Cairo University

PREDICTION OF RATE OF PENETRATION IN ROTARY STEERABLE SYSTEM DRILLING USING STATISTICAL APPROACH

By

Eng. / Mohamed Mohamed Refat Ali Rageh

B.Sc. in Petroleum Engineering
Faculty of Engineering
Al Azhar University

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
Petroleum Engineering

FACULTY OF ENGINEERING, CAIRO UNIVERSITY,
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Under the Supervision of

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Dedication

To

My Mother
and
My Wife

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Nomenclatures

AG:	Abu-Gharadiq filed
API:	American Petroleum Institute
A/R:	Abu Rawash
AZI:	Azimuth
BHA:	Bottom Hole Assembly
BI:	Bihaith field
deg:	Degree
DLS:	Dog Leg Severity
ECD:	Equivalent Circulating Density
f:	Function
ft:	Feet
gpm:	Gallons per Minute
H:	Hole Size
HIS:	Horsepower per Square Inches
HP:	Horsepower
hr:	Hours
ID:	Inside Diameter
in:	Inches
INC:	Inclination
lbf:	Pounds Forces
lbm:	Pounds Masses
KCL:	Potassium Chloride
KJO:	Kuwait Joint Operation
KOC:	Kuwait Oil Company
L:	Length
LWD:	Logging While Drilling
M:	Mass
MD:	Measured Depth
MN:	Minagish filed
MTR:	Motor
MW:	Mud Weight
MWD:	Measurement While Drilling
OBM:	Oil Base Mud
OD:	Outside Diameter
P:	Pressure
PDC:	Polycrystalline Diamond Compact
PDM:	Positive Displacement Motor
POOH:	Pull Out of Hole
PPG:	Pound per Gallon
PPM:	Parts per Million
PSI:	Pounds per Square Inch
Q:	Flow Rate
Qn:	Flow Rate/Inch
ROP:	Rate of penetration
RPM:	Revolution per Minute
RSS:	Rotary Steerable System
S:	1/Speed
SPP:	Stand Pipe Pressure
SPSS:	Statistical Package for the Social Sciences
T:	Time
TC:	Tungsten Carbide

TD:	Total Depth
TOC:	Top of Cement
TVD:	True Vertical Depth
U:	Upper
WBM:	Water Base Mud
WD:	Western Desert
WOB:	Weight on Bit
π:	Pie groups used in Buckingham method
ρ:	Mud density

Abstract

Directional and horizontal drilling have now become an essential element in oilfield development, both in onshore and offshore operations. There are several types of deflection tools; the most common of which are downhole motors (PDM) and rotary steerable system (RSS). A rotary steerable system (RSS) employs specialized downhole equipment to replace mud motors. A rotary steerable system (RSS) is able to make continuous changes in inclination and azimuth without interrupting drilling operations. It produces a cleaner and smoother wellbore while reducing drag, improving the transfer of weight on bit and increasing the rate of penetration. The RSS system offers the potential to drill safe and faster sections due to the fact that no time is wasted in orienting the toolface prior to drilling especially in extended reach drilling where tool orientation is particularly difficult.

There are many challenges to drill a directional well compared to a vertical well, such as limitation in weight on bit, hole cleaning, trajectory control, etc., this lead to difficult selection to the proper parameters to increase the rate of penetration.

Prediction of ROP is necessary for planning and cost estimation. ROP depends mainly on operational variables and formation types.

In the present study, the effective parameters on directional drilling of ten wells, drilled between 2007 and 2015 in Egypt are used to predict the rate of penetration using RSS drilling. This is accomplished using various statistical approaches including R-Squared method, SPSS statistical software, and Buckingham π theorem. Additional five directional wells from the Middle East area, drilled between 2011 and 2016, are used to verify the prediction model.

Results showed that the prediction model derived using Buckingham statistical approach is capable to predict the rate of penetration of RSS in directional wells with 85% match for the wells drilled in Egypt and 98% - 99.6% for the wells drilled in the Middle East area. Such results indicate the potential use of the proposed prediction model for evaluating the economics of RSS in drilling directional and extended reach wells.