Abstract

This project explores a crucial question in energy efficiency: how do changes in volume affect the performance of devices called volumetric expanders, which are used in energy systems to convert heat into useful power under two-phase conditions? Specifically, the focus is on understanding how these expanders work under different conditions, where both liquid and vapor phases of the working fluid are present, and how this impacts their efficiency and operation.

The main goals are to investigate how factors like the ratio of volume change (how much the fluid expands or contracts), the quality of the vapor, and the temperature influence the efficiency of these expanders as they move from handling a mixture of liquid and vapor to handling only vapor.

This project is innovative because it focuses on the wet expansion process, which is critical for the efficiency and performance of volumetric expanders. Although these technologies are becoming more popular, there is still a lack of detailed analysis that combines experimental data with advanced modeling techniques, especially concerning the transition from wet to dry expansion. Filling this gap is essential for improving the design and operation of energy systems that use these expanders. Analyzing how the multi-vane expander works under different conditions provides valuable insights. In two-phase conditions, the expander deals with both liquid and vapor phases, which involves significant changes in density. Understanding these changes helps identify inefficiencies such as leaks, pressure drops, and friction losses. The pioneering aspect of this project is its focus on the phase changes within the expansion process, specifically in multi-vane expanders. Previous studies have not thoroughly explored the dynamics of these phase changes. This research aims to fill that gap by providing new experimental data and insights.

The research methodology includes experimental tests, theoretical and numerical modeling, and AI-based predictions and analysis using techniques like artificial neural networks and deep learning. The project will run for 36 months, combining hands-on experiments with advanced AI methods to set new standards for studying and optimizing these energy systems. Successful completion of this project will enhance understanding of the wet-to-dry expansion process, addressing significant knowledge gaps in energy efficiency. The use of AI to predict and optimize efficiency represents a cutting-edge advancement, promoting AI applications in energy research. Improving the efficiency and reliability of multi-vane expanders will have direct benefits for small-scale power generation and refrigeration systems, leading to more energy-efficient and cost-effective solutions for industries and consumers.