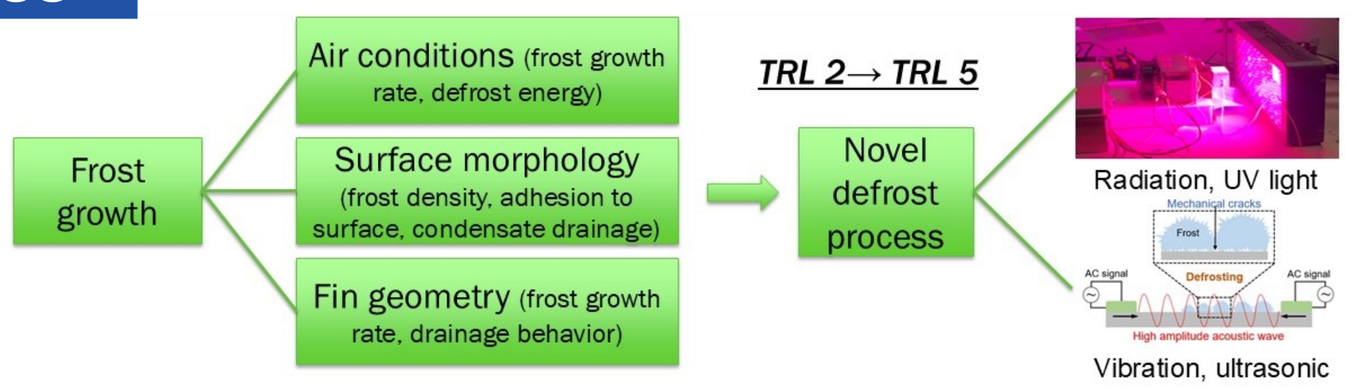
- Frost growth presents a challenge for both commercial refrigerators/freezers and cold-climate heat pumps
- Frost buildup degrades energy efficiency, and the defrosting process consumes additional energy, accounting for 15%–25% of annual electricity consumption
- State-of-the-art frost mitigation methods have limited applications because of scalability, durability, and cost issues

This project develops an understanding of frost growth and demonstrates scalable and cost-effective defrosting.

Frost buildup in a walk-in freezer and cold climate heat pumps

Research Approach and Progress

- Radiation-based defrosting and vibration-based defrosting can provide novel approaches with significantly lower energy consumption
- Continuous or intermittent defrosting processes
- Key research tasks
  - Characterize the frost growth on various surfaces
  - Analyze the feasibility of practical applications

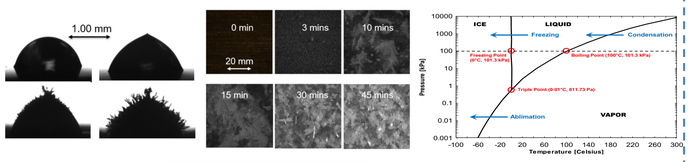


Fundamental Research

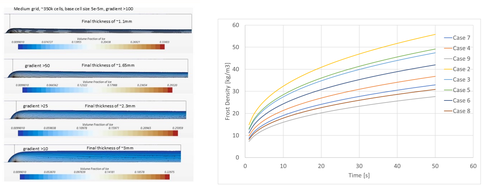
- Overview of existing technology
  - Cycle-interruption defrosting process

Method	Compressor	Thermal source	System complexity	System stability	Defrost effect	Scalability	Efficiency degradation
Compressor shutdown	OFF	Ambient air	Low	High	Low	High	Moderate
Electric heater	OFF	Electric power	High	High	High	Moderate	High
Hot gas bypass	ON	Electric power	Moderate	Moderate	Moderate	Low	Moderate
Reverse cycle	ON	Electric power	High	Low	High	Low	High

- Frost growth on a cold plate

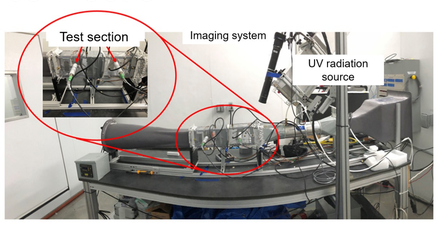


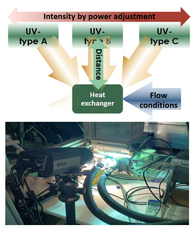
- CFD analysis



Experimental System

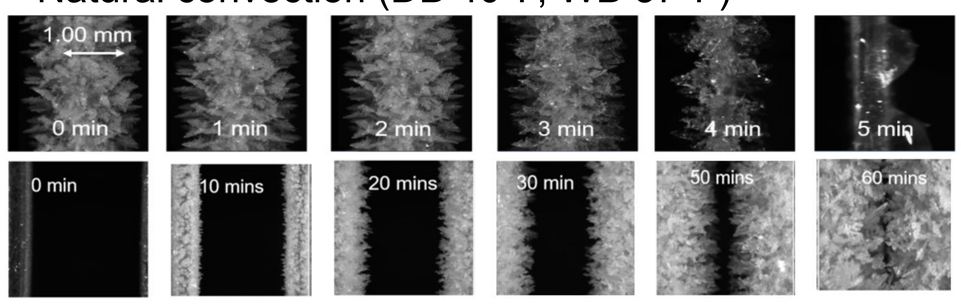
- An open-loop wind tunnel placed in a controlled environmental chamber
- Experimental classifications
  - Frost growth process
  - Natural/forced-convection defrosting
  - Radiation- and/or vibration-assisted defrosting process without natural/force convection



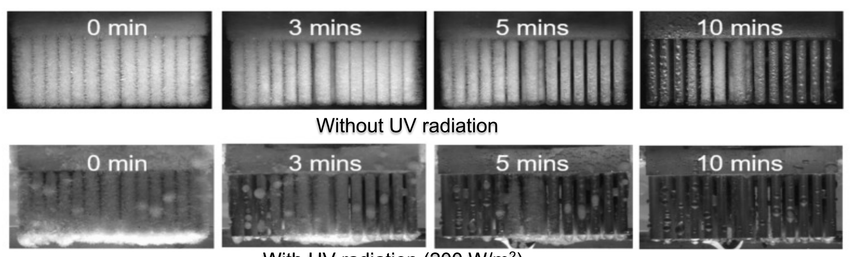


Frost Growth and Defrosting Process

- Natural convection (DB 40°F, WB 37°F)



- Forced convection (1 m/s)



Future Works

- Assess various types of radiation for their potential use in defrosting
- Conduct a comprehensive study of the characteristics of radiation (wavelength, view factors, intensity, etc.) on the characteristics of frost (density, thermal conductivity, thickness, etc.) with and without natural/forced convection
- Assess the vibration-based defrosting technology
- Construct and install developed defrosting technologies for field performance evaluation
- Develop a commercialization plan based on lab-scale and field-level assessments

https://solutions.rdtonline.com/blog/the-impacts-of-icing-in-your-commercial-freezer

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