NOVATEUR PUBLICATIONS
INTERNATIONAL JOURNAL OF INNOVATIONS IN ENGINEERING RESEARCH AND TECHNOLOGY
[IJIERT] ISSN: 2394-3696 Website: ijiert.org
VOLUME 9, ISSUE 3, Mar. -2022

ANALYSIS OF FLUID FLOW BEHAVIOR IN THE FRACTURED RESERVOIRS: REVIEW PAPER

Mustafa M. Alobaidy
Department of Petroleum Engineering, School of Chemical and Energy Engineering, Faculty of Engineering, Universiti Teknologi Malaysia, 81310, Johor Bahru, Malaysia

Abdul Rahim Risal
Department of Petroleum Engineering, School of Chemical and Energy Engineering, Faculty of Engineering, Universiti Teknologi Malaysia, 81310, Johor Bahru, Malaysia
abdulrahimrisal@utm.my

ABSTRACT
The naturally fractured reservoirs are considered complex reservoirs in the petroleum industries where the engineers face some difficulties in the modeling of naturally fractured reservoirs. The main problem of fractures is the tectonic movements of fractures which affect the hydrocarbons flow during transportation from matrix to fracture, and drilling and productions processes. This review paper presented some previous about hydrocarbons leakage, drilling and production damages, and modeling issues which caused a loss of hydrocarbons in the naturally fractured reservoirs. The purpose of this review paper is to analyze the hydrocarbons flow behavior during production processes even to reach the perfect model in this study. This review paper depended a lot on Warren and Root's theory and extended by using new parameters and assumptions. This study got on perfect results to analyze hydrocarbons flow. This review paper is shown that the difference in the properties of natural fractures affected the flow of hydrocarbons during the transition from the matrix to the fractures, which affected drilling operations and hydrocarbon production. In addition, dual-porosity affected the movement of the fluid. Dual porosity resulted in fractures and or dissolving that produces holes in the reservoir.

Keywords: Radial flow; Naturally fractured reservoirs; Matrix and fractures systems; Hydrocarbons flow modeling; Production and drillings damages

1. INTRODUCTION

1.1. General Background

Fractures are created naturally like diastrophism and volume shrinkage, where distribute as a consistent connected network throughout the reservoir. **(Ordonez, Peñuela, Idrobo, & Medina, 2001).** Fracture mechanics ideas have been employed in petroleum engineering for more than 50 years. Understanding what happens to rocks in the subsurface when fracture stress is applied is the goal of rock fracture mechanics. Many of the theories and designs utilized in hydraulic fracturing were created by other engineering disciplines many years ago **(Ordonez, Peñuela, Idrobo, & Medina, 2001)**. Fractured reservoirs consider one of the most complex types of reservoirs in terms of production efficiency, however, fractured petroleum reservoirs cover 20% of the world's reserves **(Lima & De Ros, 2019; Lima et al., 2020).** Naturally fractured reservoirs may occur in rocks like shales, sandstones, carbonates, and igneous rocks. **(Jaffré, Mnejja, & Roberts, 2011)**. The naturally fractured reservoirs are characterized into three to four types based on Nelson **(Nelson, 2001)** and Aguilera **(Aguilera, 1974).** Naturally fractured reservoirs give advantage or disadvantage effects on the flow of hydrocarbons. The matrix includes a high storage capacity with low flow capacity while the fractures include a high flow capacity with low storage capacity. Naturally fractured reservoirs are one of the unique and specialized challenges in hydrocarbons extraction. **(Beckner, 1990)**

