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Evaluation and Hydraulic Fracturing Design for Optimization of Effective Conductivity in Multilayer Reservoir

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Abstract. The HI-68 is an existing well carried out by the fracturing program in layer A1 at an interval of 1254 – 1260 m. In this work, the fracturing fluid was pumped at a rate of 17 bpm and an average tubing pressure of 2000 psi, using 70 klbs carbolite proppant size 20/40 at a concentration of 1 to 8 ppa ramp and followed by a 30 bbl flush (under displacement 4 bbl) using slickwater. Hydraulic fracturing in the HI-68 was carried out 2 times, but the well did not experience a significant increase in oil, but there was an increase in watercut. This condition occurs as a result of hydraulic fracturing which results in low fracture conductivity. This is due to the problem of low fluid efficiency and the type of completion of the multilayer reservoir which results in unwanted early screen outs. Furthermore, the HI-68 well was modified for a limited entry multilayer completion in order to easily control fracture initiation which aims to reduce fluid loss into the rock, fracture initiation is a modification of the conventional method of hydraulic fracturing which is initiated by pressure, not velocity. Using rate to create pressure (as a consequence of Darcy's law). As the pressure increases, fracturing will begin as the pressure rises above the breakdown pressure of the weakest point along the hollow interval. The perforation interval 1254 – 1270 m has different price values and is divided into three areas, first interval area 1254 – 1260 m, second interval area 1260 – 1265 m and third interval area is 1265 – 1270 m, if the three areas are carried out hydraulic concurrent fracturing, it is possible for an early screen out to occur due to narrowing in the second interval area due to the stress load generated from the first and third areas which suppresses the second interval area so that fracture initiation does not develop. Using medium to high density proppant will be advantageous, because it is expected to form short and wide fractures with high conductivity around the wellbore. Results of sensitivity the proppant size larger than mesh size of proppant, resulting greater retained permeability, it will affect fracture conductivity value. From the economic aspect, the net present value for 1 year obtained depends on the fracture conductivity, so the combination of proppant type and proppant size is adjusted to the formation permeability conditions.

Keyword(s): effective conductivity; hydraulic fracturing; multilayer reservoir.

I. INTRODUCTION

The implementation of hydraulic fracturing in its implementation often does not consider the diameter of the perforation hole, the location and length of the perforation interval. This is one of the important factors in determining the success of a hydraulic fracturing job (Economides, M.J. 2000). In this case study, hydraulic fracturing in the HI-68 well was carried out 2 times, but the well did not experience a significant increase in oil, but there was an increase in watercut. This condition occurs as a result of hydraulic fracturing which results in low fracture conductivity. This is due to the problem of low fluid efficiency and the type of completion of the multilayer reservoir which results in unwanted early screen outs. Early screen out is a condition for the formation of a compact proppant around the fracture wall, which is because all the pad fluid has entered the formation when the addition of the fracture stops. The compressed proppant around the fracture wall will be thicker so that the gel in the slurry will be difficult to enter into the formation. Furthermore, the HI-68 well was modified for a limited entry multilayer completion in order to easily control fracture initiation which aims to reduce fluid loss into the rock, fracture initiation is a modification of the conventional method of hydraulic fracturing which is initiated by pressure, not velocity. Using rate to create pressure (as a consequence of Darcy's law). As the pressure increases, fracturing will begin as the pressure rises above the breakdown pressure of the weakest point along the hollow interval.

Kolawole, O., et al. (2019) in a paper entitled "Optimization of Hydraulic Fracturing Design in Unconventional Formation: Impact of Treatment Parameters" stated that optimization of hydraulic fracturing design is very important to achieve successful hydraulic fracturing operations. In his research performs optimization of treatment on three wells with sensitivity of fracture length, type of fracturing fluid and proppant size and density. For example in well B, optimization of hydraulic fracturing was carried out with the sensitivity of three different fracture length values using 40# Crosslink Gel Frac. Fluid and Northern White 30-50 Proppant. The results of the study, in the two-well example shows that optimization of effective hydraulic fracturing results in larger fracture lengths in some cases, due to greater proppant coverage. From the results obtained on various sizes of proppant and fracturing fluids in the samples of wells two and three, it can be observed that northern white 30-50 proppant produces lower fracture conductivity (2 mD-ft on average) and fracture half length of 91 to 123 ft. Meanwhile, the use of 100 mesh badger and RC sand PC 16-30 proppant resulted in greater fracture conductivity (> 3 mD-ft) with a fracture half-length of 129 to 148 ft.

