High production improvement using channel fracturing in a tight conglomeratic sandstone reservoir

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Abstract. A novel method of hydraulic fracturing is by pulse pumping proppant into formation. The proppant is mixed with fibrous material, and this material will hold the formation from closing, even though channel if formed in the formation. A well producing from poorly sorting conglomeratic reservoir with secondary porosity and muddy micro-porosity. The well recently only produces intermittently 9 to 20 BOPD on sucker rod pump. Well permeability is 1.78 mD with reservoir pressure of 1188 Psi. The first step is to further evaluate the well, from rock mechanic and stress of formation, which is called Candidate Selective Factor (CSF). And then, a fracturing operation is designed, based on well parameter and surrounding wells. After performing pre-fracturing; consists of breakdown test, step rate test, and minifrac test; the operation is re-designed. The re-design includes special pulsing pumping technique, and the mainfrac operation. In the actual operation, the proppant was pulsing into formation for eleven times. The results of after channel fracturing shows that the productivity index increases 10.3 times. This new hydraulic fracturing method; Channel Fracturing; will also give less possibility of screen out, in addition to its successful result.

1. Introduction

During an early stage of a hydrocarbon field life, production strategy has to be established in order to get the most of hydrocarbon reserves. If a well produces a very small production rate, the will not economically feasible to be produced. One of many ways to increase production rate is by performing stimulation; an operational effort regarding an attempt to increase production rate by giving stimulant to a well. Hydraulic fracturing is one of several stimulation efforts to increase well production rate, by creating a fracture in the reservoir; near well bore; in order to have some kind of additional well extension and reduce restriction due to skin. Conventional hydraulic fracturing will include several operational steps, before the mainfrac is performed. In the mainfrac, propping agent; called proppant, a solid sand like material that keep the opening fracture due to frac job being kept open; is pumping in one period of pumping time. A new method of hydraulic fracturing is introduced, called channel fracturing. The main improvement is the way channel fracturing injecting proppant; the proppant is injecting in a pulse, alternating proppant pumping with fibrous material, to keep the proppant intact with the formation. This method has several addition benefits as compared to conventional hydraulic fracturing [1].
2. Channel fracturing

Open channel fracturing was first introduced by Medvedeev et al. [1], which is a new technique in hydraulic fracturing, by pulse pumping proppant into the formation; instead of one pumping period in the conventional hydraulic fracturing; and alternating each pulse by pumping into the formation a fluid with fiber additive, which is then called fibrous fluid. The fibrous fluid prevents the proppant to be dispersed due to pulse pumping technique. The proppant will be in place, intact with the formation fracture created by the proppant. Since proppant is pumped alternately with fibrous material, the proppant mass or volume usage will be much less than conventional hydraulic fracturing.

The proppant size is heterogenic; which is for tail-in stage of the fracture opening. Tail-in stage is the last proppant pumping with no alternate fibrous material, so it is expected the proppant will pack in sand face of the well bore. It is also expected, the proppant will act as pillar or buffer of the fracture, so that the fracture will not close; after injection pressure is released. By pulse pumping, it is also expected that reservoir fluid will not flow through proppant, but rather that the reservoir fluid flows through the channel created by the proppant and with proppant as the pillar. This channel fracturing will have high conductivity as compared to conventional fracturing method; with almost no pressure drop across the channel. Figure 1 is the illustration of the occurrence of channel fracturing in the reservoir, in the well bore vicinity [2].

![Channel Fracturing](image)

**Figure 1.** Channel fracturing.

Operational steps should be taken for channel fracturing, is the same as in the conventional hydraulic fracturing:

- Initial fracturing design.
- Pre-fracturing test; to have better understanding of reservoir parameters and its rock mechanic parameters; which includes:
  - Breakdown test; will obtain maximum tubing pressure, closure pressure, fracture gradient, bottom hole initial shut in pressure, reservoir pressure, permeability, transmissivity, and transmissibility; by pumping only brine base fluid for several rate.
  - Step-rate or step-up-step down test; will obtain fracture extension pressure, fracture extension gradient fracture extension rate, perforation friction pressure drop, near wellbore friction, effective perforation, pumped fluid pressure, and the dominant cause of wellbore friction; by pumping brine fluid with several increasingly rate and followed by several decreasingly rate.
and Minifrac or Calibration test, by pumping fracturing fluid pad for the Mainfrac; will obtain bottom hole initial shut in pressure, closure pressure, closure gradient, fracture gradient, fluid efficiency, and spurt loss.

