OPEN ACCESS Freely available online

ISSN: 2090-4568
Journal of Advanced Chemical Engineering

Research Article

Mathematical Modeling of Alagoas well Density using Artificial Neural Networks

Tatiana G.D Da Silva*, **Everton Lourenco, Marcio A. Sampaio Pinto's, Dheiver Santos**

Department of Petroleum Engineering, Centro Universitario Tiradentes, Maceio, Brazil

ABSTRACT

Density is a physical-chemical characteristic that is commonly applied to analyze the quality of oil and is fundamental to the sizing and application of equipment, which makes processes more efficient. The same is used during production and oil refining to verify the properties of the oil to be explored. Therefore, this work analyzed oil samples from the Sergipe-Alagoas basin, from the Pilar and Tabuleiro do Martins fields, through the characterization of the density and the training and prediction through Artificial Neural Network (ANN). The research showed that the data obtained from the oil density of the Sergipe-Alagoas Basin were in the light oil frame, and that from the analysis performed on the ANN the desired output data are very close to the network output. Therefore, the characterization of density becomes fundamental in several industrial processes where there is fluid transfer from one place to another, besides being indispensable to find useful techniques for an adequate flow.

Keywords: Physical-chemical properties; Alagoas oil; Artificial neural network; Density; Fluid transfer

INTRODUCTION

Petroleum is composed predominantly of hydrocarbons, however, it also has other components in its structure, such as sulfur, nitrogen, etc. Oil develops in underground reservoirs that have different depths and vary in color, odor, and flow properties that reflect the diversity of their origin. One of these properties is the density of the crude oil, which is obtained through physical-chemical analysis, and which helps in the understanding of the processes referred to the oil. In addition, this property indicates the function and performance of the product in service [1].

Density is one of the most significant physical properties to classify and characterize crude oil, which is used together with the API grade that serves to establish standards for production, refining, and distribution of petroleum products, as it indicates possible changes that may occur in the oil's composition. Density is one of the most significant physical properties to classify and characterize crude oil, which is used together with the API grade that serves to establish standards for production, refining, and distribution of petroleum products, as it indicates possible changes that may occur in the oil's composition. The API grade is calculated by the relative density, where it can be obtained from the ratio between the absolute density of petroleum in relation to water at a temperature of 60°F [2]. Crude oil can be classified into less dense oil (light oil) which is preferable to denser oil because it contains low boiling point constituents and waxy molecules and more dense oil (heavy oil), which is composed of compounds with higher boiling points [3].

Therefore, this work aims to demonstrate the method of physical-chemical analysis for obtaining the density of Alagoas oils from the Sergipe-Alagoas Basin between 25 and 50°C. In addition, this work will model the data of densities in relation to temperature through neural networks and report the importance of the analysis applied to the oil industry.

MATERIALS AND METHODS

In this work, a methodology that aggregates two steps for the characterization of Alagoas oil samples from the Sergipe-Alagoas Basin, from the Pilar and Tabuleiro dos Martins fields, was carried out. The first step was employed to achieve density data

Correspondence to: Tatiana G.D Da Silva, Department of Petroleum Engineering, Centro Universitario Tiradentes, Maceio, Brazil; E-mail: tatiana.doria@outlook.com

Received: 19-Sep-2022, Manuscript No. ACE-22-18076; **Editor assigned:** 22-Sep-2022, PreQC No. ACE-22-18076 (PQ); **Reviewed:** 06-Oct-2022, QC No. ACE-22-18076; **Revised:** 17-Jan-2023, Manuscript No. ACE-22-18076 (R); **Published:** 27-Jan-2023, DOI: 10.35248/2090-4568.23.13.297

Citation: Silva TGDD, Lourenco E, Pinto's MAS, Santos D (2023) Mathematical Modeling of Alagoas well Density using Artificial Neural Networks. Adv Chem Eng. 13:297.

for each oil. While the second uses the data from the previous stage to model it using a neural network. The steps are described below:

Step 1: Density measurement

The density measurements were performed on an Anton Paar DMA 4500 M densimeter. The equipment is used for density measurements of various materials such as ionic liquids, petroleum fractions, and crude oil among other compounds (Table 1).

Table 1: Anton Paar DMA 4500 M densitymeter technical specifications.

Technical specifications DMA 4500 M	
Measuring range	Densidade: 0 g/cm³ a 3 g/cm³ Temperature: 0°C a 100°C (32°F a 212°F)
Accuracy	Densidade: 0.00005 g/cm³ Temperature: 0.03°C/0,05°F

The density measurements of the oils are determined over a temperature range that varies from 25°C to 50°C with increments every 5°C, to obtain the linear behavior of density with temperature. Initially, to validate the equipment, a check test is performed with ultrapure Milli-Q water. This check consists in inserting a water sample, approximately 2 ml, in the densimeter. Through reference data from the equipment, it checks whether the density is within the measurement range and issues a warning validating or not the equipment.

