# Optimum Production Design System for Multizone Well

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**Abstract:** Well completion is when a well, designed for production or injection, has been completed. It is mainly concerned with developing the bottom of the borehole to suitable conditions, which can be operated in a production tube and connected downhole tools. The production of the multizone well may be derived from one or two string tubing, but depending on the pressure difference, depths and liquids contained in the formation it is possible to use multiple strings. This study is primarily based on the ideal well completion model for multi-zone wells (single string and dual string) in the TAL block region of XYZ field, which includes various formations having different pressures. The well produces 4 zones (multi-tiered wells) & the completion is being designed with successful PROSPER software after which episodes of single-string multi-zone and dual-string multi-zone completions are assayed, showing superior performance and being economically feasible. This research focuses on choosing a powerful completion for a multi-zone well (single or dual string completion) that requires significantly less maintenance, which is economically appreciated by Exploration & Production companies. Consequently, it is necessary to plan each step before installation of completion. This research will choose which method (single-string or dual-string) are appropriate in lieu of multi-zone completion & from which completion, the excess production will come.

**Keywords:** *Well completion, Single-String completion, Dual-String Completion, Multizone Completion*

## 1. Introduction

In petroleum production, well completion is the system of building a proper system for production or injection mechanism[1]. This includes making well ready to the bottom of the hole to the required conditions, running in the production tubing and it is linked down hole equipment as well as perforating and stimulating as required. Sometimes, the method of running in and cementing the casing is additionally built-in or installing equipment in the well to enable a secure and managed go with the flow of petroleum from the well.

Once the logging study and DST have demonstrated the actual feasibility of the design, a decision must be made as to the efficient and competitive execution of the type to be used. The word "environmentally friendly" uses a seal that presents minimal resistance to the fluid entering the wellbore and thus introduces the least additional pressure drop downhole, except for the pressure drop within the reservoir rock.

### *1.1. Purpose of Well Completion*

- Connect the reservoir to a surface to allow fluids to be pumped out of or injected into the reservoir.
- Prepare a path for well stimulation remedies.
- Separate the several production zones from various zones.
- Provide support to the reservoir, specifically in soft/loose layers.
- Provide a path to determine the modifications in flow rate and pressure required to proceed a well test.

### *1.2. Methods of Well Completion*

Following are various completion methods:

- Open hole completion
- Cased hole completion
- Liner completion
- Gravel Pack completion
- Limited entry completion
- Frac and pack completion

### *1.3. Types of Well Completion*

Following are few completion types:

- Single zone completion
- Multizone completion
    - Single string completion
    - Dual string completion

## 2. Literature Review

This paper presents six different advanced well completion solutions to meet specific reservoir and production needs. Several new and field proven technologies are integrated to obtain the completion goals. Multi-disciplinary approach covering well production, reservoir monitoring, inflow manage, well integrity, surface data acquisition systems etc., are critical for a most advanced well completion [2].

The recent market climate demands the optimization of costs and increased return on assets. Advanced gas detection techniques supply critical information to characterize key reservoir components for landing point selection. In the lateral section, cuttings analysis and the LWD spectral gamma ray tool represent a cost – efficient solution to maximize overall reservoir contact by integrating a more practical geochemistry approach into current well placement models [3].

The paper was on Well completion technology applied in ultra deep reservoirs must be rated for high pressure and temperature, minimize pressure losses in pumping and production, and be able of multizone, single trip (MST) completions. There have been more than 600 successful applications of MST, but not in ultra deep environments [4].

This article is all based on the stack nature of the Niger Delta reservoir, the main types of completion are dual-string multi-zone completion and single-string multi-zone completion. These designs were approved to reduce the amount of infill wells required to expand the installation [5].

This paper was on Multizone completion methods which are used wide reaching as a proficient technique to enhance reserves recovery. There are numerous assets in the deep-water Gulf of Mexico where this expertise is the favored alternative for increasing drainage of multiple zones and reservoirs in the similar well completion [6].

This paper emphasizes the benefits of dual tubing that allows through the tubing wireline servicing and recompletion of a lower zone, that effectively solves the problems created because of dual string completion. This approach of dual completion shows tremendous results in terms of reduced initial completion problems, reduced workover costs and flow versatility [7].