II. METHODS

The HI well that will be analyzed is the HI-68 well, the HI-68 well produces hydrocarbon fluids from the A1 layer sandstone formation. Based on the analysis of available data, these wells still have a reservoir pressure that is high enough to produce fluid. Then, hydraulic fracturing was applied to create a conductive path to increase the production potential of these wells. Evaluation and redesign of hydraulic fracturing was carried out to determine the optimum fracturing initiation based on operational constraints in the field and economic analysis. Collecting data to be used including geological data, reservoir data, well data and post job report data.

1. Perform calculations on the physical properties of the reservoir fluid & reservoir characteristics/parameters.
2. Analyze production performance data to determine wellhead pressure data.
3. Perform fracture geometry analysis based on post job report data using Mfract software from wells that have been hydraulic fracturing.
4. Sensitizing the size and type of proppant, injection rate and pad volume using Mfract software to determine the optimum hydraulic fracturing design and calculate the net present value based on the parameters used in the hydraulic fracturing design.
5. Performing nodal analysis using pipesim software to optimize production potential before and after redesigning hydraulic fracturing.
6. Sensitivity of hydraulic fracturing parameters to perforation parameters in multilayer reservoir conditions needs to be carried out to obtain a comparison between multi fracture and fracture initiation on operational safety and the formation of the best and economical fracture effective conductivity.
7. Make conclusions and recommendations on hydraulic fracturing results based on the results of the overall analysis and discussion.

A schematic description of the methodology of writing this paper is shown in Figure 1.

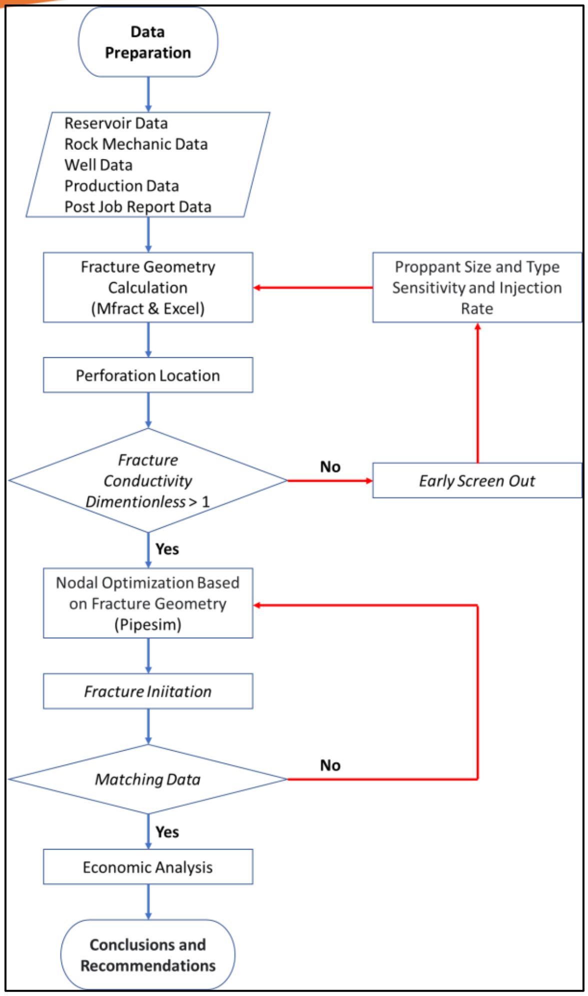

Figure 1. Flowchart

III. RESULTS AND DISCUSSION

Main fracturing in the HI-68 well was carried out by injecting crosslinked-zirconium system type fracturing fluid and 20/40 proppant ceramic type with a concentration of 1 ppga – 8 ppga at a depth of 1254 – 1260 m. During operation, the pressure behavior in Figure 5.9. shows that the operation is in a safe range according to the analysis of the step rate test and mini frac test. In this case, the operating method used is lean, where the pressure behavior tends to decrease slowly during proppant injection. This method of operation is intended so that the planned proppant stage can enter completely into the fracture. After proppant injection, then flush 30 bbl (under displacement 4 bbl) at an injection rate of 17 BPM for 32 minutes. The average tubing pressures are recorded in Figure 5.9. of 2000 psi.

