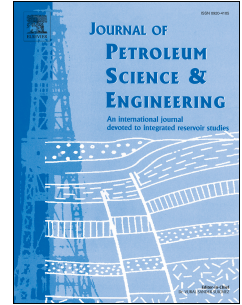


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Development of a New Rock Drillability Index for Oil and Gas Reservoir Rocks Using Punch Penetration Test

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Abstract

Punch penetration test has shown a good relationship with the rate of penetration (ROP) of tunnel boring machine (TBM) into hard rock. In addition, various indices have been determined from the analysis of the force-penetration curve of the penetration test to present rock drillability, boreability, and brittleness. Therefore, in the present paper, punch penetration test will be used to determine rock drillability index (RDI). In this research, 9 samples were taken from the same formation in two wells drilled at southwestern Iran. Considering the limitations in taking more samples, and also to enhance reliability of the results, each of the samples was divided into smaller specimens, so as to conduct multiple tests at each sampling point. Evaluation of the force-penetration curves of samples indicated that most samples of well 1 have little changes of forces early in the test, but they increase as the test proceeds. Because the samples from the Well 1 were taken from shallow depths, The change in the slope of the curve determined on the basis of the samples taken from Well 1 can be explained by the pores existing in these samples. Different indices were extracted from the analysis of the force-penetration curve of each specimen, including first peak slope index (BI_1), maximum peak slope index (BI_2), area under the curve (BI_3), and RDI. Initial examination of relationships between each of indices and the measured ROP follow an either exponential or power-law model. Evaluation of these models between each of these indices and actual ROP indicated that, an exponential curve gives the best fit to the obtained values. A comparison between estimated ROPs from the fitted relationships against measured values showed that the estimated ROP using the proposed index is highly accurate and reliable and can present a good measure of the reservoir rock drillability.

Keywords: drillability, Punch penetration test, rate of penetration, Brittleness

1. Introduction

Grinding of rock in the course of drilling can be evaluated using different indices including rock mass drillability (RDI, required time to drill 1 m of the well), drilling hardness (a dimensionless index), and energy intensity (Tanaino, 2005). RDI is a measure of ease of drilling the rock. RDI is a very important parameter in selecting the appropriate drilling method and drilling bit, predicting ROP, and determining the bit life (Hoseinie *et al.*, 2009; Kahraman *et al.*, 2000; Morris, 1969; Persson *et al.*, 1993; Shrivastava *et al.*, 2013). RDI is defined by numerous parameters (Figure 1 - Black *et al.*, 2008; Kahraman and Alber, 2006; Prikryl, 2001; Reckmann *et al.*, 2007; Thuro and Plinninger, 2003) which are either not well understood or not communicated to the end user (Prasad, 2009).

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