Design and Development of a Low Temperature Tube Calorimeter for Ammonia Refrigerant

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In 1987, with the ratification of the Montreal Protocol, the United Nations agreed that environmentally harmful refrigerants would need to be phased out. This decision has created a need for refrigerants with low global warming (GWP) and low ozone depletion potential (ODP). Ammonia refrigerant is promising in this regard because it possesses both of these characteristics and is also a naturally occurring compound. Unfortunately, ammonia is toxic and corrodes copper; thus it is not commonly used in HVAC systems. Recent government policies encourage the use of low GWP refrigerants and the interest in ammonia has grown since. However, there is a lack of information regarding the frictional pressure drop during two-phase flow phase change processes when ammonia is used inside the tubes of a heat exchanger.

In this project, a tube calorimeter is used to measure the differential pressure drop across a 180° U-bend. The calorimeter is constructed from 3/8", 3/4", and 1" stainless steel tubing with pressure transducer taps at specific distances. The bend radius to tube diameter ratio ranges from 1.2 to 2.5. Flow visualization data are recorded across the 180° glass U-bend using a high-speed camera and a pressure chamber. The data from this study are used to improve pressure drop models of ammonia.

Increased energy efficiency and more predictable heat transfer can be expected for heat exchangers that are designed using the new model. Because of this, ammonia has the potential to become an attractive refrigerant for wide usage in HVAC and refrigeration applications. Currently, the testing facility is nearing the end of construction and testing will be feasible late 2018.

Statement of Research Advisor:

Ford assisted in the design and construction of two heat transfer fluid loops and two refrigeration loops. Additionally, he was responsible for all design and construction of the test apparatus. The new test facility developed under this project will allow our research group to gather new data for pressure drops in U-bends of heat exchangers for ammonia refrigerant-based refrigeration systems. The facility isolates and quantifies the energy losses and inefficiencies associated with U-bends in heat exchangers.
—Lorenzo Cremaschi, Mechanical Engineering