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Geometry Modified Square Edge Orifice Valve Study for Efficiency Gas Lift with Computational Fluid Dynamic (CFD) Method

(Studi Modifikasi Geometri Square Edge Orifice Valve Untuk Efisiensi Gas lift Dengan Menggunakan Metode Computational Fluid Dynamic)

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Abstract

The gas lift lifting system is widely used as an artificial lift on the X Field, with an average depth of gas lift production wells of 3,000-3,500 ft. Design of 3 to 5 Gas lift Valves (GLV) designwith size of 1 inch is ussualy applied. While at the point of gas injection, the GLV square edge orifice is applied. The problem in the optimization of gas lift wells is the flow instability due to gas flow rate fluctuations, the limited volumetric gas injection and limited gas compressor pressure. With the limited compressor pressure, the lift flow and gas design speed is very dependent on the amount of pressure on the compressor, the production wells with limited injection pressure will result in a limited amount of gas injection, the square edge orifice requires a pressure difference of 40% to achieve the maximum gas flow rate. This study aims to find the modification of the GLV orifice geometry to improve the efficiency of the gas lift system so that it can get optimal production. This GLV design modification includes changing the GLV orifice geometry. Design studies using Computational Fluid Dynamic (CFD) simulations aim to analyze any changes in GLV geometry design to the performance of the gas flow rate in the orifice valve described in the valve performance curve. The design modification approach is in accordance with the GLV venturi orifice geometry and the availability of equipment for GLV modification. The CFD simulation results of the first modification geometry by increasing the orifice diameter from 0.25 to 0.5 inch with the condition of upstream 650 psig and downstream 625 psig pressure increasing the injection gas flow rate capacity by 355% and modifying the second geometry with the venturi orifice form by 280%. In modifying the shape of the orifice venture to reach critical flow requires a pressure difference of 10%. Based on simulation results, the modified orifice application is able to increae production up to 44%.

Keywords: Gas Lift Valve, Orifice, Computational Fluid Dynamic

Sari

Sistem pengangkatan gas lift banyak digunakan sebagai artificial lift di lapangan X, dengan kedalaman rata-rata sumur produksi gas lift sebesar 3.000-3.500 ft. Pada umumnya digunakan desain 3 hingga 5 Gas lift Valve (GLV) ukuran 1 inch. Sedangkan pada titik injeksi gas digunakan square edge orifice GLV. Permasalahan pada optimasi sumur gas lift adalah ketidakstabilan aliran karena fluktuasi laju alir gas, jumlah volumetrik gas injeksi dan tekanan gas compressor yang terbatas. Dengan keterbatasan tekanan compressor maka laju alir dan gas lift desain sangat tergantung besarnya tekanan pada compressor, pada sumur-sumur produksi dengan keterbatasan tekanan injeksi akan berakibat pada terbatasnya jumlah gas injeksi, pada square edge orifice diperlukan perbedaan tekanan sebesar 40% untuk mencapai critical flow. Penelitian ini bertujuan untuk mencari modifikasi geometri orifice GLV untuk meningkatkan efisiensi system gas lift sehingga dapat mendapatkan produksi yang optimal. Modifikasi desain GLV ini mencakup perubahan geometri orifice GLV. Kajian desain dengan menggunaan simulasi Computational Fluid Dynamic (CFD) bertujuan untuk menganalisis setiap perubahan desain geometri GLV terhadap performance laju alir gas di dalam orifice valve yang digambarkan dalam valve performance curve. Pendekatan modifikasi desain sesuai dengan geometri venturi orifice GLV dan ketersediaan peralatan untuk melakukan modifikasi GLV. Hasil dari simulasi CFD modifikasi geometri pertama dengan meningkatkan diameter orifice dari 0.25 ke 0.5 inch dengan kondisi tekanan upstream 650 psig dan downstream 625 psig meningkatkan kapasitas laju alir gas injeksi sebesar 355% dan modifikasi geometri kedua dengan bentuk orifice venturi sebesar 280%. Pada modifikasi bentuk orifice venture untuk mencapai critical flow membutuhkan perbedaan tekanan sebesar 10%. Berdasarkan hasil simulasi, penerapan modifikasi orifice dapat meningkatkan produksi hingga 44%.

Kata-kata kunci: Gas Lift Valve, orifice, Computational Fluid Dynamic

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I. INTRODUCTION

Gas lift is one of the artificial lift methods used in X Field. The main focus in X Field is to maintain oil production. Continuous optimization of gas lifts is an effort to obtain optimal oil production. One of the problems that arise in gas lift systems is for wells with locations far from compressors, this results in a limited available pressure for the system in achieving the optimal gas lift injection flow rate. This greatly impacts gas lift wells which have a high productivity index. The use of orifice Gas Lift Valve (GLV) with a square edge shape has limitations to achieve maximal injection. It requires a high differential pressure (50% of the upstream orifice pressure). So that efforts are needed to increase the capacity of the optimal gas flow rate. To increase the optimal gas flow rate, GLV geometry authentication is needed, the analysis of GLV geometry modification using Computational Fluid Dynamic (CFD) software.