1.2.RELATED WORK ON HYDROCARBONS FLOW IN FRACTURED RESERVOIRS

In this section, the researchers discussed the problems of hydrocarbons loss due to fractures in the reservoir. Nolte and Settari started to discuss the process of explaining the fracture behavior to control the leakage of hydrocarbons to solve the fluid loss problem by classical theory. They worked at the expense of the speed and rate of dropout **(Nolte, 1986; Settari, 1985).** Then Fan and Barree worked to derive a pressure-dependent leakage model for the purpose of studying fluid loss more precisely **(Barree & Mukherjee, 1996; Fan & Economides, 1995; Yew, Ma, & Hill, 2000).** Otherwise, Van Den Hoek developed this fluid leakage model by means of high permeability fracturing, given that fluids flow in a non-linear manner. Also, his theory resulted that natural fractures have a high impact on fluid loss **(Van den Hoek, 2002).** While Vinod and co-workers studied fluids in low permeability formations through chamber experiments, which showed some beneficial effects for reservoir fracture designs **(Vinod, Flindt, Card, & Mitchell, 1997).** Ditzel, Kohler, and Rodgerson followed by Van den Hoek which they presented and put this previous model in the development stage by assuming the existence of some main considerations such as fracture properties and also the effect of fracture propagation on fluids in fractured reservoirs **(Dietzel & Koehler, 1998; Rodgerson, 2000).** Oil and gas leaks have a significant impact on the environment. This study showed that the failure to control oil and gas leakage in naturally fractured reservoirs affects the safety of the well, which generates pollution in the wells. This study confirmed that gas is the most liquid lost when a safety failure occurs as a result of the presence of failed valves on the surface **(King & King, 2013)**. This study has dealt with the explanation of some concepts related to the fractures and barriers that expose the reservoirs to the leakage of hydrocarbons **(Onajite, 2017)**. The 2021 study has completed the relevant studies from 2013 to 2019 and 2020 on the design of barriers in wells to prevent hydrocarbon leakage, as well as the use of water injection as one of the existing operations at the implementation site. This study has developed from the concepts of previous studies, which made it resort to P&A design. This design specializes in increasing the production of hydrocarbons and the level of the shutdown **(Johnson, Sefat, Elsheikh, & Davies, 2021). All**

Contrary to other studies, Other researcher discussed the problems of production and drilling processes in the fractured reservoirs even to reach the optimization of oil and gas recovery. John W. Colbert has worked on the study of drilling problems in highly fractured reservoirs. John W. Colbert worked with the Light Annular Mud Cap Drilling (LAMCD) method and applied the Cogollo formation in South America and more recently for drilling sour formations in Kazakhstan. John W. Colbert studied the migration of hydrocarbons during drilling, as it shown that hydrocarbons may migrate out of the formation as a result of a hole resulting from the high-pressure fracture in the casing **(Colbert & Medley, 2002).** Then P. Vieira presented the problems of conventional drilling that apply in naturally limestone fractured reservoirs. While P. Vieira confirmed that the traditional drilling technique works on a large loss of drilling fluids in the formation **(Vieira et al., 2007).** In contrast, A. Moreno and S. Rosales, composition assessment performed correctly in naturally fractured reservoirs. A. Moreno and S. Rosales considered that the process of drilling and extracting oil from horizontal wells in fractured reservoirs is a complicated matter **(Moreno et al., 2014).** Then Vasilev, Y. Alekshakhin, and G. Kuropatkin have discussed the study of naturally fractured reservoirs and their effect on hydrocarbon flow. Muhammad Moawwaz UlHaque and Abdul Saboor developed unbalanced drilling technology to address formation damage in the reservoir and improve the reservoir performance through drilling operations and development of productivity **(Bonter et al., 2018).** Fanhui Zeng, Yu Zhang, and Jianchun Guo introduced more advanced techniques for treating hydrocarbon leakage and flow by hydraulic fracturing to improve the efficiency and performance of the unconventional reservoir **(Zeng et al., 2021).**

