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ANALYSIS ON HYDRAULIC FRACTURING IN SHALE GAS RESERVOIR FOR OPTIMUM RECOVERY

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ABSTRACT

Sustainable discoveries in shale gas resources are complicated because of main challenges which is extremely limited permeability, limited porosity therefore, shale gas production is produced at very low rates. Hence, unconventional gas may not achieve even more positive outcomes. One of most important technique that utilized to increase recovery of such reservoir is Hydraulic Fracturing. In this research, this reservoir is based on a three dimensional dual permeability model of shale gas reservoir. The base case scenario includes a hydraulic fracture horizontal well of shale gas horizontal well which are first history match with recovery rate of shale gas reservoir. Sensitivities are carried out multistaged hydraulic fracturing of horizontal well to decide best completion scenario based on recovery rate. Furthermore, sensitivity result has shown that multistaged hydraulic fracturing of horizontal well yields high reservoir recovery rate i.e. 34.83%. Impact on fracturing parameters for hydraulic fracturing are also studied in this work. Through sensitivity analysis & comparison of hydraulic fracturing, it has been concluded that by increasing fracture conductivity, half length, width, number of fractures, variation of half-length along with width consequently recovery rate of well is increased . However by decreasing value of fracture spacing recovery rate is increased.

Keywords: Shale Gas Resource, Hydraulic Fracturing, Unconventional Resource, Barnet, Recovery Rate.

I. INTRODUCTION

Due to extremely less permeability, less porosity, an excessive amount of organic carbon as well as natural fractures are classified by shale formations. The value of permeability varies around 0.000009 to 0.0001md while the value varies around 2 to 8 percent porosity. Unconventional gas may not achieve even more positive outcomes through the method of horizontal well drilling and hydraulic fracking process, due primarily to its poor permeability. Reservoirs of unconventional gas having high organic matter, altering from one trap to another. An unconventional gas reserve consists of gas stored in matrix pore volume as well as adsorbed onto solid organic matter. Primarily mechanism of adsorption gas seems to be essential to dissertation. Furthermore, modelling of complex fracture networks is also of significant importance for shale gas reservoir stimulation. At present, unconventional gas makes up approximately partial of natural gas generated in U.S. And, according to a U.S report of Energy Information Agency, the ratio will grow to 70 percent in 2040[1, 2, 3, 4]

It is essential to improve productivity for commercial growth of unconventional gas by examining reservoir properties, flow attributes as well as efficient design of fracture treatment that affects well efficiency [5]

Process of hydraulic fracking being utilized by petroleum industry to improve well's efficiency by pumping water sand and a combination of chemicals at extremely intense pressures, fracturing the rock and creating fissures to flow more easily from the formation of hydrocarbons [6].

Multi-stage hydraulic fracking in horizontal wells has encouraged the petroleum industry to improve performance economically from hydrocarbon reserves, particularly from natural shale reservoirs. An approach included formation of various fractures by pumping large proppants quantities as well as fracturing fluid with rising pressures at almost singular stage of hydraulic fracking. Vast hydraulic fracturing optimization studies have been performed performed to produce maximum hydrocarbons performance by unconventional resources [7].

unconventional reservoirs, several parameters affect the efficiency of the recovery process. The impacting parameters comprise the constraints of production and injection along with the configuration of the hydraulic fracturing that can be analyzed to achieve the wide flow response of the reservoir. Furthermore the fracture permeability ,fracture spacing ,fracture length, width, half-length of each fracture, while fracture conductivity

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are frequent hydraulic fracturing design parameters that have been designed to achieve optimum recovery [11,12,13,14,15,16,17].

In Texas, Most famous basins are named as Forth worth then other is known to be Permian basin in which Barnett shale gas contained. Moreover first Barnett Shale well was drilled in 1981 overall other countries. Firstly "Core/Tier I" while Barnett shale are separated in undeveloped regions. The Barnett Shale's "Core/Tier I" part correlates towards its regions which are actively being developed. Furthermore counties of "Parker, Wise, Johnson" including those nearby are indeed where it is primarily found. Mainly underdeveloped part refers to its Barnett regions that have yet to be developed by the corporations. Moreover working as well as dormant sectors of something like Barnett have been subsequently separated for simulation reasons because it spreads across two petroleum basins in distinct parts of Texas. Figure 1 shows the location of the shale, as determined by Wood Mackenzie. [9, 10]

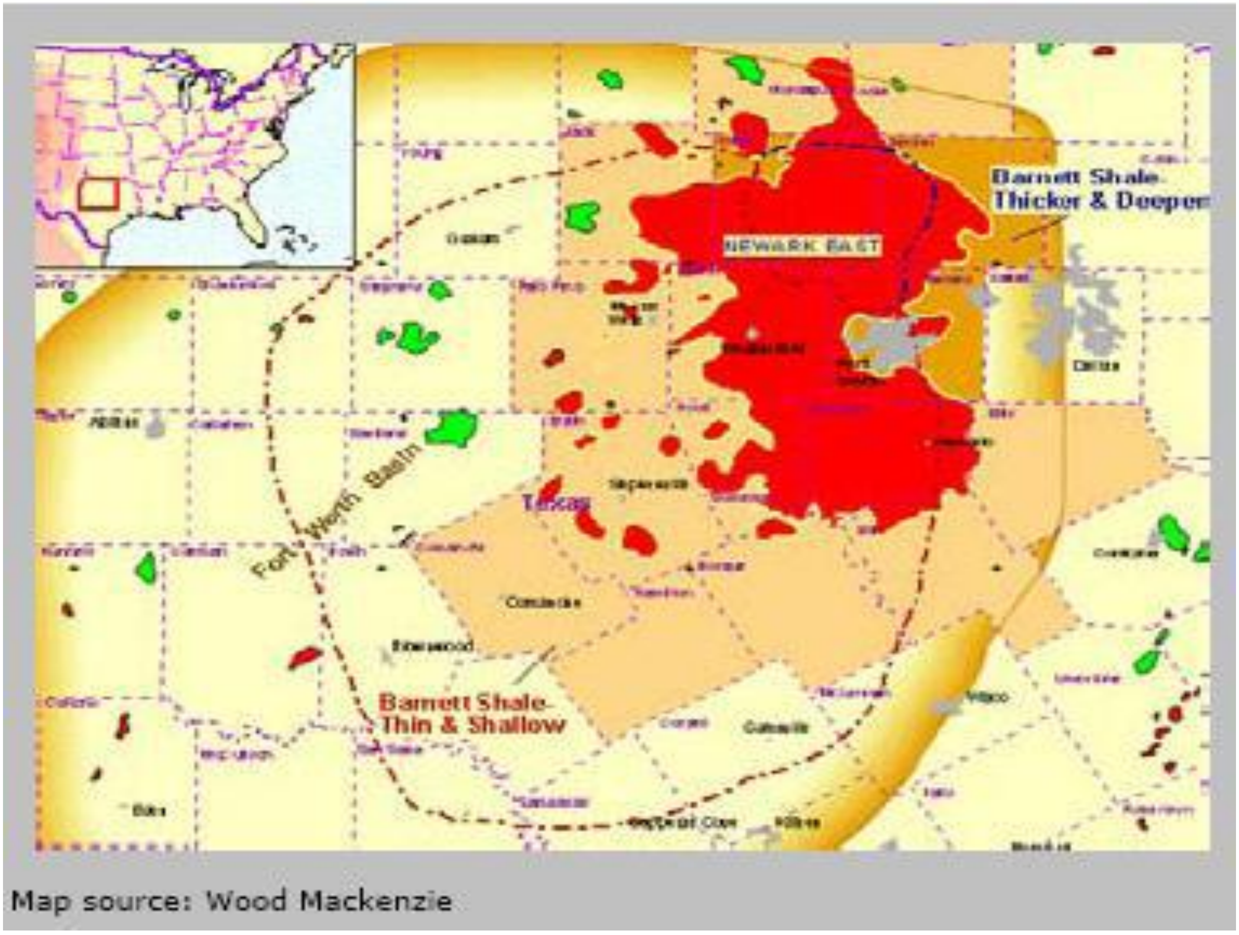

Figure 1: Play Field of Barnett Shale Gas

II. METHODOLOGY

Begins with the gradational of modelling of shale gas reservoir. The different cases of various reservoir planes and fracturing parameters which affect the productivity of shale gas reservoir are discussed. The methodology adopted for completing the whole study is shown in figure 2.

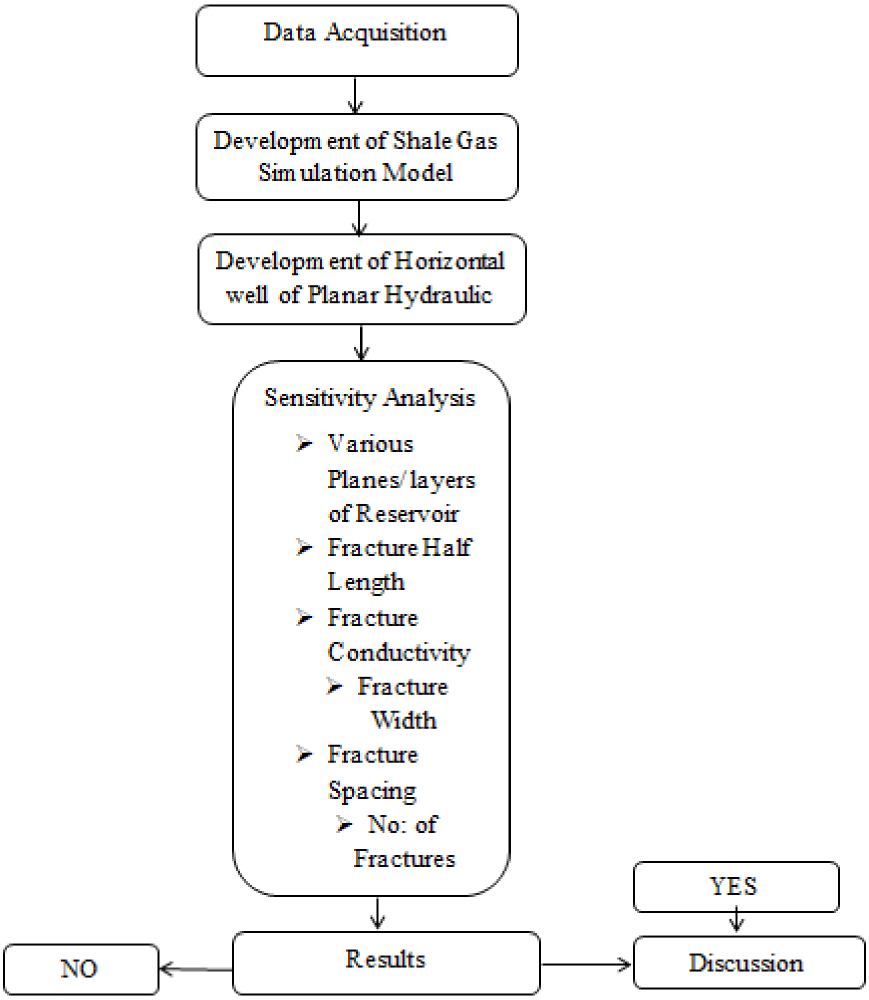

Fig 2: Flow chart of Methodology

Method and analysis which is performed in your research work should be written in this section. A simple strategy to follow is to use keywords from your title in first few sentences.

III. MODELING AND ANALYSIS

It also includes the validation of shale gas reservoir model with a commercial reservoir simulator by CMG (Computer Modelling Group). The candidate shale gas of reservoir in X-area has drainage area of approximately 28800ft with square geometry. Moreover this shale gas reservoir is divided into 15 layers of equal thickness. Reservoir has length of 4800ft and width of 1000ft and 20ft per thickness however total 15 layers is identified in shale gas reservoir model.

Due to extremely less permeability, an excessive amount of carbon as well as natural fractures are classified by shale gas reservoir formation. The value of permeability varies around 0.00009 to 0.001md while the value varies around 2 to 8 percent of porosity

❖ **Development of Sensitivity Cases:**

After the development section of model, the primary point to investigate the recovery obtained the following well that are independently in simulation model.

(1) Horizontal Well

(2) Horizontal Well with Hydraulic Fractures

All the above simulation cases are run for 20 years of production. The recovery obtained from all the above wells is to be compared with each other to determine a technically feasible well completion scheme. Consequently the effect of following parameters on productivity of shale gas is analyzed individually for both fractures including hydraulic Fractures selection of feasible well.

(3) Sensitivity Impact of variation of different plane of Reservoir for Planar Fracturing of Horizontal Well

(4) Sensitivity analysis on following Fracturing Parameters of hydraulic fracture

(4.1) Fracture Spacing

(4.2) Fracture conductivity

(4.3) Fracture Width

(4.4) Fracture Half Length

(4.5) Fracture Stages

(4.6) Variation of fracture half length along with fracture width

❖ **MODEL VALIDATION**

After development of horizontal well, the shale gas reservoir model is having extremely less permeability of 0.00025 md (milli-darcy) and porosity of 5% containing horizontal well with three fractures of half length 350ft has been stimulated in CMG simulator. This model is validated the results obtained from Computer Modelling group simulator. The two dimensional 2D and three dimensional 3D view of Shale Gas reservoir model is shown in Figure 3 and Figure 4.

