STUCK PIPE PREDICTION/ELIMINATION BASED ON HOLE CLEANING.

by

Boma Femi Julius – SLB Gabon
Reza Sanaee - *Robert Gordon University*
Ibe Kevin Ejiogu
Srikant Kumar Mahapatra

Abstract:

The most expensive problem the oil industry faces is that of stuck pipe. Such a problem leads to losses of millions of dollars and sometimes abandonment of wells. Many studies show that most stuck pipes are due to inadequate hole cleaning. To tackle stuck pipe problem caused by hole cleaning, the reason for inefficient cleaning in vertical, deviated and horizontal wells have been studied. Complex wells, such as horizontal and ERD wells, make it more challenging to keep all parameters in spec to avoid the occurrence of stuck pipes.

In the present study, the software is designed to work with real-time drilling parameters necessary for hole cleaning so that accurate predictions can be made before facing stuck-up problems. Eight wells have been analyzed, with three having stuck pipes due to poor hole cleaning.

Introduction:

Stuck pipe is a challenge while drilling, especially when drilling deviated, horizontal and ERD wells. Hole cleaning seems to be the main culprit, which leads to being stuck up.

Lack of knowledge and information of the specific parameters leads to poor hole cleaning and, in turn, stuck up. Real-time monitoring of the detailed mud parameters, like YP, LSRYP, MW, CCI, ROP, rotation per minute, annular velocity, flow rate, and cutting size, are essential to prevent stuck-up.

Many scientists and scholars have worked on stuck pipe prediction from various perspectives, though not much has been done concerning hole cleaning. Some hydraulic software is being used by drilling fluid companies to get some historical values, but it is not suitable for real-time monitoring. Moreover, the user needs separate training to run that software.

In the present work, an app has been designed that can predict stuck pipe, as long as the input values of the parameters are correct and factual.

Existing Models:

Siruvuri, Nagarakanti and Samuel (2006) utilized an application of neural network methods for understanding the cause of differential stuck up.

Meschi, Shahbazi and Pardel (2010) presented a finding done in Iran by analyzing mud logging data and DMR of 75 wells. MW, YP, PV, initial gel strength, marsh funnel viscosity, solid content and temperature were employed to introduce a new parameter called Reducing Stuck Index (RSI).

Muqeem, Weekse and Ali (2012) reviewed drilling activities in Saudi Aramco and developed the following strategies: best practices for stuck pipe avoidance, stuck pipe awareness posters, and stuck pipe reporting template.

Yarim et al. (2007) developed a plan to approach the problem of stuck pipes by reviewing prior technical literature. They developed a new training course, which helped them reduce stuck pipes by 25%.

Aims and Objectives:

The aim of the research work is to investigate stuck pipe based on hole cleaning. A significant key to reducing these phenomena is the ability to predict occurrence correctly and in time. An Excel model was used to calculate several parameters to achieve the objective. Later, this Excel sheet was developed into an app so that mud engineers could use it on a real-time basis to avoid any occurrence of stuck pipes.

To generate information for the development of the app, data from eight wells drilled in Nigeria and Saudi Arabia were evaluated. Out of these eight wells, four were drilled without being stuck up and the other four encountered stuck up. Data were collected from DMR and from End of well Report.

Parameters	**Well –I**		**Well-II**			**Well-III**	
	Section-I	**Section-II**	**Section-I**	**Section-II**	**Section-III**	**Section-I**	**Section-II**
Hole Size, inch	16	12.25	14 3/4	12.25	12.25	16	12.25
Mud Type	WBM	OBM	OBM	OBM	OBM	WBM	OBM
MW,ppg	8.8	10.2	11.3	14.5	14.5	8.6-9.1	12.9
Inclination, Degree	35-75	35-75	-	-	-	35-75	35-75
Depth, ft.	615-2691	2691-5090	2862	4300	6255	2965	2965
6 rpm	15	12	16	20	12	20	14
3 rpm	14	11	15	18	11	14	13
YP, lb/100 ft2	24	18	25	27	20	33	19
LSRV	12	10	14	15	9	13	10
Had stuck pipe	NO	NO	NO	NO	NO	NO	NO
Flow Rate,GPM	500	602	652	650	420	497	700
AV, FPM	53	118	89	128	92	58	135
RPM	60	-	-	35	40	-	60
ROP, Ft/Hr	16	25	26	46	43	44	39
Flow Type	TURB	TURB	TURB	TURB		TURB	TURB
CCI	2.41	3.65	1.36	2.93		3.44	1.9
Hole Cleaning	GOOD	GOOD	GOOD	GOOD		GOOD	GOOD

