SPE/IADC 140211

Which Material is Less Resistant to Buckling: Steel, Aluminum or Titanium Drill pipe?

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This paper was prepared for presentation at the SPE/IADC Drilling Conference and Exhibition held in Amsterdam, The Netherlands, 1–3 March 2011.

Abstract

Access to reservoirs in ultra-deep and extended reach drilling projects leads the industry to develop new resistant and higher-strength materials. Drilling equipments manufacturers and drilling contractors have to meet higher requirements of operators to manufacture and operate quality tubulars in these severe environments. However, with the increasing complexity (deep, long, high-pressure/high-temperature, sour service) of drilled wells, steel may become a limiting drill pipe material. A non-steel alternative material may exist such as aluminum, titanium or composite materials.

Buckling of steel, aluminum and titanium tubulars inside wellbore has been the subject of researches and articles in the past. According to some authors, the light Young Modulus of lightweight drill pipes does not affect their buckling response: the relative low stiffness of the pipes would be balanced by reduced contact forces with the wellbore.

This paper presents a full study discussing clearly the buckling response of steel and lightweight drill pipes in both experimental bench and real field conditions.

This paper shows a full comparative study between steel, aluminum and titanium drillstrings in Extended Reach Drilling (ERD) wells and studies the opportunity to use aluminum and titanium drillstring in ERD wells while the buckling, drilling efficiency and drillstring integrity stays acceptable. Critical buckling loads for each drill pipe material and dimension is reviewed and presented, using our numerical model and in the form of charts which could be used by drilling engineers. Along this comparison, we also focus on drillstring rotation, friction and tortuosity effects on buckling loads.

Finally, this paper should give a better comprehension of the mechanical behavior of lightweight material for drill pipe, which can improve significantly well planning to drill wells with an increasing depth, length and complexity.

State of the art

Introduction

Buckling occurs when the compressive load in a tubular exceeds a critical value, beyond which the tubular is no longer stable and deforms into a sinusoidal or helical shape. The sinusoidal buckling (first mode of buckling) corresponds to a tube that snaps into a sinusoidal shape. The first mode of buckling is sometimes called lateral buckling, snaking or two-dimensional buckling. The helical buckling (second mode of buckling) corresponds to a tube that snaps into a helical shape (spiral shape).

The first work dedicated to the buckling behavior in oil-well operation was initiated by Lubinski. Since then, many theoretical works and/or experimental studies have been developed to better understand the buckling phenomenon. A larg part of these studies concentrated on the buckling phenomenon assuming steel drill pipes. Few studies (proposed by Gelfgat *et al.*[1] & Smith *et al.*[2]) provided informations about buckling behavior of aluminum and titanium pipes.

Today, materials such as aluminum or titanium are considered as viable options for drilling operations. Specific physical and mechanical properties of these materials ensure high strength-to-weight ratio and a good corrosive resistance under given pH connditions.

Physical and Mechanical Properties of Materials:

Many industrial and research studies have exposed the idea of using non-steel drillstrings in order to reduce torque and drag loads in deep and extended reach-drilling. These materials are: high strength steels, aluminum, titanium and composites.

In actual drilling operations and field developments, steel is the most widely used material. Steel grades have continuously been optimized for a better handling/manufacturing and a higher strength. The most important improvement is the yield strength which limits the stress beyond which the material starts to yield. The recent steel drill pipes (SDP) developments lead