A Review on Nanofluids Thermal Properties Determination using Intelligent Techniques or Soft Computing Tools

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Abstract— Nanofluids are the dispersion of nano-sized particles into base fluids. Nanofluids have wide scope for applying as coolant in many of the engineering fields because of its higher thermal conductivity and more desirable thermal properties. Numerous mathematical models and experimental models have been proposed to predict the thermo physical properties for the past two decades. It has been noticed that many discrepancies between the mathematical and experimental results of thermo physical properties of nanofluids, in particular, thermal conductivity and viscosity. To mitigate those discrepancies, Intelligent Techniques with flexible mathematical structure that is capable of identifying complex non-linear relationships between input and output data were utilized to accurately predict the thermal properties of nanofluids. The data mining model based on genetic neural network has been widely applied to the procedure of data mining on thermal physical properties of nanofluids to acquire the pattern knowledge. This paper is to review the thermal conductivity of nanofluids research publications which are inter linked with soft computing tools. The outcome of this review shall lead to optimize the nanofluids properties while applying heat transfer nanofluids and to reduce the experimental test runs and number of hypothesis posed by different investigators.

Key words: Nanofluids, Thermal Conductivity, Soft computing tools, Genetic algorithm

I. INTRODUCTION

Nanofluid is the current frontier in technology. It is widely used in engineering applications such as refrigeration and air conditioning systems, automobiles, thermal power plants, chemical and textile processing industries, ranging from transportation to energy production and medical applications. It is potential heat transfer fluids with enhanced thermo physical properties such as thermal conductivity, viscosity, density and specific heat and they depend on many parameters like particle size, shape, base fluid, pH value, temperature, volume concentration, particle materials, thermal conductivity of base materials, method of fabrication of nano particles and different types of nanofluids.

For the past one decade, many mathematical models and experimental models have been proposed to predict the thermo physical properties. It is noticed that there are discrepancies between them. In order to overcome these limitations, recently some of the researchers tried to incorporate the soft computing tools for determining the thermal properties of nanofluids. Data Mining is a process designed to analyze and explore the data in search of consistent patterns or to analyze the systematic relationships between data or variable and to validate the findings by applying the detected patterns to new subsets of data[1].They have worked out with the help of the major kinds of data mining methods including generalization, characterization, classification, clustering, association, evolution, pattern matching, data visualization and meta-rule guided mining for different kinds of databases in nanofluids field. Therefore the objectives of this review paper are to review the thermal conductivity and viscosity of nanofluids research publications which are inter linked with soft computing tools to analyze which affect their thermal and flow performance.

II. DESIRABLE THERMAL PHYSICAL PROPERTIES OF ANANOFLUIDS- AN OVERVIEW

Nanofluids clearly exhibit improved thermo-physical properties such as thermal conductivity, thermal diffusivity, viscosity and convective heat transfer coefficient. The property change of nanofluids depends on the particle size, shape, conventional fluids, ph value, concentration, particle materials, thermal conductivity of base materials, method of fabrication of nanoparticles and temperature.

Shung-Wen Kang et. al.[2], reviewed about the relation between thermal resistance and size of nanoparticle. They reported that thermal resistance is directly proportional to the size of the nanoparticle. Thermal resistance is decreases with increasing heat and concentration of nanoparticle. Nanoparticles of various sizes ranging between 5nm and 100nm.Fotukian and M.Nasr Esfahany [3] ,experimentally investigated that addition of small amount of nanoparticles to pure water improves the heat transfer performance significantly. Mushed [4], concluded that the size of the nanoparticles is an important factor that affects the thermal conductivity enhancement, The general trend in his experimental data is that the thermal conductivity of nanofluids increases with decreasing particle size. However, there is also a significant amount of contradictory data in the literature was found that indicates decreasing thermal conductivity with decreasing particle size. However, for the case of nanofluids with Al2O3nanoparticles, the results shows increasing thermal conductivity with decreasing particle size.

