Engineering Failure Analysis 65 (2016) 74–85

Contents lists available at ScienceDirect

Engineering Failure Analysis

journal homepage: www.elsevier.com/locate/engfailanal

Failure analysis of drillstring in petroleum industry: A review

M.T. Albdiry, M.F. Almensory

Department of Materials Engineering, College of Engineering, University of Al-Qadissiya, Al-Diwaniya, Iraq

ARTICLE INFO

Article history:
Received 24 September 2015
Received in revised form 13 March 2016
Accepted 14 March 2016
Available online 16 March 2016

Keywords:
Drillstring
Drill collar
Drilling bit
Hammer bit
Drilling performance
Petroleum industry

ABSTRACT

Understanding the failure analysis of drillstring and its components i.e., drill collar and drilling bit is one of the essential issues in the oil and gas industry for the high cost of oil well drilling. Different ways such as air drilling, percussion drilling and downhole hydraulic ultra-high pressure (UHP) jet assisted drilling have been often used to improve the rate of penetration (ROP), minimize the cost of drilling per foot and diminish well deviation. Nevertheless, these drilling ways aggravate the working conditions of the downhole drilling tools materials and hence their properties cannot meet the demands of these conditions and consequently causing a risk drillstring failure. The unfavorable geological conditions and the repeated impact for breaking the rock may also cause severe bit bouncing and violent vibration. Tooth loss, tooth fracture, tooth wear and microcracks in addition to drill pipe fatigue from bending stress caused by buckling load are realistic examples of failure modes which occurred in the drilling tools. This study comprehensively describes the reasons causing these failure modes in order to manage risks and achieve high performance of wells and borehole sections. The role of working parameters i.e., bottom hole temperature and solid content on the drilling tools' life time, and the role of predrill predictions of pore pressure or wellbore stability on the drilling process are presented.

Contents

E-mail address: mushtaqalbdiry@gmail.com (M.T. Albdiry).

http://dx.doi.org/10.1016/j.engfailanal.2016.03.014
1350-6307/

1. Introduction

1.1. Drilling process in the oilfield

In the petroleum industry, the paramount way to get oil and gas is well drilling which is used to create holes in the earth subsurface using a special machine called drilling rig. The term “rig” generally refers to the complex of equipment that is used to penetrate the surface of the Earth's crust. The lower part of drilling rig is hollow column or string called drillstring which is typically made up of three sections: Bottom hole assembly (BHA), transition pipe and drill pipe [1]. The first section, BHA including drill collar that is a rock breaking tool and drill bit where the BHA is heavy with a thick walled hollow tube used for drilling fluid being pumped down through it and circulated back up the annulus (the void between the casing and the drillstring). The second section is a heavyweight drill pipe (HWDP) used to provide a flexible transition between drill collars and drill pipe which in turn, works to reduce the number of fatigue failures occurred directly above the BHA and add additional weight to the drill bit. The third section is a drill pipe, makes up the majority of the drillstring back up to the surface. Each drill pipe comprises a long tubular diameter portions with an outside diameter called the tool joints which has a male “pin” threaded connection at one end and a female “box” connection at the other end for making segment to the next segment. Although, all drill pipe has the same diameter, its upper section is handled by using a higher strength material to carry a higher axial loading and supporting the entire drillstring in these portions. For further information, Fang and Duan [2] comprehensively described the development of oil and gas fields by improving drilling speed and quality. They also described the drilling platform categories in the relation to their operation characteristics, while the current and historical costs of the oil and gas wells drilling processes are described in Lukawski et al. [3].

1.2. Drilling operation efficiency

In order to improve the rate of penetration (ROP) at less overall cost and good borehole conditions and enhancing drilling efficiency at high performance in wells and borehole sections; different ways were used such as the optimal design of downhole and well trajectory, using drilling fluid aligned with drillstring and reducing the well placement uncertainty in both depth and azimuth [4]. Percussion drilling was also widely used in oil and gas industry for its contribution in a significant increase in the ROP with less well deviation and less formation damage compared to ordinary mud drilling [5]. The air drilling technology has also proven to significantly increase the ROP [6].

Furthermore, hydraulic ultra-high pressure (UHP) jet assisted downhole drilling is installed right above the drill bit in order to improve the ROP and utilize the intensifier by the way of producing UHP jet flow via pressurizing the drilling fluid, cutting and breaking the rock. This technique is further incorporated with cutting-cleaning mechanisms [7].

On the other side, each of the drilling ways discussed above, has its own drawback that could possibly add a significant threat to the drillstring safety due to the severe working conditions. For instance, in percussion drilling, bit rotation is used to make the bit tooth impacts new positions on the rock each time so that severe drilling tool failures such as tooth loss, tooth fracture and tooth wear occurred where they restricted the further development of the drilling process [5]. Also, despite the truth of using percussion drilling or air drilling with drillstring is resulted in a high quality well drilling at less cost per foot in the lowest time possible, it may also result in emerging of several factors limiting the drilling performance such as drilling vibration [8]. Along with this, using drilling fluids like water-based fluid muds in drilling boreholes to cool and lubricate the drill bit, clean the hole bottom and carry cuttings to the surface. However, this fluid may contain various dissolved synthetic chemical compounds (e.g., alkalies, salts and surfactants), various insoluble substances (e.g., barite and clay) and organic polymers in colloidal state and emulsified oil, which can be aggressive and give rise to corrosion threat for the drillstring tool materials [9]. Thus, a sophisticated study determining the modes and mechanisms of drilling tool failures occurred in drilling operations is required. Hence, this review article mainly aims at conducting failure modes occurring at drilling tools through the cutting processes of the oilfields.

1.3. Scope of the research

This research attempts to comprehensively review most failure modes occurred in the drilling tools (drillstring and drill bit) during the drilling process of the oilfield. To discuss the main concepts of the drilling process and important aspects of drillstring components as well as the drilling aid methods that used to improve the drilling efficiency. It also highlights the main reasons behind these failure modes in order to manage risks and achieve high performance of wells and borehole sections. The research also presents the role of working parameters i.e., bottom hole temperature and solid content on the drilling tools' life time and the role of pre-drill predictions of pore pressure or wellbore stability on the drilling process.