National Institute of Technology Rourkela

Synopsis Seminar

Seminar Title	: Design and Development of Hollow Fiber Membrane Based Liquid Desiccant Dehumidifier for Air-Conditioning and Drying Applications
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Venue	: ME Seminar Hall
Date and Time	: 13 Aug 2025 (05.00 PM)

Abstract : This research presents the design and development of a three-fluid operated hollow fiber membrane-based liquid desiccant dehumidifier (THFD), which offers a promising alternative to conventional dehumidifiers having issues like desiccant carryover, high pressure drops, and imbalanced thermal management. The THFD can integrate effectively with systems such as heat pumps, atmospheric water harvesters, adsorption chillers, and solar collectors. For that a precise design, performance assessment, and optimization are essential. A thermal model is developed to analyze and compare a novel M-cooler-based indirect contact dehumidifier with a conventional structured packing dehumidifier. The performance analysis considers vapour desorption rates and energy exchange per membrane area, along with the influence of Eckert and Prandtl numbers. An analytical model based on an integral technique is introduced for assessing performance in drying applications, focusing on thermal and moisture effectiveness. A case study on conventional and desiccant dryers, using vapour absorption rate and energy exchange as performance parameters, is presented, highlighting the importance of inlet parameters like air mass flow rate and specific humidity. Three data-driven models Artificial Neural Networks (ANN), Adaptive Neuro-Fuzzy Inference System (ANFIS), and k-Nearest neighbour (KNN) are used to estimate key output parameters. Additionally, a Physics-Informed Neural Network (PINN) framework is developed, integrating physical laws into the loss function to predict mass and energy exchange in THFD systems. The fabricated THFD uses Lithium Chloride (LiCl) as the liquid desiccant and incorporates air and water as the working fluids. Experimental results depict a maximum vapour absorption rate of 156 g/hr and energy exchange rates of 3.4 kW/m² (membrane) and 2.4 kW/m² (water jacket). The THFD system is optimized using NSGA-II and FC-WCPD techniques, with surrogate models trained on experimental data to generate Pareto fronts revealing trade-offs between thermal energy exchange and vapor removal rates. A MATLAB Simulink-based NTU framework is used for simulation and thermodynamic assessment, followed by exergy analysis to evaluate system components. This study key outcomes demonstrate that the developed thermal models simplify performance, adsorption kinetics evaluation, and AI/ML techniques can be applied for designing, predicting, and optimizing energy and mass exchangers. The THFD shows great potential for real-time applications in air conditioning and drying.