The role Of controlling drilling-induced vibrations On ROP optimization: A literature review

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Abstract

Abstract:Objectives/ Scope:
Drilling-induced vibrations can cause drilling dysfunction and offset the rate of penetration (ROP) optimization when vibration levels increase. Low vibrations levels as well show a limitation to ROP and associated weight on bit (WOB) and the overall borehole quality. This paper reviews two approaches of controlling drilling vibrations and its influence of ROP optimization: data-driven and physical-based approaches.

Methods, Procedures, Process:
Drilling-induced vibrations can be either torsional, axial, or lateral which result in the occurrence of stick-slip, bit-bounce, and whirl respectively. The first approach aims in controlling all vibrations types by training a machine learning (ML) classification algorithm. The algorithm determines if the outcome of given configuration of operational control drilling parameters will result in extreme vibrations. It utilises stick skip index (SSI) to measure the torsional vibrations' intensity and downhole-accelerometers to measure axial and lateral vibrations. The second approach focuses on controlling torsional vibrations by using the top drive as a boundary actuator to control wave propagation inside the drillstring.

Results, Observations, Conclusions:
The data-driven approach split collected data into training and test data. Training data was used for building an ROP model by utilising four analytical models and to train the ML classifier to determine the output of a set of drilling control parameters (High/Low vibrations). After feeding the classification model with ROP, WOB and RPM, a random forest algorithm was utilised to model SSI and lateral-vibrations as an associated function. Afterwards, the model was used on test data to predict the class of lateral-vibrations and SSI for a new set of parameters. This will optimise ROP through the selection of controlled parameters while excluding high torsional and/or lateral-vibrations associated parameters. On the other hand, the physical-based approach proposes a vibration controller method that applies for all 1D wave equation systems. It derived a non-reflective boundary condition for the controller resulting in a less-aggressive torsional vibration controller. This was achieved by adjusting the top-drive’s dynamic response to the incoming wave form \( v \) causing a time delay, which allows it to propagate to the bit end. Results of the continuous rotary wave machine showed that the stick-slip controller effectively absorb torsional vibrations at different frequencies while keeping the top-drive speed as required which consequently optimises ROP.
**Novel/ Additive Information:**

This paper reviews two approaches of controlling drilling-induced vibrations, where the first utilised a data-driven approach of controlling all vibration types and the last utilised a physics-based approach to control torsional vibrations. Both approaches resulted in optimising ROP while considering the role of vibrations unlike conventional ROP optimization methods where they are not accounted for directly.