FULL WELL PAD OPTIMIZATION – MULTIWELL OPTIMIZATION FOR A WHOLE WELL PAD

**Pad and Pad Optimization:**

A drilling pad is a location which houses the wellheads for a number of horizontally drilled wells. The benefit of a drilling pad is that operators can drill multiple wells in a shorter time than they might with just one well per site.

In the picture above, each of the four drilling pads hosts six horizontal wells. Pad drilling allows producers to target a significant area of underground resources while minimizing impact on the surface. It also helps the producer reduce costs associated with managing the resources above-ground by concentrating the wellheads. Moving a drilling rig between two well sites previously involved "rigging down" and "rigging up" (disassembling the rig and reassembling it at the new location) even if the new location was only a few yards away. One of the industry's more recent innovations, pad-to-pad moves, underlines the efficiency gains from rig mobility and pad drilling.

An increase of horizontal wells has led to more multi-well pads. Multi-well pads require more scientific completion optimization workflow to achieve an optimized design in a faster/cheaper manner and a complex automation solution to effectively manage facilities.

In our opinion, multi-well pad optimization could be achieved by integrating following three components:

1. Intelligent Drilling/ Landing location Optimization
2. Completion Optimization
3. Automation of well pad facilities.

This document focuses on item 2, Completion Optimization
Completion optimization workflow for well pad:

Problem - statement:

Industry trend has generally been toward bigger fracs, with more proppant and more fluid; and in horizontal well pad completion industry is clearly following the trend towards higher well rates with more fracture stages.

Most of the operator is following the same for their well completion design without optimization and loosing money on completing their wells.

Proposed solution:

To truly determine the impact of increased fracture stages alone would need to add some additional filters, such as; type and amount of frac fluids, cluster spacing, horizontal well length and the staging plus the amount of proppant. Proposed a Completion Optimization Workflow to determine the optimal number of stages, optimal number of clusters/stage and optimal cluster spacing for completion design.

Methodology:

An integrated fracture modelling and reservoir simulation study was performed with the intent of identifying fracture designs that take advantage of this increased understand of reservoir flow potential.

Effect of Cluster Spacing:
Base Case field design: 5 cluster, 50 BPM pumping/injection rate 4400 barrels (bbls) clean fluids and ~180,000 lbs proppant.

In the first plot, 50 ft. spacing results (base case); shows strong interaction among those propagating fractures. It is mostly bending and arresting. Out of 5 clusters 3 of them take most of the fluid and propagate and create most of the fracture area / SRV.

In the middle plot, 60 ft. spacing results also shows strong interaction among those propagating fractures and it is mostly arresting. Out of 5 clusters 4 of them propagating, but 3 of them are prominent take most of the fluid and propagate and create most of the fracture area / SRV.
Similar result is observed in the case of 75 ft. spacing cases.

Effect of Cluster Spacing

Also investigate injection pressure response for 50 ft., 60 ft., 75 ft. and 120 ft spacing cases and it is evident that as spacing increases the interaction among HFs decreases. That means in 75 ft. cluster spacing more fracture area can be generated with less injection pressure.

Pressure Response of Cluster Spacing

As 75 ft. spacing provide better result, in next sets of simulation spacing kept constant at 75 ft. and vary #cluster and injection rate- one at a time.

Effect of Number of Cluster and Injection Rate:
From the upper set of figure/top 3 (in 4 clusters cases) out of 4 clusters 3 fracture propagate and one get arrested! Even though increasing injection rate does not help inner fracture to propagate as we wanted to. In 3 cluster cases (bottom 3) all three clusters/fracture propagates almost uniformly!
Considering the generated total fracture area for 3 and 4 clusters cases for different injection rate, it is evident that 4 clusters tend to create more fracture area. And higher rate tends to generate more area than lower rate, i.e. it is benefited only at the high rate case!

Considering the fracture area generated from different clusters-standard deviation, it appears that 3 clusters option has better cluster efficiency (almost 100%) that benefit at all rates.

When both criteria generated fracture area and cluster efficiency combined together, 3 clusters completion turn up as a better option!

**Recommendations:**

Considering fracture area (the QUANTITY) and the fracture QUALITY (conductivity of the generated fractures); previous five cluster 50’ spacing design that asset team decided to implement as a completion design for field development was not optimal. Recommended 3 clusters 75’ spacing design for the field that provide the best result ever.

- Pumping rate has a great influence on fracture conductivity, which decreases rapidly in higher pumping rate. Seems we over-kill conductivity by pumping faster.
- Higher injection volume provides greater fracture length, fracture height and conductivity. In contrast conductivity generated by lower injection volume is enough to get good connectivity between well and targeted flow units.
- Pumping less volume at the optimum rate (50-60 BPM) will provide reasonable frac height and a more conductive fracture.
• The bigger the job, the longer the fracture, and the higher the IP30. Bigger jobs also lead to greater EUR.

Effect of implementing the recommended workflow:

• Average EUR jumps from 3 BCF to 11 BCF after implementing optimized design.
• Well productivity increases ~25% by changing completion and fracture design.
• Design changes added Net Present Value of ~90 Million (reduce fracturing cost)
• Unlock more dry gas that added NPV of ~1.0 Billion