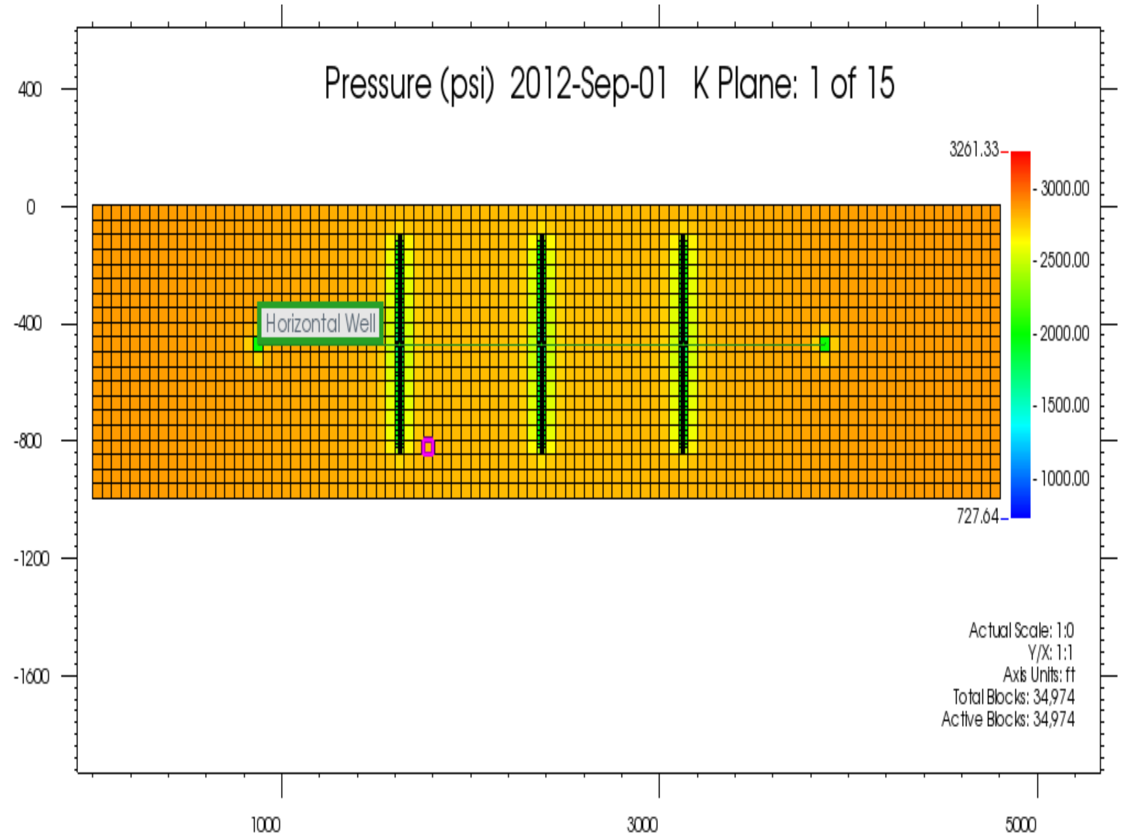

Figure 3: Simulation Model in IJ-2D Areal view of Shale Gas Reservoir Model in CMG

The horizontal well perforation from CMG simulator is shown in Figure 3 and Figure 4 in three dimensional 3D views the bounding boxes means horizontal well length 4800ft, width 1000ft and thickness of shale gas reservoir are also shown in below Figure 4.

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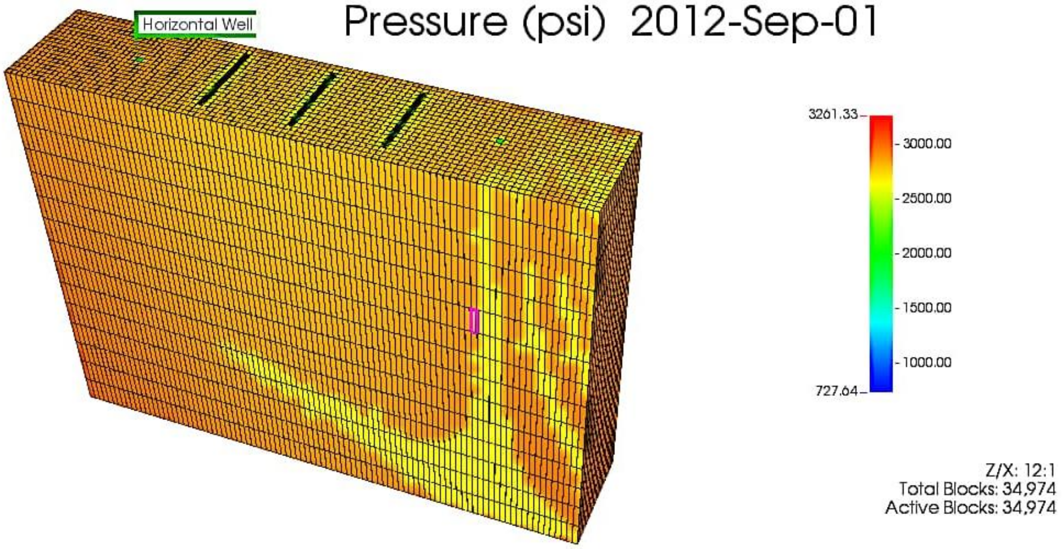

Figure 4: Simulation Model in IJK-3D view of Shale Gas Reservoir Model in CMG

❖ **WELLS SCHEME**

To investigate the recovery of horizontal well scheme in shale gas reservoir; a sensitivity cases have been carried out on the shale gas reservoir of horizontal well as well as multistaged planar fracturing on the horizontal well and also sensitivity case on complex or network fracturing of horizontal well is applied. The following set of data well has been used in simulation cases:

Table 1: Wells Scheme Data

Parameter	Horizontal Well	Multistaged Planar Fracturing Horizontal Well
Horizontal Well Length	4800ft	4800ft
Fracture Half Length	-	350ft
Fracture Width	-	0.001ft
Number of Fractures	-	10
Fracture Spacing	200ft	200ft
Fracture Conductivity	-	35ft
Number of Refines	-	7,7,1

IV. RESULTS AND DISCUSSION

(1) Horizontal Well

In this simulation case, the horizontal length of horizontal well is 4800ft that is simulated in CMG GEM simulator (Figure 5). The pressure scenario around the horizontal well after the twenty years (20yrs) of shale gas production is showing in Figure 6.

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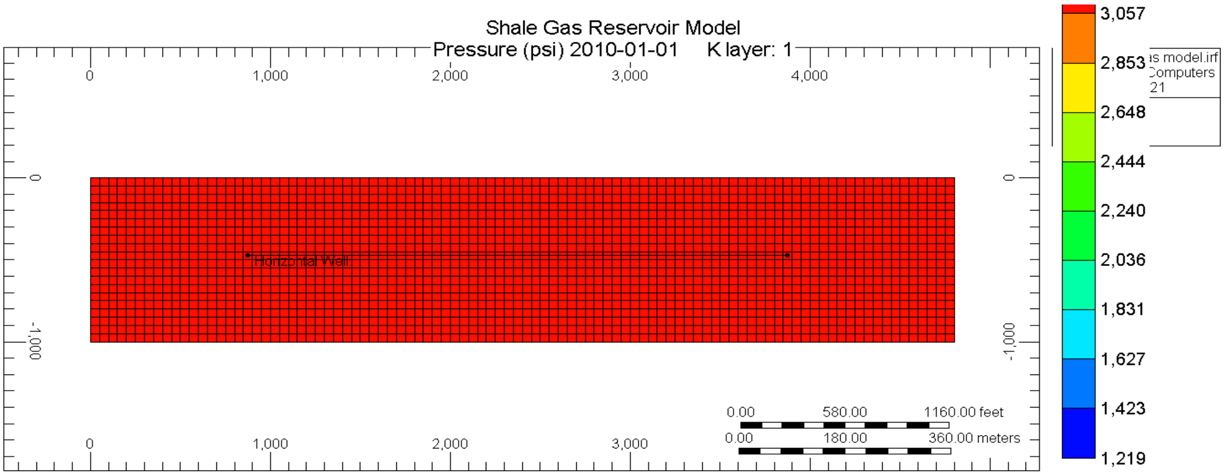

Figure 5: Reservoir Pressure in Horizontal Well at initial time t = 0 years

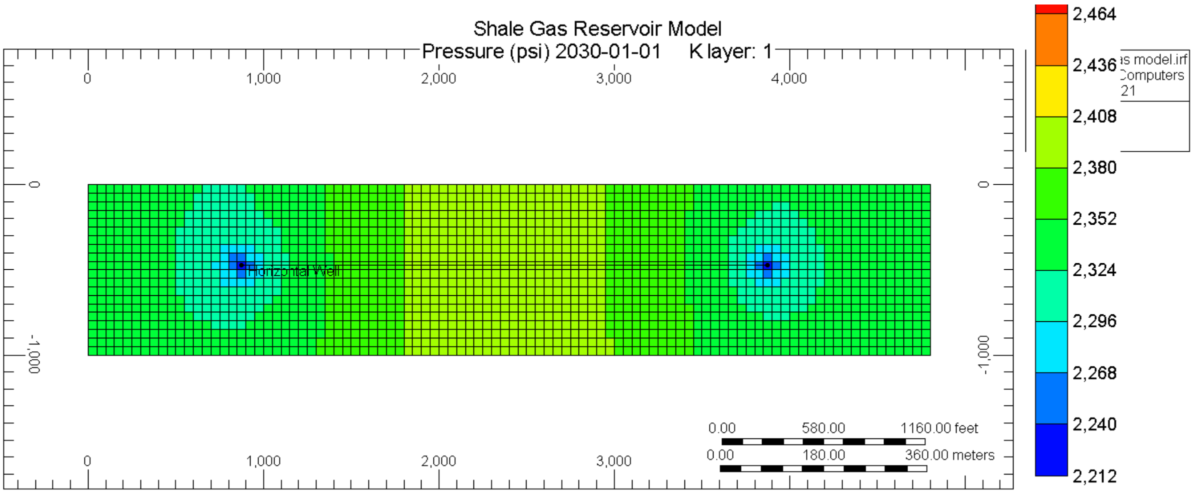

Figure 6: Reservoir Pressure in Horizontal Well after the completion of time t = 20years

(2) Multistaged Planar Hydraulic Fracturing Horizontal Well

In this simulation study, horizontal length of well is equal to 4800ft that is furthermore hydraulically fractured with 10 number of fractures (Figure 7). Figure 8 illustrate the pressure response with respect to gas recovery factor of this study after the completion of 20 years of production.

