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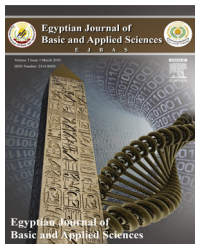

Review Article

Early detection enhancement of the kick and near-balance drilling using mud logging warning sign

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ABSTRACT

Early kick detection is of great concern while drilling wells. The late kick detection can lead to uncontrolled blowout which increases the possibility of injury and potential lose of life and equipment. Causes of kick and the importance of early kick detection are introduced. Kick detection from mud logging real time data and kick detection in the offshore Nile Delta are discussed. Limitation of the conventional well control procedure in low permeable formation is introduced. A comparison between gas parameters warning sign and drilling parameters warning sign was carried out. A new advanced early kick detection method is proposed based on more than 10 years of experience in monitoring real time mud logging data while drilling and analyzing flow and kick reports. The proposed advanced early kick detection method uses additional accurate flow check using trip tank and recommends adding two additional accurate pressure sensors while shut-in well. The proposed method has a great advantage using gas parameters which can detect near-balance state before kick occur. The advanced kick detection method does not require any rig equipment modification nor interfere with any drilling operation. Case studies in the offshore Nile Delta wells illustrate the limitation of the conventional well control procedure and the advantage of the proposed method.

1. Introduction

The kick prevention and early kick prediction is of great concern in the petroleum industry. The late kick detection can increase the amount of formation fluids that enters the well borehole, which increases the kick pressure and makes it hard controlling the kick. It leads to uncontrolled blowout, lose circulation, waste time and losing the hole section. Consequently it costs the oil industry billions of dollars a year, as well as the more serious consequences of injury and potential loss of life.

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Table 1 – The mud logging terms used in this work.

Terms	Symbols	Definitions
Background Gas	BG	The gas enters the drilling mud as the formation is drilled by the bit and usually maintains a steady but low level.
Blowout preventer	BOP	A large valve at the top of the well that may be closed if the drilling crew losses control of formation fluids.
Connection Gas	CG	The gas released from the formation to the bore hole while pump off at pipe
Differential pressure	—	The difference between the hydrostatic pressure and the formation pore pressure in the well
Equivalent Circulating Density	ECD	The combination of the hydrostatic pressure of the mud in a static condition, plus the fractional forces caused by mud moving up the annulus.
Hydrostatic pressure	—	The pressure exerted by an overlying static column of mud fluid corresponding to its density and vertical height
Measurements while drilling	MWD	Tools uses for measuring the physical properties of the well while drilling
Near-balance	—	The state when formation pore pressure increase close to hydrostatic pressure and hydrostatic pressure still higher
Pump off Gas	POG	The same like connection gas but occurs when pump off without pipe connection
Rate of penetration	ROP	The speed at which the drill bit can break the rock and thus deepen the wellbore
Shut-in casing pressure	SICP	The surface pressure exerted at the top of the annulus when the BOP is closed, this pressure represent the difference between the formation pressure and the hydrostatic pressure in the annulus when kick occurs
Shut-in drill pipe pressure	SIDP	The surface pressure exerted at the top of the drill pipe when the BOP is closed, this pressure represent the difference between the formation pressure and the hydrostatic pressure in the drill pipe when kick occurs
Total Gas	TG	The measurement of the total combustible hydrocarbon gasses which are present in the mud out flow
Trip Tank	—	A low-volume, calibrated tank that can be isolated from the remainder of the surface drilling fluid system and used to keep track of fluid volumes while tripping

The use of mud logging gas anomalies was recommended as an overpressure indicator and as a warning of impending blowouts [1]. Similarly [2], proposed mud gas anomalies as an aid in controlling drilling fluids hydrostatic head–pore pressure relationships. Nowadays there are a lot of complicated services for early kick detection, but mud logging service is still the first choice for early kick detection because it is simple, cheap, requires low technological maintenance and does not interfere with any drilling operation.

The objective is to focus on real time mud logging warning signs not only when kick starts with small intensity specially in low permeable zone (e.g. shale) using drilling parameters but also before kick occurs when pore pressure increased gradually close to hydrostatic pressure (near-balance state) using gas parameters warning sign like increase in background gas (BG), appearance of connection gas (CG) and pump off gas (POG). Finally recommendations for early kick detection while drilling will be achieved. The mud logging terms used in this study are listed in Table 1.

2. Causes of kick

A kick is defined as an unintentional influx of formation fluids into a borehole. It occurs because the pressure exerted by the drilling fluid column is not great enough to overcome the pressure exerted by the fluids in the formation drilled.

As described by Nas [3] there are three conditions required for a kick to occur in the open hole and these are:

1 The exposed formation pore pressure must be greater than the drilling fluids pressure in the open hole.
2 The formation must have sufficient permeability to allow flow into the open hole.
3 The pore fluids must have sufficient low viscosity so that it can flow.

Therefore, this explains why some intervals of low permeable zone (mainly shale) in the Nile Delta were drilled underbalanced without hole problems till drilling a permeable zone which allow kick flow.

3. The importance of early kick detection

The time from start of formation fluids influx to the detection of a kick is of great importance. If the kick is detected early, the amount of low density fluids that enters the borehole can be reduced and thereby the maximum pressure that occurs at a given location in the well can be reduced. Therefore, evaluating the existing kick detection parameters is important. Where late kick detection increases the influx amount, which decreases the hydrostatic pressure, then additional influx of formation fluids increases the possibility of flammable and toxic gas to come out, as well as the more serious consequences of injury and potential lose of life and equipment. According to gas expansion [4] and gas solubility in mud [5], the late gas influx detection can lead to rapidly expansion near surface. For example one cubic meter gas influx at depth 4000 m if ignored may become 50 cubic meter or more at depth 500 m by which time the gas bubble is rapidly expanding. So any small warning sign for kick indication from mud logging real time data must be taken into consideration.