

AZƏRBAYCAN RESPUBLİKASI ELM VƏ TƏHSİL NAZİRLİYİ

AZƏRBAYCAN DÖVLƏT NEFT VƏ SƏNAYE UNİVERSİTETİ

MINISTRY OF SCIENCE AND EDUCATION

REPUBLIC OF AZERBAIJAN

AZERBAIJAN STATE UNIVERSITY OF OIL AND INDUSTRY



**“NEFTİN, QAZIN GEOTEXNOLOJİ PROBLEMLƏRİ VƏ KİMYA” ELMİ-TƏDQIQAT
İNSTITUTUNUN**

ELMİ ƏSƏRLƏRİ

SCIENTIFIC PROCEEDINGS

SCIENTIFIC RESEARCH INSTITUTE

“GEOTECHNOLOGICAL PROBLEMS OF OIL, GAS AND CHEMISTRY”

Sci. Proc. SRI GPOGC. Volume 24, Number 1, 2024

BAKU-2024

Significant impact the width of hydraulic fracturing on well production

Jabrayil Eyvazov*, Mehri Guliyeva, Amil Aliyev

Azerbaijan State Oil and Industry University, 20 Azadlig Avenue, AZ1010, Baku, Azerbaijan

Abstract. Hydraulic fracturing, often referred to as "fracking," is a process that involves the injection of a mixture comprising fluid, proppant, and additives into tight rock formations, particularly shale, at high pressures. This operation serves to create new cracks or expand existing ones, facilitating the smoother flow of hydrocarbons from the formation into the wellbore and eventually to surface facilities. Hydraulic fracturing is commonly utilized in the production of hydrocarbons. The proppant component within the hydraulic fracturing fluid is crucial as it prevents the newly formed cracks from closing immediately, allowing for the gradual release of hydrocarbons from the tight formation over time. The additives used consist of various chemicals, each contributing to specific properties of the fluid that are vital for the success of the hydraulic fracturing process.

Designing an effective hydraulic fracturing operation is paramount to achieving the desired production outcomes, especially in unconventional reservoirs like tight gas, shale gas, coal bed methane, and other reservoirs with very low permeability. Multiple factors come into play during the design and execution of hydraulic fracturing operations. These factors extend beyond variables such as pump rate, propping agent size and concentration, fracture spacing, number of fractures, fracture geometry, fracture conductivity, fracture length, and fracture width. Additional parameters include considerations like flowback and shut-in periods, reservoir depth and thickness, microcosmic geological events, the presence of faults and natural fractures, all of which can significantly impact the process. The influence of these parameters varies depending on the unique characteristics of the reservoir, rock properties, types of reservoir fluids, and geographical location. As a result, there is no one-size-fits-all method for hydraulic fracturing that can be universally applied without a thorough evaluation of the specific underground formations housing hydrocarbons. Each hydraulic fracturing operation requires a tailored approach to ensure its effectiveness and efficiency.

Keywords: hydraulic fracturing, fracture conductivity, fracture length, fracture width, well stimulation

*Corresponding author. Tel.: +994 55 9672223

E-mail: jabrayil.eyvazov88@gmail.com

Introduction.

Hydraulic fracturing, commonly known as "fracking," is a process that involves the injection of a mixture comprising a fluid, proppant, and additives into tight rock formations like shale under high pressures. This operation creates cracks or widens existing ones, facilitating the flow of hydrocarbons into the wellbore and eventually to the surface facilities. Fracking is primarily used in hydrocarbon production. The proppant in the fracking fluid plays a crucial role in preventing the newly formed cracks from closing immediately, allowing for the gradual release of hydrocarbons from the tight formation over time. The additives are composed of various types of chemicals, each serving a specific purpose to enhance the fluid's properties necessary for the success of the hydraulic fracturing process.[1]

There are several reasons for employing hydraulic fracturing:

Well Bore Damage Mitigation: Hydraulic fracturing is used to address damage near the wellbore that can negatively impact productivity. Damage often arises from fines entering the formation during drilling and from chemical incompatibility between the drilling fluids and the formation. This can be remedied either through matrix treatments or hydraulic fracturing to restore conductivity between the wellbore and the formation.
Enhancement of Hydrocarbon Pathways: Hydraulic fracturing creates conductive pathways for hydrocarbons within the formation, improving productivity. According to Darcy's law, this process increases the permeability of the formation, enhances fracture height and area coverage, and maintains or elevates reservoir pressure, ultimately enhancing well productivity.[2]