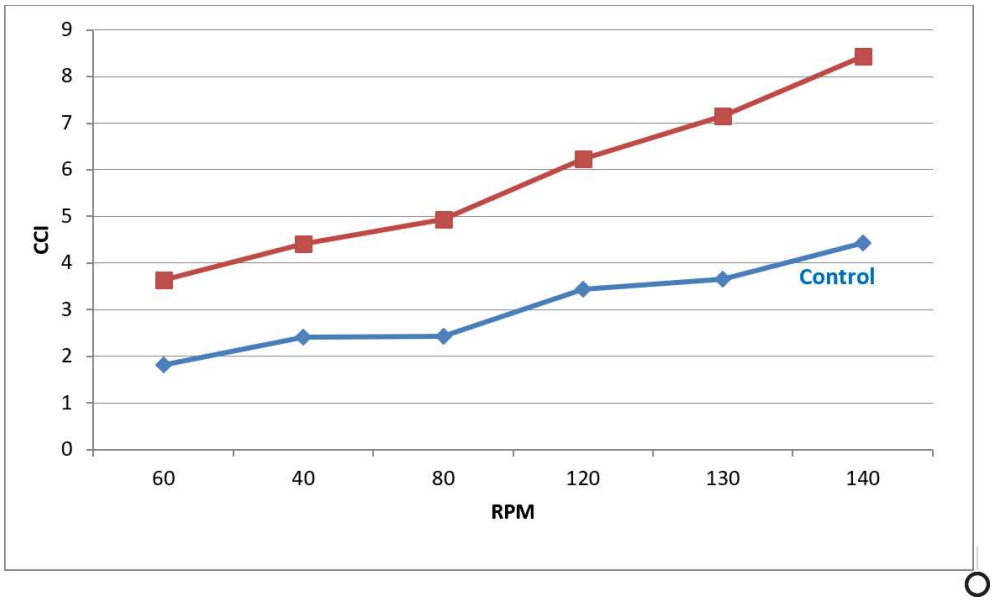
Parameters	Well-IV	Well- V	Well -VI	Well –VII	Well – VIII
Hole Size, inch	6.125	8.5	8.5	6.125x7 ¼	16
Mud Type	OBM	OBM	OBM	OBM	WBM
MW, ppg	11.2	9.8	11.5	11.2	10.6
Inclination, degree	90	-	73	42	49.32
Depth, ft	10090	5065	14351	7765	5163
6 rpm	9	4	9	7	18
3 rpm	7	3	8	6	15
YP, lb/100 ft2	19	4	15	8	30
LSRV	6	2	7	5	12
Had stuck up	NO	YES	YES	YES	YES
Flow Rate, GPM	300	450	414	280	850
AV, FPM	494	233	187	31	90
RPM	130	80	-	140	40
ROP, Ft/Hr	65	27	-	50	17
Flow Type	TURB	LAM		TURB	TURB
CCI	4.44	0.31		0.95	2.99
Hole Cleaning	GOOD	POOR		POOR	GOOD