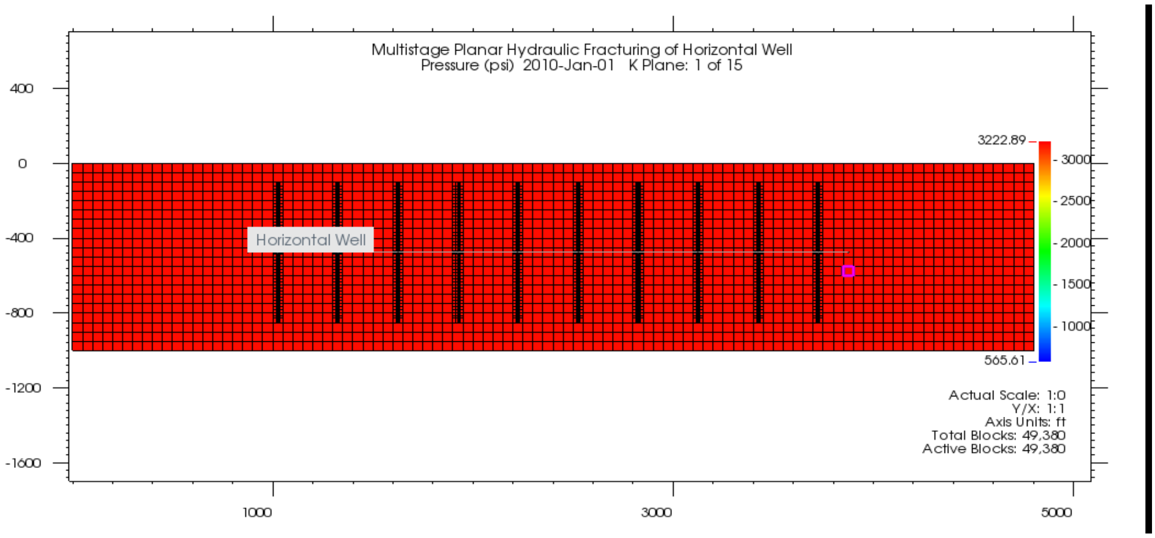

Figure 7: Reservoir Pressure in Multistage Planar hydraulic fractured of Horizontal Well at initial time at t = 0 years

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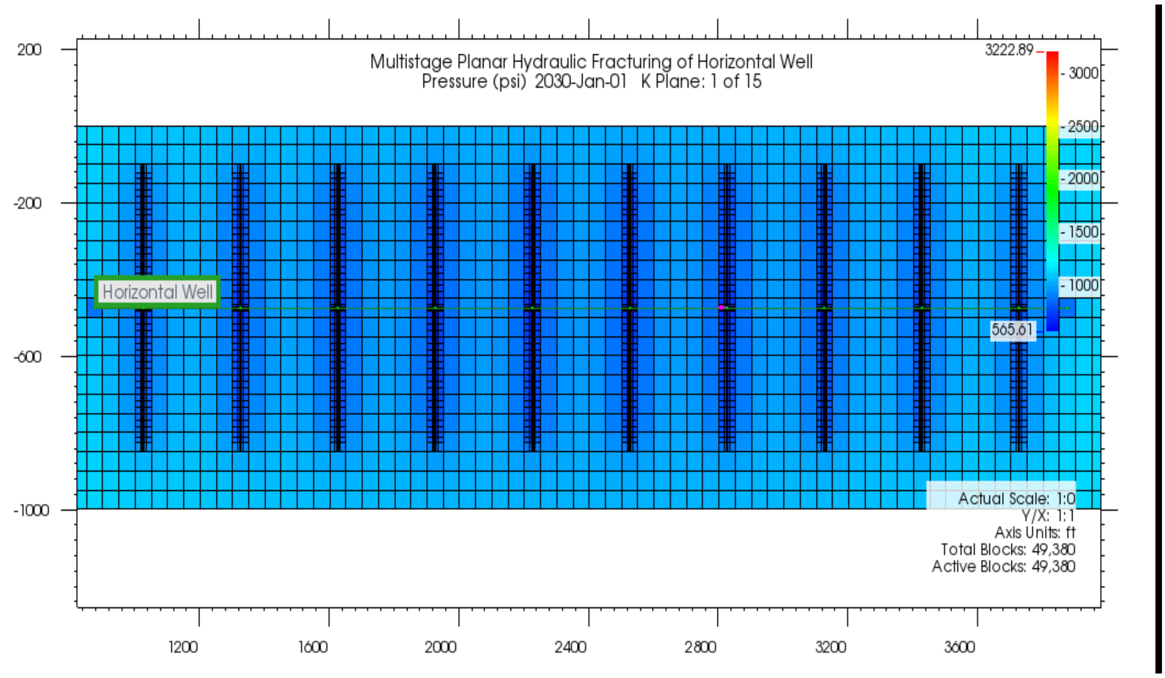

Figure 8: Reservoir Pressure in Multistage Planar Hydraulic Fractured Horizontal Well after the completion of time t = 20 years.

❖ **Discussion on Well's Scenarios**

After comparing the overall production responses of shale gas reservoir of horizontal well, multistaged planar fracturing of shale gas reservoir of horizontal well compare the results of Gas recovery factor SCTR with respect to shale gas reservoir of horizontal well. Consequently, the result of gas recovery factor SCTR for shale gas reservoir of horizontal well after the 20 years is 3.74%, the result of gas recovery factor SCTR of Planar hydraulic fracturing for shale gas reservoir of horizontal well after the 20 years of simulation study is 34.8344% in figure 10. consequently it is proved that the result of Gas recovery factor SCTR of multistaged planar fracturing for shale gas reservoir of horizontal well is higher than the results of gas recovery factor of shale gas reservoir of horizontal well. Moreover, multistaged hydraulic fracturing is best completion strategy for shale gas reservoir of horizontal well however some values may vary depending on the nature of reservoir type.

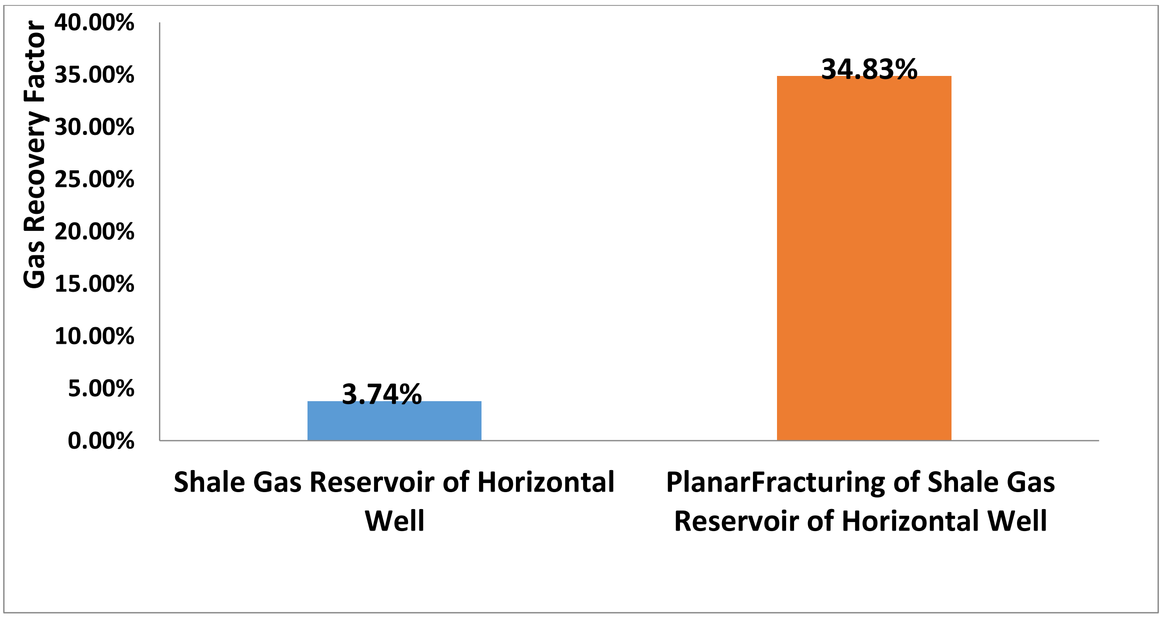

Figure 9: Comparison of Gas Recovery Factor SCTR with respect to Column

(3) Sensitivity Impact of variation of different plane of Reservoir for Planar Fracturing of Horizontal Well

In order to analyze the impact on different plane of shale gas reservoir with planar fracturing of horizontal well, Sensitivity analysis is carried out on different plane of reservoir including 1st Plane, 5th plane, 7th plane, 9th plane, 13th plane and on 15th plane of reservoir. In order to understand recovery factor and recovery factor versus different plane of reservoirs results are plotted in Figure 10 and Figure 11 respectively.

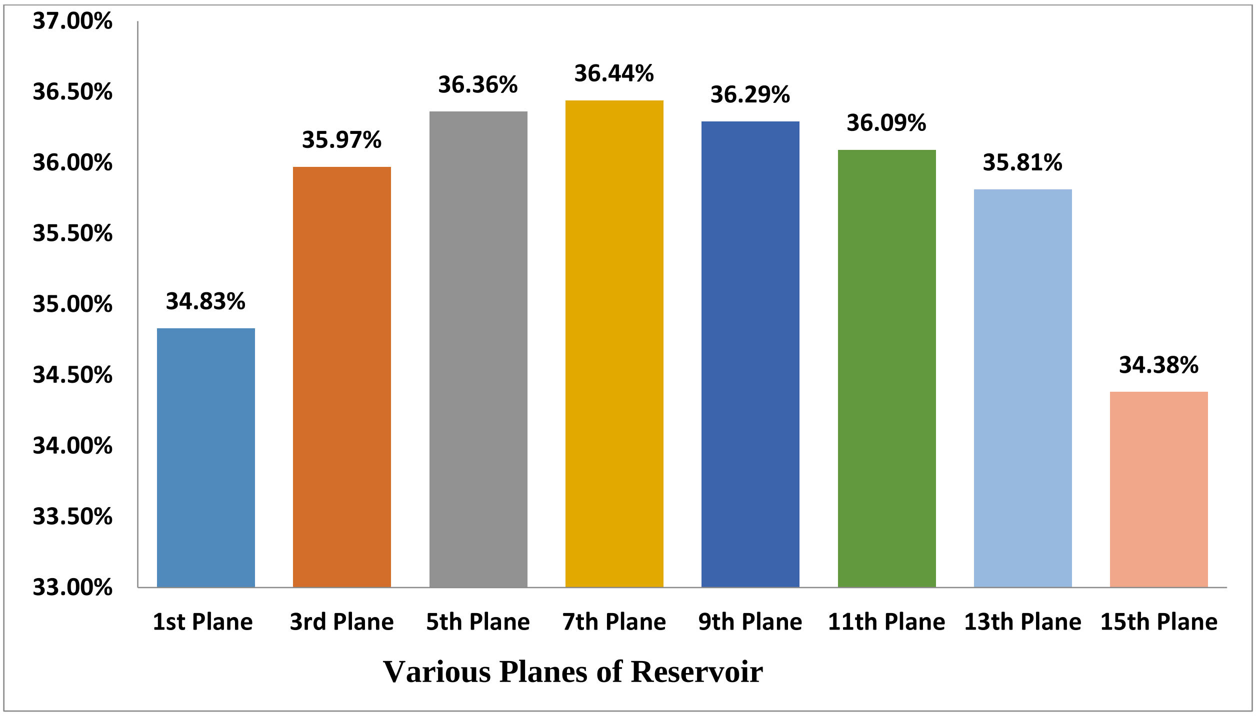

Figure 10: Recovery Factor Sensitivity on Various Planes of Reservoir

Furthermore, Figure 4.31 shows that the gas recovery factor is fluctuated with the various planes of shale gas reservoir of planar fracturing of horizontal well.

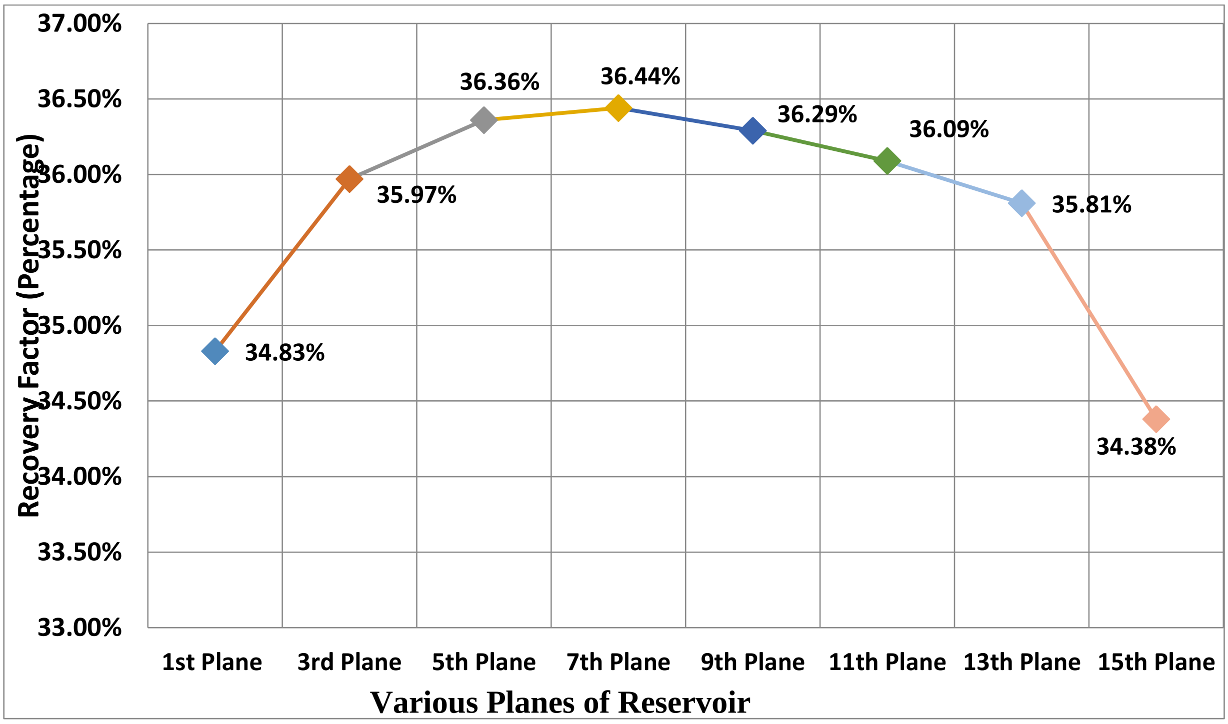

Figure 11: Recovery Factor Sensitivity on Various Planes of Reservoir

It can be seen from recovery factor of gas SC that the recovery of gas is increases from 1st plane of reservoir to 7th plane of reservoir because depth of reservoir is increased from 1st plane of reservoir to 7th plane of reservoir and maximum portion of well is filled with gas from 1st to 7th layer due to presence of maximum amount of gas hence the recovery of gas is increased from 1st to 7th plane of shale gas reservoir whereas recovery of gas on 9th plane, 11th plane, 13th plane and 15th plane becomes less than previous planes of reservoir because well is filled with gas along with water that's why the recovery of gas is lesser than 1st up to the 7th Plane of shale gas reservoir of planar fracturing of horizontal well.