Optimizing the hydraulic fracturing process aims to maximize oil and gas production by increasing the volume of fractured reservoir rock. The optimization process is based on a model of fracture propagation in elastic media induced by viscous fluid injection. The model's input parameters include the surface characteristics of the cavity in an infinite elastic medium, the fluid pressure responsible for initiating and propagating the fracture, and the properties of the elastic medium. Output characteristics include fracture surface, fracture width distribution, and the speed of fracture front propagation. Solving the direct problem of fracture propagation allows for predicting fracture geometry, the volume of hydrocarbons extracted from the fracture, and the costs associated with the process. Optimizing hydraulic fracturing treatment involves adjusting the ratio of fracture length to drainage radius. In blanket reservoirs, optimal fracture length and drainage radius can be determined by analyzing flow rate over time in relation to fracture length and drainage radius. In lenticular reservoirs, drainage radius is a fixed parameter, often determined through geological studies. After estimating a likely drainage radius value, engineers can optimize propped fracture half-length by adjusting the ratio. For an effective well performance in a fracture stimulation program, two critical parameters are fracture half-length and fracture conductivity. Fracture conductivity plays a significant role in productivity. It is influenced by factors such as the type and strength of the proppant and the characteristics of the fracturing fluid.

Proppants are used to maintain the fracture open during hydraulic fracturing. Weaker proppants may get crushed due to fracture closure stress, leading to reduced permeability and conductivity. Fracture fluids, containing various additives, are used to achieve the desired rheological properties during hydraulic fracturing.[5]

2. Experiment Part

This study was conducted in an unconventional reservoir characterized by a permeability range of 5-13 millidarcies (mD). The primary objective of the research project was to determine the optimal hydraulic fracture length and fracture width for a specific well within this unconventional reservoir.

The study involved a sensitivity analysis focusing on the hydraulic fracturing length. Two scenarios were considered:

First Case (Horizontal Section Length: 150 meters): In this case, the study conducted several simulations, varying the hydraulic fracture length. The total gas production results were carefully evaluated and compared. The outcome indicated that a hydraulic fracture length of 125 meters was found to be the most favorable result for this particular well within this scenario.

Second Case (Horizontal Section Length: 200 meters): In the second scenario, which involved a longer horizontal section of 200 meters, similar simulations were conducted. The hydraulic fracture length was varied, and the resulting total gas production was compared. Once again, the study concluded that a

hydraulic fracture length of 125 meters yielded the best results for this specific well within this scenario. These findings suggest that, regardless of the horizontal section length (150 meters or 200 meters), a hydraulic fracture length of 125 meters appeared to be the optimal choice for maximizing gas production in this particular well within the unconventional reservoir. The consistency of this result across both scenarios highlights the significance of this hydraulic fracture length in achieving the desired production outcomes.[4]

Table 1. The impact of hydraulic fracturing length in arange of 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

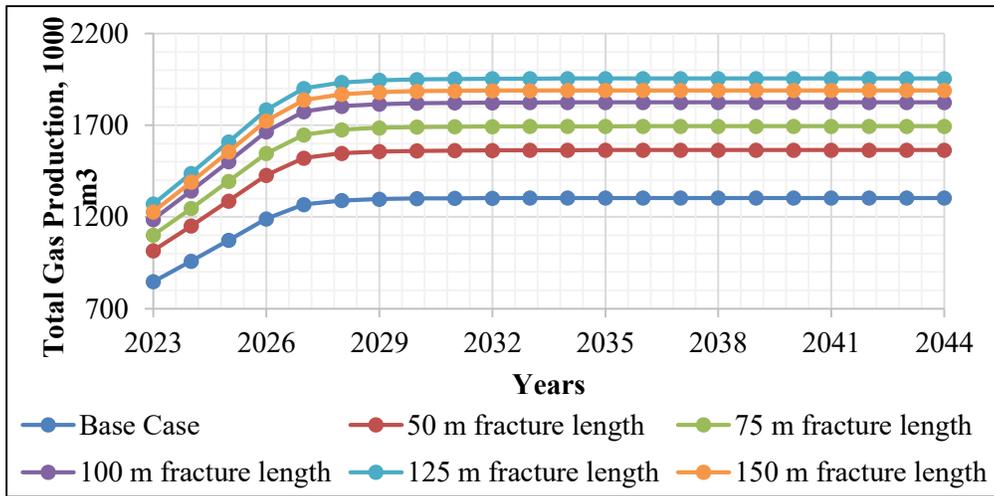


Figure 1. The impact of hydraulic fracturing length in a range of 50-150 metres to the well production

Table 2. The impact of hydraulic fracturing length in a range of 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
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

