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The Effect of Different Hydraulic Fracturing Width to the Well Production

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Abstract: By applying high pressure to tight formations like shale, a fluid, proppant, and additives create fractures or widen already existing ones to facilitate the flow of hydrocarbons into the well bore and ultimately to the surface facilities. Fracking, as hydraulic fracturing is more popularly known nowadays, is primarily utilized to produce hydrocarbons. The hydraulic fracturing fluid's proppant makes sure that once cracks are formed, they do not immediately seal, allowing hydrocarbon to gradually flow out of the tight formation. The additives are made up of several chemical types, and each one of them improves a particular quality of the fluid needed for the hydraulic fracturing process to be successful. In order to produce the desired amount of gas from unconventional reservoirs like tight gas, shale gas, coal bed methane, or other very low permeability reservoirs, an efficient hydraulic fracturing design is essential. Numerous elements need to be taken into account while developing and carrying out a hydraulic fracturing operation. These variables may also include flow back and shut in period, depth and thickness of reservoir, microcosmic events, the faults and natural fractures, which can play a significant role depending on reservoir properties, rock properties, type of reservoir fluids, etc. These variables are not only limited to pump rate, size and concentration of propping agent, fracture spacing or number of fractures, fracture geometry and conductivity, fracture length, and fracture width. These factors can differ greatly depending on where you are in the world. Without a thorough examination of underground formations holding hydrocarbons, there is no global hydraulic fracturing technique that can be used anywhere in the world.

Keywords: Hydraulic Fracturing, Proppant Agent, Fracture Conductivity, Fracture Length, Fracture Width

1. Introduction

A technique called "well stimulation" is used to increase oil or gas output from the reservoir to the wellbore. It has been crucial in the development of oil and gas wells, ensuring profitable outcomes. The wells have recently been treated using a variety of inventive and imaginative methods. By injecting hydraulic fluid at a pressure greater than the formation pressure, hydraulic fracturing increases oil and gas production by causing a crack in the reservoir well. [3] In the sector, hydraulic fracturing continues to get more attention for well stimulation. However, other case studies also highlight the significance of acidizing. It is crucial to use primary acids such hydrochloric acid as well as additional acids like hydrofluoric acid, formic acid, and acetic acid. The most popular stimulation methods are matrix acidization, fracture acidization, and hydraulic fracturing. [5] Each of these methods for stimulating a well has unique benefits and restrictions. The decision between fracturing and acidizing has frequently come under scrutiny. Actually, the choice of whether to fracture or acidize a well depends on a number of variables, including the geology of the formation, the history of production, and the well-intervention goals. [1] While tight formations with substantially lower porosity and permeability call for highly intensive hydraulic fracturing, loose formations with relatively superior porosity and permeability do not. Before executing hydraulic fracturing, it is crucial to consider the formation permeability. [8] Hydraulic fracturing, however, has a strong propensity to result in formation collapse in loosely connected formations because of the pressure of the overburden. Furthermore, it is not advised to use hydraulic fracturing to stimulate a formation that has been damaged by drilling and production. For such formation, matrix acidizing is more appropriate. [2]

Acid fracturing is frequently used on carbonate rocks, which are abundant in dolomites and limestones. To stop the fracture surface from closing due to overburden stress, the acid is injected into it. In carbonate rocks with lots of natural fissures and high permeability, acid fracturing works well. The penetration depth of matrix acidizing is typically not very great for sandstone formations. [9] Compared to hydraulic fracturing and fracture acidizing, matrix acidizing typically has a penetration depth of just approximately 0.3 m. Because it needs a lengthy deep penetration depth to be adequately stimulated, it is typically not employed for formations with limited permeability. As a result, hydraulic fracturing is more appropriate here. [4]

By applying high pressure to tight formations like shale, a fluid, proppant, and additives create fractures or widen already existing ones to facilitate the flow of hydrocarbons into the well bore and ultimately to the surface facilities. [7]

Fracking, also known as hydraulic fracturing, is a process used primarily to produce hydrocarbons. The hydraulic fracturing fluid contains proppant to make sure that once cracks are generated, they do not immediately shut, allowing the hydrocarbon to flow out of the tight formation over time. The additives are made up of several chemical types, and each one of them improves a particular quality of the fluid needed for the hydraulic fracturing process to be successful. [11] Following are a some of the causes of hydraulic fracturing:

