Improved Braze Joint Quality Through Use Of Enhanced Surface Technologies

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

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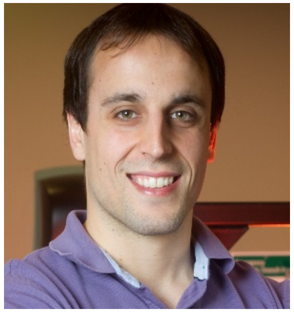
University of Illinois Team



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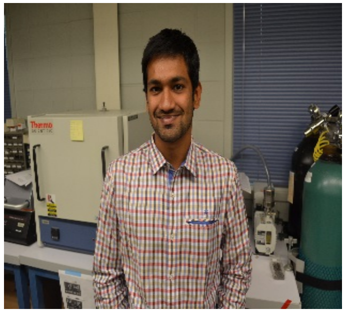
Co- PI



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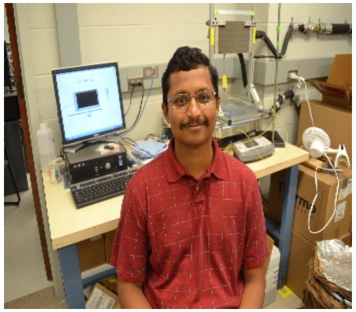

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University of Illinois' Energy Transport Research Lab's research intersects the multidisciplinary fields of thermo-fluid sciences, interfacial phenomena, and renewable energy. We aim to bring about transformational efficiency enhancements in energy (power generation to oil and gas to renewables), water, agriculture, transportation and electronics cooling by fundamentally manipulating heat-fluid-surface interactions across multiple length and time scales. The focus of our research is directed towards both:1) fundamental research on micro/nanostructured surfaces for phase change, interfacial phenomena, and electro kinetics 2) applied research on devices and systems

"What If" Future or Problem Definition

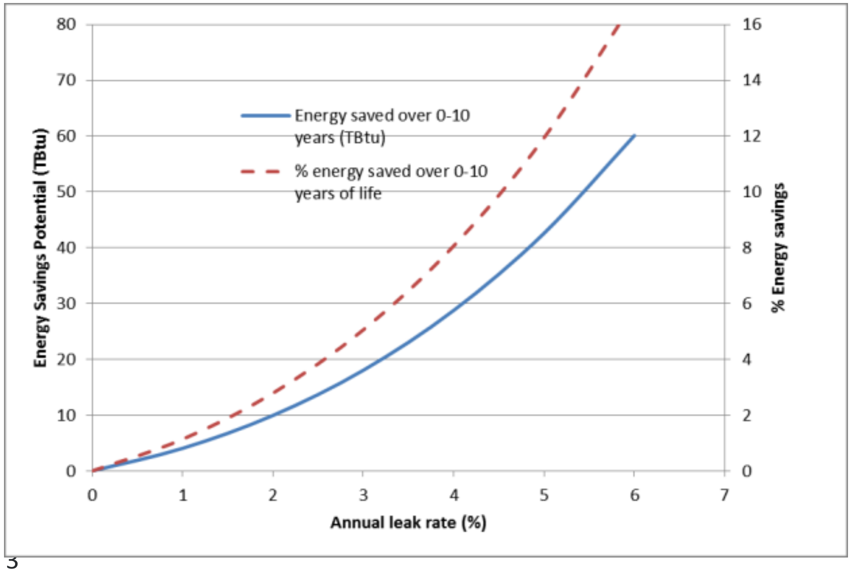
One of the causes of reduced efficiency on commercial and residential HVAC products is loss of refrigerant charge, which is typically a result of leakage through braze or solder joints. There are billions of braze joints within these HVAC products. These leaks directly create two detrimental impacts to society:

Direct global warming potential (GWP) emissions increase

Direct increase in energy use

Brazing has several issues that create variation in the HVAC equipment manufacturing process:

- braze alloys have relatively high surface tension, which makes it difficult to spread over large areas, or climb surfaces
- it is difficult to evenly apply alloys into joints, thereby the joint strength suffers and cracks initiate during cyclic thermal loading.