DRILLING FLUID HYDRAULICS CALCULATOR

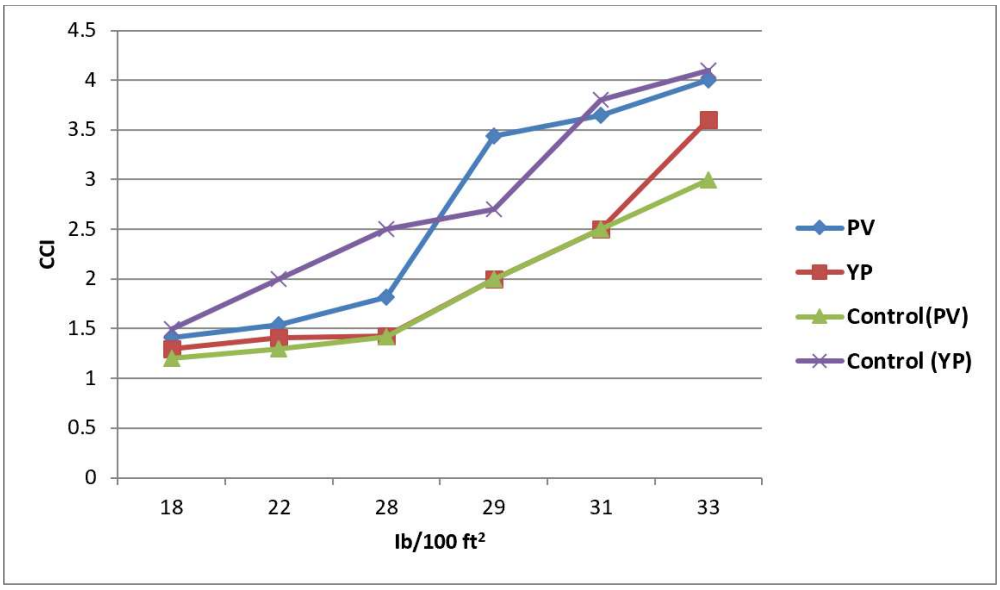
		Shear Rate Sec $^{-1}$	Shear Stress Dynes/Cm	Apparent Viscosity	PV	YP	n	k	Annular Velocity Feet/min	Annular pressure losses	ECD in ppg	Effective Viscosity	Reynolds No.	Critical Annular velocity, ft/min	HPP	Jet Velocity, ft/sec	Flow Type	Annular Velocity Ft/sec	Slip Velocity, ft/min	Cutting Carrying Index	Hole Cleaning
MW in ppg	11.2				42	8	0.88	0.21	319	479.26	12.68	10.21	11056.72	364	583.20	173.62	TURB	5.32	29.81	0.95	POOR
TVD in Feet	6237																				
Pipe Length in feet	6237																				
Hole Dia in inch	6 1/8							Annular capacity,bbl/ft				Critical Flow rate, gpm				Pressure drop across bit in psi				Jet Impact Force,psi	
Pipe dia in inch	4								0.020901				319.93605								
Flow Rtae in GPM	280																272.57			281.82	
Nozzle Size	15					Herschel Bulkley						HB Modified Power law									
Stand Pipe pressure	3570					True Yield			Shear stress			n	K								
600	92	1021.92	469.2	45.91357				23.95		445.25		0.77044	189.25637								
300	50	510.96	255	49.90606				23.95		231.05											
200	43	340.64	219.3	64.37882				23.95		195.35											
100	29	170.32	147.9	86.83654				23.95		123.95											
6	7	10.2192	35.7	349.3424				23.95		11.75											
3	6	5.1093	30.6	598.9079				23.95		6.65											
Hydraulics dia	2.125																				
X	742.8718																				
Diameter of cutting in inch	0.2																				
Density of cutting ppg	21.658																				
No. of Nozzle	3																				
Nozzle Area in Sq Inch.	0.517																				

Input Cell
Calculated Cell

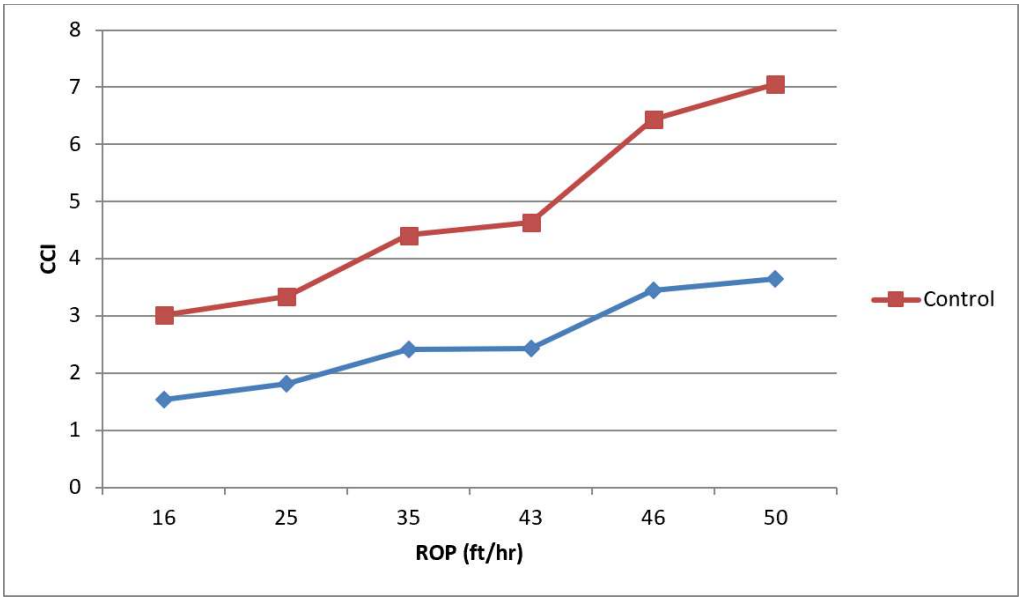
Excel Sheet developed by Dr. Srikant used for the calculation of Hydraulics parameters