One obstacle in optimizing the increase in well oil production using the gas lift system is the limitation of casing head pressure, especially in gas lift wells that have a remote location with compressors due to high pressure drop. This condition is very influential on oil production wells that have a high injection rate and productivity index requirement, due to high flowing gradients (above 0.18 psig / ft) so that the pressure difference that can be generated on the GLV upstream orifice and down stream is only 10-20% which results in a limit of the gas flow rate at GLV.

Based on those problem this study aim to get solution about :

- How to modify GLV so that it can increase the capacity of the injection gas flow rate?
- What is the effect of GLV modification on gas lift well production performance?

The purpose of this research is to provide an optimal analysis of GLV modification design so that it can increase the gas flow rate in the gas lift system and oil production from gas lift wells. The purpose of this research is:

- Examine the performance of the GLV orifice that exists in the field using a CFD model simulation.
- Examining the relationship of modification of GLV geometry changes to the performance of injection gas flow rates on GLV, using CFD simulations.
- Simulate the performance of gas lift elevator production using GLV that has been modified.

The scope of this research is the geometry modeling of the Gas lift valve with the Computational Fluid Dynamic method and the modeling of well production performance with Nalal Analysis software. Research on efforts to optimize the production of oil production wells using the gas lift system by modifying GLV geometry, modifying analysis using CFD software tools, CFD software used to create valve performance curves that illustrate the relationship of injection flow rates with variable pressure differences on GLV

The problem limits in this study are:

- This research was conducted using a numerical simulation method.
- The study was conducted on a 1 inch GLV, which was used on the X Field.
- Pressure variable (Head Pressure Casing) is taken from X Field conditions.
- Determination of gas lift valve performance curve using CFD Software.
- Simulation of the production performance of gas lift wells using the Nodal Analysis (PIPESIMS) software.

This research is expected to increase oil production of gas lift production wells by providing recommendations for modifying the gas injection valve geometry design to increase the capacity of the injection gas flow rate with limited pressure on the casing head. This research is expected to contribute to science where it can provide analysis and discussion of gas flow in GLV, as well as the relationship between GLV modifications of GLV performance in sending injection gas.

II. METHOD

The preparation before starting the research is to collect all the necessary field data related to GLV modification, namely detailed geometry and material from GLV (Figure 4), gas injection composition, casing head pressure data, well production data, gas lift design, PVP, reservoir data. After the data is ready, the systematic analysis sequence is as follows:

- Analyzing the performance of gas lift wells by using Nalal Analysis software, to obtain gas lift performance curves and limitations of conventional GLV.
- Analyze the simulation of gas flow through the initial GLV using CFD Software software.
- Simulation the GLV design with modification of the orifice size and variations in the size of the injection hole using CFD Software software.
- Simulation of the comparison between the venturi orice design and GLV that has been modified with CFD Software software.
- Analyzing the effects of GLV modification on oil well production using gas lifts.

Figure 1 shows the process of selecting candidate gas lift wells to be used as study cases. The criteria for the well to be chosen consider the following matters:

1. Wells with gas lift performance that are not optimal where indications of Total Gas Lift Ratio is less than 600 scf / stb
2. Wells that have a fairly good Productivity Index with a PI value more than 5.
3. Priority of wells with low WC in order to obtain a significant potential increase in production.

Figure 2 shows simulation flow chard while using software CFD.

III. RESULTS AND DISCUSSION

In order to get the optimal production of Wells A, B and C, a simulation of gas lift injection performance at the injection point is made, from the simulation results to achieve an optimal gas flow rate of 700-800 kscfd (Figure 5, Figure 6 and Figure 7). The maximum available head pressure casing cannot reach optimal conditions injection flow rate is not possible. To achieve the optimal gas injection flow rate can be done by modifying the geometry of the orifice in order to reduce the pressure loss in the orifice by increasing the area of the orifice so that with the same pressure difference the injection gas delivery capacity can be increased.

In model 1 (Figure 8) with a 650 psig upstream pressure and 625 psig downstream pressure with a pressure difference of 25 psig the injection gas flow rate is 360 Mscfd. To get the optimal gas flow rate for Wells A, Wells B and Wells c of 700 Mscfd a pressure difference of 150 psig is needed, so that with limited casing head pressure on Wells A, Wells B and Wells c by using the orifice ¼ " the optimal gas flow rate is not can be achieved. In the Model 1 graph (Figure 8) it can be seen that the pressure difference is 50 psig gas flow rate of 455 Mscfd and flow at a pressure difference of 250 psig gas flow rate of 869 Mscfd, this trend is consistent with the results in the reference paper, where a pressure difference above 40 % to get the maximum gas flow rate. And from the graph seen in the range of pressure difference of 25-250 psig / P downstream 400-625 psig with changes in downstream pressure will result in a significant change in gas flow rate so that it influences the flow rate of well production, this affects the stability of gas lift well production