The objective of this paper is to describe the challenging well intervention on first of its kind where dual string completion naturally flowing well was converted to artificial lift completion. It was the first time in the world that an artificial lift method was installed in short string through rig less intervention. The well's shallow zone was being produced with sucker rod pump while deeper zone was producing naturally [8].

This paper describes that dual completion is a forward step in the increased adaptableness and efficiency of oil field development. In this paper, advantages of dual completion with Jet pump technology for multi-level oil and gas recovery have been identified [9].

This paper demonstrates the case history of Malaysia where single string multizone sand control system with hydraulic workover was installed. This well comprises of two zones, and both are completed with single string gravel completion. All operations involved were completed with significant cost saving to the operator [10].

This paper explains the problems faced in single string completion during production logging runs. To obtain water entry points in such a well, the well should have dual completion or 9-5/8" cased wells to accommodate dual string completion [11].

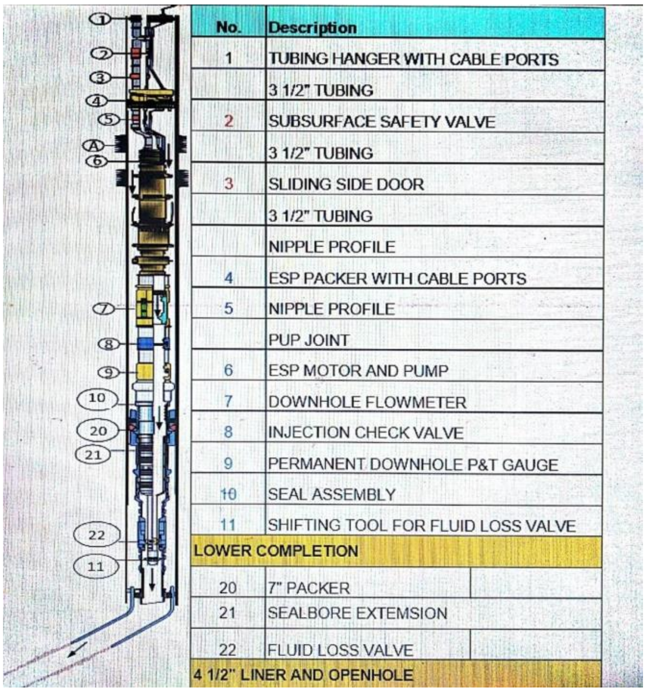



Fig: 1: Completion string with downhole flowmeters, sensors, and ESPs [2]

## 3. Methodology

The methodology states that the step-by-step work consists of designing the execution of a multi-zoned well. The first step is to start working on a study or literature review then the 2nd step is to collect data which includes fluid and reservoir, in 3rd step software work is defined. Prosper software is used to generate IPR and VLP curve and then check production rate from Noddle analysis.

### 3.1. *Collection of Data*

PVT data require for designing well completion in "Prosper" software:

Table.1. Pressure Volume Temperature information

| S.No | Data | Values |
|---|---|---|
| i. | S. GOR (SCF/STB) | 3144.9 |
| ii. | Crude Oil Gravity (API) | 39.3 |
| iii. | Sp. Gravity | 0.74 |
| iv. | CO2 (%) | 1.51 |
| v. | Water Salinity (ppm) | 999.9 |

Table.2. Inflow Performance data for multi-layer well

| S.No | Parameters | Layer-I | Layer-II | Layer-III |
|---|---|---|---|---|
| i. | Depth of Layer (ft) | 12217.9 | 13940.1 | 16404 |
| ii. | Pressure of Layer (Psig) | 7416.8 | 7522 | 7966.9 |
| iii. | Flowing Radius of Layer (feet) | 0.355 | 0.355 | 0.355 |
| iv. | GOR of Layer (Scf/STB) | 2321.1 | 3010 | 2070 |
| v. | Permeability of Layer (md) | 12 | 0.93 | 5.6 |

### 3.2. *Using Software Approach*

Well Completion design is usually based on software, in this case Prosper software is used to design optimum well completion.

