World Academy of Science, Engineering and Technology
International Journal of Energy and Power Engineering
Vol:17, No:09, 2023

Understanding the Processwise Entropy Framework in a Heat-powered Cooling Cycle

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Abstract : Adsorption refrigeration technology offers a sustainable and energy-efficient cooling alternative over traditional refrigeration technologies for meeting the fast-growing cooling demands. With its ability to utilize natural refrigerants, low-grade heat sources, and modular configurations, it has the potential to revolutionize the cooling industry. Despite these benefits, the commercial viability of this technology is hampered by several fundamental limiting constraints, including its large size, low uptake capacity, and poor performance as a result of deficient heat and mass transfer characteristics. The primary cause of adequate heat and mass transfer characteristics and magnitude of exergy loss in various real processes of adsorption cooling system can be assessed by the entropy generation rate analysis, i. e. Second law of Thermodynamics. Therefore, this article presents the second law of thermodynamic-based investigation in terms of entropy generation rate (EGR) to identify the energy losses in various processes of the HPCC-based adsorption system using MATLAB R2021b software. The adsorption technology-based cooling system consists of two beds made up of silica gel and arranged in a single stage, while the water is employed as a refrigerant, coolant, and hot fluid. The variation in process-wise EGR is examined corresponding to cycle time, and a comparative analysis is also presented. Moreover, the EGR is also evaluated in the external units, such as the heat source and heat sink unit used for regeneration and heat dump, respectively. The research findings revealed that the combination of adsorber and desorber, which operates across heat reservoirs with a higher temperature gradient, shares more than half of the total amount of EGR. Moreover, the EGR caused by the heat transfer process is determined to be the highest, followed by a heat sink, heat source, and mass transfer, respectively. in case of heat transfer process, the operation of the valve is determined to be responsible for more than half (54.9%) of the overall EGR during the heat transfer. However, the combined contribution of the external units, such as the source (18.03%) and sink (21.55%), to the total EGR, is 35.59%. The analysis and findings of the present research are expected to pinpoint the source of the energy waste in HPCC based adsorption cooling systems.

Keywords : adsorption cooling cycle, heat transfer, mass transfer, entropy generation, silica gel-water
Conference Title : ICHTE 2023 : International Conference on Heat and Thermal Energy
Conference Location : London, United Kingdom
Conference Dates : September 18-19, 2023