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Identifying Inefficient Drilling Conditions Using Drilling-Specific Energy

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Abstract

A novel correlation identifying inefficient drilling conditions is presented using experimental and field data. Historically, Mechanical Specific Energy (MSE) has been used to improve the drilling performance with mixed results. Drilling Specific Energy (DSE) is the amount of energy required to destroy and remove underneath the bit a unit volume of rock. DSE includes axial, torsional and hydraulic energy. DSE is different than MSE because it includes a hydraulic term. The initial MSE correlation (Teale, 1964) has been modified to accommodate the new hydraulic term.

Experimental and field data presented on the paper show that DSE can be used to identify inefficient drilling conditions. Experimental results illuminate the importance of including bit hydraulics into the specific energy analysis for drilling optimization. Field results reveal specific patterns for inefficient drilling conditions such as; bit balling and friction limited wells. These field results also enligthen a good correlation between the calculated DSE and the rock compressive strength.

The novel correlation presented in this paper will help to improve the drilling efficiency worldwide. The new hydraulic term included on the specific energy correlation is the key to correctly matching the amount of energy used to drill and the rock compressive strength. Also, this new term illuminates how much hydraulic energy is needed to drill faster and efficiently when the mechanical energy (axial and torsional) is increased.

Introduction

Mechanical Specific Energy (MSE) has been used to improve drilling performance with mixed results. MSE has been defined as the mechanical work done to excavate a unit volume of rock.[1, 2] Teale proposed calculating MSE based on its two components (“trust” and “rotary”) as follows:[1]

$$MSE = \frac{WOB}{A_B} + \frac{120 * \pi * RPM * T}{A_B * ROP} \qquad (1)$$

Teale also noticed that the minimum value for the specific energy correlates with the crushing strength of the medium drilled.[1]

Pessier and Fear introduced a bit specific coefficient of sliding friction to express torque as a function of WOB on the MSE correlation, as follows:[3]

$$\mu = 36 \frac{T}{D_B * WOB} \qquad (2)$$

Or

$$T = \frac{1}{36} \mu * D_B * WOB \qquad (3)$$

Substituting T in Eq. 1 by Eq. 3 yields:

$$MSE = \frac{WOB}{A_B} + \frac{13.33 * \mu * RPM * WOB}{D_B * ROP} \qquad (4)$$

For field applications, μ is usually assumed to be equal to 0.25 for tricone bits, and 0.5 for PDC bits.