In the model 2 (Figure 9) with a 650 psig upstream pressure and 625 psig downstream pressure with a pressure difference of 25 psig the injection gas flow rate is 1258 Mscfd. To get the optimal gas flow rate for Wells A, Wells B and Wells c of 700 Mscfd with limited casing head pressure on Wells A, Wells B and Wells c the flow rate can be achieved using the orifice 1/2 ", with the geometry modification of the orifice ¼ "To 1/2" there is a very significant increase in gas from 360 Mscfd to 1258 Mscfd for a pressure difference of 25 psig. In the Model 2 graph, we can see the pressure difference of 250 psig gas flow rate of 3078 Mscfd. From this result, the capacity of the gas flow rate injection is too large which will result in the potential leakage of gas flow rate (excessive gas injection) this trend is in accordance with the results found in the reference paper, where a pressure difference above 40% is needed to obtain the maximum gas flow rate . And from the graph seen in the range of pressure difference of 25-250 psig / P downstream 400 - 625 psig with changes in downstream pressure will result in a significant change in gas flow rate so that it influences the flow rate of well production, this affects the stability of gas lift well production. The geometry modification of model 2 will be very effective on wells that require injection gas 1500-2000 Mscfd because the injection gas capacity is very large, to study case Wells A Wells B and Wells c modification of this geometry can be used keeping in mind the regulation of gas flow is done by setting gas lift choke and adjusted for optimal injection gas flow requirements.

In the model 3 (Figure 10) with a 650 psig upstream pressure and 625 psig downstream pressure with a pressure difference of 25 psig the injection gas flow rate is 912 Mscfd. To get the optimal gas flow rate for Wells A, Wells B and Wells c for 700 Mscfd with limited casing head pressure on Wells A, Wells B and Wells c the flow rate can be achieved using venturi orifice, with modified geometry from orifice ¼ "to venturi there is a very significant increase in gas from 360 Mscfd to 912 Mscfd for a pressure difference of 25 psig. In the Model 3 graph it can be seen from the pressure difference of 250 psig the gas flow rate of 1081 Mscfd. From the trend of gas flow rate only with a pressure difference of 10%, the maximum gas flow rate can be obtained. In addition, from the graph in the range of pressure difference of 25-250 psig / P downstream 400-625 psig with changes in downstream pressure does not result in a significant change in gas injection flow rate so that it does not affect the flow rate of well production, this affects the stability of gas well production elevator. The geometry modification of model 3 will be very effective on wells that have limited head pressure casing so that the pressure difference of 10% will get the optimal injection gas flow rate.

IV. CONCLUSIONS

The conclusions of this research are:

1. From the simulation results of Square Edge Orifice performance CFD with GLV upstream pressure of 650 psig and 25 psig pressure difference of 325 Mscfd gas flow rate, and with a pressure difference of 250 psig at 869 gas flow rate Mscfd.
2. Changes in model 2 geometry by increasing the bore diameter of the square edge orifice from ¼" to ½" with a GLV 650 psig upstream pressure and a 25 psig pressure difference can increase the capacity of the flow rate from 325 Mscfd to 1.258 Mscfd (387%) and with a pressure difference of 250 psig the flow rate is 3.093 Mscfd (355%).
3. Change in geometry of model 3 by modifying the square edge orifice shape to the venturi orifice with a GLV 650 psig pressure upward and a 25 psig pressure difference can increase the capacity of the flow rate from 325 Mscfd to 912 Mscfd (280%) and with a 250 psig pressure difference of 1081 MScfd (120%). Critical flow is obtained with a pressure difference of less than 10% from upstream pressure.

4. From the simulation results with the implementation of modification of model 2 and the model 3 wells A, B, and C has the potential to increase production by an average of 44%.

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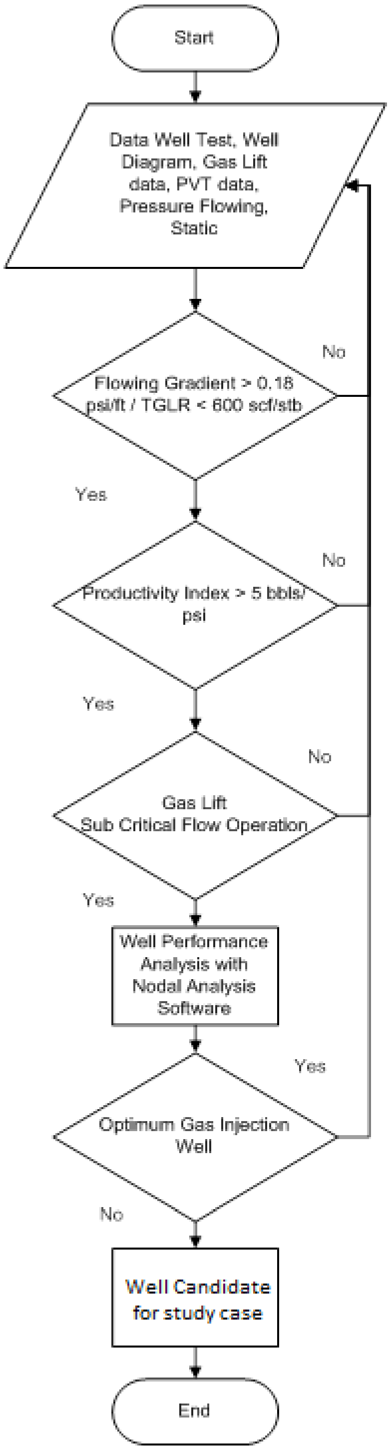