Afterwards acetone is inserted, approximately 2 ml, followed by a stream of air dehydrated in silica for 5 minutes in order to dry the tube. After this validation procedure the oil is inserted into the U-tube and carefully checked for air bubbles, which should be avoided because they influence the measurements. After verifying that there are no bubbles, measurements is made over a range of 25°C to 50°C and a measurement is obtained every 5°C. The API grade is calculated by the densimeter itself.

Step 2: Artificial neural network training and prediction

The use of Artificial Neural Networks (ANNs), has been encouraged by the recognition of the function of the human brain to compute in a totally different way than the conventional digital computer. That is, an ANN is a machine designed to model the way in which the brain performs a certain task or function of interest. The network usually implements electronic components or simulates them through software in order to achieve good performance. Furthermore, ANNs employ a massive interconnection of simple computational cells known as "neurons" or "processing units" [4].

Therefore, this work implemented the data obtained by the density analysis to create a neural network. The neural network was created from Matlab software and had as input data the temperature and output data the density of each oil. In addition, the modeling had 8 neurons, 1 layer for the input data and a value of 1000 interactions, as shown in Figure 1 below:

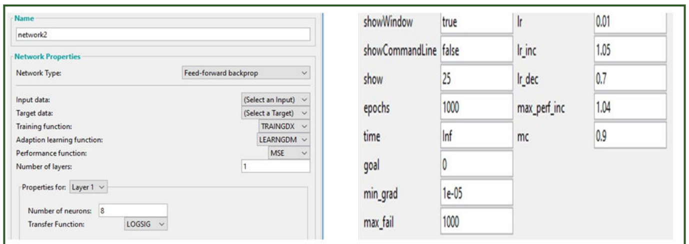


Figure 1: Neural network modeling data.

RESULTS AND DISCUSSION

Through the density analysis of the oil samples, by the Anton Paar DMA 4500 M equipment, the results were density data in a temperature range of 25°C to 50°C, which are expressed in Table 2.

Table 2: Density data of oil samples from Alagoas.

	PILAR		Tabuleiro	
Temperature (°C)	**Density (g/cm^3)**	**Standard deviation**	**Density (g/cm^3)**	**Standard deviation**
25	0,8265	0,0023	0,8358	0,00012
30	0,8245	0,0002	0,8312	0,00020
35	0,8206	0,0026	0,8271	0,00026
40	0,8166	0,0018	0,8233	0,00025

45	0,8134	0,0006	0,8195	0,00016
50	0,8094	0,0003	0,8158	9,19E-05
Media	0,8185		0,8254	

Table 2 shows the density data in g/cm^3, where it can be seen that the density of the oil samples from Tabuleiro dos Martins and Pilar are less dense than water. Thus, through the values obtained from the density of the oils, it was possible to calculate the API (American Petroleum Institute) degree of each oil sample, through the equipment itself, represented by the Table 3 below:

Table 3: API degree of the oil samples.

	PILAR	Tabuleiro
Grau API	38,35	36,17

The API grade is an arbitrary scale that measures the density of petroleum derived liquids and the higher the density of the oil, the lower the API grade will be. Consequently it will have a lower associated market value, because it will produce derivatives of lower aggregate profitability. Thus, by determining the API degree shown in Table 3, it is possible to characterize the oils according to the standardizations used in the oil industry, because the higher the API degree of the crude oil, the lighter it is. Both the Tabuleiro field oil sample and the pilar sample fall into a light conventional oil, and they have a high economic value on the market. For, both present lighter compounds and a low boiling point, which demonstrates a greater ease of flow during their production and their refinement produces a large quantity of gasoline [5].

The density definition is directly associated with the recovery alternatives of a well, in order to increase the oil flow in a given time. Because of the oil's mobility characteristics during production, oils with low density and high viscosity have a low pour point that hinders the production process [6].

One of the characteristics of petroleum is that with the increase in temperature there is a decrease in density, as represented in Figures 2 and 3, where the density of the Pilar sample begins with a value of 0.8265 g/cm^3 for a temperature of 25°C and along the temperature increments, decreases to a value of 0.8094 g/cm^3 for a temperature of 50°C.

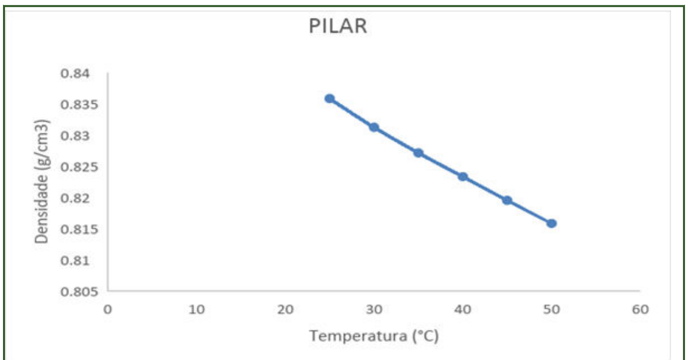


Figure 2: Density variation of the Pillar sample with increasing temperature.

