

Recent Advances in Heat Exchanger Technologies: A Review on Machine Learning and Thermal Management Techniques

Manglesh Dubey
dubeymanglesh1998@gmail.com

Khemraj Beragi
khemrajberagi@gmail.com

Abstract – Heat exchangers are critical components in thermal management systems across diverse industries, playing a vital role in the efficient transfer of thermal energy between fluids. With the growing need for improved energy efficiency and system reliability, recent advancements have focused on the incorporation of innovative materials and computational techniques. This review explores the integration of machine learning (ML) algorithms, nanofluids, and phase change materials (PCMs) in heat exchanger design. Machine learning has emerged as a powerful tool in optimizing heat exchanger performance by predicting heat transfer rates, identifying optimal design configurations, and enhancing maintenance practices. Nanofluids, with their enhanced thermal conductivity, and PCMs, offering thermal energy storage capabilities, represent significant advancements in improving heat exchanger efficiency and sustainability. The combination of these technologies, along with computational fluid dynamics (CFD) and optimization algorithms, paves the way for the next generation of heat exchangers that are more efficient, compact, and adaptable to modern industrial needs. The findings in this review highlight the importance of these technologies in advancing thermal management systems and offer insights into their future applications.

Keywords – CFD, Genetic Algorithms, Machine Learning, Nanofluids, Optimization, PCM, Predictive Modeling, Heat Transfer, Sustainable Energy.