SPE 115987

An Analysis of Noise Characteristics of Drill Bits

Christian Gradl, SPE, BP; Alfred W. Eustes, SPE, Colorado School of Mines; and Gerhard Thonhauser, SPE, University of Leoben

This paper was prepared for presentation at the 2008 SPE Annual Technical Conference and Exhibition held in Denver, Colorado, USA, 21–24 September 2008.

Abstract

There have been papers that analyse the relationship between drill bit design and its vibrational characteristics. These papers typically are based on the analysis of three-axis down-hole vibration sensors located near the bit. In this paper the authors take a simpler approach. Using a standard microphone literally pointed at the bit, they record the noise of the bit/rock interaction while drilling and analyse the resulting noise for basic information on the bit.

The data were gathered at the Colorado School of Mines in Golden, Colorado. The noise of a PDC, roller cone, and diamond bit were recorded under various operational parameters using microphones and a uniaxial geophone (used for confirming the data recorded on the microphones). Using a Fast Fourier Transform, the frequency spectra were extracted from the recorded data.

Summarizing the results of the analysis of the roller cone bit, the PDC, and the natural diamond bit, major differences in their frequency characteristics could be detected and furthermore, for drag bits, the frequency characteristics could be related to the bit's design. The frequency spectra of the roller cone bit can best be described with a general high amplitude level that is relatively evenly distributed over the whole frequency spectrum. The drag bit data showed a strong relationship between the number of cutting elements and frequency peaks on a plot of amplitude vs. cycles per revolution. Frequency peaks were observed at multiples of the number of cutting elements. In general this relationship was strongly visible on the PDC bit data but not a strong on the diamond bit data. The conclusion is that bit characteristics can be determined using only acoustical data (ie. the noise of a bit). Potential applications of this research include detecting and diagnosing bit problems (e.g. broken teeth, bit balling) in real time using acoustic data.

Introduction

The process of drilling in general always produces noise as a by-product. This noise is generated from the rock-bit interface, regardless of the type of bit or material the bit is drilling in (rock, wood, concrete, metal). Although there has been previous research and publications linking drill bit vibrations to the vibrational characteristics of a bit, until now this hasn't been done for the noise emitted by a bit. Even though no research has been done on this topic until now, personal experience from using a hand drill shows one that drilling in wood sounds different from drilling in concrete. And one can really hear while drilling in wood when one drills into a nail!

The objective of this research performed at the Colorado School of Mines in Golden, Colorado was to determine whether drill bits used in petroleum engineering applications have unique frequency characteristics, if this is the case, then whether these frequency characteristics can be linked to bit design parameters.

Vibration Theory

The theoretical background of this paper is the slip-stick theory[1], which describes the cutting actions of drag bits (PDC, diamond bits). Figure 1 illustrates this theory. In top of the figure, the diagram shows the cutter of a PDC bit that has completed fracturing the rock, leaving a crater. The cutter then slips along the bottom of this crater. At the end of the crater, the cutter encounters the edge where it sticks for a short time (slows, stops turning or even rotates backwards in relation to the drill pipe). This sticking phase generates a rise in torque. When torque has reached a threshold value high enough to fracture the rock, the rock fractures and the cutter starts moving again and creates yet another crater. In an ideal stick-slip scenario where the bit is perfect and matches the shear strength of the rock, only one rock chip would be produced between each of the cutters.