Experimental Study of the Effects of Sample Geometry on Hydraulic Fracturing Under Triaxial Stresses

Mohammad Darbor[1], Hadi Shakeri[*1]
1. Sahand University of Technology, Tabriz, Iran

Extended Abstract

(Paper pages 67-94)

Introduction

Hydraulic fracturing is one of the most important stimulation methods for oil and gas reservoirs with low permeability. Various factors, such as in-situ stresses, joints and natural fractures of the formation, fluid rheology, mechanical properties of the formation, injection fluid flow rate and perforation operation, effect on the pressure and hydraulic fracture geometry. Many researchers have studied hydraulic fracturing behavior of rocks since decades ago. The researches have showed that hydraulic fracturing operations increase the production of oil wells by up to 30 percent and increase gas wells by 90 percent. Currently, this operation is performed on about 60% of all drilled wells.

Material and methods

In this research, for the experimental investigation of the hydraulic fracturing, considering the reservoir condition, 39 concrete cubic samples with 100 × 100 × 100 mm dimensions and 60 concrete cylindrical samples with a diameter of 54 mm and a height of 110 mm were constructed and the effect of the sample geometry and in-situ stress field on the fracture geometry, breakdown pressure, the pattern of crack propagation and finally the cross fractures in vertical wellbores were investigated.

Results and discussion

In cubic specimens under uniaxial stress, with increasing vertical stress to 8 MPa, first the breakdown pressure has been increased by about 132% and then with increasing vertical stress to 16 MPa, the breakdown pressure

has been decreased by about 69%. In cylindrical specimens under uniaxial stress, with increasing vertical stress to 12 MPa, first the breakdown pressure increased by about 113% and then with increasing vertical stress to 16 MPa, the breakdown pressure decreased by about 6%. As the vertical stress increases to a certain limit, the pores and micro-cracks inside the sample close, thus the tensile strength and breakdown pressure increase. In the following, increasing vertical stress causes more small cracks to open and reduces the tensile strength of the rock. In cubic specimens under triaxial stresses, with increasing vertical stress, the breakdown pressure has been increased. Also, in cylindrical specimens under triaxial stresses as the maximum horizontal stress increased, the breakdown pressure increased.

Conclusion

The obtained results demonstrated that increasing the uniaxial stress in the vertical wellbore in both types of studied sample geometry, first the breakdown pressure increases and then from one boundary onwards, with increasing vertical stress, the breakdown pressure decreases. In cubic specimens under triaxial stress, with increasing vertical stress, the breakdown pressure increases. Additionally, in cylindrical specimens under triaxial stresses as the maximum horizontal stress increases, the breakdown pressure increases, so that, in the 8 MPa maximum horizontal stress, the breakdown pressure increases by about 81%.

Keywords: Hydraulic fracturing, in-situ stress field, sample geometry, breakdown pressure, fracture geometry

*Corresponding Author: shakeri@sut.ac.ir