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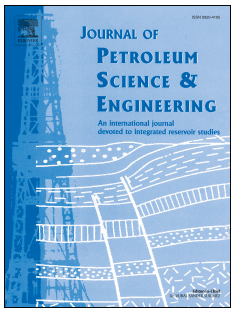

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Estimation of density and compressibility factor of natural gas using artificial intelligence approach

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Abstract

Natural gas density is commonly measured by Coriolis density meters and gas chromatographs, both of which are used to calculate the natural gas mass flow rate. In this study, two networks are proposed to predict the density and compressibility factor of natural gas. The first network (N_1) uses temperature, pressure and Joule Thomson (JT) coefficient of natural gas as input variables and density of natural gas is selected to be the target. This network is proposed to predict the natural gas density at natural gas pressure drop stations (CGSs). For this network, the gas mixture compositions are unnecessary. The second network (N_2) is proposed based on the pseudo reduced temperature and pressure as input variables that the network by using these two variables can predict the density and compressibility factor of natural gas. This model needs the gas mixture compositions. For these targets, a novel idea based on artificial intelligence is used. Five models of artificial intelligence are implemented that are fuzzy inference system (FIS), adaptive neuro-fuzzy inference system (ANFIS), ANFIS optimized with genetic algorithm (ANFIS-GA), multilayer feed-forward neural network (MLFFNN) and group method of data handling (GMDH). The results demonstrated that the ANFIS-GA and GMDH model performed better than the FIS, MLFFNN and ANFIS models. For N_1, root mean square error (RMSE) for ANFIS-GA and GMDH models were obtained as 0.2405 and 0.2042 (kg/m^3), respectively. For N_2 (compressibility factor), the value of RMSE for ANFIS-GA and GMDH models consecutively was achieved 0.0061 and 0.0054. Also, for N_2 (density), RMSE for ANFIS-GA and GMDH models was taken 2.2735 and 2.6113, respectively. These values of RMSE were reported for the testing phase of the models.

Keywords: Natural gas density; Compressibility factor, Fuzzy inference system; Adaptive neuro-fuzzy inference system; Genetic algorithm; group method of data handling

1. Introduction

Natural gas is a subcategory of petroleum that is composed of complex mixtures of hydrocarbons and a minor amount of inorganic compound. Compressibility factor of natural gas is an essential requirement for the determination of several natural gas properties. An accurate knowledge of gas compressibility factor is used to calculate the formation volume factor, compressibility, viscosity and density of natural gas [1]. Also, this parameter is requirement in the most petroleum and natural gas engineering applications such as gas metering and compression, design of processing units and pipelines [2,3]. The gas ideal behavior is used to describe the most gases at various temperature and pressure conditions close to atmospheric [4]. Density metering and volume flow metering of natural gas are required in order to calculate mass flow metering. The natural gas flow metering should be measured in many places including pressure drop stations (City Gas Stations (CGSs)) [5].

Over the last years, many devices are used to measure natural gas density such as Coriolis density meters, gas chromatographs and etc. [6]. These devices have shown many problems to calculate natural gas density. For example, Coriolis density meters are potential erosion because of abrasive particles, sensitivity to pulsation and