Most of the researchers report that increasing thermal conductivity with increasing particle volume fraction, Liu et. al. [5], investigated that thermal conductivity increases with particles volume fraction but decreases with elapsed time. Particle shapes is another important parameter of thermal conductivity, it is broadly classifies in to two they are Cylindrical and Spherical . Kavitha et. al.[6], investigated that thermal conductivity of nanoparticle is increased when using spherical shaped nanoparticle. In addition to these experimental results, the fact that nanofluids with carbon nanotubes generally show greater thermal conductivity enhancement than nanofluids with spherical particles should also be considered. However, it should be noted that nanofluids with cylindrical particles

usually have much larger viscosities than those with spherical nanoparticles.

Various researchers reported that a significant decrease in thermal conductivity ratio with increasing pH values. Lee et. al. [7], revealed thermal conductivity of nanofluids is affected by pH level. It was also observed that the rate of change of thermal conductivity with particle volume fraction was dependent on pH value. Hadi Pirahmadian and Azadeh Ebrahimi [8], studied enhancement of heat transfer rate by considering clustering effect of nanoparticle. Abu Nada [9], states that severe clustering of nanoparticles must be prevented because excessive clustering may result in sedimentation, which decreases the enhancement of thermal conductivity.

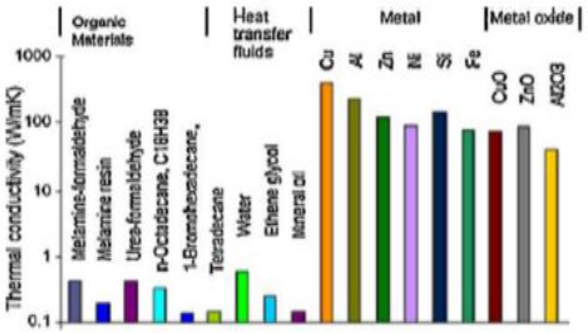

Fig. 1: Comparison of the thermal conductivity of common liquids, polymers and solids[10]

In nanofluids, change of temperature will affect the enhancement of thermal conductivity. Alpesh V Mehta et. al.[11], investigated that thermal conductivity of nanofluids is increased with increasing temperature. Vajjha and Das [12] also agreed that thermal conductivity is dependent not only on the nanoparticles concentration but also on the temperature.

III. AN OVERIEW OF GENETIC-NEURAL APPROACH

A Neural Network is a collection of many processing elements, called "neurons" and all are interconnected. Learning process of neural network is an iterative learning process. Learning process is classified in to two ways, Supervised learning and Unsupervised learning .The data set is divided into three distinct sets called training, testing and validation sets. The training set is the largest set and is used by neural network to learn patterns present in the data. The testing set is used to evaluate the generalization ability of a supposedly trained network. A final check on the performance of the trained network is made using validation set.

Genetic algorithm is an adaptive heuristic and direct search method. The parameters used by the GA are initialization, selection, crossover and mutation. The first parameter is initialized populations are values of type integers that correspond to randomly selected rows of data. The second one is to select the excellent individuals from current population. The third parameter will exchange genes from two different individuals selected at the same location, and then a new entity created. Last one is an individual gene that should be selected randomly from the group and then change the value of a gene with small probability.

Neural networks and genetic algorithms are data mining tools widely used for classification and prediction in a complex data set. Neural networks have two major disadvantages Initialization of the neural networks weights it is a blind process and network output can run towards local optima which can affect the global solution. Neural networks are very slow in convergence and so it is possible that network may never converge. Problems of neural networks can be solved by using optimized initial weights, optimized by GA. GA works on potential solution population which allows the elimination of weak individuals and favour the survival of the best ones.

IV. A REVIEW ON NANOFLUIDS THERMAL PROPERTIES USING INTELLIGENT TECHNIQUES

Numerous studies have shown that nanofluids have desirable properties among which thermal conductivity and viscosity have been studied most extensively. Tajik and Zam Zamian [13], described the way to optimize and report the effects of various parameters like the ratio of the thermal conductivity of nanoparticles, particle volume fraction, particle size and temperature on the effective thermal conductivity of nanofluids by using nonlinear optimization methods and artificial neural network. It compares the performance of application of the generalized reduced gradient method and artificial neural networks in order to optimize of the thermal conductivity of nanofluids. It proves that artificial neural network is more accuracy than the generalized reduced gradient.