- Prosper is a part of the (IPM) suite and is a well software.
- It is used to model performance, design, and optimization programs well.
- This device is the industry trendy properly modelling tool with important operators worldwide.
- Used to model and enhance well completions including layered, multilateral, and horizontal wells.
- Model and enhance the sizing of tubes and hoses.
- Generates lift curves for use in simulators.
- Calculates pressure drops in wells, pipelines, and in chokes.
- Design and optimization of gas, hydraulic and ESP lift pumps.
- Monitor well performance to quickly identify wells that require corrective action.

Prosper is divided into the following section and for the completion design it is compulsory to use data for the sections completing.

#### 3.2.1 *PVT - Defining the fluid*

PVT-Pressure Volume Temperature data defines fluid properties.

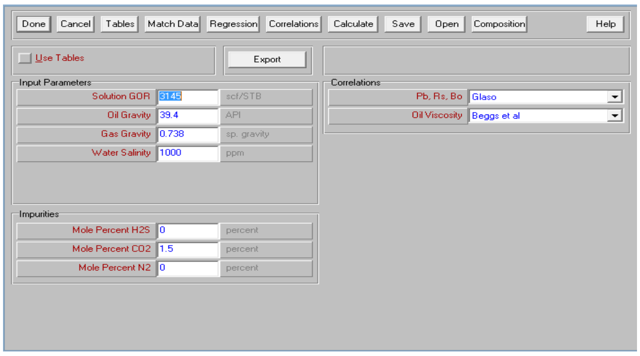



Fig: 2: PVT Data

#### 3.2.2 *IPR*

- IPR is described as the relationship between the bottom hole flowing pressure and production rate.
- Inflow Performance Relationship shows what reservoirs can produce.
- Different methods used for IPR generation depend on the type and phases of fluid which is present.
- Different IPR methods are available for different conditions which define reservoir performance.
- Gilbert IPR is used for single phase flow while Vogel method is used for saturated oil and Generalized IPR shows composite form of Gilbert and Vogel IPR.
- Multilayer and Multilateral IPR are used for more than one producing zone.
- Different IPR methods are used for different conditions to show reservoir performance.

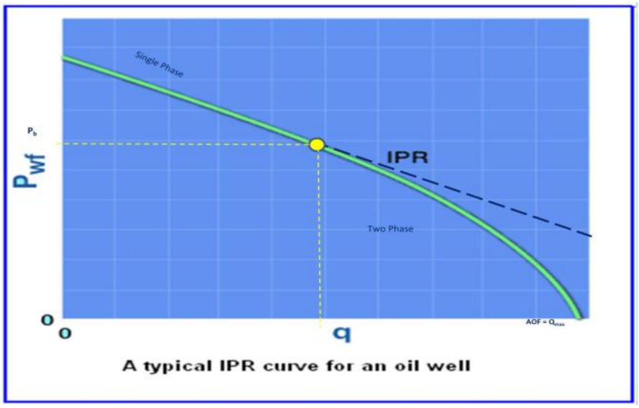



Fig: 3: A Typical IPR Curve

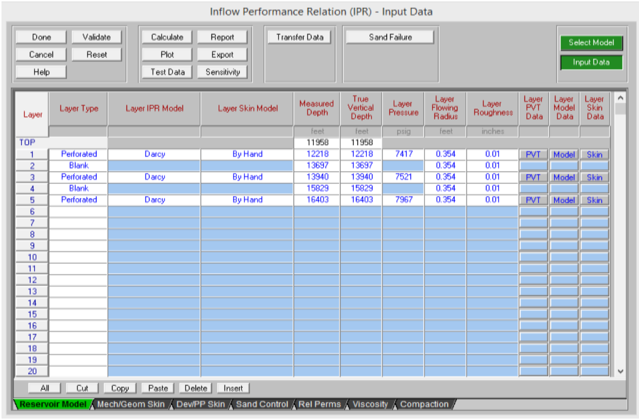



Fig: 4: IPR Data

#### 3.2.3 *Completion Equipment Data*

- Completion equipment is optimally designed for efficient production.
- Completion equipment is properly sized to obtain optimal production from the well.
- Well Completion tools include:
  - Wellhead
  - SSV
  - Tubular Joints
  - Completion Tools
  - Casing

