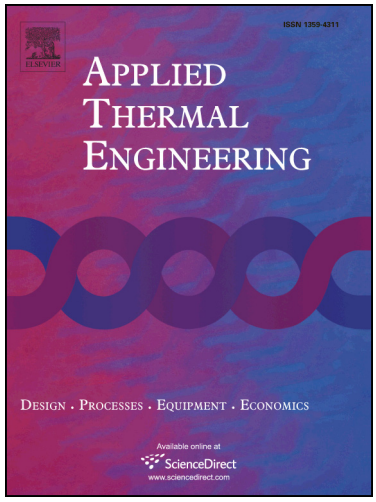

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Abstract

4% of the natural gas produced globally is flared at oilfields due to the absence of gas handling infrastructure and unfavorable economics. Recent work has proposed the utilization of this excess gas for atmospheric water harvesting (AWH) for oilfield operations, wherein gas-powered refrigeration cycles generate the cooling capacity for large scale dehumidification, via condensation. This work develops an indepth, comprehensive, analytical modeling framework to predict the water condensation in waste gas-powered AWH systems. Firstly, gas powered refrigeration systems are analyzed to identify key system parameters and considerations. Secondly, an analytical model is developed to capture the complex heat and mass transfer phenomena associated with condensation of humid air in a fin and tube heat exchanger. This involves using heat and mass transfer relations to estimate the dehumidification process line. The model can predict the water condensation rate as a function of the gas flow rate, ambient weather and the refrigeration system utilized. The model is used to predict flared gas-based water harvests in the Eagle Ford (Texas) and Bakken (North Dakota) Shale oilfields, which account for the majority of US flaring. Results indicate that 1 cubic meter of natural gas can condense 2.3 and 0.65 gallons water (on an annual average basis) in Texas and North Dakota, respectively. The weather-dependent condensation rates range from 3-10 (Texas) and 0-0.8 (North Dakota) gallons/day/square meter of condenser area. Overall, flared gas-based AWH can utilize 77% and 40% of the excess gas in Texas and North Dakota, respectively. This work analyzes various aspects of humid air condensation and evaluates the sensitivity of the condensation rate to key engineering parameters. Overall, this work develops the foundational modeling tool to predict the performance of all types of humid air condensation systems.

Keywords: condensation, heat exchanger, refrigeration, atmospheric water harvesting, flaring, natural gas