(4) FRACTURING PARAMETERS

For analyzing the impact of production by changing fracturing parameter for the multistage planar fracturing of shale gas reservoir of horizontal well however it is taken as it is providing higher recoveries in the candidate reservoir for planar fracturing. Consequently, Sensitivity analysis is individually applied on both multistage planar fracturing of horizontal well. Moreover, the base multistage planar fracturing of shale gas reservoir of horizontal well has the following set of data.

Table 2 (a): Base Model value for Sensitivity analysis

Parameters	Ranges
Various Plane of Reservoir	1st Plane to 15 Plane
Fracture Spacing	200ft
Fracture Conductivity	35md-ft
Fracture width	0.001ft
Fracture Half Length	350ft
Number of Fractures	10

In addition to overall ten fractures are asymmetrical and having same set of fracturing parameters of planar fracturing of shale gas reservoir of horizontal well. The reservoir parameters are kept same as described in Table 1 .Consequently, the affect of fracturing parameters is investigated one by one by changing the single parameter value while keeping the other data will be same. The ranges of fracturing parameters are as follows;

Table 3 (b): List of Fracturing Parameters and their ranges for sensitivity analysis

Parameters	Ranges
Various Plane of Reservoir	1st Plane to 15 Plane
Fracture Spacing	50 – 600 ft
Fracture Conductivity	5 – 1700 md-ft
Fracture width	0.001 – 0.1ft
Number of Fractures	10
Fracture Half Length	100 – 600ft

4.1 Fracture Spacing

Fracture Spacing has a sufficiently great affect in extremely low-permeability reservoir production. By reducing the value of fracture spacing; large number of fractures can be accommodated in a horizontal well length which can ultimately enhance the shale gas reservoir production. Furthermore, the sensitivity analysis is carried out on value from 50ft to 600ft.

However, the recovery factor is increased by decreasing the value of fracture spacing and if we increased the value of fracture spacing then the recovery of gas becomes less. Moreover, the pressure depletion profile is plotted in (figure 12 and 13). In addition to show that there is high depletion pressure when going from high value of fracture spacing to low value of fracture spacing. Consequently, the maximum reservoir pressure is depleted on fracture spacing 50fthowever the gas recovery factor is higher. Furthermore, a proper design of multistage plannar hydraulic fractures requires some optimal value of fracture spacing.

Figure 4.31: Sensitivity of Gas Rate SC on Fracture Spacing

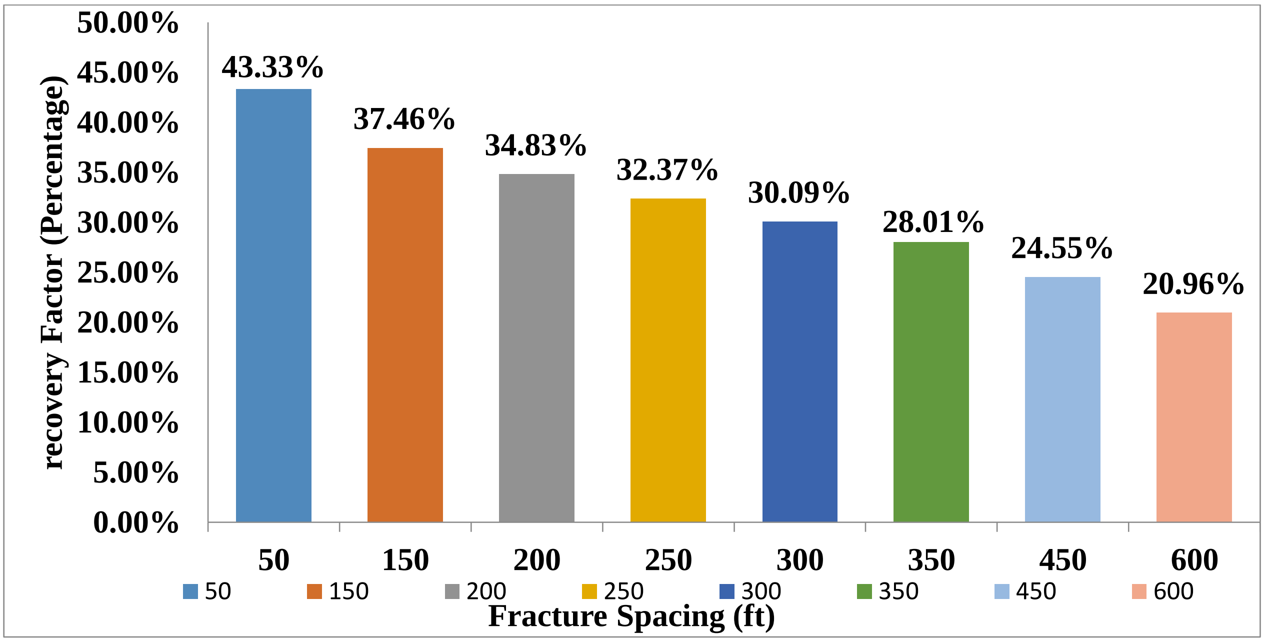

Figure 12: Sensitivity Analysis of Recovery Factor on Fracture Spacing

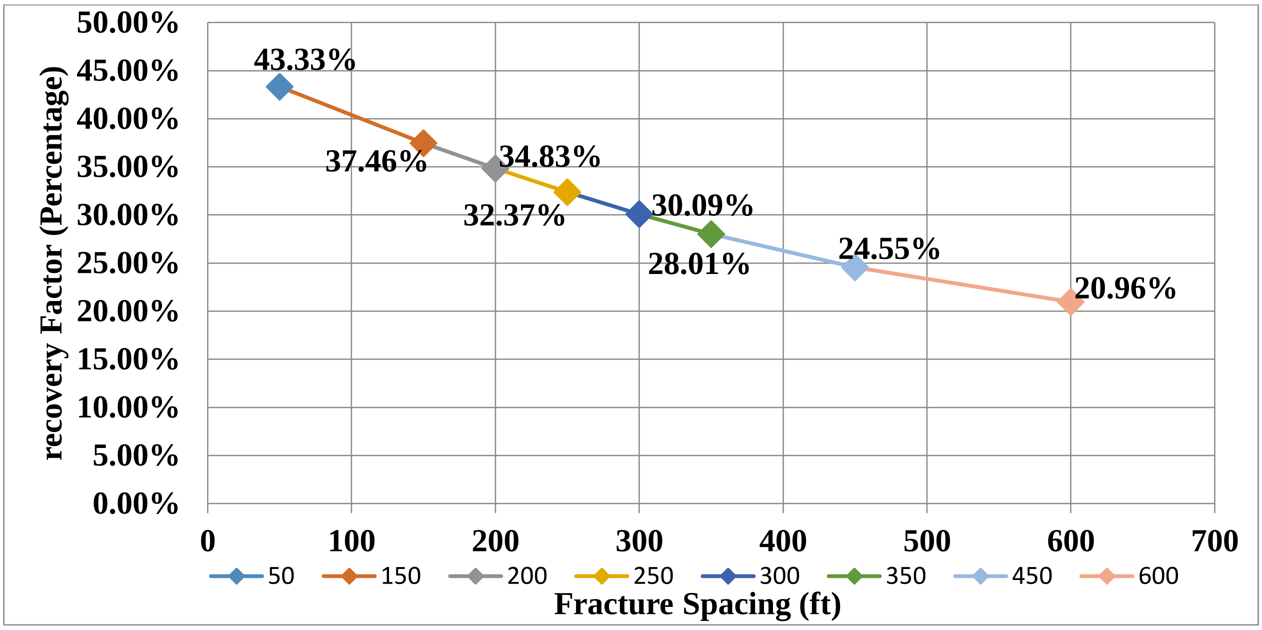

Figure 13: Fracture Spacing versus Recovery Factor

The figure 13 shows more enhancement of production or particularly recovery factor of gas when the value of fracture spacing is changed from 600ft to 50ft than it is proved that by reducing the value of fracture spacing increases the amount the gas recovery factor. When the value of fracture spacing is 600ft than the gas recovery factor is increased 20.96%, value of fracture spacing is 450ft than the gas recovery factor is increased 24.55% so it's proved graduallyreducing the value of fracture spacing increased the gas recovery factor. This suggests that maximum gas recovery factor value lies on 50ft of fracture spacing which is technically and economically feasible.

4.2 Fracture Conductivity

Fracture conductivity is the product of fracture width with fracture permeability. In order to understand the impact of fracture conductivity, the sensitivity analysis is carried out by taking values of 5md-ft, 35md-ft, 100md-ft, 400md-ft, 700md-ft, 1000md-ft, 1300md-ft and 1700md-ft. Consequently the result shows that by varying value of fracture conductivity does increase the gas drainage and flow along specified value of fracture half length but the recovery of gas is not linear. Furthermore, the recovery of gas is increased by increasing the value of fracture conductivity hence gas recovery factor with respect to reservoir average pressure are plotted in Figure 14 and Figure 15.

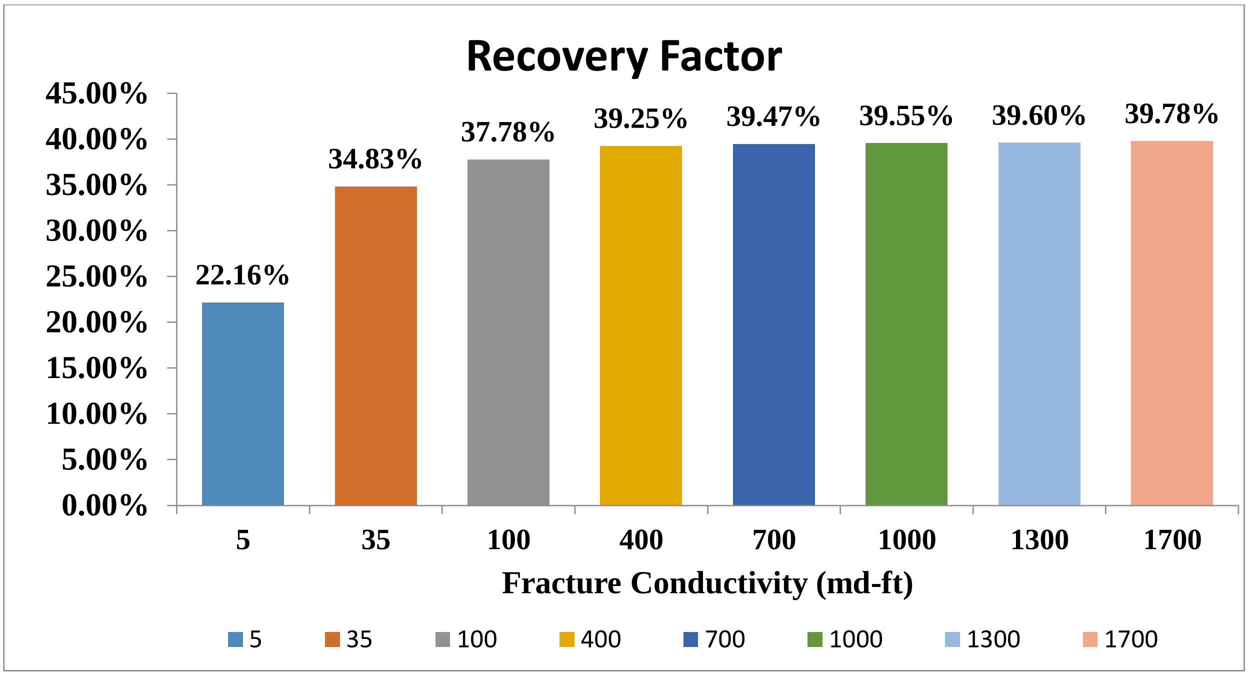

Figure 14: Sensitivity of Recovery Factor on Fracture Conductivity.