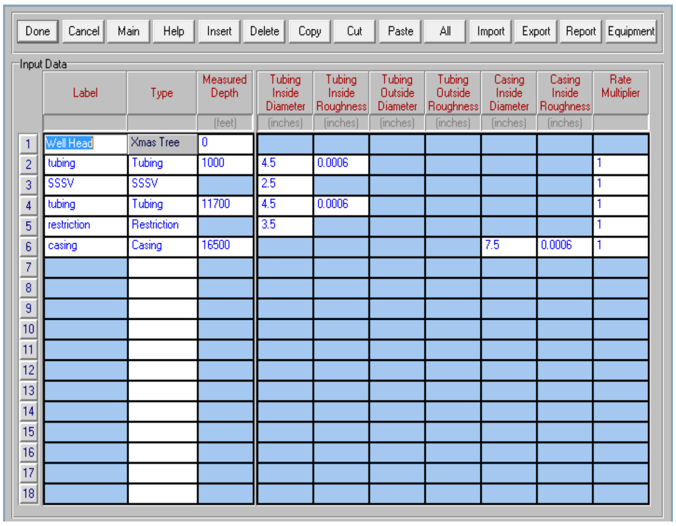



Fig: 5: Completion Equipment Data

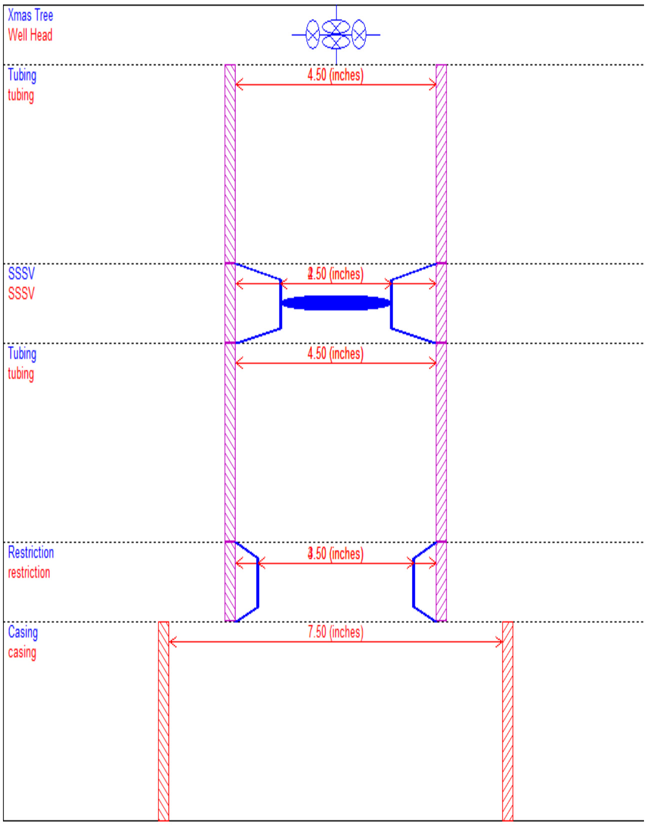



Fig: 6: Model of the Well Completion

### 3.2.4 *Vertical Lift Performance*

- The vertical lift performance (VLP) curve shows what well produced.
- Vertical Lift Performance (VLP) relationship describes pressure at bottom of well as a function of flowrate.
- Pressure drops in bringing the fluids from bottom to the surface is often an essential part of the system.
- This Pressure drop verifies the bottom hole pressure for a specified WHP.
- Three components of pressure drop in tubing.
    - Gravity
    - Friction
    - Acceleration