Figure 1. Well Candidate Determination

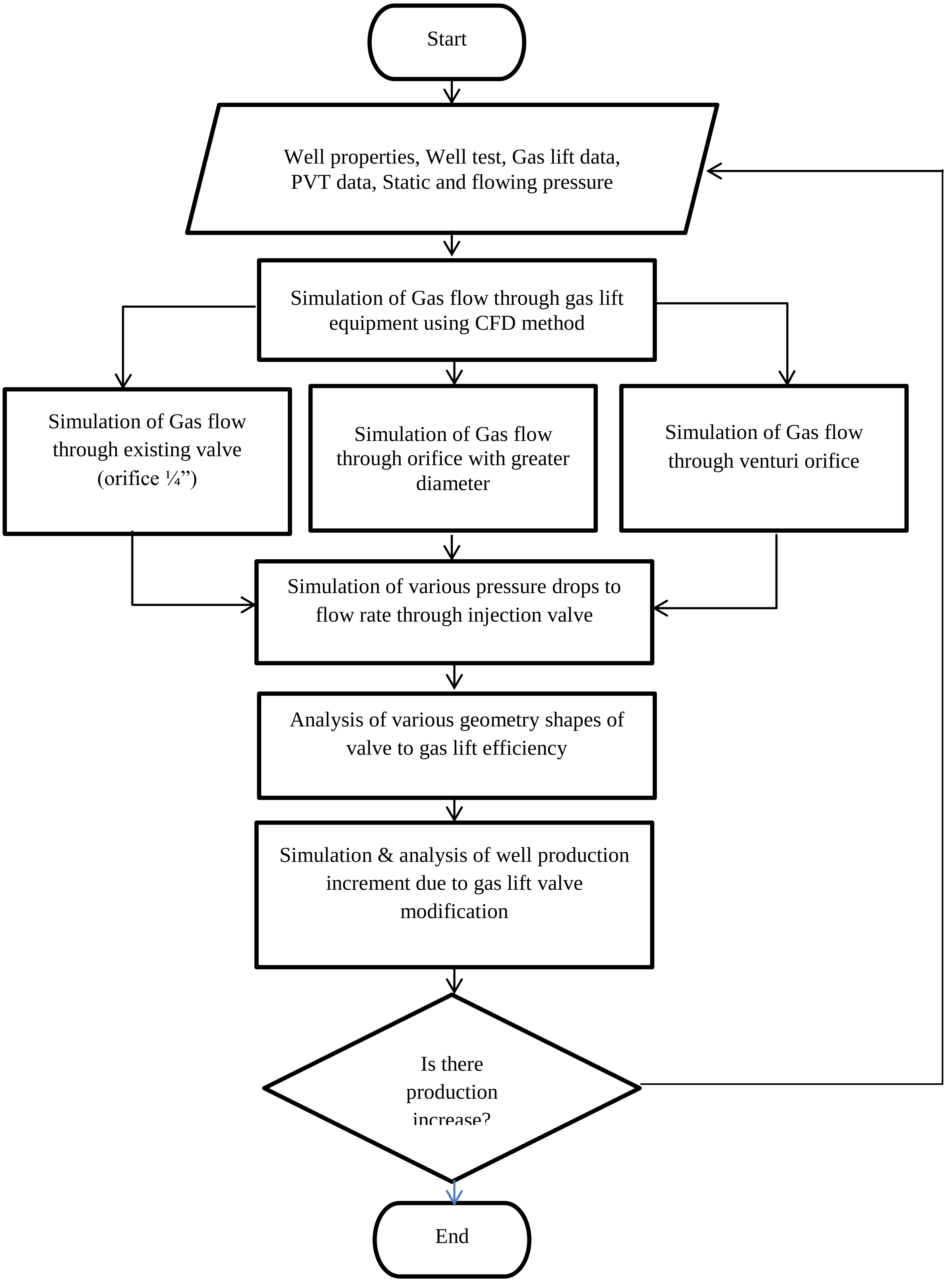


Figure 2. Simulation Flow Chart

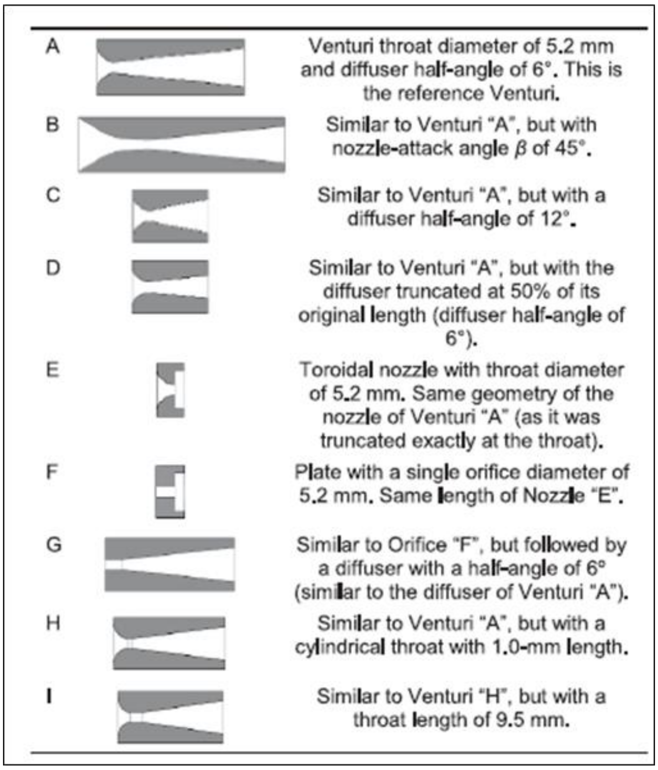
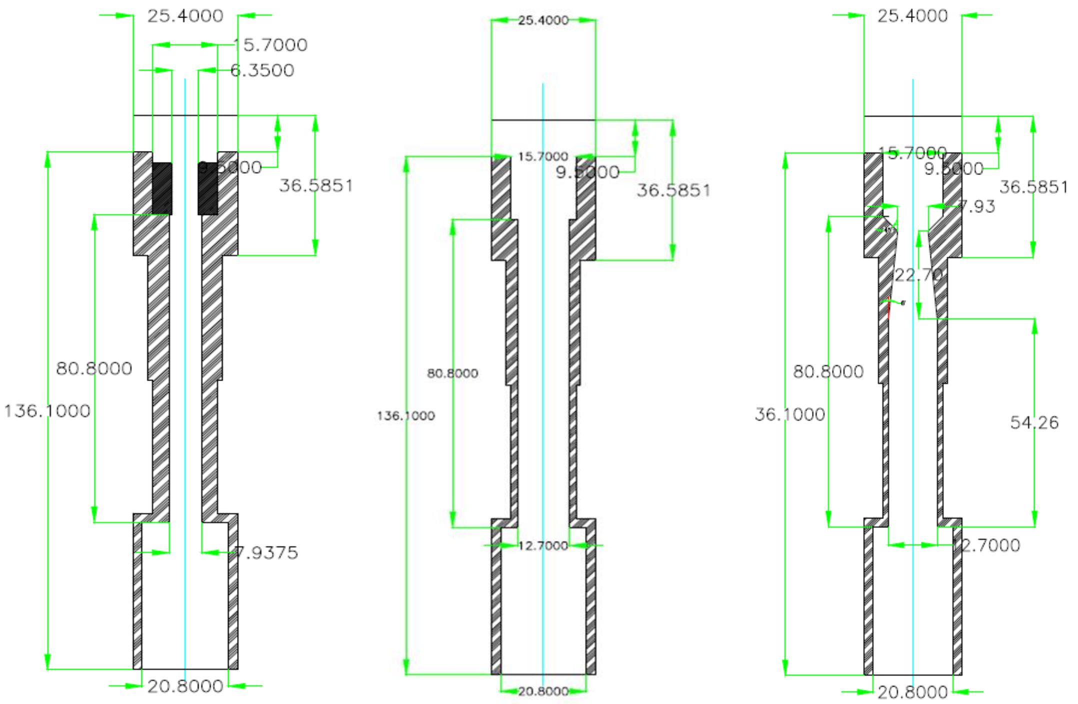


Figure 3. Study of Ventury GLV Orifice Geometry



(a) **(b)** **(c)**

Figure 4. Geometry Modification (A) Gas Lift Valve Initial Geometry (B) Gas lift Valve Modification by increase bore hole to ½" (C) Gas Lift Valve Modification Ventury Orifice

