7th National Congress on Civil Engineering, 7-8 May 2013
University of Sistan and Baluchestan, Zahedan, Iran

Existing Ambiguities in the In-Situ Stresses Determination by Hydraulic Fracturing

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Abstract

Determination of the horizontal stresses in rocks by hydraulic fracturing (HF) method is very common today and can be used in almost any rock formation. The HF method involves the pressuring of a borehole interval that is sealed off by packers, until a fracture occurs or a pre-existing fracture starts to propagate, when the tensile strength of the rock is exceeded. The classical interpretation of HF test data in terms of the *in situ* principal stresses assumes that rock is linearly elastic, isotropic and homogeneous, and that the pore-fluid effect on rock strength obeys Terzaghi's effective stress law. Despite twenty five years of experience during which hundreds of HF stress tests have been performed, there are several important issues that have not yet been satisfactorily addressed. In this paper, the existing uncertainties are gathered then some summaries and suggestions are expressed about relevance between breakdown pressure and the maximum horizontal stress.

Keywords: In-Situ Stresses, Hydraulic Fracturing, Breakdown Pressure.

1. INTRODUCTION

The hydraulic fracturing (HF) method was first used in the oil and gas industry. The HF technique, which has been developed in recent decades, has created numerous applications such as oil and gas reservoir stimulation in petroleum industry, in-situ stress determination and disposal of nuclear waste [1-4].

In general, the HF test can be performed in three stages. At the first step, the fluid is injected into an isolated zone by packers. Then, the injected fluid pressure increases and creates lateral tensile stresses in the borehole wall and therefore cracks occur in the rock mass when the tensile stresses exceed the tensile strength of rock. The HF process in vertical borehole is shown in Figure 1.

In a typical graph of wellbore pressure versus time, the peak pressure that is called the breakdown pressure (P_b). When the injection stops, the wellbore pressure reduces (Shut-in stage) and the pressure obtained during this stage is the shut-in pressure (P_s). And in the last stage (flowback), the hydro fracturing fluid withdraws from the wellbore (Figure 2).

There are a large number of uncertainties for determining in-situ stresses by the HF method. Two important assumptions are required for the HF method. The first assumption is constant pressure along the fracture, which should be elliptical in shape. But the fluid pressure is reduced by rough surface of the crack length. The Other important one is assumption of dominantly tensile fracture, which represents a major crack in a single plane that is perpendicular to the minimum principle stress (Figure 1). Experimental analyses show that the tensile fracture is associated with shear fractures and branches. Hence, the main plane of fracture may not be perpendicular to the minimum principle stress [5]. It is not desirable that those uncertainties are considered in the HF model because they can cause the complexity of HF method.

Other ambiguities are related to significant points that are the breakdown and shut-in pressure in the wellbore pressure versus time curve. The greatest and least in-situ stresses can be estimated by employing these points. One of the most fundamental questions is about which criterion of the HF technique is more