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A Review of Artificial Intelligence Methods in Predicting Thermophysical Properties of Nanofluids

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Abstract

Nanofluids, colloidal suspensions of nanoparticles in base fluids, exhibit fascinating thermophysical properties that have garnered significant attention in various fields, particularly in thermal engineering and nanotechnology. Accurate prediction of these properties is crucial for their effective utilization in applications such as heat transfer enhancement, cooling systems and advanced manufacturing processes. Traditional methods for predicting nanofluids properties often face challenges due to the complex interactions between nanoparticles and base fluids. In recent years, artificial intelligence (AI) techniques have emerged as promising tools for predicting the thermophysical properties of nanofluids. This article provides a comprehensive review of the application of AI methods, including machine learning and deep learning, in predicting the thermophysical properties of nanofluids. The review explores various AI algorithms, data sources and modelling approaches employed in this domain, highlighting their advantages, limitations and future prospects.

Keywords: Nanofluids • Machine • Nanoparticles

Introduction

Nanofluids, engineered colloidal suspensions of nanoparticles dispersed in base fluids, have demonstrated remarkable enhancements in thermal conductivity, heat transfer coefficient and other thermophysical properties compared to conventional fluids. These unique properties have led to widespread interest in leveraging nanofluids for various applications, including heat exchangers, electronic cooling, solar energy systems and biomedical devices. However, accurately predicting the thermophysical properties of nanofluids remains a challenging task due to the complex interactions between nanoparticles and base fluids, as well as the influence of factors such as particle size, shape, concentration and surface chemistry. Traditional experimental and theoretical methods for predicting nanofluid properties often entail significant time, cost and effort. In recent years, Artificial Intelligence (AI) techniques have emerged as promising alternatives for efficiently and accurately predicting the thermophysical properties of nanofluids [1].

Literature Review

AI encompasses a broad range of computational techniques that enable machines to mimic human intelligence, learn from data and make predictions or decisions. In the context of predicting nanofluid properties, Machine learning (ML) and Deep Learning (DL) algorithms have shown considerable potential. ML algorithms, such as Support Vector Machines (SVM), random forests and Artificial Neural Networks (ANNs), learn patterns and relationships from training data to make predictions on unseen data. DL, a subset of ML, employs neural networks with multiple layers to extract hierarchical features from raw data, enabling more complex modeling of nanofluid behaviors [2].

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Discussion

Several studies have utilized AI methods for predicting various thermophysical properties of nanofluids, including thermal conductivity, viscosity, density and specific heat capacity. These predictions are essential for optimizing the performance of nanofluid-based systems and designing novel applications. AI models are trained on datasets containing experimental or simulated data on nanofluid compositions, processing parameters and thermophysical properties. By leveraging large datasets, AI algorithms can capture intricate relationships between input variables and output properties, thus enabling accurate predictions across a wide range of conditions [3].

Despite their promise, AI-based approaches for predicting nanofluid properties face several challenges and limitations. One major challenge is the availability and quality of data, as experimental data on nanofluids may be limited or inconsistent. Moreover, AI models may struggle to generalize predictions beyond the range of training data or to account for complex phenomena such as particle agglomeration or interfacial effects. Additionally, the interpretability of AI models can be limited, making it challenging to understand the underlying mechanisms driving predictions [4].

Despite the challenges, the application of AI methods in predicting the thermophysical properties of nanofluids holds immense promise for advancing the field of thermal engineering and nanotechnology. Future research efforts should focus on addressing data limitations, improving model interpretability and developing novel AI algorithms tailored to the unique characteristics of nanofluids [5]. Furthermore, interdisciplinary collaborations between researchers in AI, materials science and fluid dynamics will be essential for accelerating progress in this domain. Overall, AI represents a powerful tool for unlocking the full potential of nanofluids and driving innovation in various applications requiring enhanced heat transfer and thermal management capabilities [6].

Conclusion

In conclusion, this review has provided an overview of the application of artificial intelligence methods in predicting the thermophysical properties of nanofluids. AI techniques, including machine learning and deep learning algorithms, offer efficient and accurate alternatives to traditional prediction methods. Despite facing challenges such as data availability and model interpretability, AI-based approaches hold great promise for advancing the field of nanofluid research and enabling the development of novel applications in thermal engineering and nanotechnology. By addressing these challenges and fostering interdisciplinary collaborations, researchers can harness the full potential of AI to drive innovation and address pressing challenges in nanofluid science and technology.

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Conflict of Interest

None.

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