- Mainfrac.

However, one more procedure to be performed, that is Candidate Selective Factor (CSF); to see if the formation is a good or bad candidate for channel fracturing implementation. Dal Vorno et al. introduced the CFS based on resulting stresses and plain stress modulus of the rock [3].

![Figure 2. Candidate selective factor.](image)

The best formation candidate or the formation perfect candidate should have high plane strain modulus per resulting stresses value greater than 1800. The viable formation candidate or sufficient formation candidates with some optimizations should have plane strain modulus per resulting stresses value between 500 to 1800. The risky formation candidate should have plane strain modulus per resulting stresses value less than 500. Basically, the channel will be close again after pumping proppant is due to the formation rocks are too fragile and too soft; not stiff enough or the resulting stresses value is too large [3].

### 3. Results and discussion

The CSF for the subject formation is in the viable region with plain stress modulus of $2.45 \times 10^6$ Psi and resulting stress of 3389 Psi. The well and reservoir parameter is depicted in table 1.

#### Table 1. Well and reservoir parameter.

| Parameter                  | Value          |
|---------------------------|----------------|
| Well Radius ($r_w$)       | 0.354 feet     |
| Middle of Perforation     | 5121 feet-MD   |
| Porosity                  | 18 %           |
| $^0$API                   | 39             |
| Formation Thickness       | 37.1 feet      |

After performing breakdown test, step up rate test directly followed by stepdown rate test, and minifrac; and lastly mainfrac is performed to the formation. Breakdown test concluded that the reservoir pressure is 2017 Psi with 1.78 md of reservoir permeability. It is concluded from the step up tests and minifrac that the bottom hole initial shut pressure is 3888 Psi, with closer pressure of 3019 Psi. By using these minifrac data, pump power requirement is calculated for the Mainfrac, which needs 2027 HP pump, to reach injection pressure of 4594 Psi. It is also design to number of pulse pumping proppant and fibrous fluid, which is 26 times.
Figure 3 is the pressure profile of Mainfrac. In the main frac, the number pulse pumping in only 8 times, this is due to the fact during main fracturing operational, one unplanned drilling procedure should be performed, first, due to drilling operation safety reason. The time duration for doing this drilling procedure might spent the chemical in the fibrous material, thus the main frac operation has to be fast.

![Figure 3. Mainfrac pumping chart.](image)

From the mainfrac, it is concluded that fracture geometry is depicted in figure 4, while the value is in table 2.

![Figure 4. Mainfrac fracture geometry.](image)
Table 2. Mainfrac fracture geometry.

| Parameter                | Unit | Value |
|--------------------------|------|-------|
| Fracture Half Length (x_f) | Ft   | 289.5 |
| Fracture Height (h_f)    | Ft   | 168.1 |
| Fracture Width (w_f)     | In   | 0.24  |
| Average Fracture Width (w_{avg}) | In | 0.152 |

From the fracture geometry above, calculation was run as if the fracturing is done by conventional fracturing. The calculation for conventional fracturing is the common equation of Zang et al. [4]. Table 3 is the comparison result of channel fracturing and conventional fracturing.

Table 3. Comparison result.

| Parameter                  | Unit  | Channel Fracturing | Conventional Fracturing |
|----------------------------|-------|--------------------|-------------------------|
| Proppant mass              | Klbs  | 33.1               | 99.47                   |
| Average Conductivity       | mD.ft | 1910               | 1013                    |
| Dimensionless Conductivity |       | 4.13               | 2.18                    |

However, the actual production data, show that the productivity increases more than 10 time.

4. Conclusion

It is concluded below for channel fracturing as compared to conventional fracturing:

- Much reduce the use of proppant material by 33%.
- Reduce possibility for the proppant sand to be produce; the proppant still intact with the fracture.
- The conductivity, theoretically is larger than conventional fracture.
- The actual production after channel fracturing gives 10 time before the treatment.

References

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