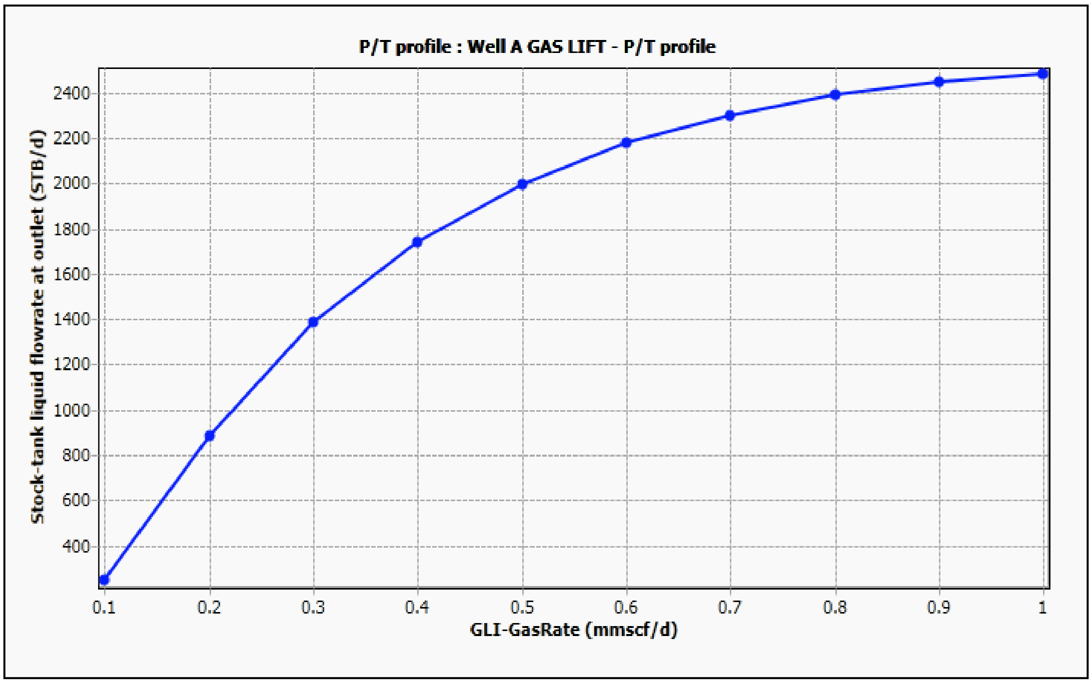


Figure 5. Potential of A Well

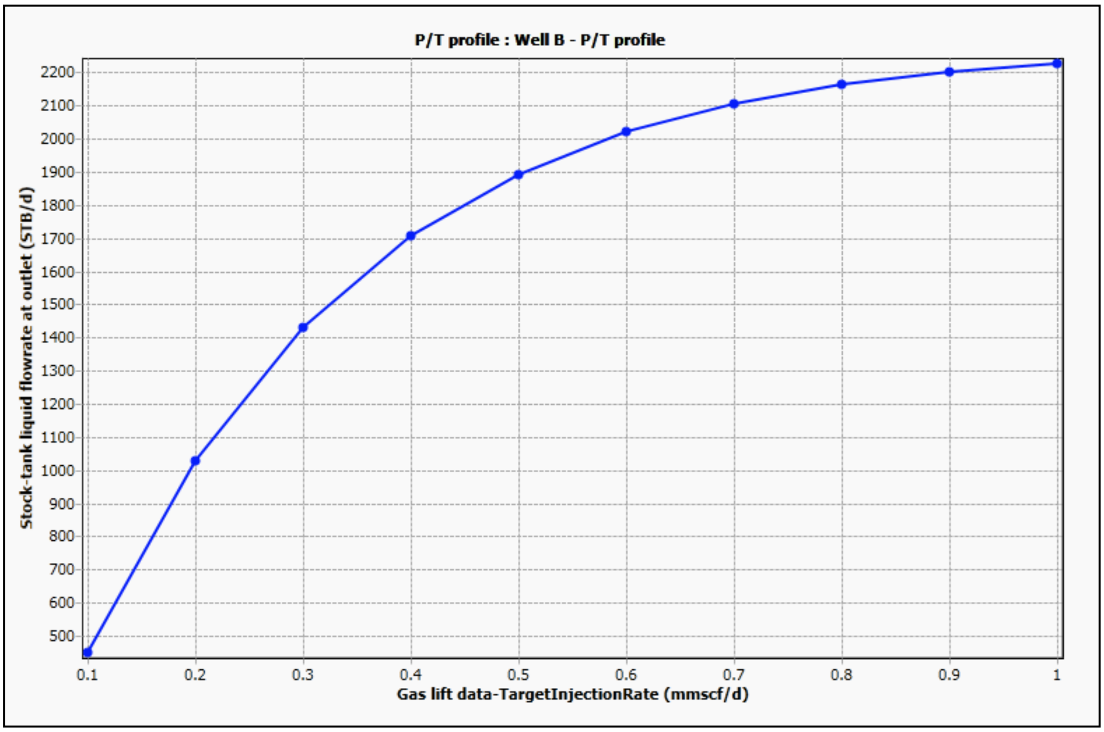


Figure 6. Potential of B Well