CCI vs RPM



CCI vs PV and YP

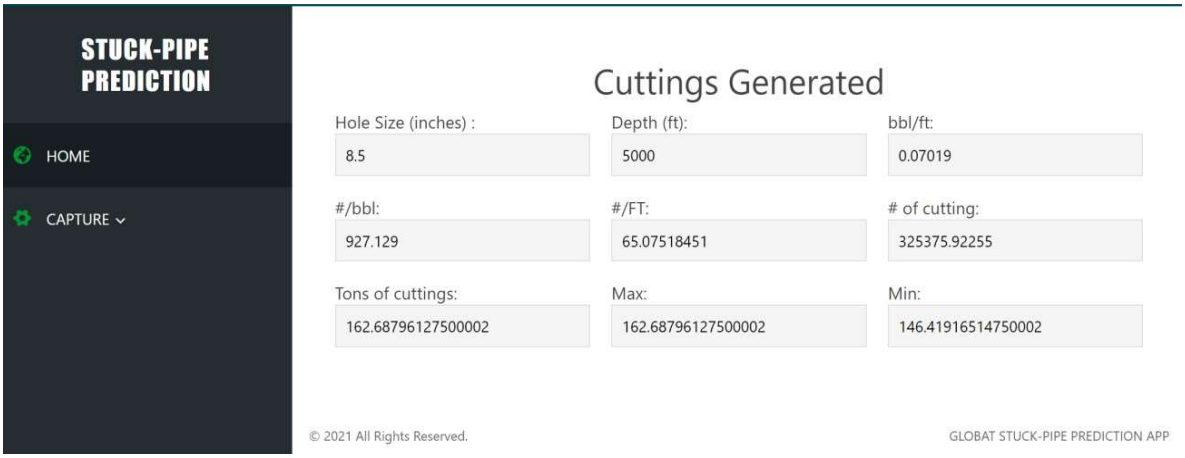


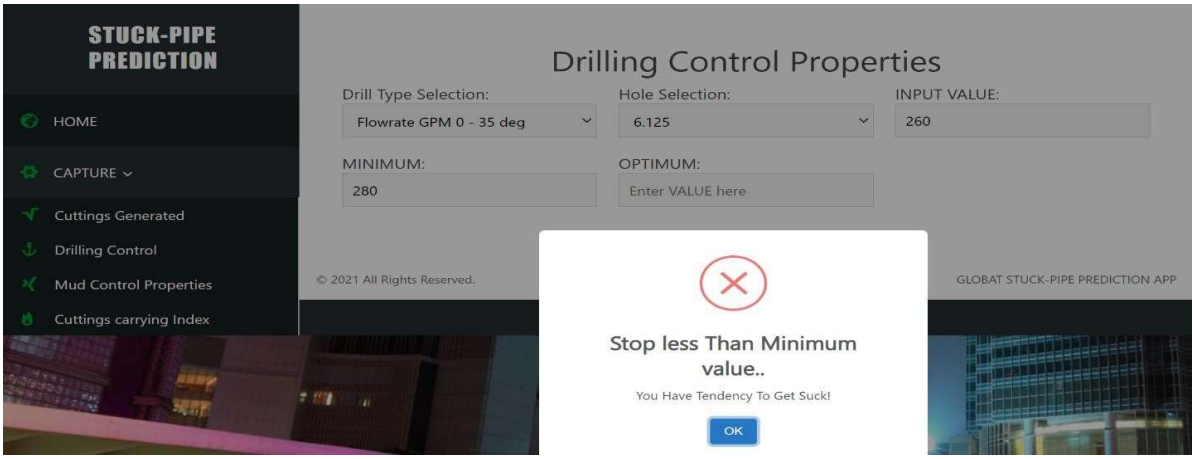
CCI vs ROP

Stuck Pipe Prediction App:

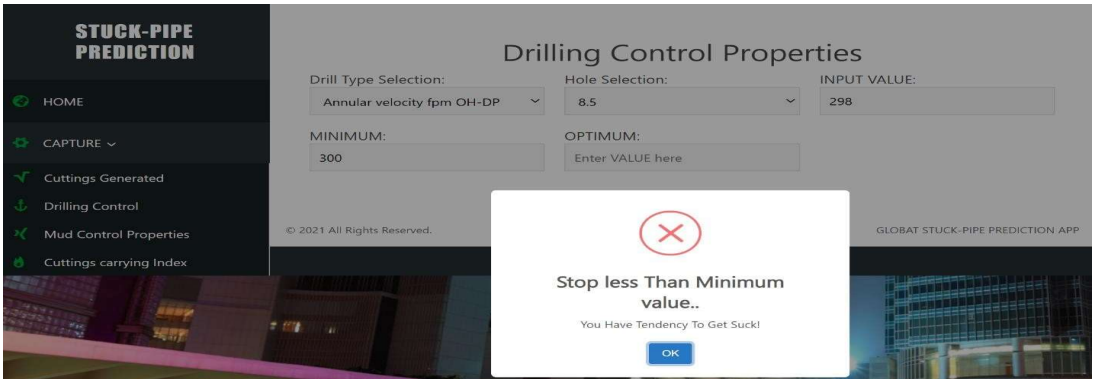
Analysis of the data and information generated of the 8 wells under study shows that the stuck-up took place in those wells where the flow was laminar, and the CCI was low. Whereas the wells with turbulent flow and high CCI did not face any stuck-up issues. However, in spite of turbulent flow and high CCI, stuck up was observed in wells no. 6 and 8. It was due to low MW and hole instability. Keeping in view, these observation, an app was developed to predict the hole condition, to avoid any occurrence of stuck up. The following parameters were taken into consideration for the development of the app.