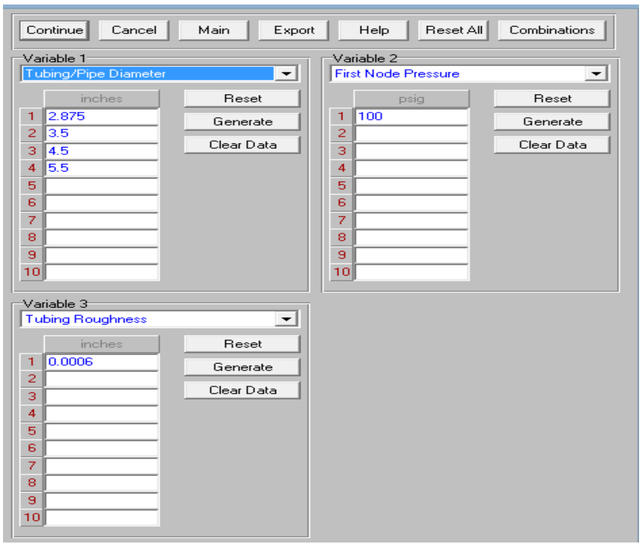



Fig: 7: VLP Data

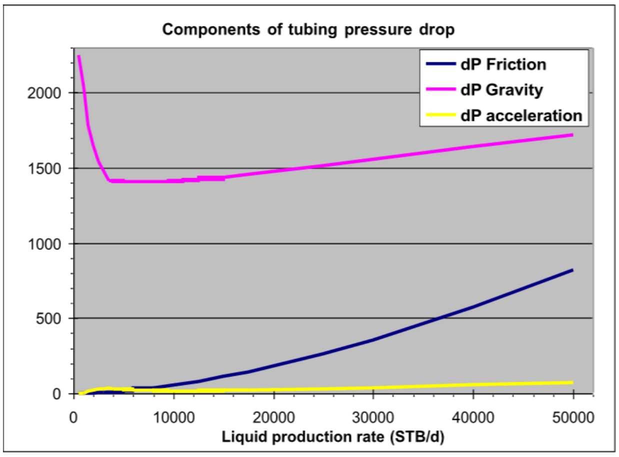



Fig: 8: VLP curve shows pressure drop in tubing

## 4. Results and Discussion

### *4.1. Reservoir Description*

A reservoir consists of one (or more) subterranean rock layers that, with few exceptions, contain liquid and/or gaseous hydrocarbons of sedimentary origination. The reservoir rock is permeable and porous, and structure is enclosed by an impermeable impediment which traps hydrocarbons.

The vertical layout of liquids in a configuration is determined by gravitational forces. The reservoir is also an invisible and composite "semi-porous" physical system which should be studied as carefully as possible, knowing that their understanding will still be limited by missing information. This research is based on two sections:

i. In this case, three layers have been completed with a single string completion.

ii. In this case, the same three layers are completed with a dual string completion.

After generating the results from software, the results were compared with available literature, which shows good alignment.

### *4.2 Case-I: Single Tubing String Multi-Zone Completion*

Data from Table: 2 is used to generate IPR curve for three producing layers, as shown in Figure 9.

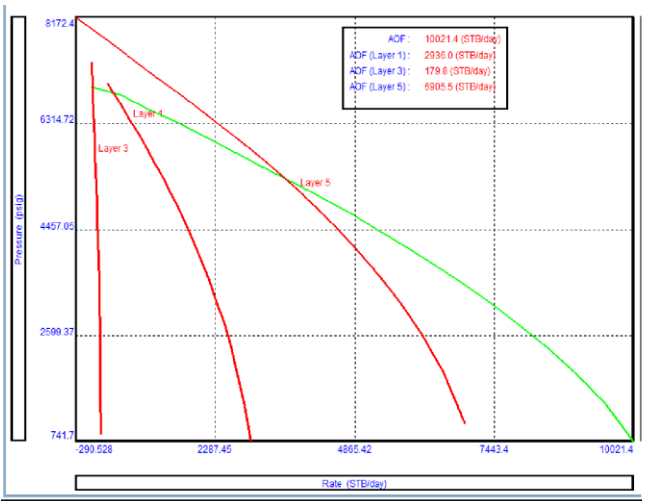



Fig: 9: Comparison of 3-layers IPR curve and multi-layer well IPR curve

It can be interpreted from the results that only 1st, 3rd and 5th Layer are perforated whereas the other middle layers are not. Production is just obtained from these three layers. AOF reveals an upper limit of production from a well, which is not feasible under actual conditions, and actual production is generally lower than AOF. For this case, 2936 STB/D is the AOF of layer 1, 179.8 STB/D is the AOF of layer 3 and 6905 STB/D is the AOF of layer 5. Layer no. 3 is dense, low permeable and has high skin. It is to be fractured hydraulically in the future. The total IPR of the well shows very promising results that the well will be producing 10021.4 STB/D.