Karimi et. al.[14], states that GA-NN model is outperform to the conventional neural nets in predicting the viscosity of nanofluids. In addition , the model determines the effective viscosity of nanofluids as a function of the temperature, nanoparticle volume fraction, nanoparticle size and the base fluid physical properties. They found that the GA-NN model is an effective method for prediction viscosity of nanofluids and have better accuracy and simplicity compared with the others models. Salehi et. al. [15], observed that the estimation of thermal efficiency and thermal resistance was accurate by using the multi-layer perception neural network, the genetically trained network is able to predict or estimate thermal efficiency and thermal resistance values comparable to those of the actual experimental measurements.

Ariana et. al.[16], developed a two-layer feed forward artificial neural network with fourteen hidden neurons architecture to estimate the thermal conductivity ratio of nanofluids as a function of temperature, volume fraction and diameter of the nanoparticle. The predictive capability of developed ANN model is found to be very efficient when it is compared with other recommended correlations. Hojjat et. al.[17], informs that the thermal conductivity of nanofluids varies exponentially with the nanoparticle concentration and increases with the temperature.

Mohanraj et. al.[18], reported the investigations on thermal conductivity of heat exchangers. They related with the applications of ANN for thermal analysis of heat exchanger. artificial neural network offers an excellent alternative methodology for the thermal analysis of heat exchanger whereas the theoretical heat exchanger analysis

involves assumptions and complicated equations leads to more expensive. Safikhani et. al.[19], performed multi-objective optimization of nanofluids in flat tubes using computational fluid dynamics, artificial neural network and non-dominated sorting genetic algorithms. The high accuracy of group method data handling polynomials was demonstrated by employing various statistical parameters. It is shown that the achieved Pareto solution includes important design information on nanofluids parameters in flat tubes.

Azari and Marhemati [20], investigated a model for estimating the thermal properties of nanofluids using a Group Method Data Handling-Polynomial Neural Network. With a remarkable agreement for the model with the experimental data was achieved. The developed model can be successively correlate and predict the thermal properties of different groups of nanofluids. Ali sadollah et. al.[21], studied the effect of various parameters on the stability of nanofluids by using response surface methodology and predicted through a trained artificial neural network. They also reported about the performance of the ANN is accurate than the RSM in terms of error percentage, linear regression between the networks outputs and the respective experimental results.

Hemmat Esfe et. al.[22,23], focussed on investigating the thermal conductivity of hybrid nonofluids. An experimental model and feed forward multilayer perceptron neural network has been employed for modelling thermal conductivity and their performance were compared and it has shown good concurrence between them.Fallah et. al.[24], Resultant polynomial neural networks are deployed to find a set of optimal solutions using multi-objective genetic algorithms, non-dominated sorting genetic algorithm. An optimized GMDH type neural network are trained to best prediction of objectives for different designing parameters values. Hemmat Esfe et. al. [25] predicted that the thermal conductivity and dynamic viscosity of nanofluids using artificial neural network. The comparisons between experimental data and the correlated using ANN were shown good agreement.

V. Conclusion

In this paper, we reviewed various research papers about the thermal conductivity of nanofluids using intelligent techniques or soft computing tools. The goal of the this review paper is to collect the basic information about the thermal conductivity of nanofluids under a wide range of circumstances and convert those information in to knowledge and acquire the pattern hidden in the large amount of data. The critical issues on nanofluids thermal conductivity and viscosity and the major factors which affect their thermal and flow performance have been discussed. The outcome of this review shall lead to reduce the experimental test runs and number of hypothesis posed by different investigators. It is concluded that only few research work is reported on the thermal conductivity and viscosity of by using soft computing / data mining tools and much scope is there to investigate the nanofluids with soft computing tool.

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