- Cutting Generated
- Drilling Control
- Mud Properties
- CCI

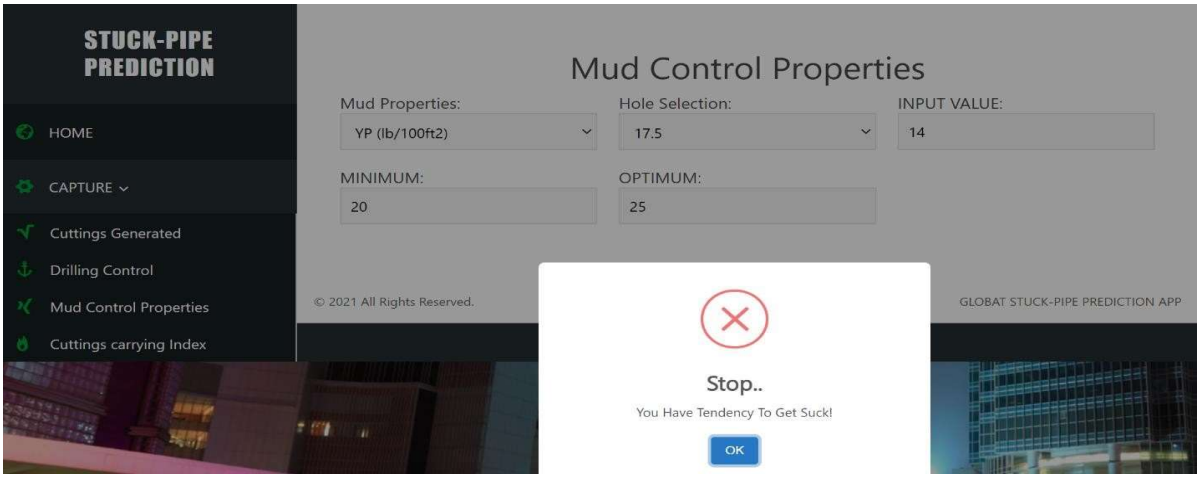


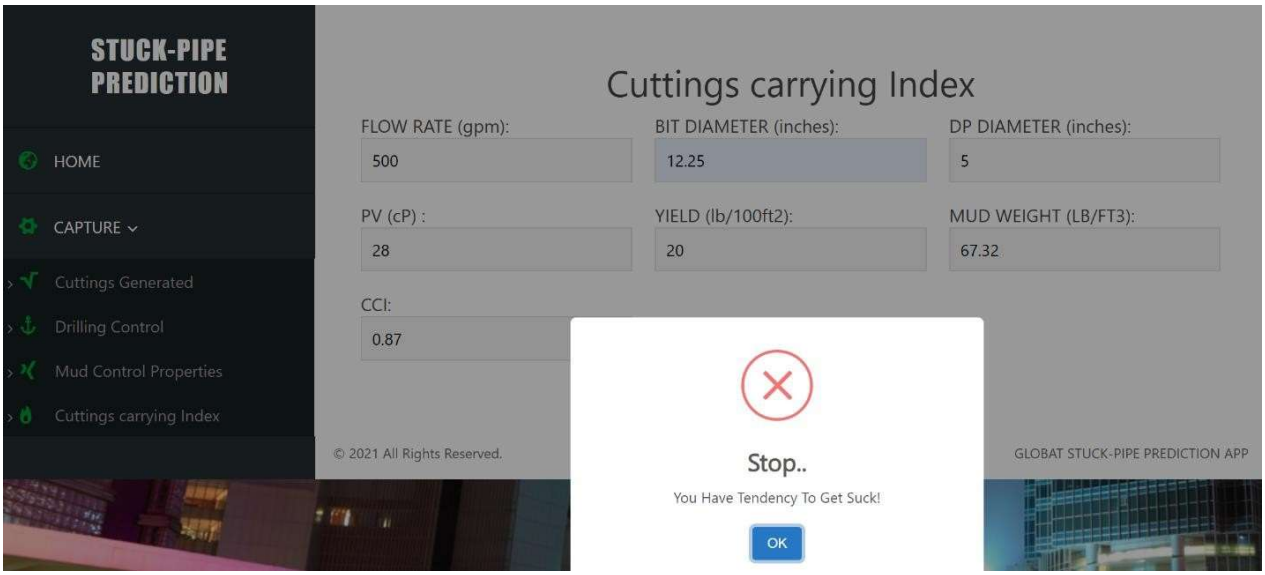


Flow Rate



Annular Velocity





Conclusion and Recommendation

The issue of hole cleaning, a significant factor associated with stuck pipe, was considered. Different hole-cleaning factors were taken into consideration during this study. The factors considered included mud properties (yield point, low shear rate viscosity, mud weight). It also considered drilling parameters such as circulation time, annular velocity, flow rate, drilling penetration rate, pipe rotation, and other factors such as cutting size, shape

and density, the formation, and well geometry.

From the factors listed above, it is established that when these parameters are not efficiently controlled, there is a likelihood of a stuck pipe.

The parameters were analyzed for each of the eight wells listed, involving calculations used in industry best practices such as the Cuttings Carrying Index.

The use of a created excel hydraulic sheet (Rheology calculation Sheet) to calculate some parameters such as ECD, Reynolds No., Critical annular velocity, Jet Velocity, Slip Velocity, Cutting Carrying Index, and Hole Cleaning, led to the newly developed software application.

The application standard was also set based on the created drilling standard data made from wells that were successfully drilled.

The stuck pipe prediction application includes all the relevant drilling and mud properties mentioned above.

It was observed that as specific parameters were altered, they affected the results and thereby dictating the possibility of a pipe being stuck.

This would help as specific parameters can be adjusted during the drilling process to avoid stuck pipe situations.

OBSERVATIONS:

With the use of the developed software, we were able to detect the parameters that led to the stuck pipe situations. When these parameters were adjusted, the results showed that the

situation could have been appropriately analyzed before further drilling commenced. The drilling parties can analyze these outcomes and appropriate recommendations and suggestions applied.

RECOMMENDATION:

The stuck pipe prediction application is apt in the calculations and predictions of stuck pipe during drilling. Therefore, I would recommend that the app is tested and tried as it can be used during real-time drilling activities.

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