VLP curves are shown that what well will produce in this case when all three layers are producing commingle from single tubing string shown in Figure 10.

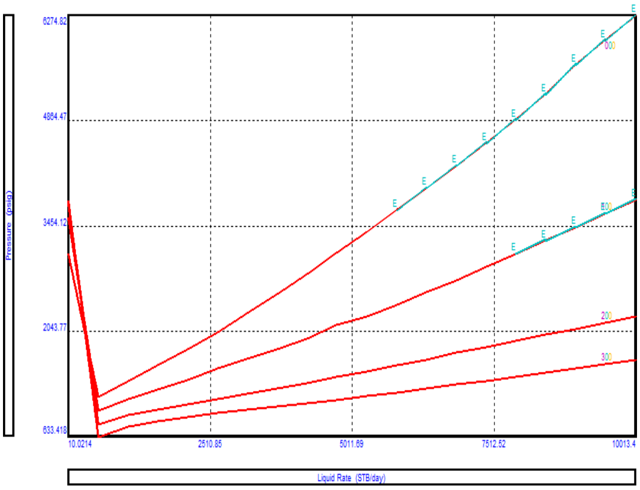



Fig: 10: VLP curves for various tubular sizes in single string multi-zone

Nodal Analysis which explains combination of IPR and VLP curves and observes operating point as shown in Figure 11.

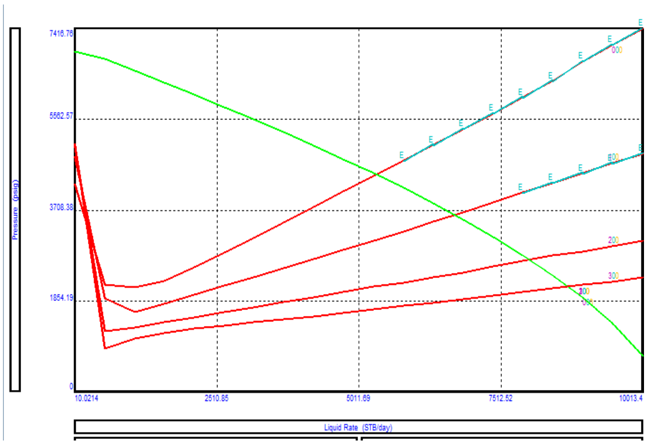


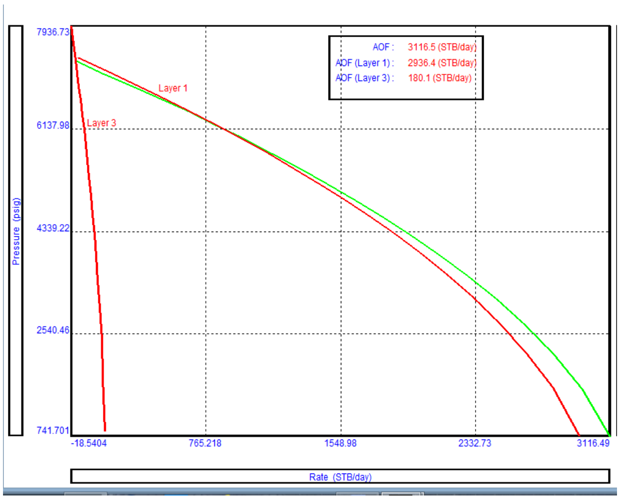

Fig: 11: Flow rates for various tubular sizes in single string multi-zone

The method offers production rates from a multi-zone single string of 5,327 STB/D from a 2.875" tubing to a higher water cut. From a 3.5" tubing we observe a production rate of 6702 STB/D with moderate water cut. Using a size 4.5" tubing, then the production rate is 8020 STB/D with the lowest water cut. The observed production rate from the 5.5-inch pipe is 8,697 STB/D.

Based on nodal study or an amalgamation of VLP and IPR curves, it was detected that the erosion rate achieved at an earlier stage causes internal tubing erosion for both 2.875 inch and 3.5-inch tubulars, i.e., 4.5-inch & 5.5-inch tubulars are desired for this case.