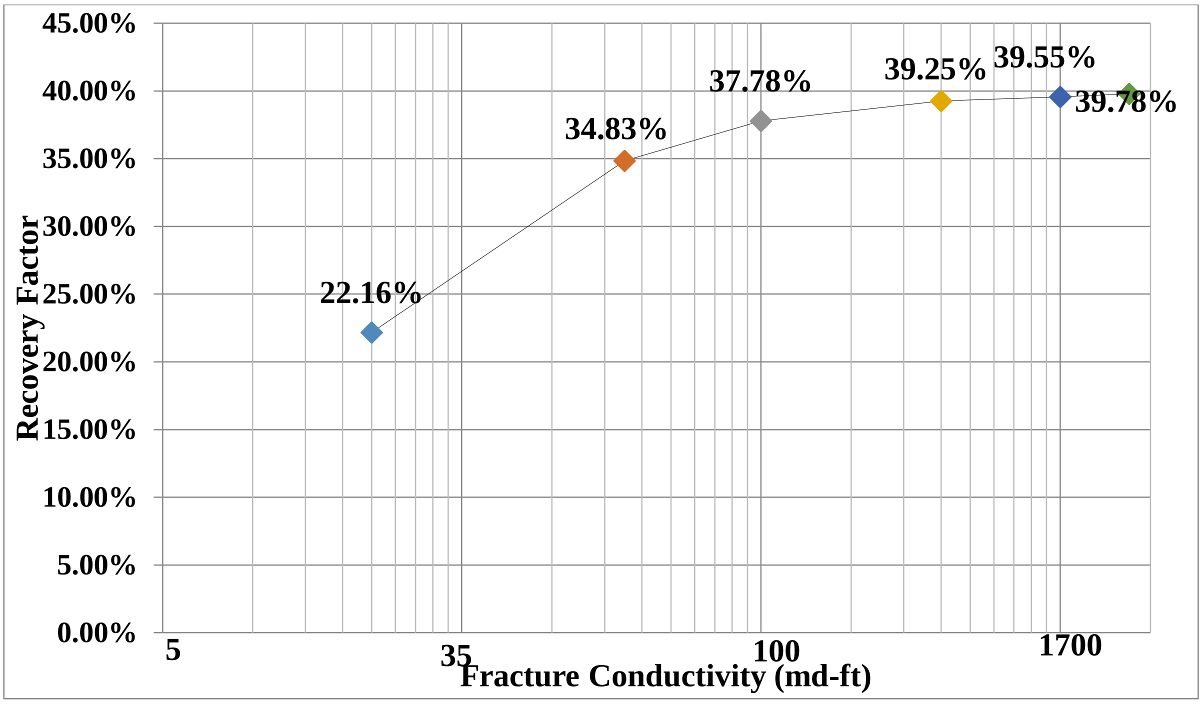

Figure 15: Fracture Conductivity with respect to Recovery Factor

The variation of recovery rate can be investigated clearly in recovery factor versus fracture conductivity plot (Figure 15). Here also, the recovery rate is higher when conductivities are varied from 5md-ft to 100md-ft. After the recovery rate from 100md-ft than the growth rate are not increasing highly but certain amount of recovery rate is often increased and often to plot a linear line that is started from 400md-ft to 1700md-ft consequently, the ideal value of fracture conductivity in this case lie among the fracture conductivity from 5md-ft to 100md-ft which can be extended up to 400md-ft. After the 400md-ft fracture conductivity the growth rates are increased within limited recovery including the recovery rate of 700md-ft fracture conductivity resulting the recovery rate is 39.47%, the recovery rate of 1000md-ft fracture conductivity resulting the recovery rate is

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39.55%, the recovery rate of 1300md-ft fracture conductivity resulting the recovery rate is 39.60 and final the recovery rate of 1700md-ft fracture conductivity resulting the recovery rate is 39.78%.

4.4 Fracture Width

The affect of fracture width is observed by varying fracture width value in the shale gas reservoir model. The values were ranged from 0.001ft to 0.1ft of fracture width. Sensitivity of Cumulative Gas SC on Fracture Width is illustrated in figure16 Furthermore, the recovery factor and the recovery factor with respect to fracture are plotted in figure 17 and figure 18.Consequently, overall results that are obtained from the conclusion that no evidently effect on recovery that is identified by varying the value of fracture width alone. Moreover, production of reservoir can be changed by changing the values of fracture width and fracture permeability consequently it is observed that fracture width is directly proportional to fracture permeability that's why by increasing fracture width the results the fracture permeability is increased. However, fracture conductivity is equal to the product of fracture width and fracture permeability consequently by increasing both values of fracture width and fracture permeability automatically fracture conductivity is increased that function is automatically saved in CMG reservoir simulation software.

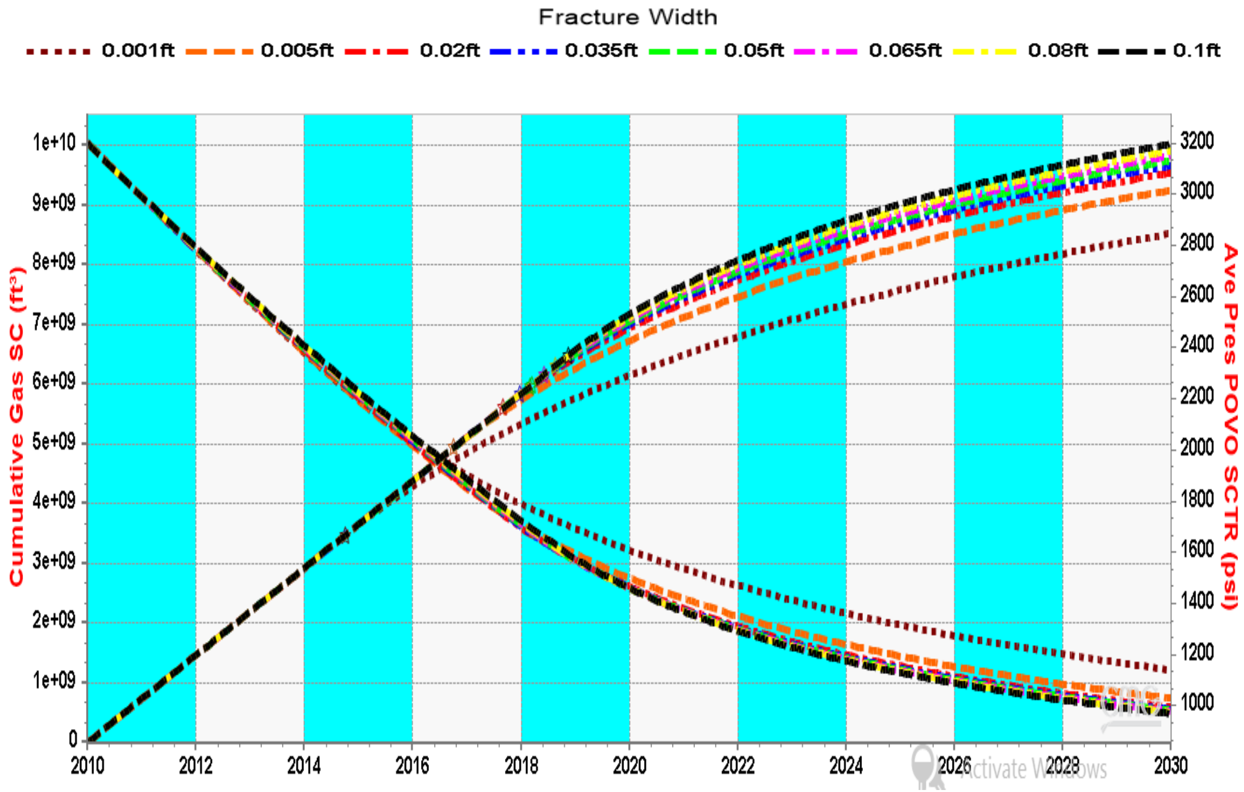

Figure 16: Sensitivity of Cumulative Gas SC on Fracture Width

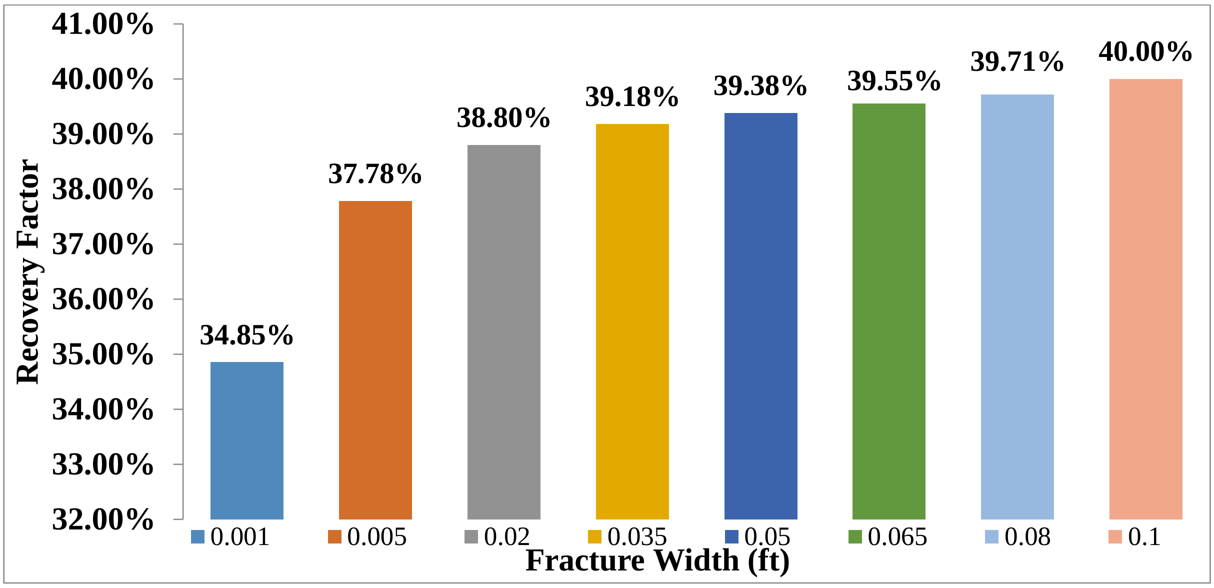

Figure 17: Sensitivity of Recovery Factor on Fracture Width

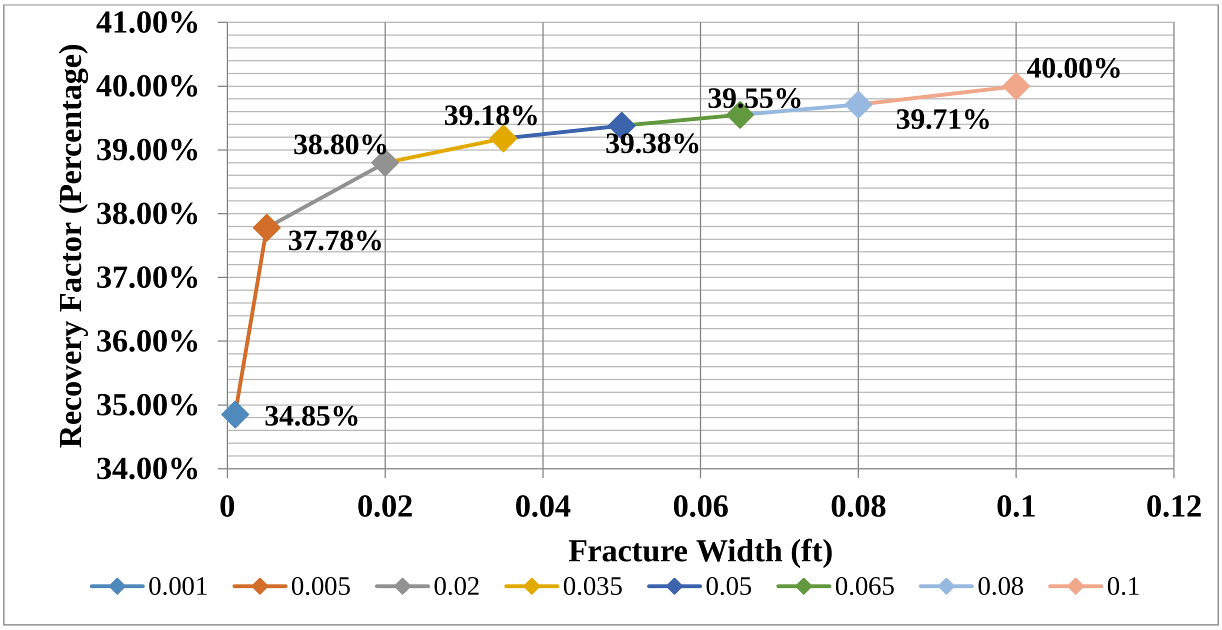

Figure 18: Fracture Width with respect to Recovery Factor

The variation of recovery rate can be investigated clearly in recovery factor versus fracture width plot (Figure 18). Here also, the recovery rate is higher when fracture widths are varied from 0.001ft to 0.1ft. After the recovery rate from 0.001ft than the growth rate of fracture width is increased from recovery factor of 34.85% to 37.78% and often to plot a line that is increased however it is started from 0.035ft to 0.1ft consequently, the maximum recovery of reservoir in this case lie among the fracture width from 0.8ft to 0.1ft. Final the recovery rate of 0.1ft for fracture width resulting the recovery rate is being increased 40%.