The purpose of redesigning hydraulic fracturing in the HI-68 well is to determine the optimal fracture conductivity with a minimum dimensionless fracture conductivity (FCD) value equal to 1. The redesign principle to be carried out is with the sensitivity of the injection rate and the type of proppant based on operating parameter limits and analysis of results. fracture geometry on production and economic aspects. The following are the operating parameter limits and economic data that will be used as redesign limits for the HI-68 well which are tabulated in Table 1 and Table 2.

Table 1. HI-68 Well Hydraulic Fracturing Operation Limitation

Data	Value
Step Rate Test, Psi	2483.19
Maximum Horse Power (Service Company), HP	1500

Table 2. Economic Data of HI-68. Well Hydraulic Fracturing Operation

Data	Value
Oil Price, US$	40
Operating Cost, US$	47354
Interest Rate, %/Tahun	10
Proppant Carbolite Price, US$/lb	0.25
Proppant Carbo HSP Price, US$/lb	0.27
Fracture Fluid Price, US$/lb	0.16

3.1. Injection Rate Sensitivity

This stage aims to determine the effect of increasing the injection rate on the fracture geometry produced, especially FCD, where the sensitivity is carried out with an injection rate range of 15 BPM - 18 BPM. The results of the injection rate sensitivity related to the operating parameters obtained can be seen in Table 3.

Table 3. Injection Rate Sensitivity to HI-68. Well Operation Parameters

Injection Rate, BPM	Max. Surface Pressure, Psi	Horse Power, HP
15	1473	478
16	1550	536
17	1621	596
18	1709	665

3.2. Proppant Type and Size Sensitivity

This stage aims to evaluate the proppant properties in order to obtain an optimal fracture geometry that can produce greater production potential. In hydraulic fracturing, proppant is a function of fracture conductivity. The sensitivity of the HI-68 well was carried out by comparing the types of proppant between low density ceramic and high density ceramic with proppant mesh sizes of 20/40 and 16/20. At this stage, the proppant sensitivity is carried out by considering the parameters operations which can be seen in Table 4.

Table 4. Proppant Sensitivity to HI-68. Well Operation Parameters

Proppant	Max. Surface Pressure, Psi	Horse Power, HP
Carbolite 20/40	1796	893
Carbolite 16/20	1796	893
Carbo HSP 20/40	1787	888
Carbo HSP 16/20	1788	889

3.3. Economic Calculation

Apart from the technical point of view, economic analysis needs to be done as a basis for evaluating the success of a project. The economic analysis of the project is carried out by calculating the value of the age of the producing well after the squeeze cementing and production optimization work is carried out, the rate of oil production obtained after the work is carried out, the decline rate, and the price of crude oil. Economic analysis is carried out separately for each well, with the aim of knowing whether the wells are successful (experiencing an increase in the rate of oil production). After doing the economic calculations with the data listed, the economic indicators (NPV, IRR, POT) were obtained for the HI-68 well. The results of the economic calculation of hydraulic fracturing activities can be seen in Table 5.

Table 5. Economic Calculation

	Parameter	Satuan	Carbolite 20/40 (Basecase)	Carbolite 16/20 (Redesign)
	Total Gross Revenue	US $ (000)	2,372	2,781
1	Opex & Depresiasi	US $ (000)	675	781
2	Contractor Take	US $ (000)	679	800
3	Government Take	US $ (000)	1,019	1,200
	NPV	US $ (000)	679	800
	IRR	%	1125.2%	1326.1%
	POT	Years	0.08	0.07
	PI	US$ / US$	12.25	14.26

IV. CONCLUSION

Based on the results of the analysis and discussion, it can be concluded as follows:

1. Perforations can be used to control the starting point of fracture (Fracture initiation) and determine the size of the conductivity value that occurs.
2. The width of the fracture is smaller and the slurry speed decreases with each fracture, so there is a greater possibility for proppant bridging and early screen out to occur.
3. The hydraulic fracturing design on the multilayer will provide a better Fracture Conductivity Dimensionless (FCD) by using the limited entry method to control the fracture initiation.
4. Limited Entry is a strategy for operational security and the formation of the best and economical fracture effective conductivity.

5. The addition of the injection rate (1 BPM - 3 BPM) will result in a fracture that develops horizontally, but does not provide an effective result for adding to the net present value, because it affects the decrease in the production potential obtained.
6. Factors that influence the formation of low conductivity fractures apart from material, operational and human error are methods of completion for the implementation of hydraulic fracturing.

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