Effect of Lubricity of Drilling Fluids on Buckling and Lockup of Coiled Tubing in Drilling Operations

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1. Introduction

The paper highlights a challenge faced by the drilling industry which is striving to go deep in order to extract beyond the unadventurous oil and gas resources. Besides other problems, one of the prominent and most frequently confronted problems in doing so is the buckling of the drillstring or coiled tubing due to increased length corresponding to the drilling depth. The factor mainly responsible for this buckling is understood to be the friction between the drillstring/coiled tubing (CT) and the wellbore that proliferate due to enormous surface area of contact. Drilling fluids serves the function of providing effective lubrication between the drillstring/coiled tubing but eventually fails to maintain its performance due to changing deep wellbore conditions. Besides overviewing the problem and its causes, the paper explains the development of an experimental setup that enabled to imitate the drilling process and study the effect of changing the drilling fluid on buckling behavior. The presented results, highlights the significance of changing the drilling fluid rheology, mainly the friction coefficient, to reduce the friction between the wellbore and the tubing, and thus improve axial force transfer which is mainly responsible for initiation of buckling and limited reach of drilling operation. The buckling patterns and force transfers were recorded corresponding to drilling fluids having different friction coefficients. The procedure for preparing different drilling fluids recipes and measurement of friction coefficient as per API standards is also discussed.

2. Dependence of Buckling On Friction

As described earlier that friction is mainly responsible for buckling of tubing which in turn generates additional wall contact forces (WCF) that could ultimately lead to a complete lock-up situation. It is thus crucial to have detailed insight upon the inter-dependence between friction, buckling and wall contact forces. Mathematically due to a lot of complex variables involved, none of the models precisely addresses the problem. In this paper, a simple approach to test the dependence of buckling on friction is introducedand improved drilling fluids are used as a solution to minimize friction and hence buckling.

3. Development of Experimental Setup

This paper presents the development of an experimental setup to investigate this problem and study the buckling behavior under varying conditions.

4. Results and Discussion

The developed setup is used to study various buckling patterns and the effect of increasing the top load on the axial force transfer was recorded. The top load was increased gradually from 0N to 1000N and the bottom loads were observed.
Three drilling fluids (S1, S2 and S3) with different friction coefficients and compositionsare reportedin table 1.

Table 1 Friction coefficient for sample S1-S3

Sample	Composition	Friction coefficient
S1	500 ml water + 30 gmBentonite	0.1405
S2	500 ml water + 15 gmBentonite and 15 gm Barite	0.2308
S3	500 ml water + 30 gm Barite	0.3057

The drilling fluid samples (S1-S3) were processed by using dynamic filtration equipment to prepare a thin mud cake. The mud cakes were then tested by using the mud cake adhesion factor meter to record the friction coefficients. The friction coefficients recorded are shown in table 1above.

Table 2 Reduction in Axial force transfer (ΔF) for samples S1-S3

Sample 1 (S1)			Sample 2 (S2)			Sample 3 (S3)		
F_t	F_b	ΔF_1	F_t	F_b	ΔF_2	F_t	F_b	ΔF_3
0	0	0	0	0	0	0	0	0
100	85	15	100	80	20	100	75	25
200	145	55	200	125	75	200	115	85
300	200	100	300	180	120	300	170	130
400	255	145	400	220	180	400	190	210
500	310	190	500	280	220	500	235	265

The results in table 2show clearly that sample S1 with lowest friction factor has minimum reduction in axial force transfer i.e. improved force transfer. The worst force transfer was observed with sample S3 which possess the highest friction factor. Thus it is concluded that by altering the friction factor the friction between the CT and wellbore can be reduced considerably while improving the axial force transfer.
The results when compared with the testes carried out without drilling fluids showed that there is a remarkable impact of drilling fluid lubricity on the buckling behavior of tubing.

5. References

[1] Abdo J., Danish MH., Nano-Enhanced drilling fluids: Pioneering approach to overcome uncompromising drilling problems, J. Energy Resources Technology (ASME) 2012; V. 134 (1), pp. 501-506.