In order to avoid well bore damage that reduces productivity, hydraulic fracturing is performed. Damage to the area close to the wellbore is a result of drilling particles getting into the formation and drilling fluids not working well with the formation of interest chemically. By using matrix treatments or hydraulic fracturing to restore the conductivity between the well bore and the formation, this can be addressed chemically. [10]

To increase productivity, hydraulic fracturing facilitates the development of conductive hydrocarbon channels into the rock. According to Darcy's law, hydraulic fracturing increases the formation's permeability, fracture height, and coverage while boosting or maintaining reservoir pressure to increase well productivity. [6]

The purpose of hydraulic fracturing process optimization is to maximize gas and oil production by increasing the amount of the cracked reservoir rock. The model of fracture propagation in elastic media brought on by viscous fluid injection serves as the foundation for hydraulic fracturing optimization. [12] The surface of the cavity in an infinite elastic medium, the fluid pumping pressure that initiates and propagates the fracture, and the elastic media characteristics are the input parameters for the fracture propagation model. The fracture surface, fracture width distribution, and fracture front propagation speed are the model's output properties. The direct problem of fracture propagation is the calculation of the output characteristics using the input parameters. By figuring it out, one may forecast how the fracture will occur, how much hydrocarbon will be extracted from the fracture, how much this procedure will cost, etc. [13]

To maximize the effectiveness of the hydraulic fracturing procedure, the ratio of drainage radius to fracture length must be maximized. By estimating flow rate vs. time as a function of fracture length and drainage radius for blanket reservoirs, the ideal fracture length and drainage radius can be found. The drainage radius in lenticular reservoirs is a constant value independent of the extent of the fracture treatment. The geology investigations of the region yield the drainage radius that is most likely. The engineer can optimize propped fracture half-length by adjusting ratio after obtaining a likely drainage radius value. The overall distribution of water and gas in conventional, tight lenticular, and tight blanket sandstone reservoir intervals is shown in a diagrammatic cross section. [14]

The two most crucial requirements for optimal well performance by a fracture stimulation program are a sufficient fracture half-length and fracture conductivity.

Fracture conductivity is a serious problem that the industry frequently faces. If the fracture is more conductive, it will produce more material. Fracture conductivity has an inverse relationship between fracture permeability and fracture breadth. The following are the main causes of the conductivity decline:

1) The proppant's type and strength
2) Fluid Fracturing

Proppants are used during hydraulic fracturing to keep the fracture open. However, if the used proppants are of inferior strength, the proppants will be crushed by the fracture closing stress. Crushing proppants will reduce permeability in two distinct ways:

1) Reducing the fracture's width will lower conductivity
2) Fines migration, which will clog pore spaces and diminish permeability

Fracture fluid is another element that reduces fracture conductivity. To obtain the desired rheology, various additives are added to the fluid used in hydraulic fracturing. [15]

2. Experiment Part

This study conducted on unconventional reservoir. The permeability is in range of 5-13 mD. The main purpose of the research project to define the optimal hydraulic fracture length and fracture width for defined well.

It done sensitivity analysis on hydraulic fracturing length.

In first case, length of horizontal section was 150 m. Several cases simulated based on hydraulic fracture length and total gas production results compared. It defined that, 125 m hydraulic fracture length is the best result for this well.

In second case, length of horizontal section was 200 m. Several cases simulated based on hydraulic fracture length and total gas production results compared. It defined that, 125 m hydraulic fracture length is the best results for this well, too.

