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Extended Abstract

Laboratory study of the effect of proppant operating variables on fracture conductivity under minimum horizontal stress conditions in one of the Iranian reservoirs

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Keywords

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Abstract

As the most significant factor determining the final success of a hydraulic fracturing operation, fracture conductivity is influenced by proppant operating variables including mesh size, proppant concentration, and crushing behavior under minimum horizontal stress. Outcrop samples of the Ilam Formation were cut and prepared in the desired dimensions to simulate fracture in one of the Iranian reservoirs. As natural proppants, two groups of silica sand were collected from Firozkoh and Hamadan mines. Three mesh sizes were used to screen the proppants: 16/30, 20/40, and 30/50. In conductivity tests, Firozkoh proppants were used at two concentrations of 2 and 0.5 pounds per square foot. Experiments were carried out with a conductivity measuring apparatus by injecting nitrogen gas into the conductivity cell at different flow rates. This was done to simulate gas flow through fracture media. As a final step, the crushed percentage of proppants was determined and Forchheimer's equation was used to calculate conductivity values. As determined by the study, a significant decrease in conductivity values was observed with increasing closure stress. Firouzkoh 20/40 displayed better conductivity than Hamedan 20/40 proppant and performed better under the same stress conditions. Higher values of sphericity and roundness explain this. A comparison of the conductivity of 16/30, 20/40, and 30/50 proppants from Firuzkoh sand revealed that the 30/50 proppant had the lowest conductivity reduction compared to the other two samples up to a stress of 7251 psi because there are more contact points between the particles, the stress distribution is better between the particles, and the proppants do not crush as easily. A comparison of two amounts of Firouzkoh 20/40 proppant showed that more particles formed in the fracture as the proppant concentration increased. Consequently, the crushed percentage was reduced and conductivity values were maintained at higher proppant concentrations.

1. Introduction

Fracture conductivity is considered as the most significant parameter that determines hydraulic fracturing final performance and success[1, 2]. In this study, two different types of natural silica sands in three practical mesh sizes were studied experimentally under various conditions affecting fracture conductivity behavior. Results provide proper proppant characteristics leading to higher conductivity values that are suitable for operation.

2. Methodology

Ilam formation is one of the most abundant hydrocarbon reservoirs in Iran which is conducive to being treated with the fracturing operation. In this regard, samples were cut from its formation outcrop. After cutting in standard dimensions, rock samples were sealed with a specific two-component silicon to prevent nitrogen gas from leakage [2]. Two types of silica sands extracted from two well-known silica mines in Iran. The

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proppants were screened in three mesh sizes: 16/30, 20/40, and 30/50. They were used in two concentrations of 2 and 0.5 pounds per square foot in conductivity tests.

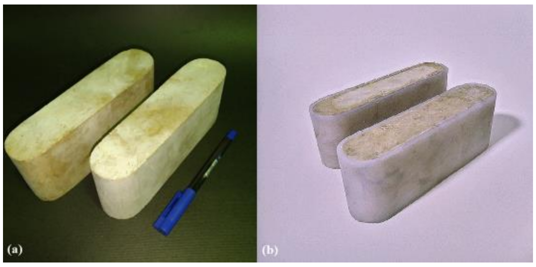

Fig. 1. Schematic of conductivity apparatus.

Fracture conductivity, has been measured using conductivity apparatus which is compatible with API RP-61 and ISO 13503-5 standards. This device has three main parts: the conductivity cell, the loading device, and the data collector device (figure1).

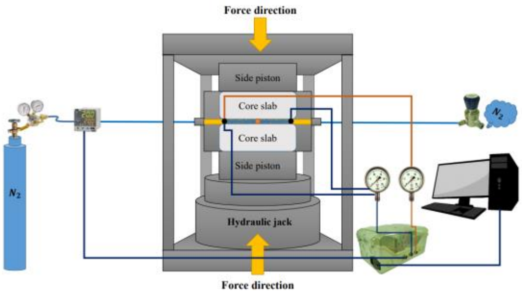

Fig. 2. Schematic of conductivity apparatus.

Nitrogen gas was used as an injection fluid to simulate gas production through the fracture. Fracture closure stresses were adjusted between zero to 7251 psi. fracture conductivity was measured for each specific closure stress using measuring pressure drop across the propped fracture at different flow rates and modified Forchheimer equation.

$$\frac{(P_1^2 - P_2^2)Mh}{2ZRT\mu L\rho q} = \frac{\beta\rho q}{w^2\mu h} + \frac{1}{k_f w_f} \tag{1}$$

In this equation, *kfwf* is the fracture conductivity. *P1*, *P2* and *q* are the pressure values at the inlet and outlet of the fracture length. Moreover, *h*, *w* and *L* present the height, width and length of the fracture, respectively. Furthermore, *M, Z, R,* μ and ρ describe N2 gas properties including molecular weight, gas compressibility factor, universal gas constant, gas viscosity and density. A straight line can be plotted for each specific closure stress that its intercept is the inverse of conductivity and its slop corresponds to inertial factor. Furthermore, after accomplishment of each series of experiments, crushing percentages were measured using sieve analysis.

3. Results and Conclusions

In order to investigate the effect of proppant opertaing variables on fracture conductivity, results divided into four groups include the effect of proppant type, size, concentration the effect of closure stress on conductivity behavior. Proppant concentration results showed that an increase in proppant mass in higher concentrations represent fewer crushing values because of better stress distributions between proppant particles.

The higher the proppant concentration, the lower the crushing behavior and the higher the conductivity values achieved. higher proppant size results in higher initial fracture conductivity, smaller particles of proppant can maintain higher fracture conductivity at high closure stresses. This is because of stress distribution between a higher number of particles. Firuzkooh 30/50 mesh size performed best under high closure stress due to less crushing behavior and better conductivity values.

Higher proppant concentrations, including multilayers of proppant, can produce higher initial fracture conductivity and maintain their conductivity more than proppant pack with less concentration. Based on better sphericity and roundness, Firuzkooh proppant showed better performance in comparison with the Hamedan proppant under different closure stress situations.

4. References

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