Keynote Lecture 6

Opportunities and Challenges for Working Fluid Mixtures

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Dr. Reinhard Radermacher conducts research in heat transfer and working fluids for energy conversion systems — in particular heat pumps, air-conditioners, refrigeration systems, and integrated cooling heating and power systems. His work resulted in more than 600 publications, numerous invention records and 15 patents. He has co-authored three books. His research includes the development of software for the design and optimization of heat pumps and air-conditioners, which is now in use at more than 80 companies worldwide.

Dr. Radermacher holds a PhD in physics, is Minta Martin professor of Mechanical Engineering and director and co-founder of the Center for Environmental Energy Engineering. He was awarded the Institute of Refrigeration J&E Hall Gold Medal and the IIR Gustav Lorentzen Medal for his innovation in the field of refrigeration.

He is co-operating agent of International Energy Agency's (IEA) HPT Annex 53 project, is Fellow ASHRAE and holds memberships in ASME, SAE, DKV and IIR. He is lifetime member of IIR and ASHRAE, and is CEO of Optimized Thermal Systems. For 17 years was the editor of the ASHRAE journal, Science and Technology for the Built Environment.

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ABSTRACT

Pure component refrigerants are at times a poor fit for a given application. Furthermore, for most heat pumping, refrigeration and air-conditioning applications, the external heat transfer fluids such as air, water or secondary refrigerants experience a temperature glide in heat exchange with refrigerant. Thus, the temperature profiles within the evaporator and condenser can be poorly matched, leading to unwanted entropy production and reduced efficiency.

Refrigerant mixtures may be suited to address both of these challenges. By blending pure refrigerants properties such as vapor pressure, flammability, and others can tuned to more acceptable values. Furthermore, most fluid mixtures are of a zeotropic (or nonazeotropic) nature, meaning that during constant pressure evaporation and condensation the saturation temperature changes, creating a temperature glide. This represents a great opportunity to match heat transfer temperature profiles of the refrigerant mixture in the evaporator and condenser to that of the external fluid for potential energy performance improvement.

This presentation will give a brief overview of the key properties of refrigerant mixtures and discuss methods for optimum integration of mixtures in vapor compression heat pump cycles, such as the use of counterflow heat exchangers, intricacies of the temperature glide profile and their impact on performance, interactions with pressure drop, impact of various internal heat exchange methods and challenges for the use of mixtures in two-stage systems.

In addition, the challenges of handling refrigerant mixtures during manufacturing and service will be presented and discussed.