### *4.3 Case-II: Dual Tubing String Multi-Zone Completion*

Considering this case, the well is having two tubing strings, one zone is having one tubing string and remaining two zones have one other tubing string. For this case, the IPR curve of each tubing string is separately generated.




**Tubing 1:**

Figure 12 shows production of two zones through single tubing string.

Fig: 12: Two zones IPR curve

The above figure shows the presentation of two zones being produced by only one tubing string. 2936.4 STB/D is the AOF of layer 1 while 180 STB/D is the AOF of layer 2. The combined AOF of these two layers is 3116.18 STB/D.

Now VLP for these zones are when these two zones produce from single string then VLP Curves are shown in Figure 13.

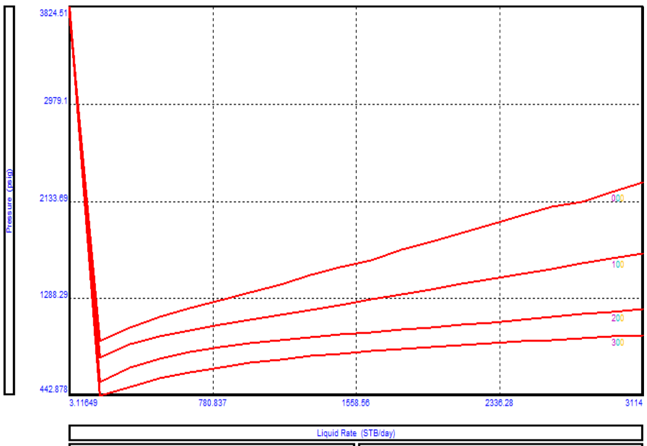



Fig: 13: VLP curves for various tubular sizes for two strings

Figure 14 shows the Nodal Analysis for 2 layers being produced from single string.

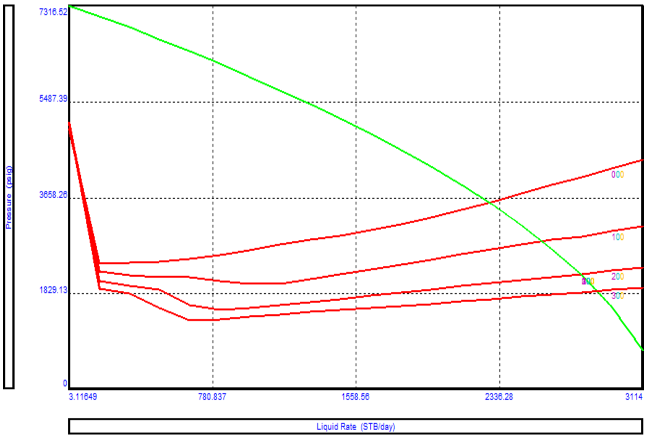



Fig: 14: Flowrates for various tubing sizes of dual string

The figure shows that 2.375-inch diameter tubing can have a production rate of 2281.9 STB/D from these two layers. From a 2.875-inch tubing, 2568.5 STB/D is observed. On the other hand, the 3.5-inch production rate is 2777 STB/D. A 4.5-inch diameter tubing can have a production rate of 2,868 STB/D.

**Tubing 2:**

Figure 15 shows IPR curve for different zones being produced by different tubular strings while well is completed with dual string multi-zone completion.

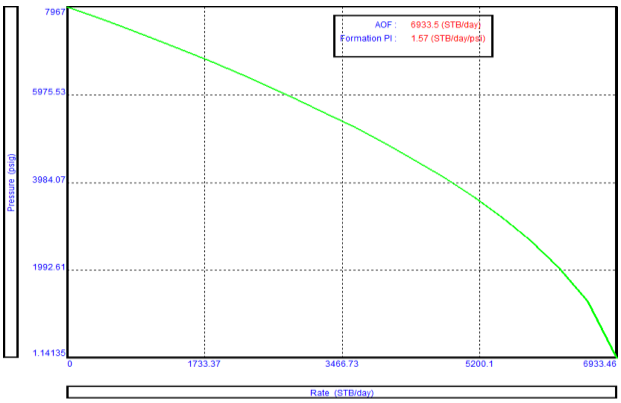



Fig: 15: Inflow performance curve for one zone

This IPR curve shows the recital of another area that is deeper and has high pressure. 6933.5 STB/D is the AOF of this deeper zone, which shows that this zone has low skin and high reservoir pressure.