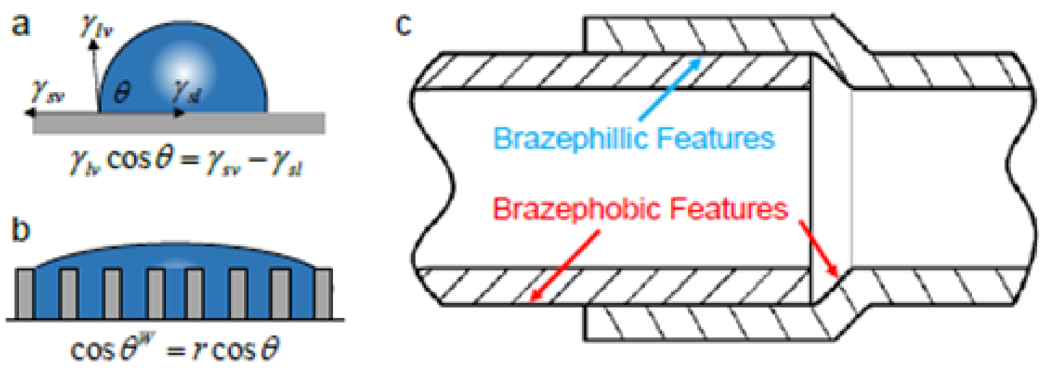


At an estimated annual leak rate average of 4% per year, energy consumption increases due to refrigerant leakage are as high as 30 TBtu over a 10 year span for just unitary rooftop products

Technology Solution

Proposal is to reduce the loss of refrigerant through braze joint leaks via enhancing braze joint strength and quality with micro engineered surfaces. The micro engineered surface structures would be used to wick braze alloy and flux to brazing joint areas to create stronger and more robust braze joints. These surfaces for brazing would be braze alloy/flux phobic or philic to help direct the brazing materials.

Due to the relatively low wetting contact angle of most braze alloys on smooth surfaces ($18 < \vartheta < 23^{\circ}$, Fig. a), the appropriate roughening of the surfaces to be joined can: 1) achieve enhanced capillarity and braze retention where it is needed (Fig. b), and 2) prevent braze from propagating to unwanted areas through liquid contact line pinning (Fig. c). The optimum roughness length scale and geometry will be engineered such that the capillary pressure inside the structures is maximized, while viscous dissipation of the melted braze-alloy is minimized, allowing



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Advantage, Differentiation, and Impact.

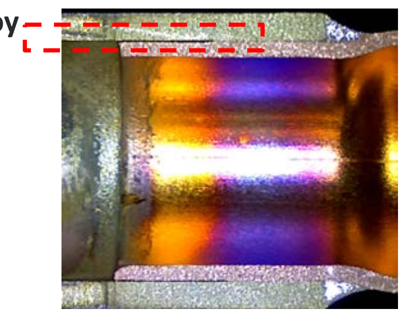
Design the optimum engineered surface microstructure for brazephilic and/or braze phobic surfaces that increase braze joint reliability through adequate wicking of braze materials

- Reduce braze joint leakage by 25% compared to state-of-the-art (SoA) brazing techniques
- Reduce braze material usage by 10% compared to SoA brazing techniques

Current Methods:

Variable processing to manage alloy movement enhancements:

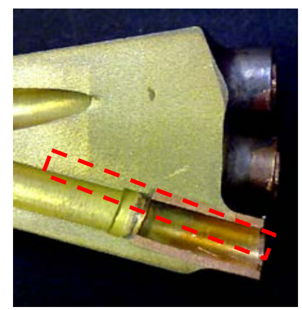
manual or chemical cleaning, gravity, & capillary action if fit up of mating parts correct will usually allow 50-70% penetration of alloy



Future Methods:

Controlled flow of alloy w/ surface

100% penetration



Oct 2016- Oct 2017: Determination of the optimum microstructure design & laboratory brazing examination

Assessment of micro structure enhancement candidates for further maturation

Complete performance testing and initial manufacturing assessment.

Oct 2017- Oct 2018 Manufacturing Readiness evaluation- (tooling, reliability evaluations, process capability)

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Thank You

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