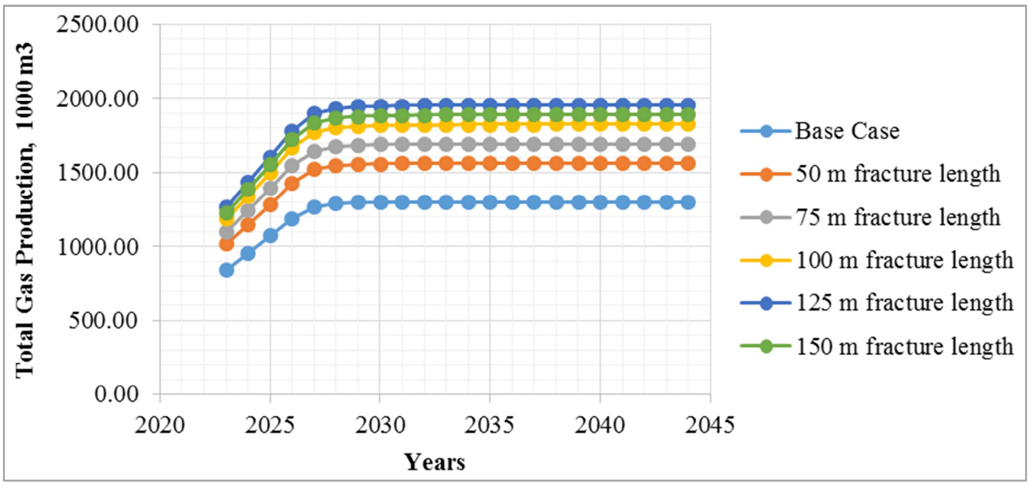

Figure 1. *The effect of hydraulic fracturing length within 50-150 metres to the well production.*

Table 1. *The effect of hydraulic fracturing length within 50-150 metres to the well production.*

Date	Base Case	Fracture length, m				
		50	75	100	125	150
2023	846.45	1015.74	1100.38	1185.03	1269.67	1227.35
2024	958.04	1149.64	1245.45	1341.25	1437.06	1389.15
2025	1071.78	1286.14	1393.31	1500.49	1607.67	1554.08
2026	1188.60	1426.33	1545.18	1664.04	1782.90	1723.47
2027	1267.11	1520.60	1647.27	1773.95	1900.67	1837.31
2028	1288.27	1546.00	1674.78	1803.58	1932.41	1867.99
2029	1296.25	1555.57	1685.09	1814.75	1944.38	1879.56
2030	1299.55	1559.52	1689.35	1819.37	1949.33	1884.35
2031	1301.09	1561.37	1691.34	1821.53	1951.64	1886.58
2032	1301.91	1562.35	1692.41	1822.67	1952.87	1887.77
2033	1302.34	1562.87	1692.95	1823.28	1953.51	1888.39
2034	1302.57	1563.14	1693.25	1823.60	1953.86	1888.73
2035	1302.69	1563.29	1693.41	1823.77	1954.04	1888.90
2036	1302.76	1563.37	1693.50	1823.86	1954.14	1889.00
2037	1302.80	1563.42	1693.56	1823.92	1954.20	1889.06
2038	1302.84	1563.47	1693.60	1823.98	1954.26	1889.12
2039	1302.87	1563.50	1693.64	1824.02	1954.31	1889.16
2040	1302.89	1563.53	1693.67	1824.05	1954.34	1889.19
2041	1302.91	1563.55	1693.69	1824.07	1954.37	1889.22
2042	1302.92	1563.56	1693.71	1824.09	1954.38	1889.23
2043	1302.93	1563.58	1693.72	1824.10	1954.40	1889.25
2044	1302.93	1563.59	1693.73	1824.10	1954.40	1889.25

Table 2. *The effect of hydraulic fracturing length within 100-200 metres to the well production.*

Date	Base Case	Fracture length, m				
		100	125	150	175	200
2023	846.45	1185.03	1269.67	1227.35	1185.03	1142.70
2024	958.04	1341.25	1437.06	1389.15	1341.25	1293.35
2025	1071.78	1500.49	1607.67	1554.08	1500.49	1446.90
2026	1188.60	1664.04	1782.90	1723.47	1664.04	1604.61
2027	1267.11	1773.95	1900.67	1837.31	1773.95	1710.60
2028	1288.27	1803.58	1932.41	1867.99	1803.58	1739.16
2029	1296.25	1814.75	1944.38	1879.56	1814.75	1749.94
2030	1299.54	1819.36	1949.31	1884.33	1819.36	1754.38
2031	1301.09	1821.53	1951.64	1886.58	1821.53	1756.47
2032	1301.91	1822.67	1952.87	1887.77	1822.67	1757.58
2033	1302.34	1823.28	1953.51	1888.39	1823.28	1758.16
2034	1302.57	1823.60	1953.86	1888.73	1823.60	1758.47
2035	1302.69	1823.77	1954.04	1888.90	1823.77	1758.63
2036	1302.76	1823.86	1954.14	1889.00	1823.86	1758.73
2037	1302.80	1823.92	1954.20	1889.06	1823.92	1758.78
2038	1302.84	1823.98	1954.26	1889.12	1823.98	1758.83
2039	1302.87	1824.02	1954.31	1889.16	1824.02	1758.87