The VLP curves for this zone when produced from tubular string are shown in Figure 16.

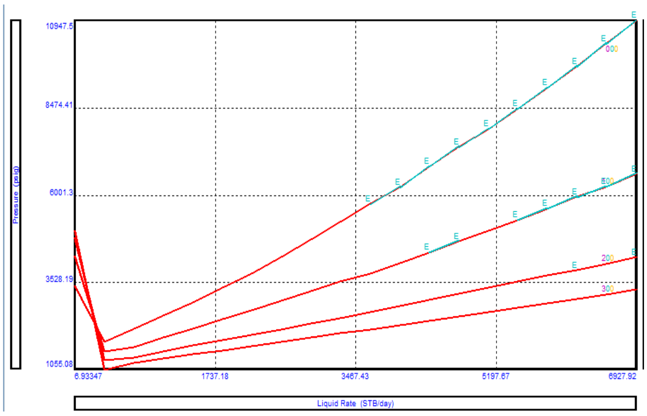



Fig: 16: VLP curves of various tubular sizes of dual string

Nodal analysis which indicates the performance of reservoir and well in a combine form in other words system performance. Nodal analysis shows that flowrate from different tubing size or what well can produce from different tubing size as shown in Figure 17.

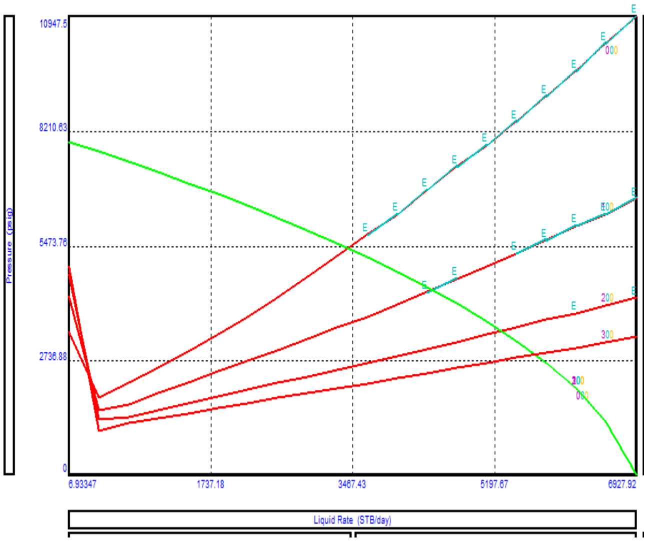



Fig: 17: Flowrates of various tubular sizes of dual string

This layer is being produced through another tubing in case of dual completion. Up to 3416.6 STB/D production rates are noted from 2.375-inch tubing size. However, 2.875-inch tubing, production rate is 4437.6 STB/D. The production rate for a 3.5-inch tubing is 5283.2 STB/D. A production rate of 5,697.5 STB/D was observed using 4.5-inch tubing.

## 5. Conclusions

The focus of this study is totally based on comparison between performance of single-string and dual-string multi-zone completion in specified field. From simulation studies it has been observed that a single string produces 8020.2 STB/D from a 4.5-inch pipe. It's a great production that's profitable. From the dual string, the observed production is:

- The production of 6724.5 STB/D dual strings from 2.375 inch or 2.875-inch tubing is observed.
- In the case of dual string, each of 2.875-inch, the production rate is 7010.4 STB/D.

Being a comparative study, for the optimal selection of well completion, it can be seen from the results that under certain limited condition, the single tubing string of 4.5-inch shows good results. But with the multi-zone double string, the performance of the tubing is low size 2.375 inches and 2.875 inches, which is not comparable. If using two 2.875-inch tubing, then Dual string production is to be considered good. Comparing the outcomes of both the cases of single string producing 8020.2 STB/D and dual string producing 7010.4 STB/D, it is concluded that single string production is more promising than dual string under limited resources. In this multi-zone well, completing with single string is the most efficient and effective method to achieve production.

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