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Using Gaussian Process Regression (GPR) models with the Matérn covariance function to predict the dynamic viscosity and torque of SiO_2/Ethylene glycol nanofluid: A machine learning approach

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Abstract

Studying the dynamic viscosity (DV) is a key factor to determine the nanofluids' hydrodynamic behavior (NFs). In this research, the effect of volume fraction (φ), shear rate (SR), and temperature (T) on the DV, and torque of SiO_2 nanoparticles (NPs)/ Ethylene glycol (EG) nanofluid (NF) are studied with an artificial neural network (ANN). Different machine learning (ML) models are examined to predict the rheological properties, and then the best model is selected for prediction. The results show that the torque mostly increased linearly with the SR in all samples. The slope of this enhancing trend is higher for lower T. The Gaussian Process Regression (GPR) models with the Matérn covariance function provided the best results on both datasets to predict the DV. The correlation results provided by this method to predict the DV in terms of Pearson's Linear Correlation Coefficient (PLCC), and Spearman's Rank Order Correlation Coefficient (SROCC) were 0.999 and 1, respectively. R squared (R^2) was 0.996 and, the Root Mean Squared Error (RMSE), and Mean Absolute Percentage Error (MAPE) values of about 0.24 and 1.61 represented the accuracy and power of this method to predict the DV values unseen data by the model. The GPR torque predictor model performed very well by providing a correlation of about 0.98 and an RMSE of about 4. Matérn covariance functions that used separate length scales per predictor with $\nu = 3/2$ (ardmatern 32) and $\nu = 5/2$ (ardmatern52) were superior to other functions. All 100 models trained on each dataset were well-trained and quite reliable. The trained models were accurate enough to be used in related applications.