4.5 Fracture Stages

Indeed numbers of fractures are essential to be observed in any reservoir simulation study especially in those cases in which having extremely permeability reservoirs. In this reservoir simulation study productivity performance of shale gas reservoir is measured by altering the number of fractures from the value of 1 to 15. The effect of changing the fracture stage on production is illustrated from the figure 19.

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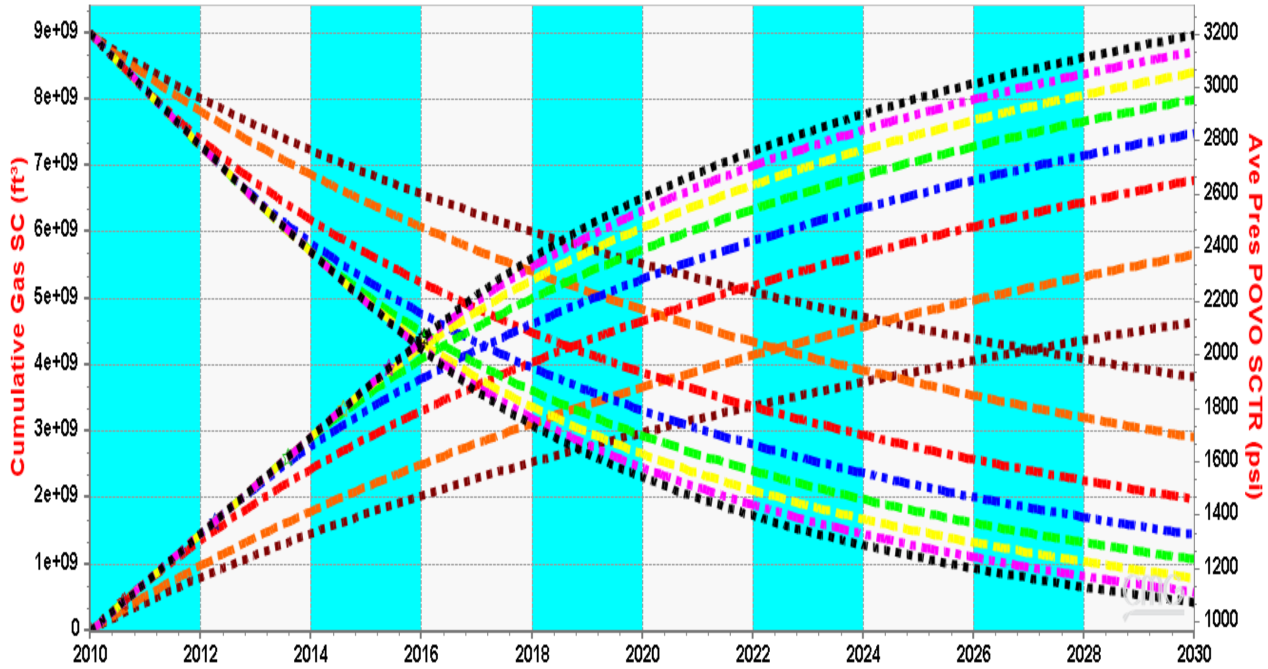

Figure 19: Sensitivity of Cumulative Gas SC on Fracture Stages

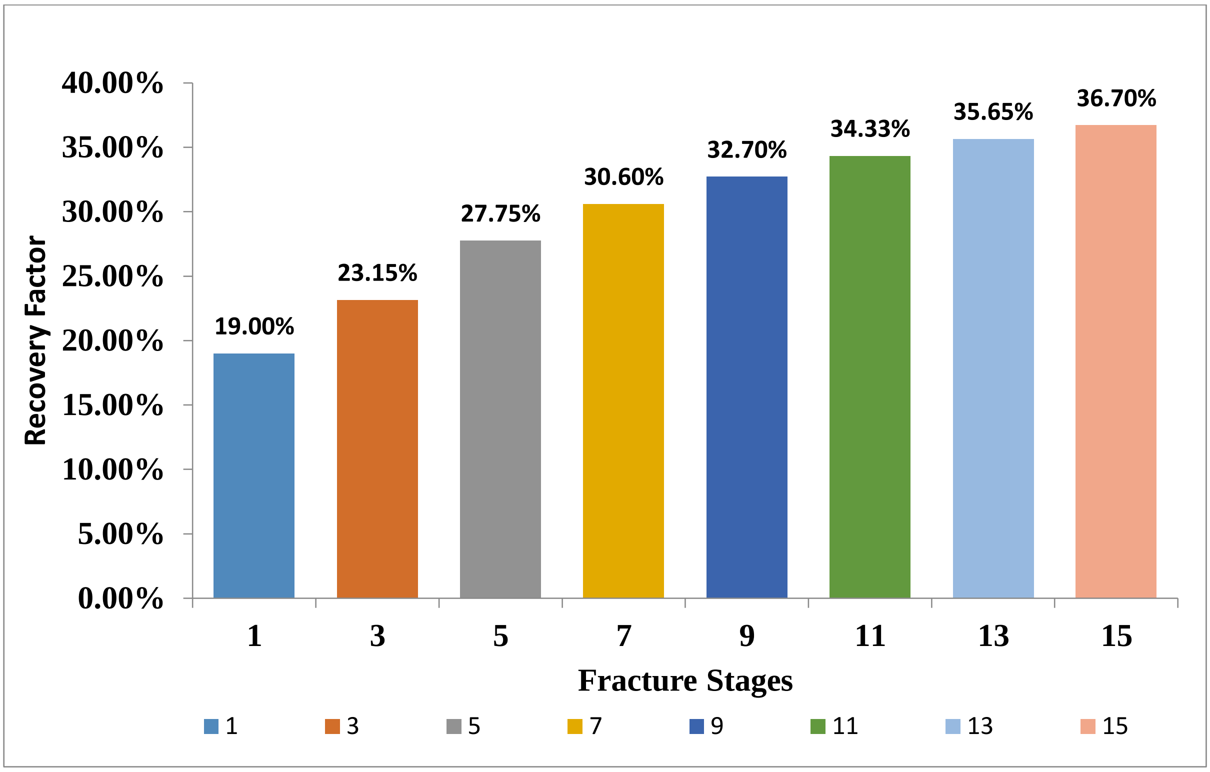

Figure 20: Sensitivity of Recovery Factor on Fracture Stages

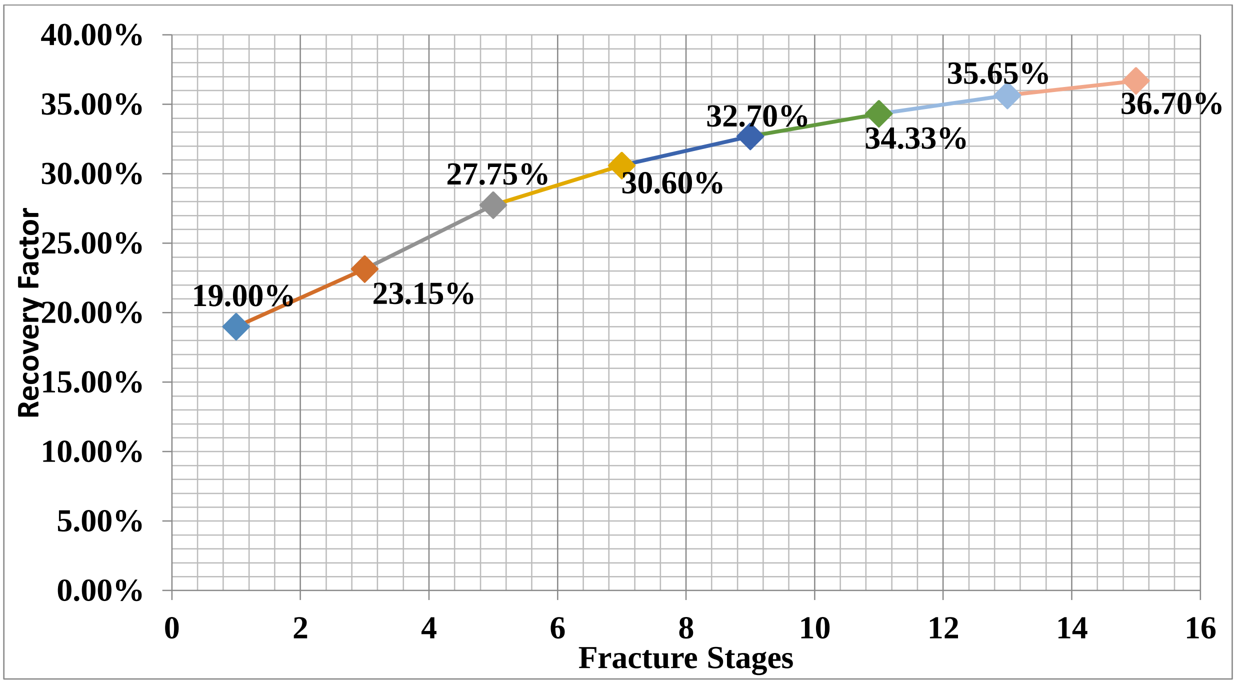

Figure 21: Fracture Stages with respect to Recovery Factor

The variation of recovery rate can be investigated clearly in recovery factor versus fracture stages plot (Figure 21). Here also, the recovery rate is higher when fracture stages are varied from 1 to 15. After the recovery rate from 1 fracture stages than the growth rate of fracture width is increased from recovery factor of 19% to 23.15% and often to plot a line that is gradually increased however it is started from 3 to 15 fracture stages consequently, the maximum recovery of reservoir in this case lie among the fracture stages from 13 to 15. It is also seen that recovery rate is increased from 11 to 15 fracture stages but the recovery rates are not high. Moreover, the recovery rate of 13 fracture stages resulting the recovery rate is increased 35.65%, final the maximum recovery rate of 15 fracture stages resulting the recovery rate is being increased up to 36.70%.

4.5 Fracture Half Length

The affect of fracture half length is observed by varying the values of fracture half length that are taken from 100ft, 200ft, 400ft, 500ft, 550ft and 600ft. As per the study literature, it is identified that the fracture half length is directly proportional to the cumulative production of gas, recovery of shale gas. It means as the value of fracture half length is increases then the production of cumulative gas and gas recovery is increased however the average reservoir pressure is inversely proportional to the recovery of gas. Furthermore, the area of fracture is propagated according to the values of fracture length if the value of fracture length is varies from lower to higher for example 100ft and 600ft then the production of cumulative gas will be much higher in 600ft. Reservoir pressure at fracture half length value 100ft & 600ft are shown in figure 22 & figure 23. Furthermore, the recovery factor and the recovery factor with respect to fracture are plotted in figure 24 and figure 25.

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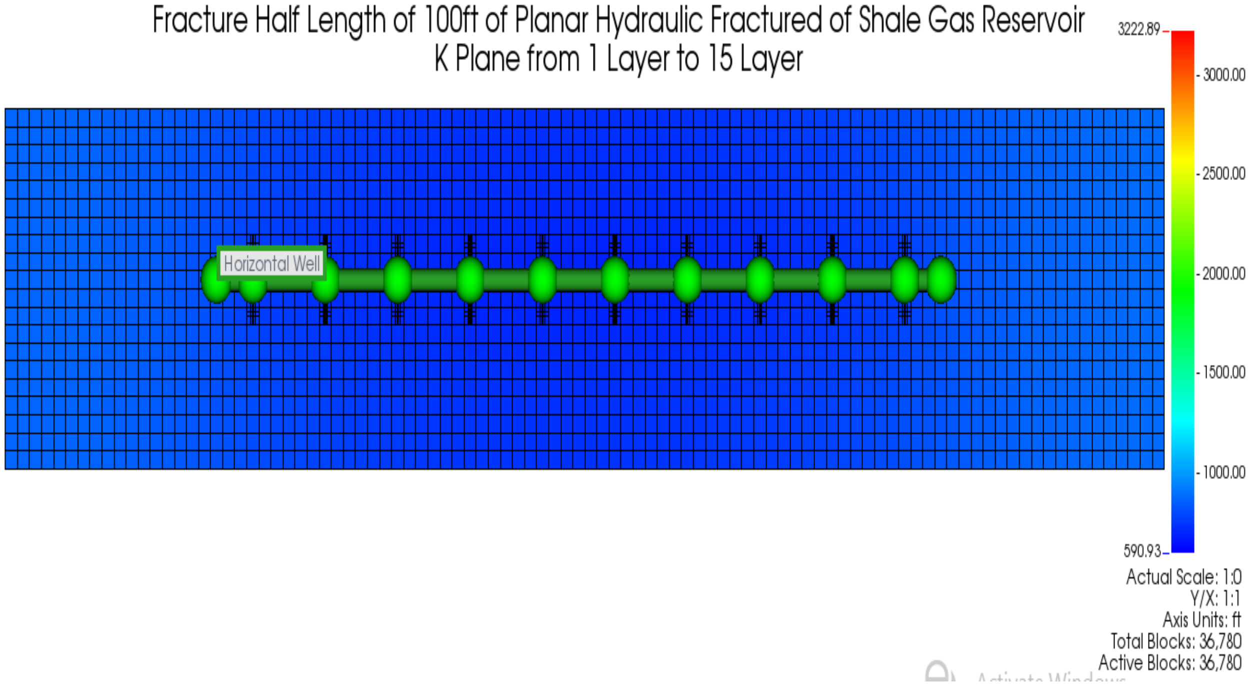

