Enhancing Steam-Side Heat Transfer via Microdroplet Ejection

Lance Brockway, Nelumbo – 2020 Project Review Meeting

Project Description and Objectives

- The objective of this project is to use droplet ejection condensation to enhance shell-side heat transfer
- This advancement can potentially reduce the cooling water requirements by **up to 40%** and improve power plant conceptual designs
- Power generation in the US withdraws an estimated **~200B gallons** of water per day and is the primary source for water usage in the country. Can it be reduced?
- Current Status of project
  - Heat transfer coefficients have been increased **>40%** relative to bare surfaces using optical characterization in air
  - Vacuum steam condenser has been constructed and calibrated - testing initiated
  - Industry/input– There has been little interest in Rankine condenser improvements - Most conversations with industry lead to other areas of the power plant.

Project Update

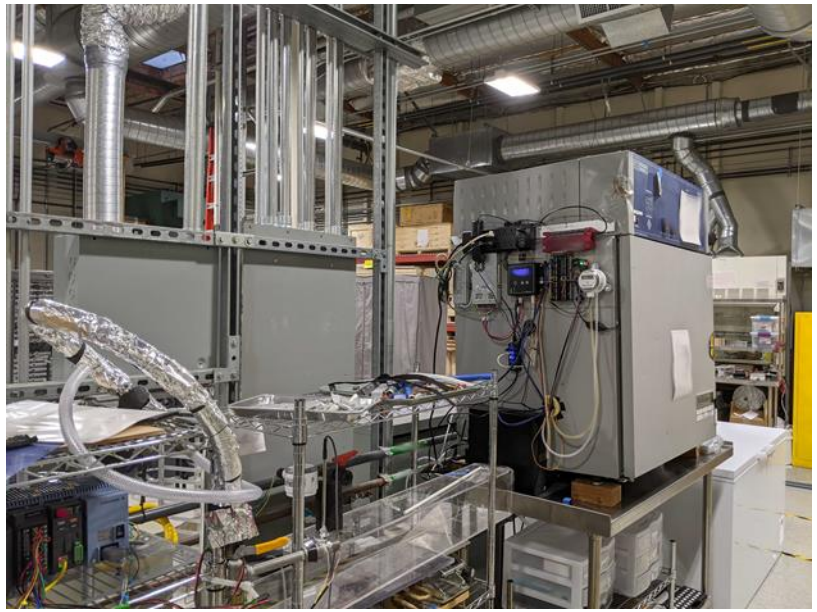
Materials

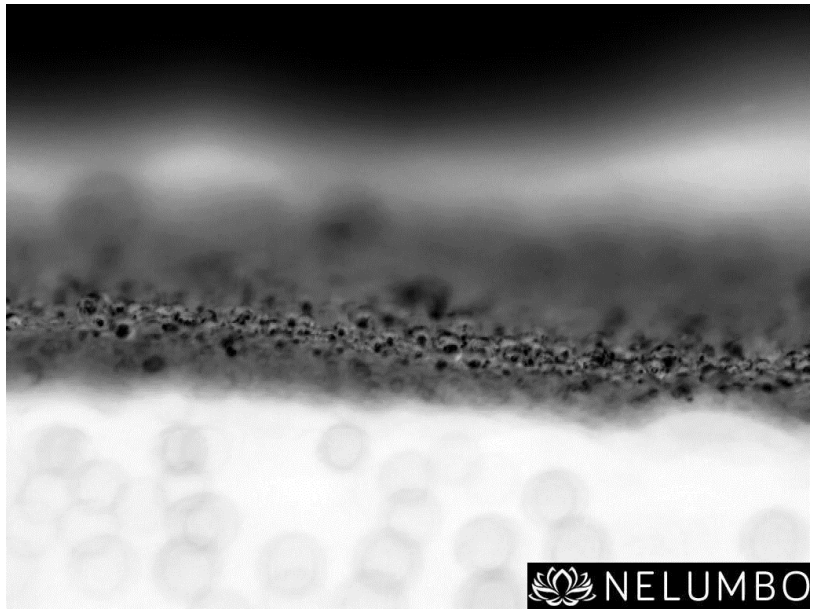
- Droplet ejection performance extended from aluminum alloys to stainless steel and copper alloys
- Durability tests performed
- Surface modification process optimized for tube geometry
- Pilot-scale apparatus built and calibrated on 304 and 316 tubing

