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Extended Abstract

Analytical Evaluation of Sand Production Process for Oil and Gas Wells in the Asmari Reservoir of the Ahwaz Field

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Abstract

Due to the significance of the sand production (SP) issue in sandstone hydrocarbon reservoirs, the main objective of this study is to evaluate the Asmari formation layers along well No. 469 in the Ahwaz hydrocarbon field in terms of SP causes and its potential capacity to provide suitable solutions for its reduction from a geomechanical perspective. The evaluation was carried out using the Techlog software. The required parameters for constructing a one-dimensional geomechanical reservoir model were estimated from available data. The Mohr-Coulomb failure criterion was adopted considering the scale effect for perforated cavities under non-hydrostatic stress conditions. After constructing the one-dimensional model, the Critical DrawDown Pressure (CDDP) curve was plotted for both open hole and perforation completions, and the susceptible SP zones were identified. The M2 layer was selected as one of the most susceptible zones for SP sensitivity analysis due to its low strength, porosity, and permeability compared to other layers. The sensitivity analysis was conducted based on well geometry, formation rock properties, field stress conditions, and perforated cavity characteristics. The analysis was performed at depths of 2822 and 2837 meters in the open hole and the perforation completions, respectively, with a dominant sand diameter of 200 microns in the potential SP zone. The Critical Bottom Hole Pressure (CBHP) and the Critical Reservoir Pressure (CRP) were estimated to be 1898 and 2735 pounds per square inch, respectively, in the maximum horizontal stress direction with a 0.4-inch perforation diameter and 861 and 2115 pounds per square inch, respectively, in the direction perpendicular to the maximum horizontal stress direction with a 0.3-inch perforation diameter. By defining and determining Transitional Deviation Angle (TDA), Minimum Safe Deviation Angle (MSDA), and Critical Perforation Orientation Angle (CPOA) based on sensitivity analyses, a novel design approach for perforation operations in sand-prone reservoirs has been introduced.

1. Introduction

The importance of Sand Production (SP) has led to extensive studies in this field in recent years. These studies mainly revolve around predicting or aiding in the understanding of SP through various experimental, analytical, laboratory, and numerical methods. Due to the challenging nature of SP in the Asmari hydrocarbon reservoir of the Ahwaz field in Iran, this article focuses on investigating the potential capacity of this phenomenon for well No. 469 using an analytical approach embedded in the Techlog software, a product of Schlumberger company. After evaluating the Critical DrawDown Pressure (CDDP) values along the reservoir length, potential SP-prone intervals have been identified. Subsequently, sensitivity analysis has been performed on 12 influential parameters. Furthermore, by investigating certain reservoir depths characterized by lower rock strength and higher SP probability, some recommendations have been proposed for SP control in such cases.

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2. Methodology

After gathering available data for the case study, missing and unavailable data have been estimated focusing on weak sand formations using relevant relationships. The Papanastasiou relationship has been used to calculate the scaled Uniaxial Compressive Strength (UCS) in the analysis related to perforation completion [1]:

$$UCS_{appar.} = 2\ UCS\ a_{ucs} \left(\frac{D_{perf}}{D_{gr}}\right)^{-n} \quad (1)$$

where $UCS_{appar.}$ is the scaled UCS around perforation cavity, D_{gr} and D_{perf} are grain and perforation tunnel diameters respectively, and a_{ucs} and n are fitting parameters.

Poroelastic relations have been used to consider the effect of pore pressure in evaluating horizontal stresses [2]:

$$S_h{}' = \frac{\vartheta_s}{1-\vartheta_s} S_v' + \frac{E_s\ \varepsilon_x}{1-\vartheta_s{}^2} + \frac{\vartheta_s\ E_s\ \varepsilon_y}{1-\vartheta_s{}^2} \quad (2)$$

$$S_H{}' = \frac{\vartheta_s}{1-\vartheta_s} S_v' + \frac{\vartheta_s\ E_s\ \varepsilon_x}{1-\vartheta_s{}^2} + \frac{E_s\ \varepsilon_y}{1-\vartheta_s{}^2} \quad (3)$$

where ϑ_s and E_s are static poisson ratio and young modulus respectively, ε_x and ε_y are tectonic strains in minimum and maximum horizontal stress directions respectively, and $S_h{}'$, $S_H{}'$, and S_v' are minimum horizontal, maximum horizontal, and vertical effective stresses respectively.

Finally, the depleted stresses have been evaluated in terms of SP possibility using the stress path and the Mohr-Coulomb relationship.

Layer M2 has been selected as the focus of the study among the potential sand-producing layers of the reservoir due to having the highest hydrocarbon production capacity, permeability, and porosity [3].

3. Results and Conclusions

In normal faulting regime governed in this field, drilling a horizontal well in the direction of maximum horizontal stress and completing it with an X-shape staggered perforation pattern by considering the permissible Critical Perforation Orientation Angle (CPOA), which is approximately 43 degrees in this case, is the best option. The greater the perf-to-perf spacing, the more stable the perforation cavities. In the case of inability to clean up perforating debris efficiently, perforation is only recommended in the upper part of the well. In vertical wells, non-staggered perforation patterns with high shot density deep penetrating guns are recommended to create smaller and deeper cavities. For inclined wells, the Minimum Safe Deviation Angle (MSDA) can be used to choose between the two recommended operational approaches, which is 47.3 degrees for the studied case. Underbalanced perforation operation is recommended in all cases, if possible, to preserve the shape of perforations.

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5. References

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