Figure 22: Reservoir Pressure at Fracture Half Length value of 100ft

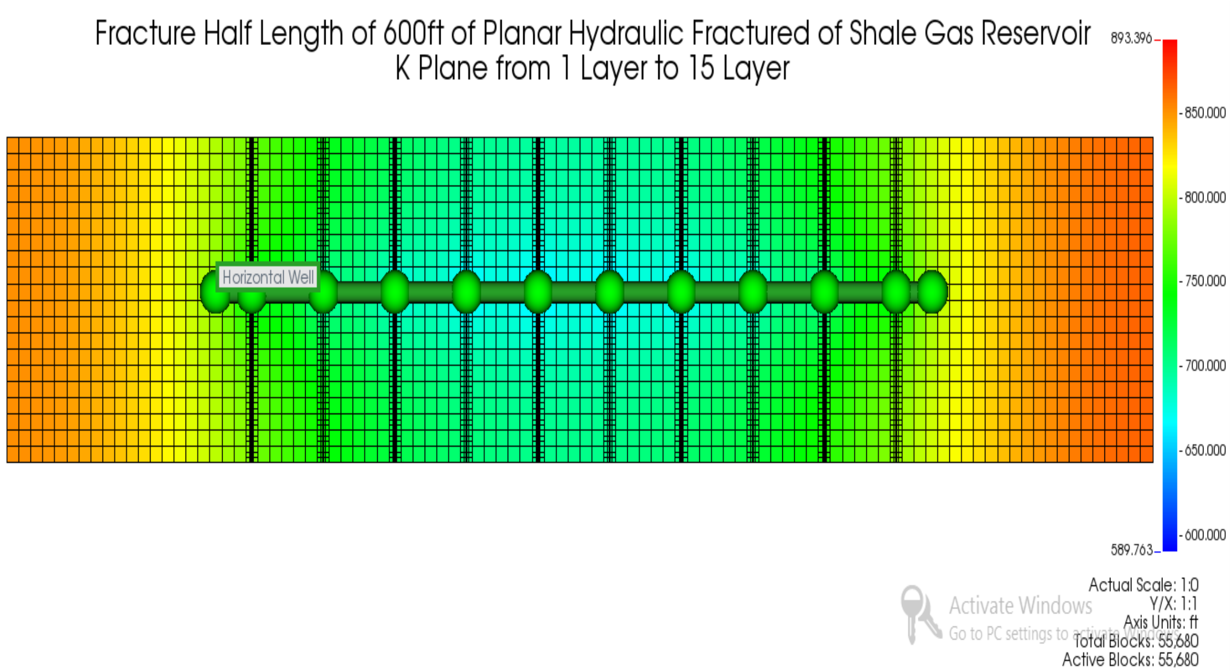

Figure 23: Reservoir Pressure at Fracture Half Length value of 600ft.

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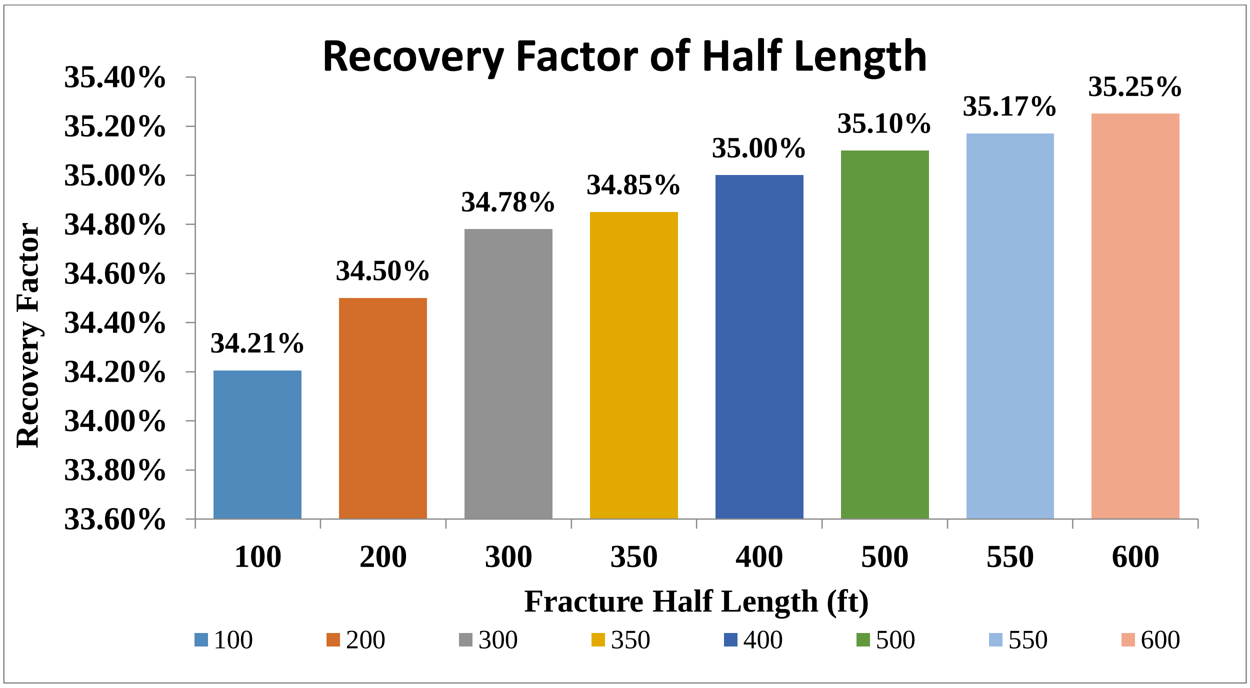

Figure 24: Sensitivity of Recovery Factor on Fracture Half Length

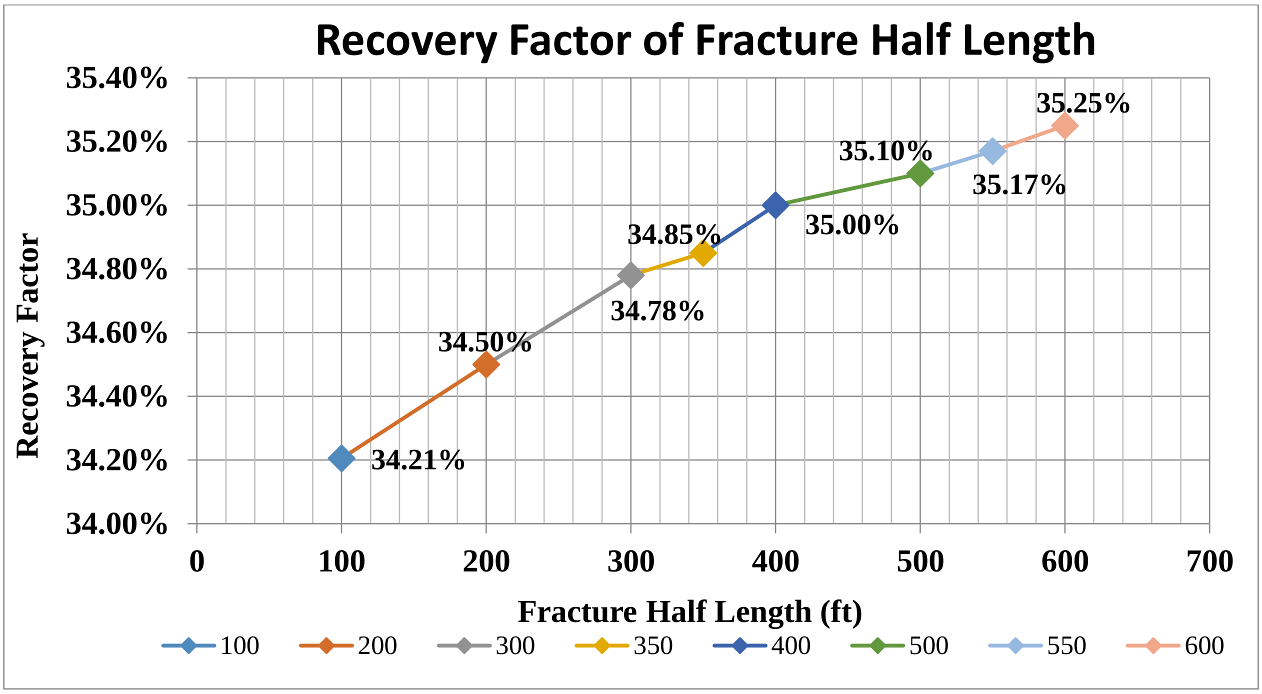

Figure 25: Fracture Half Length with respect to Recovery Factor

The variation of recovery rate can be investigated clearly in recovery factor versus fracture half length that is plotted in (Figure 25). Here also, the recovery rate is higher when fracture half lengths are varied from 100ft to 600ft. After the recovery rate from 100ft fracture half length than the growth rate of fracture width is increased from recovery factor of 34.21% to 34.50% final the maximum recovery rate of 600ft of fracture half length resulting the recovery rate is being increased up to 35.25%.

4.6 Effect of variation of Fracture Half Length & Fracture width of Planar Hydraulic Fracture of Shale gas reservoir

Subsequently the succeed planar hydraulic fractured model of shale gas reservoir was based on their planar geometry in which the fracture width as well as fracture height and the fracture half length was concluded to be the constant over the whole propagation area. In case of more practical fracture, the fracture width keeps on

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varying as fracture half length increases. Consequently for understanding the impact of more authentic fracture in the formation hence another planar fracture model technique has been supposed to the model fracture in the reservoir furthermore fracture width keeps on varying as the fracture half.

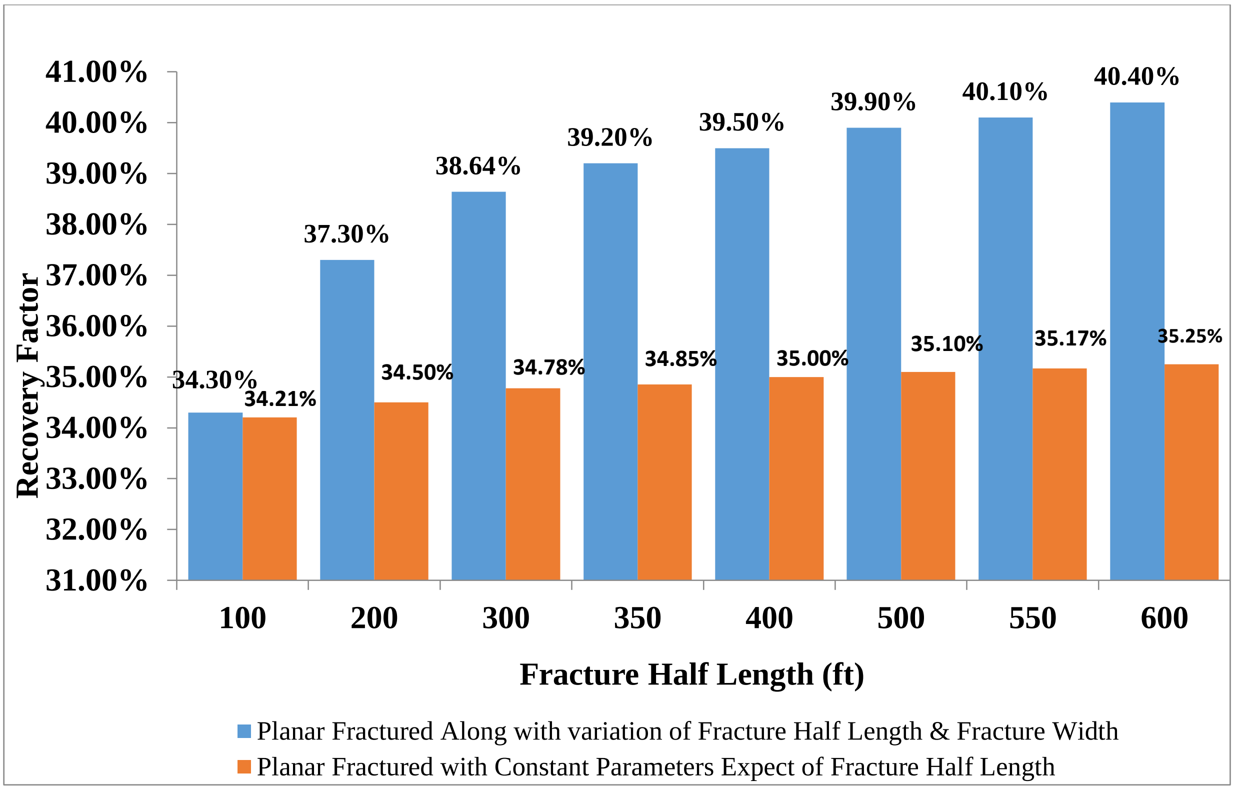

Figure 26: Comparsion of Recovery Factor of Planar Fractured with variation of Half Length & Fracture Width and Planar Fractured with constant fracturing parameters expect of fracture Half Length

