Iranian Journal of Engineering Geology
Spring 2019, Vol.12, No.1

# Numerical modeling for determining effective factors on fracture initiation pressure in hydraulic fracture operation

M. Aria[1] , M. Hosseini[2*]

**Abstract**

According to increasing demand of the country for more production rates and output from oil reservoirs, it's necessary to re-activate the oil wells in Iran. Oil production in overtime reduces, the reason of this event is decreased reservoir's Pressure and closure the cracks and microscopic holes. Hydraulic fracture as a method for stimulating oil reservoirs related to various factors including the characteristics of the environment which the fracture grows. Mechanical properties of the layers recognized as the one of the most effective parameters on the progress of hydraulic fracture and its geometry. In this study, we try to indicate the various factors involved in hydraulic fracture and the effect of each of them on hydraulic fracture until reduce both operation costs and better and more efficient failure. In this research, numerical modeling was done by ABAQUS software in 10 different cases and then, the effect of the each input parameters on the hydraulic fracture pressure was investigated by performing sensitivity analysis. Actually these input parameters are well's data and including Young's modulus, minimum and maximum horizontal stress, vertical stress, tensile strength, poison's ratio and pore pressure. Required information is obtained from excavated wells in carbonate rocks in Iran. The results show's minimum horizontal stress has the most effect on the hydraulic fracture pressure and parameters such as vertical stress and Young's modulus are not effective in determination of hydraulic fracture pressure.

***Keywords:*** *Hydraulic Fracturing, Sensitivity Analysis, Numerical modeling, ABAQUS software*

[1]M. Sc. student, Department of Mining Engineering, Imam Khomeini International University
[2]Associate Professor, Department of Mining Engineering, Imam Khomeini International University
*** Corresponding Author**

**Extended Abstract:**

## 1. Introduction

Oil production continued its decline over time due to loss of reservoir pressure and closing microscopic pores/cracks in the reservoir rock. The hydraulic fracturing – as a technique for simulating oil reservoirs – depends on several parameters such as the environment where fracture grows. Mechanical properties of the layers affect the propagation of hydraulic fracture and its geometry. Differential stress – the difference between the greatest and the minimum horizontal stress – and angle of contact between the natural and hydraulic fractures both significantly affects the fracture's shape and propagation. Blanton provided a measure for assessing the interactions between natural and hydraulic fractures (Blanton, 1986). Zhang and Chen studied the propagation of hydraulic fractures and provided a model for the direction of fracture propagation based on the mechanism of fractures and theories of hydraulic fracturing (Zhang and Chen, 2010). Akrami and Hosseini provided numerical modeling of hydraulic fracturing under laboratory condition using a modified Hoek Triaxial Cell (Akrami and Hosseini, 2017). They used thick-walled hollow cylindrical samples of carbonated rocks and found the fracture pressure to be increased with the lateral stress, but not under axial stress. The results also indicated that the crack propagation direction is mainly perpendicular to the lateral stress.

The present study was designed to assess different factors causing and/or affecting the hydraulic fracture, aiming to determine the optimal site for a cost-effective and efficient hydraulic fracturing operation.

## 2. Materials and methods

The ABAQUS software was used for numerical modeling under 10 different modes. The effect of each input parameter on hydraulic fracturing was assessed by Sensitivity Analysis (SA) technique. Input parameters include elastic modulus, the greatest and the minimum horizontal stress, vertical stress, tensile strength, Poisson's ratio, and pore pressure, all of them are, in fact, data obtained from oil wells. Data were obtained from wells excavated in carbonate rocks of Iran.

## 3. Tests results

According to the results of the present study, the vertical stress that indicates the reservoir's depth doesn't affect the hydraulic pressure. As depth increases, the greatest and the minimum horizontal stress increase provided that the tectonic stresses be not dominant in the area. This reduces the difference between the greatest and the minimum horizontal stress and the increase in the fracture pressure. In addition, the difference between greatest and the minimum horizontal stresses, tensile strength, pore pressure and Poisson's ratio all are effective in estimating fracture pressure. The sensitivity analysis was repeated to determine the parameter that has a greater effect on the fracture pressure. And so the intensity of each parameter was increased by 10%, aiming to assess the changes in the fracture pressure under a constant increase in the intensity of the parameters. Results of the sensitivity analysis are as follow:

- The 10% increase in the maximum horizontal stress leads to a 21% increase in the fracture pressure.
- The 10% increase in the minimum horizontal stress leads to a 5% increase in the fracture pressure.
- The 10% increase in the tensile strength leads to a 0.97% increase in the fracture pressure.

- The 10% increase in the pore pressure leads to a 6.6% increase in the fracture pressure.
- The 10% increase in the Poisson's ratio leads to a 0.16% increase in the fracture pressure.

Results of the sensitivity analysis showed that the 10% increase in the maximum horizontal stress, the minimum horizontal stress, tensile strength, pore pressure and Poisson's ratio leads to 21%, 5%, 0.97%, 6.6% and 0.16% increase in the fracture pressure, respectively.

## 4. Conclusion

The results of numerical modeling showed that the minimum horizontal stress, pore pressure, the maximum horizontal stress (i.e. the difference between the greatest and least horizontal pressure), tensile strength and Poisson's ratio have the most effect on the fracture pressure, respectively.

## References:

Blanton T. L., 1986. Propagation of hydraulically and dynamically induced fractures in naturally fractured reservoirs, Presented at the SPE/DOE Unconventional Gas Technology Symposium, 18-21 May, Louisville.

Zhang G. and Chen M., 2010. Dynamic fracture propagation in hydraulic re-frecturing", Journal of Petroleum Science and Engineering, 70: 266-272.

Akrami, A., Hosseini, M., 2017. Numerical modeling of hydraulic fracturing in carbonate rocks of Bangestan reservoir, New Finding in Applied Geology, Iran, 12(21): 83-91.

Chamanzad, M.A., Ramezanzadeh, A., Tokhmechi, B., Norouzi, H., 2015. Geomechanical modeling and determination of safe drilling mud window: a case study in the Azadegan oil field well, 1st National Conference on Petroleum Geomechanics, NIOC-RIPI, Tehran, Iran.