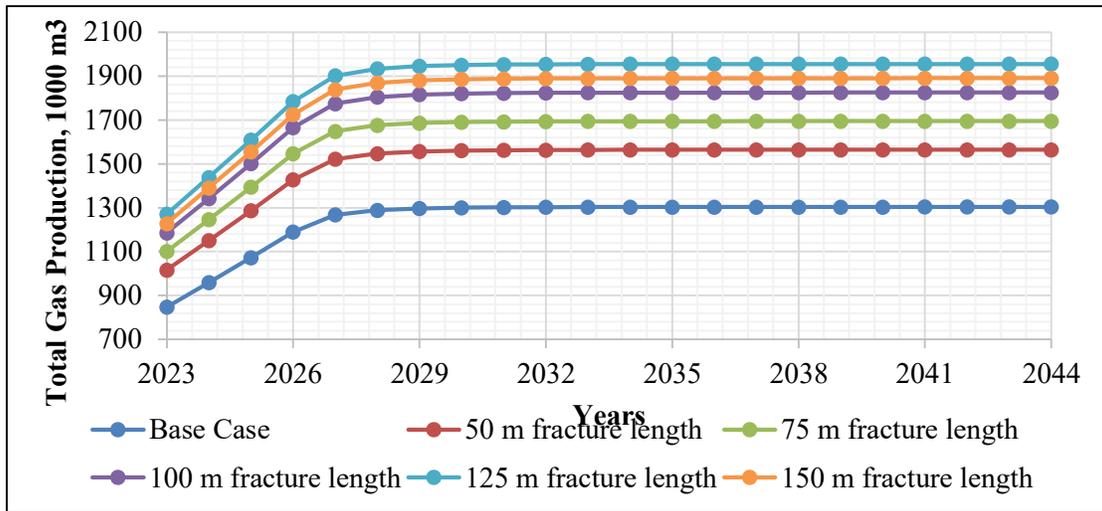


Figure 2. The impact of hydraulic fracturing length in a range of 50-150 metres to the well production

Table 3. The impact 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

Following the sensitivity analysis conducted in the study, where various fracture widths were applied to a hydraulic fracturing operation with a constant length of 125 meters, it was determined that a fracture width of 0.045 meters (45 millimeters) is the most optimal configuration.

Remarkably, this optimal fracture width not only maximized gas production but also led to the attainment of the highest well oil production. This finding emphasizes the critical role of fracture width in achieving the most favorable results in terms of hydrocarbon production from the well. It underscores the significance of well-designed hydraulic fracturing operations that consider both fracture length and width to achieve the best possible outcomes in unconventional reservoirs.[3]

Conclusion

The study has made a significant observation that a longer hydraulic fracture length does not necessarily result in the highest production. Instead, the research has defined that, for the specific well under investigation, the optimal hydraulic fracture length is 125 meters.

Following this determination, the researchers conducted reservoir simulations, keeping the hydraulic fracture length constant at 125 meters but varying the hydraulic fracture width. The goal was to identify the ideal fracture width for this hydraulic fracturing operation. Upon analyzing the results, it was established that a fracture width of 0.045 meters (45 millimeters) is the optimal width for achieving the best production results in this hydraulic fracturing operation for this well. This finding underscores the importance of considering both fracture length and fracture width as critical parameters in the hydraulic fracturing design process, and it demonstrates that longer fractures do not always equate to higher production rates.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research.

References

1. Hussain, A.J. (2014). Advanced Technologies For Produced Water Treatment And Reuse. International Petroleum Technology Conference (p. 22). Doha: Society of Petroleum Engineers.
2. Ahmed, U., Thompson, T.W, Kelkar, S.M, Strawn, J.A, Veghte, R., and Hathaway, S.: "Optimizing Hydraulic Fracture Designs in Formations with Poor Containment," SPE 13375, presented in Eastern Regional Meeting, Charleston, West Virginia, 31 October – 2 November 1984.
3. Eyvazov, J., and Hamidov, N.N. The effect of hydraulic fracturing length to the well production. Journal of Physics Conference Series 2594(1):012022. DOI: 10.1088/1742-6596/2594/1/012022
4. Eyvazov, J., and Hamidov, N.N. The Effect of Different Hydraulic Fracturing Width to the Well Production. International Journal of Oil, Gas and Coal Engineering. 2023; 11(4): 74-78. <http://www.sciencepublishinggroup.com/j/ogcedoi:10.11648/j.ogce.20231104.12>ISSN: 2376-7669 (Print); ISSN: 2376-7677 (Online).
5. Zhai, F.A. A new tool for multi & multi-well hydraulic fracture modeling, SPE-173367-MS (2015)