بسم الله الرحمن الرحيم

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تم رفع هذه الرسالة بواسطة /صفاء محمود عبد الشافى

بقسم التوثيق الإلكتروني بمركز الشبكات وتكنولوجيا المعلومات دون أدنى مسئولية عن محتوى هذه الرسالة.

ملاحظات: لايوجد

USING ARTIFICIAL NEURAL NETWORKS TO PREDICT THE RHEOLOGICAL BEHAVIOR OF DRILLING FLUIDS

By

Moamen Ahmed Gasser Hassan Kamel Ibrahim Kamel

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
In
CHEMICAL ENGINEERING

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Under the Supervision of

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Title of Thesis:

Using Artificial Neural Networks to Predict the Rheological Behavior of Drilling Fluids

Key Words:
Drilling fluids; Rheology; Additives; Nanoparticles; Artificial Neural Network

Summary:

Drilling fluids are essential factor in the success of the drilling operations as they perform many functions from controlling the well, lubricating and cooling the drill bit. Lately, the petroleum field has shown a grown interest in enhancing the properties of the drilling fluids using nanoparticles.

In this research, two nanoparticles (MgO and ZnO) have been used to enhance the behavior of three types of drilling fluids. The obtained experimental results in addition to data from literature have been used to build artificial neural network (ANN) models that can predict the rheological properties of the drilling fluids.

The two nanoparticles have shown improvements and promising effects on the behavior of the drilling fluids. Also, ANN models were able to predict the rheological properties of the drilling fluids based on their composition with high accuracy which paves the way to the mechanization of the drilling operations.

Disclaimer

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sources used and have cited them in the references section.

Name: Moamen Ahmed Gasser Hassan Kamel Ibrahim Kamel Date:../../2022

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Table of Contents

List of Tables

List of Figures

Nomenclature

AARE: absolute average relative error
ANN: artificial neural networks
ARE: average relative error
AV: apparent Viscosity
DP: date pit
ECD: equivalent circulating density
gel 10 sec: gel strength at 10 seconds
gel 10 min: gel strength at 10 minutes
GNPs: graphene nanoparticles
GS: gel strength
HBLE: hibiscus-leaf extracts
HLE: henna-leaf extracts
LSNDM: low solid non-dispersed mud
MAE: mean absolute error
MAPE: mean absolute percentage error
MgO: Magnesium oxide
MSE: mean-squared error
NPs: nanoparticles
OBM: oil-based mud
PEs: processing elements
PSD: particle size distribution
PV: plastic viscosity
R^2: correlation coefficient
RD: relative deviation
RMSE: root-mean-squared error
SBM: synthetic-based mud
SD: standard deviation
SSR: sum of squares error
TEM: transmission electron microscopy
WBM: water-based mud
YP: yield point
XRD: X-ray diffraction
XRF: X-ray fluoresce
ZnO: Zinc oxide

Abstract

Drilling process is one of the main operations in the extraction of hydrocarbons from petroleum reservoirs. It comes right after the exploration processes. Drilling fluids are necessary for controlling the wells and performing different functions during the drilling operation. They perform many roles in lifting the cuttings from the bottom of the well to the surface and cooling/lubricating the drill string and bit. Furthermore, they provide the desired hydrostatic pressure to overbalance pore pressure in addition to produce a thin/impermeable filter cake that can prevent or reduce the possible damage to the formations. It is mandatory to keep monitoring, enhancing, and optimizing the properties of the drilling fluids.

Recently, different additives, among which nanoparticles (NPs), have been investigated to improve, and maximize the benefits of the drilling fluids accordingly to meet the new challenges. The rheological behavior of such complex fluids has shown different enhancements up on the utilization of those additives. The rheological properties of the drilling fluids are accurately measured on the surface; however, the behavior of those properties may change according to the used additives and their composition. For that, different models are introduced and used to predict and optimize the rheological characteristics of such fluids.

In this study the effect of two types of NPs (MgO and ZnO) on the rheological properties of KCl-polymer, low solid non-dispersed mud, and bentonite water-based mud have been investigated. Also, Particle size distribution (PSD), zeta potential analysis, scanning by transmission electron microscopy (TEM), and x-ray diffraction (XRD) are discussed in this section for the NPs are presented and used in explaining the behavior of the nano-modified drilling fluids. Increasing the concentration of MgO up till 0.7wt% as shown an increase in the rheological properties of the drilling fluids. While, ZnO has shown a significant improvement for at lower concentrations of 0.1wt%.

Bingham, Herschel-Bulkley, Power Law, Casson and others are commonly used as rheological models to predict the drilling fluid behavior. In the last decade, a new trend of developing new models and correlations using the artificial neural networks (ANN) have been introduced to the petroleum field. Mathematical formulas can be developed using ANN, which then can be used to predict the behavior of certain parameter(s) by knowing other ones. Using ANN have shown to be more reliable and accurate in predicting the rheological properties of the drilling fluids, such as apparent viscosity (AV), plastic viscosity (PV), yield point (YP), maximum shear stress, and change in the mud density at various conditions.

In this work five mathematical models were constructed using ANN to predict the rheological properties of the nano-modified drilling fluids based on their composition at 120 ˚F and atmospheric pressure. The models were evaluated by conducting statistical tests like correlation coefficient (R^2), root mean square error (RMSE), absolute average relative error (AARE), and standard deviation. The five models are models that can predict PV, AV, YP, gel strength at 10 seconds, and 10 minutes with overall $R^2$of 0.9017, 0.941, 0.878, 0.961, and 0.9, respectively. The effect of NPs-type, size, concentration, and drilling fluid formulations were considered, which may pave the road for new applications and efficient utilizations.