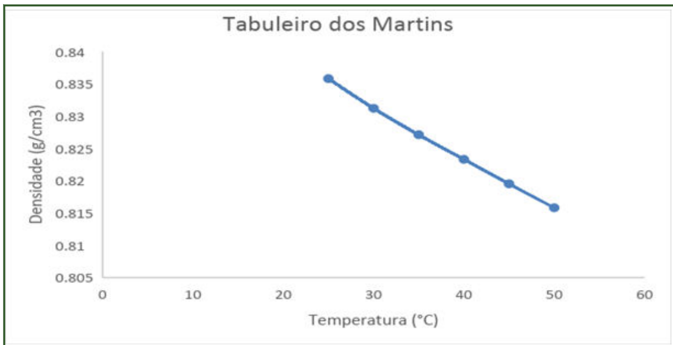
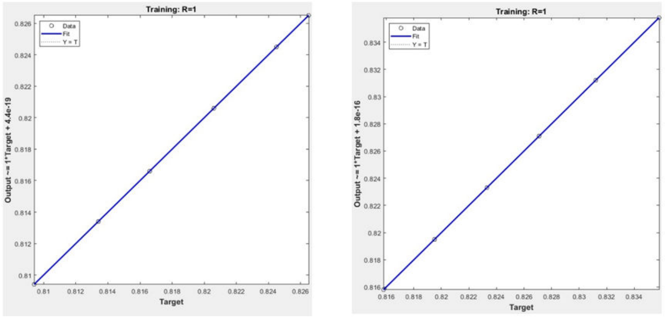


Figure 3: Density variation of the Tabuleiro dos Martins sample with increasing temperature.

Using the previously obtained density and temperature data of the oils, as shown in Table 2, it was possible to model a neural network, as shown in Figures 4 (a) and (b). The ANNs were built through Matlab software in order to demonstrate a relationship between the data obtained by the experimental analysis and those generated by the computational modeling. Neural networks present a structure with the ability to adapt by means of a learning algorithm, fault tolerance, neurobiological analogy, and uniformity of design analysis [7].

In Figure 4 (a) and (b), the x-axis represents the output data, *i.e.*, the density data obtained from the chemical analysis and the y-axis represents the data generated from modeling with, ANN. Thus, according to the Figure below, the desired output data (solid line) is very close to the network output (circles), indicating good neural network performance [8].



(a) (b)

Figure 4: Neural network of the density of the oils from (a) Pilar and (b) Tabuleiro dos Martins.

CONCLUSION

The physicochemical properties of oils are very useful in many industrial processes where fluids are transferred from one location to another. For example, crude oil migration within the reservoir requires low viscosity and low density to flow effectively. There is also the need to check the oil's density and obtain the API grade value to assess the oil's classification. This need arises from the production characteristics, because if it falls into the heavy or extra heavy oil category, the study is indispensable to find useful techniques for an efficient flow of the crude oil. However, according to the analyses performed on the samples of Alagoas oils, from the Sergipe Alagoas Basin, both fall into light conventional oil. Furthermore, they are very profitable in the economic market due to the production of derivatives of high commercial value, such as gasoline, diesel and QAV. However, although both oils are light, the Pilar oil sample has a higher added value, since it is lighter than Tabuleiro oil and during refining will produce a larger quantity of more profitable derivatives.

REFERENCES

1. Sánchez AS, Rodrigues DA, Fontes RM, Martins MF, de Araujo Kalid R, Torres EA. Wave resource characterization through in-situ measurement followed by artificial neural networks modeling. Renew Energy. 2018;115:1055-1066.
2. Filgueiras PR, Sad CM, Loureiro AR, Santos MF, Castro EV, Dias JC, et al. Determination of API gravity, kinematic viscosity and water content in petroleum by ATR-FTIR spectroscopy and multivariate calibration. Fuel. 2014;116:123-130.
3. Abiodun OI, Jantan A, Omolara AE, Dada KV, Mohamed NA, Arshad H. State of the art in artificial neural network applications: A survey. Heliyon. 2018;4(11):00938.
4. Sebaaly H, Varma S, Maina JW. Optimizing asphalt mix design process using artificial neural network and genetic algorithm. Constr Build Mater. 2018;168:660-670.
5. Soares JD, Pasqual M, Lacerda WS, Silva SO, Donato SL. Utilization of artificial neural networks in the prediction of the bunches' weight in banana plants. Sci Hortic. 2013;155:24-29.
6. Fakher S, Khlaifat A, Hossain ME, Nameer H. A comprehensive review of sucker rod pumps' components, diagnostics, mathematical models, and common failures and mitigations. J Petrol Explor Prod Technol. 2021;11(10):3815-3839.
7. Ghannam MT, Hasan SW, Abu-Jdayil B, Esmail N. Rheological properties of heavy and light crude oil mixtures for improving flowability. J Pet Sci Eng. 2012;81:122-128.
8. Takahashi LT, Maidana NA, Ferreira WC, Pulino P, Yang HM. Mathematical models for the Aedes aegypti dispersal dynamics: Travelling waves by wing and wind. Bull Math Biol. 2005;67:509-528.