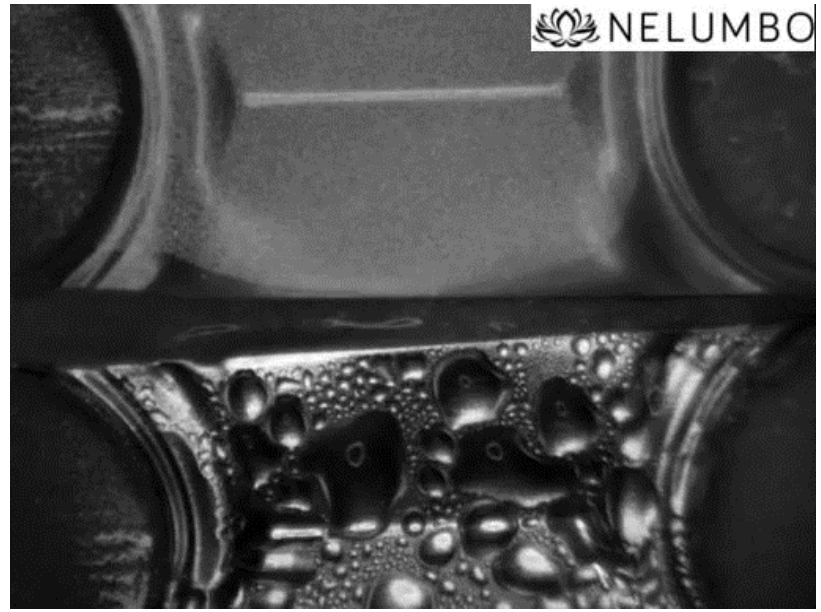
Project Update

Air Testing

- Heat transfer coefficient improved by over 40% in air
- Mechanism maintained through high degree of saturation
- Potential issue recognized moving forward: fouling



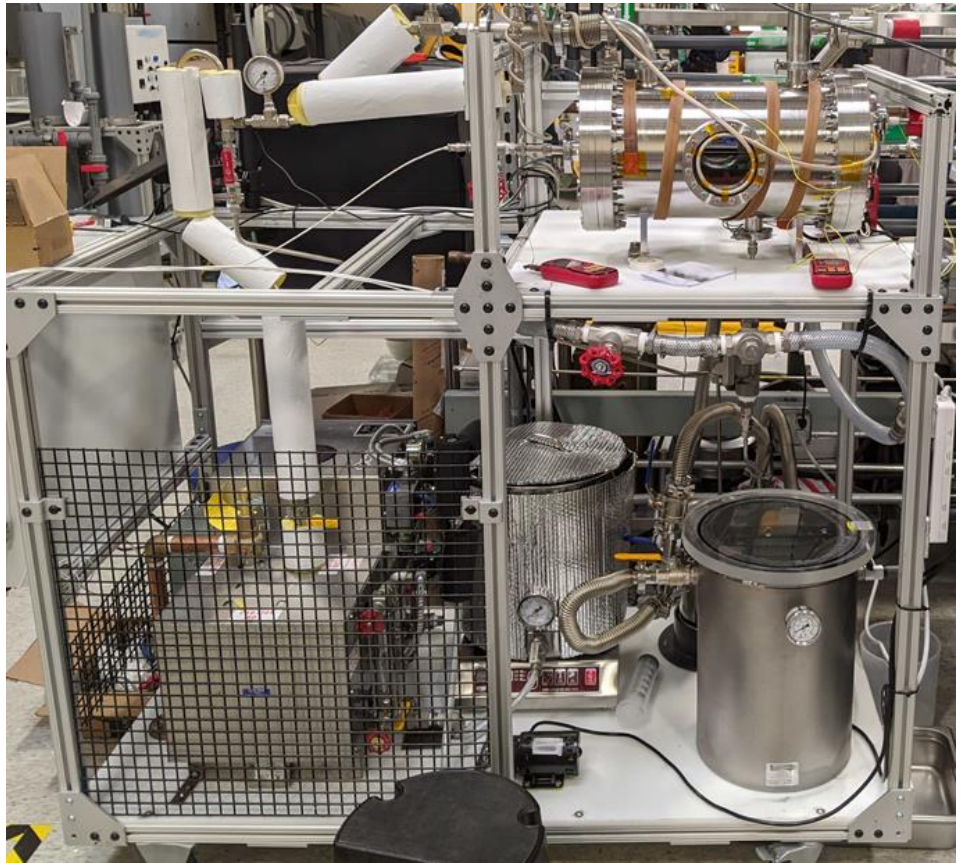




Project Update

Vacuum Testing

- Rankine steam condenser built and calibrated
- Bare tube results consistent with theoretical predictions
- Testing to be started on modified tubes Q12021
- Potential issue: high supersaturation reverting to dropwise condensation



Preparing Project for Next Steps

Market Benefits/Assessment

- Surface modifications can greatly enhance Rankine condenser performance
- This technological advancement can potentially save about **160k gallons of water per minute** valued with an annual savings of about **$12MM per gigawatt** of steam power generated

Technology-to-Market Path

- Path: This technology can be commercialized by partnering with condenser manufacturers or plant developers for development and testing
- Limitations: Field testing of the technology is required to enter the market
- Opportunities: The condensation of water drives corrosion and microbial growth. Keeping surfaces dry has become increasingly important due to current global conditions. Antifouling surfaces have also been of recent industrial interest
- Status: We are currently working with industrial suppliers & service providers, HVAC manufacturers, and textiles suppliers to bring our technologies to market

Concluding Remarks

- Our technology can potentially reduce the cooling water requirements by **up to 40%** and improve power plant conceptual designs
  - Due to our low cost and scalable application methods, our technology can be used to realize the full value of domestic energy resources
  - This can be addressed through increased efficiency plant efficiency and water conservation
- The next steps for this project are to establish the limitations of operation within the Rankine condenser and to map the tube performance
- This data will be used within a model created by LBNL to predict efficiency improvements and water savings of a Rankine cycle power plant