Risk Planning and Mitigation in Oil Well Fields: Preventing Disasters

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ABSTRACT

Lost circulation presents one of the major risks associated with drilling. The complete prevention of lost circulation is impossible but limiting circulation loss is possible if certain precautions are taken. Industry experience has proved that is often easier and more effective to prevent the occurrence of loss than to attempt to stop or reduce them once they have started. The problem of lost circulation was magnified considerably when operators began drilling deeper and/or depleted formations. A strategy for successful management of lost circulation should include preventative (best drilling practices, drilling fluid selection, and wellbore strengthening materials) and remedial measures when lost circulation occurs through the use of lost circulation materials. In this paper the authors present lost circulation zones and causes, potential zones of lost circulation, excessive downhole pressures causes, preventive measures, tools and methods for locating loss zones and determining the severity of loss, lost circulation materials, and recommended treatments.

Keywords: Cross-Linked Polymers, Depleted Zones, Drilling Fluid, Equivalent Circulating Density (ECD), Gunk, LCM, Lost Circulation, Pills, Seepage Losses, Thief Zone, Wellbore Strengthening

INTRODUCTION

Drilling of oil, gas or geothermal well is technically demanding process that often accompanied by a variety of unexpected problems which result in additional cost and time. One of them is certainly lost circulation. Lost circulation or lost returns can be simple defined as the uncontrolled flow of mud into a thief zone. Although this problem as well as his cause is well known for many years, there isn’t unique technical solution. Based on recent data the petroleum industry spends millions of dollars a year (e.g. expenses associated with rig, drilling fluid costs and equipment delays) to prevent and cure lost circulation problems. The new challenges in drilling such as drilling high temperature and high pressure well, drilling through complex lithology, drilling through unconventional shale, and drilling extended rich drilling wells (ERD) require finding the new solutions for already known problems.

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There are several potential problems associated with lost circulation during drilling. They include: loss of mud, lost time, poor cement job, reduced safety, stuck pipe, additional casing string, failure to reach target depth, blowout and kill operations, downhole blowouts, environmental incident, and the abandonment of expensive wells. Moreover, lost circulation has even been blamed for minimized production because the losses have resulted in failure to secure production tests and samples, while the plugging of production zones have led to decreased productivity.

The complete prevention of lost circulation is impossible because some formations, such as inherently fractured, vugular, cavernous, unconsolidated (high-permeability zones) or depleted low-pressure formations (usually sands), are not avoidable if we want to reach the target zone (Al Ubaidan et al., 2000; Algu et al., 2007; Bell et al. 1987; Davidson et al., 2000; Ferras et al., 2002). The problem of lost circulation was considerably magnified when operators began drilling deeper and/or depleted formations (Sanders et al., 2003; Suyan et al., 2009). The petroleum industry has invested a significant effort into understanding the mechanisms behind lost circulation, developing new tools to help locate the thief zone, and implementing new steps to minimize or eliminate this problem because prevention is more effective than remediation (Whitfill et al., 2007).

Problem Statement and Research Objectives

Loss of drilling fluid is technoeconomically expensive to oil companies around the world. It is becoming an increasing problem for the oil industry as wells are drilled through and/or depleted formations. Lost circulation causes not only the loss of mud but also lost time, poor cement job, reduced safety, stuck pipe, additional casing string, failure to reach target depth, blowout and kill operations, downhole blowouts, environmental incident, and the abandonment of expensive wells. Therefore, the focus of this study was to review the relevant literature to identify the key factors associated with lost circulation and then to develop methods of assessment and mitigation. The secondary research purpose was to show researchers how they may continue to extend the body of knowledge about lost circulation and petroleum engineers working in the field how they can apply newly acquired knowledge to solve the project-related problems in practice.

LITERATURE REVIEW

In past decades, scientific (researches) from different companies tried to find a new innovative solution for lost circulation problem that occurs in increasingly demanding subsurface conditions as the result of drilling technology development.

Conventional lost circulation materials including pills, squeezes, pretreatments, and drilling procedures using equivalent circulating density management often reach their limits in effectiveness and become unsuccessful in the deeper hole conditions where some formations are depleted, structurally weak, or naturally fractured and faulted (Wang et al., 2005, Savari et al., 2015). Whitfill (2003) recommends a fully engineered approach that incorporates a number of planning tools, including: borehole stability analysis, hydraulics modeling to estimate Equivalent Circulating Density (ECD), drilling fluid and Lost Circulation Materials (LCM) selection to help minimize effects on ECD.

A variety of methods to enhance the integrity of the wellbore and prevent lost circulation have been developed, and include techniques such as: wellbore isolation (Benaissa et al., 2006), fracture propagation resistance (Morita et al., 1990), fracture closure stress (Dupriest, 2005; Aston et al., 2004; Majidi, 2015), and hoop stress enhancement (Majidi, 2015). Proposed mechanisms behind various means proposed and used to enhance wellbore-pressure containment include
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