Date	**Base Case**	**Fracture length, m**				
		100	**125**	**150**	**175**	**200**
2040	1302.89	1824.05	1954.34	1889.19	1824.05	1758.90
2041	1302.90	1824.06	1954.35	1889.21	1824.06	1758.92
2042	1302.92	1824.09	1954.38	1889.23	1824.09	1758.94
2043	1302.93	1824.10	1954.40	1889.25	1824.10	1758.96
2044	1302.93	1824.10	1954.40	1889.25	1824.10	1758.96

Table 3. *The effect of hydraulic fracturing width to the well production.*

Date	**Fracture width, m**								
	0.01	**0.015**	**0.02**	**0.025**	**0.03**	**0.035**	**0.04**	**0.045**	**0.05**
2023	1258.24	1258.88	1259.51	1260.15	1269.67	1274.12	1274.75	1275.39	1275.00
2024	1424.12	1424.84	1425.56	1426.28	1437.06	1442.09	1442.80	1443.52	1443.09
2025	1593.20	1594.00	1594.81	1595.61	1607.67	1613.30	1614.10	1614.90	1614.42
2026	1766.85	1767.75	1768.64	1769.53	1782.90	1789.14	1790.03	1790.92	1790.39
2027	1883.56	1884.51	1885.46	1886.41	1900.67	1907.32	1908.27	1909.22	1908.65
2028	1915.01	1915.98	1916.95	1917.91	1932.41	1939.17	1940.13	1941.10	1940.52
2029	1926.88	1927.85	1928.82	1929.79	1944.38	1951.18	1952.15	1953.12	1952.54
2030	1931.78	1932.76	1933.73	1934.71	1949.33	1956.15	1957.12	1958.10	1957.51
2031	1934.07	1935.05	1936.02	1937.00	1951.64	1958.47	1959.44	1960.42	1959.83
2032	1935.29	1936.27	1937.24	1938.22	1952.87	1959.70	1960.68	1961.65	1961.07
2033	1935.93	1936.91	1937.88	1938.86	1953.51	1960.35	1961.32	1962.30	1961.71
2034	1936.27	1937.25	1938.22	1939.20	1953.86	1960.69	1961.67	1962.65	1962.06
2035	1936.45	1937.43	1938.40	1939.38	1954.04	1960.87	1961.85	1962.83	1962.24
2036	1936.55	1937.53	1938.51	1939.48	1954.14	1960.98	1961.96	1962.93	1962.35
2037	1936.61	1937.59	1938.57	1939.54	1954.20	1961.04	1962.02	1962.99	1962.41
2038	1936.67	1937.65	1938.63	1939.60	1954.26	1961.10	1962.08	1963.05	1962.47
2039	1936.72	1937.69	1938.67	1939.65	1954.31	1961.15	1962.12	1963.10	1962.51
2040	1936.75	1937.72	1938.70	1939.68	1954.34	1961.18	1962.15	1963.13	1962.54
2041	1936.78	1937.75	1938.73	1939.71	1954.37	1961.21	1962.18	1963.16	1962.57
2042	1936.79	1937.77	1938.74	1939.72	1954.38	1961.22	1962.20	1963.17	1962.59
2043	1936.81	1937.78	1938.76	1939.74	1954.40	1961.24	1962.21	1963.19	1962.60
2044	1936.81	1937.78	1938.76	1939.74	1954.40	1961.24	1962.21	1963.19	1962.60

Then different fracture width applied to the hydraulic fracturing operation. The hydraulic fracturing length is 125 m. Based on this sensitivity analysis, it defined that, 0.045 m of fracture width is the most optimal case. In this case, well oil production reached its maximum gas production.

3. Conclusion

Hydraulic fracturing length and width influence to the oil and gas production. According to the study, it defined that, the highest fracture length does not mean highest production. In this study, for this well, the optimal fracture length is 125 m. After this length, hydraulic fracturing length does not effect to the oil production. Afterwards reservoir model simulated in various hydraulic fracture width for this well in 125 m of hydraulic fracturing length. It was determined that, 0.045 m of fracture width is the optimal width for this hydraulic fracturing operation. Higher value from this width does not effect to the oil production. In some values, it is reducing the oil production.

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