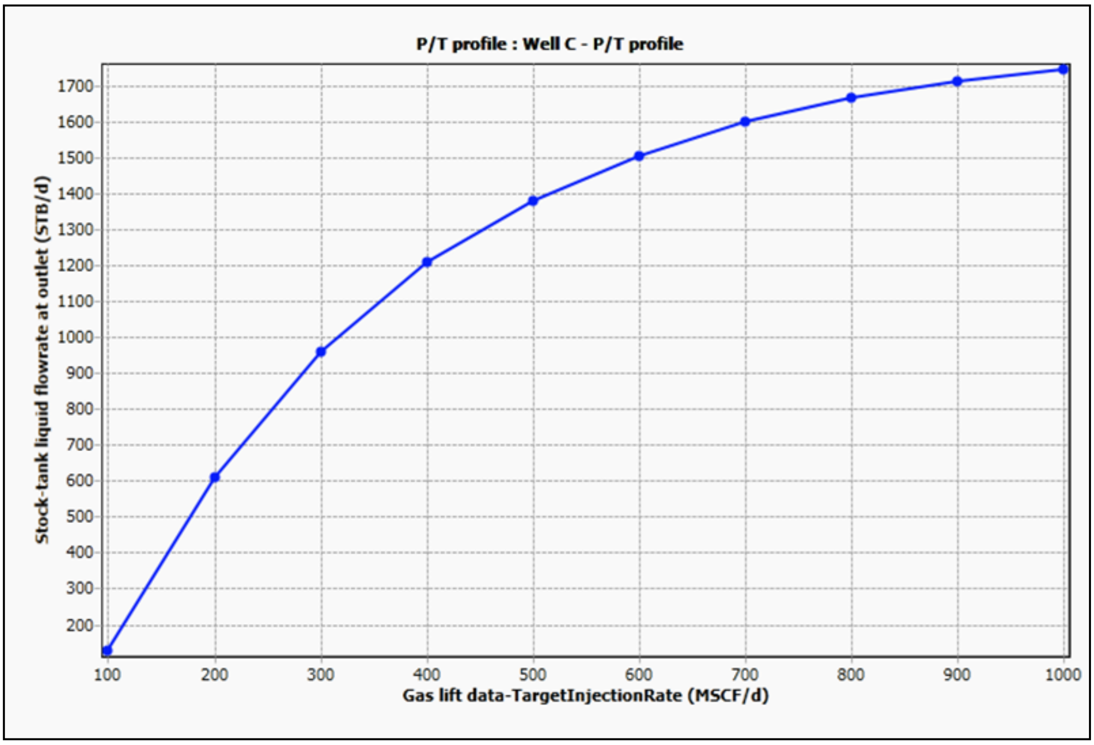


Figure 7. Potential of C Well

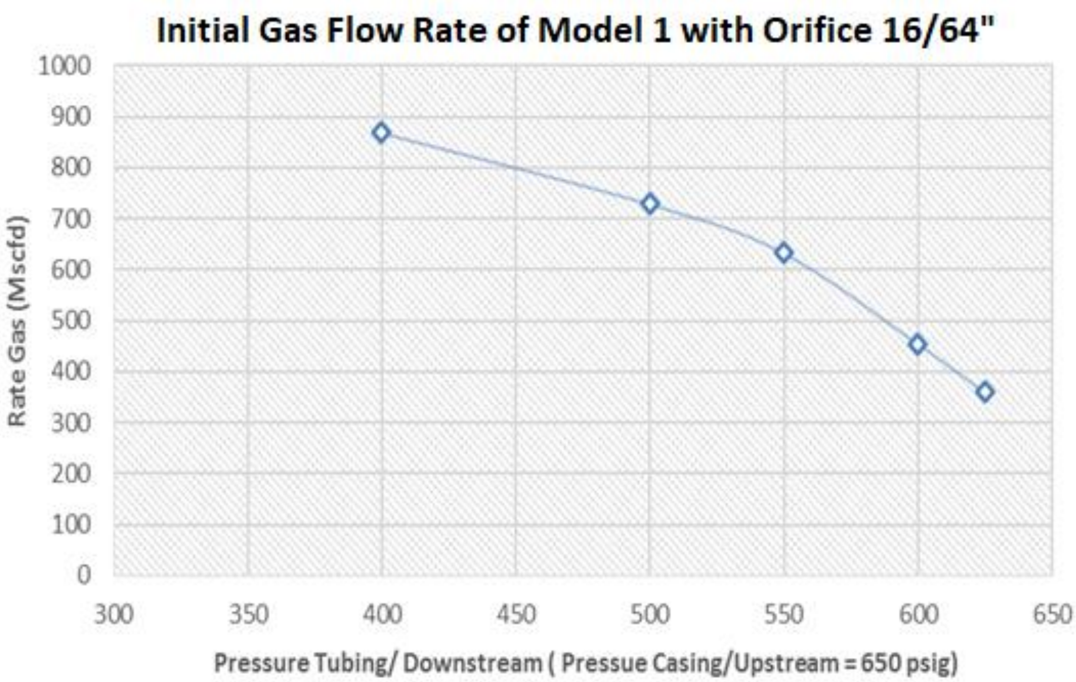


Figure 8. CFD Simulation Result of Model 1