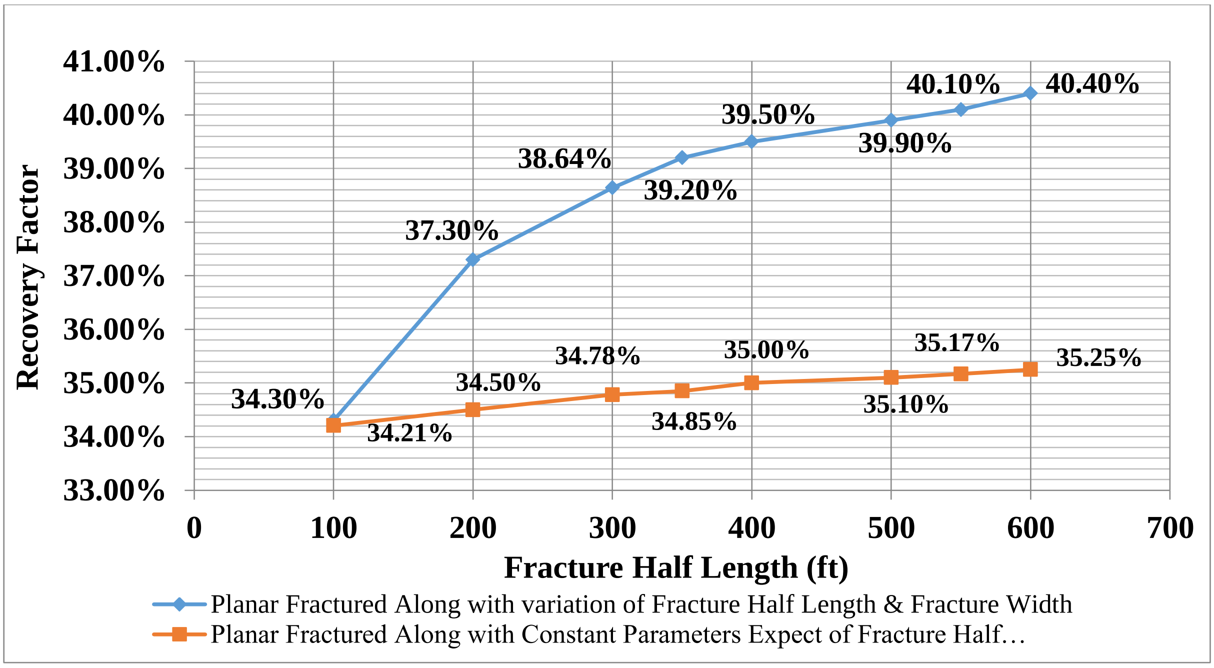

Figure 27: Comparison of Recovery Factor With Respect to Planar Fractured with variation of Half Length Along with variation of Fracture Width & Planar Fractured with constant fracturing parameters expect of fracture Half Length

Figure 26 illustrate standard enhancement in recovery of both planar fractured with variation of half length along with variation of fracture width & planar fractured with constant fracturing parameters expect of fracture half length. Figure 27 illustrate the recovery factor in the percentage for the both value of planar fractured with variation of fracture half length along with variation of fracture width & planar fractured with constant fracturing parameters expect of fracture half length. It is certain conspicuous from the above generated curves that result of simulation study of fracture through planar geometry with variation of fracture half length along with variation of fracture width having maximum production than the planar geometry with constant fracturing parameters expect of fracture half length. This is due to the value of fracture half length increases as well as continuously the recovery increases with the increases of half-length however the fracturing parameters remains constant as we have used in previous simulation study. Furthermore the value of fracture half-length increases along with the enhancement of fracture width hence continuously the recovery increases with the increases of half-length along with the increases of fracture width. The variability in recovery ranges from approximately 1 to 5.20% in the productivity between planar fractured with variation of fracture half-length along with variation of fracture width & planar fractured with constant fracturing parameters expect of fracture half length.

V. CONCLUSION

The research can be summarized into the following key points.

(1) Cartesian grid of dual permeability model for shale gas reservoir can highly efficient with highly advantage of developing planar hydraulic fracture

(2) The reservoir production is compared on horizontal well and horizontal well with hydraulic fractures. Consequently the recoveries rate that are simulated from horizontal well is 3.74 percent, horizontal well with planar hydraulic fractures is 34.83 percent and horizontal well. Furthermore it is concluded that multistage hydraulic fracture of horizontal well has the highest recovery capability among the horizontal well

(3) On the bases of sensitivity analysis, sensitivity analysis is carried on individually on fracture spacing for planar hydraulic fracturing on horizontal well. Recovery of shale gas with planar fracturing is increased by decreasing the value of fracture spacing. Furthermore fracture spacing is varied from the range of 600ft, 450ft, 350ft, 300ft, 250ft, 200ft, 150ft and 50ft. Maximum recovery of shale gas for hydraulic fracturing is calculated on fracture spacing of 50ft is 43.33 percent.

(4) On the bases of sensitivity analysis, sensitivity analysis is carried on individually on fracture width for planar hydraulic fracturing on horizontal well. Recovery of shale gas with planar fracturing and is increased by increasing the value of fracture width. Furthermore fracture width is varied from the range of 0.001ft, 0.005ft, 0.02ft, 0.035ft, 0.05ft, 0.065ft, 0.08ft and 0.1ft. Maximum recovery of shale gas for hydraulic fracturing is calculated on fracture width of 0.1ft is increased up to 40.00 percent.

(5) On the bases of sensitivity analysis, sensitivity analysis is carried on individually on fracture conductivity for planar hydraulic fracturing on horizontal well. Recovery of shale gas with planar fracturing is increased by increasing the value of fracture conductivity. Furthermore fracture conductivity is varied from the range of 5md-ft, 35md-ft, 100md-ft, 400md-ft, 700md-ft, 1000md-ft, 1300md-ft and 1700md-ft. Maximum recovery of shale gas for hydraulic fracturing on fracture conductivity at the value of 1700md-ft is increased up to 39.63 percent.

(6) On the bases of sensitivity analysis, sensitivity analysis is carried on individually on fracture stages for planar hydraulic fracturing on horizontal well. Recovery of shale gas with planar fracturing is increased by increasing the number of fracture stages. Furthermore sensitivity analysis is carried out on various fracture stages from 1 to 15. Maximum recovery of shale gas on fracture stages at which 15 fracture stages is created in reservoir therefore recovery factor is increased up to 37.70 percent.

(7) On the bases of sensitivity analysis, sensitivity analysis is carried on individually on various planes of reservoir for planar hydraulic fracturing on horizontal well. Recovery of shale gas with planar fracturing is increased from 1st plane of reservoir up to 7th plane of reservoir. Furthermore sensitivity cases is applied on 1st plane, 3rd plane, 5th plane, 7th plane, 9th plane, 11th plane, 13th plane and on 15th plane of reservoir. Maximum recovery of shale gas for planar fracturing on 7th plane of reservoir is increased up to 36.44 percent.

(8) On the bases of sensitivity analysis, sensitivity analysis is carried on individually on fracture half length for planar hydraulic fracturing of shale gas on horizontal well. The recovery of shale gas with planar fracturing is increased by increasing the value of Half-length fracture. Furthermore Half-length fracture is varied from the

range of 100ft, 200ft, 300ft, 350ft, 400ft, 500ft, 550ft and 600ft. Maximum recovery of shale gas on fracture half length at the value of 600ft is increased up to 35.12 percent.

(9) On the bases of sensitivity analysis, sensitivity analysis is carried on individually on variation of fracture half length along with fracture width for planar hydraulic fracturing of shale gas of horizontal well. The recovery of shale gas with planar fracturing is increased by increasing the value of fracture half length along with increasing of fracture width. Maximum recovery of shale gas for planar fracturing on fracture half length at the value of 600ft along with value of fracture width 0.1ft is increased up to 40.83 percent.

VI. REFERENCES

[1] Energy Information Administration (EIA). Shale Gas Production Drives World Natural Gas Production Growth.2016.Available online: http://www.eia.gov/todayinenergy/detail.cfm?id527512 (accessed on 20 December 2017).

[2] Energy Information Administration (EIA). Annual Energy Outlook. 2017. Available online: https://www.eia.gov/outlooks/aeo/pdf/0383(2017).pdf (accessed on 10 December 2017).

[3] Martin, J.P., Hill, D.G., Lombardi, T.E., and Nyahay, R., 2010. A Primer on New York's Gas Shales.http://offices.colgate.edu/bselleck/AppBasin/GasshaleMartin.pdf.

[4] Zhang, S.C., Mou, S.R.,Cui, Y., 2011. Numerical Simulation Models with Hydraulic Fracturing in Shale Gas reservoirs. Natural Gas Ind. 31, 81-84. doi: 10.3787/j.issn.1000-0976.2011.12.014.

[5] Guo B. and Gao D., 2014. The significance of fracture face matrix damage to the productivity of fractured wells in shale gas reservoirs, Petroleum Science andTechnology 32(2), 202–210.

[6] Nijhuis, M. 2006. How Halliburton Technology is Wrecking the Rockies. Onearth Summer Web.12 Jul.

[7] Numerical Simulation of Hydraulic Fracturing Propagation, DEVELOPMENT OF HYDRAULIC FRACTURING SIMULATORS by Belyadi 2017

[8] Cipolla, C.L.; Fitzpatrick, T.;Williams, M.J.; Ganguly, U.K. Seismic-to-simulation for unconventional reservoir development.In Proceedings of the SPE Reservoir Characterisation and Simulation Conference and Exhibition, Abu Dhabi, UAE, 9–11 October 2011. SPE-146876-MS

[9] Cipolla, C.L., Warpinski, N.R., Mayerhofer, M.J., Lolon, E.P., Vincent, M.C., 2008. The Relationship Between Fracture Complexity, Reservoir Properties, and Fracture Treatment Design. Paper SPE 115769 Presented at SPE Annual Technical Conference and Exhibition, Denver, Colorado, USA, September 21-24. http://dx.doi.org/10.2118/115769-PA.

[10] Dalton et al., 2017Dalton, C. A., Broussard, M. B., and W. J. Al-Mudhafar. Proxy-based Optimization of Hydraulic Fracturing Design in Horizontal Wells through CO2 Flooding in Shale Oil Reservoirs. American Rock Mechanics Association, San Francisco,CA (2017).

[11] Lin et al., 2015; Lin, M., Chen, S., Ding, W., Chen, Z. (John), and J. Xu. Effect of Fracture Geometry on Well Production in Hydraulic- Fractured Tight Oil Reservoirs. Journal of Canadian Petroleum Technology. 54(03):183-194 (2015). https://doi.org/10.2118/167761-PA

[12] Nguyen et al. , 2015; Nguyen, N. T. B., Dang, C. T. Q., Chen, Z., and L. X. Nghiem. Optimization of Hydraulic Fracturing Design with Future EOR Considerations in Shale Oil Reservoirs.SPE-174307-MS,EUROPEC,(1-4June),Madrid,Spain(2015). https://doi.org/10.2118/174307-MS

[13] Podhoretz and Valk , 2014; Podhoretz, S. B. and P. P. Valk. Hydraulic-Fracture Design for the Lower Tertiary Gulf of Mexico: Optimization underUncertainty. OTC-25179-MS, O_shore Technology Conference,(5-8May),Houston.TX (2014). https://doi.org/10.4043/25179-MS

[14] Saldungaray and Palisch , 2012; Saldungaray, P. M. and T. T. Palisch. Hydraulic Fracture Optimization in Unconventional Reservoirs. SPE-151128-MS, SPE Middle East Unconventional Gas Conference and Exhibition, (23-25 January), Abu Dhabi, UAE (2012). https://doi.org/10.2118/151128-MS

[15] Suarez et al. , 2015; Suarez, M., Pichon, S., Lacentre, P., Badesasich, M. F. Fracturing-to-production Simulation Approach for Completion Optimization in the Vaca Muerta Shale. SPE-177058-MS, SPE Latin American and Caribbean Engineering Conference, (18-20 November), Quito, Ecuador (2015). https://doi.org/10.2118/177058-MS

[16] Yu and Sepehrnoori , 2013). Yu, W., and K. Sepehrnoori. Optimization of Multiple Hydraulically Fractured Horizontal Wells in Unconventional GasReservoirs. Journal of Petroleum Engineering. Volume 2013 (2013), Article ID 151898, 16 pages. http://dx.doi.org/10.1155/2013/151898