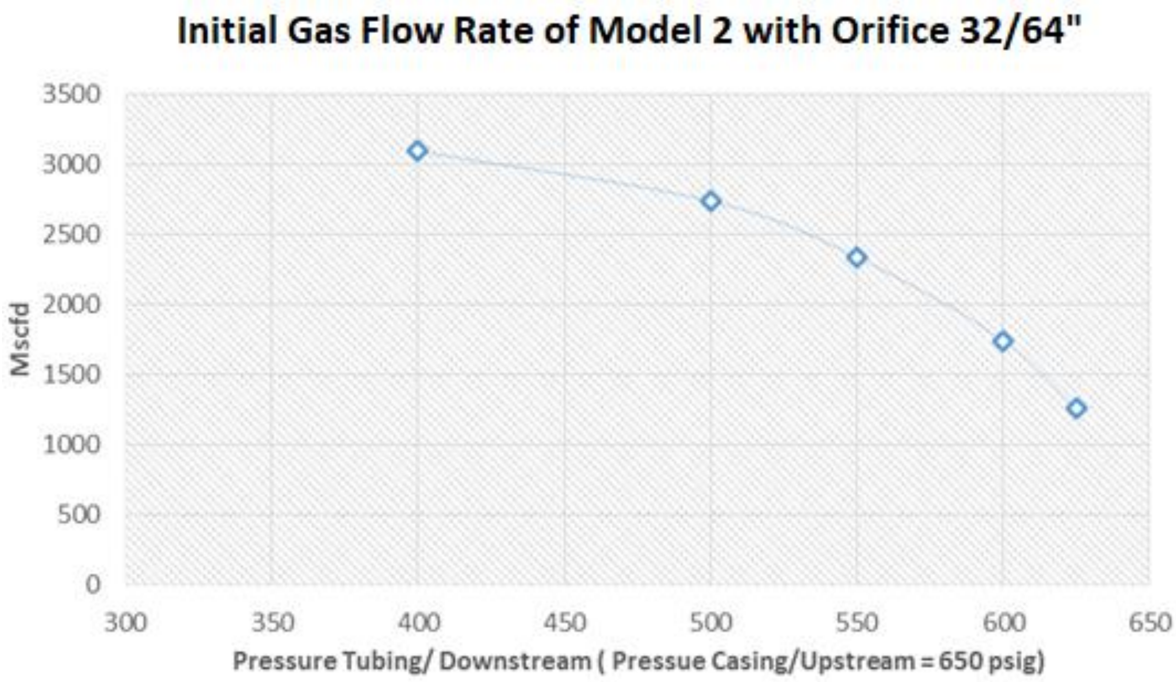


Figure 9. CFD Simulation Result of Model 2

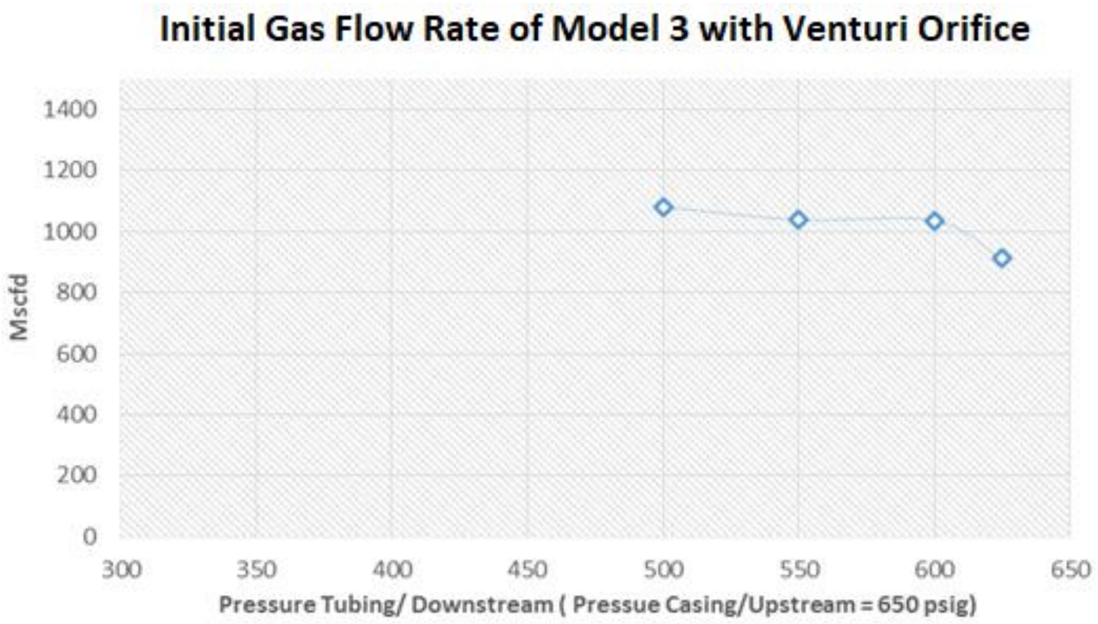


Figure 10. CFD Simulation Result of Model 3