The Pollard method was a distinctive method of acid stimulation. This method applied in limestone wells for the purpose of evaluating acid treatments in limestone fields **(Pollard, 1959)**,. It is designed to predict the outcome of acid treatments and the analysis of the Pollard study was expanded by Pirson for the purpose of calculating the pore volume system of the matrix and also calculating the impact radius before and after treatment through the well modelling process **(Pirson & Pirson, 1961).** considered inaccurate despite its application in field tests according to some authors' opinions. Warren and Root developed an idealized model for studying fluid flow in heterogeneous reservoirs**(Pulido, Samaniego, Rivera, Camacho, & Suárez, 2002)**. Kazemi **(Kazemi, 1969)** created an ideal model for the specific cases for the model of Warren and Root. This study has been followed by De Swaan **(De Swaan O, 1976)** who developed the unstable state theory which explains well pressure responses to naturally fractured reservoirs that form fractures that have high permeability and tight matrix mass. Najurieta **(Najurieta, 1976)** extended the theory that explains the transition period. Dreier et al. **(Dreier, Ozkan, & Kazemi, 2004)** introduced two quadruple porosity models for naturally fractured reservoirs in 2004. this model includes a triple-fracture network with a single matrix system.

1.3.CONTRIBUTION AND OBJECTIVES

The objective of this review paper is to review the naturally fractured reservoirs to evaluate the hydrocarbon leakage and predict hydrocarbons flow behavior. In this review paper, modeling of fractured reservoirs consider more difficult for create new Ideal model. This study develops of Warren and Root's theory and Kazemi model where Warren and Root's consider the first researches who present the dual porosity model based on Interporosity flow coefficient and Storativity ratio. Thus, this review paper develops of Warren and Root's theory by using different assumptions and parameters which are

1) Dual porosity model.
2) Single well system.
3) Pseudo steady state.
4) Without wellbore storage and skin factor. While the parameters will be Interporosity flow coefficient and Storativity ratio as input, but the shape factor and the fracture porosity as output even modelling as equations in the machine learning. This review paper introduces a new technique that is machine learning. The input data and output data shows in this machine learning as models. These models can help our study to analysis the hydrocarbons movements in the naturally fractured reservoirs. Machine learning contributes in improving the in the development process of the naturally fractured reservoirs analysis in the future. Also, this review paper can develop of petroleum industry in the modelling of reservoirs based on a new technique called machine learning.

2. STRUCTURE OF THE ARTICLE

The review article provides an overview of the current research status with regard the fracture impact on hydrocarbons flow behavior, by summarizing existing experimental, analytical simulation-based studies. remainder of this article is divided into three sections, **as shown in Fig 1.** In the first section, analytical studies are introduced through by using implantation methods to study the reasons of hydrocarbons leakage. Obstruct, the second section is presented the production and drilling processes damages in the naturally fractured reservoirs by using practical methods. While the third section is shown the modelling of the naturally fractured reservoirs. Warren and Root's is reviewed in the third section.

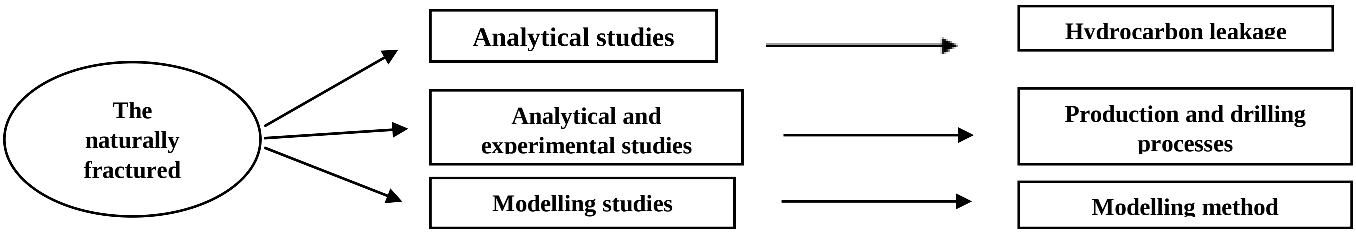

Fig. 1. Structure of fracture impact on hydrocarbons flow behavior literature review

2.1 HYDROCARBONS LEAKAGE

Nolte and Settari discussed the process of explaining the fracture behavior to control the leakage of hydrocarbons to solve the fluid loss problem by classical theory. They supposed that this theory represents the combined effect of all phenomena as a physical property. They worked at the expense of the speed and rate of dropout. They used Carter's equations as a mathematical model. They resulted that the fracturing pressure changes with increasing pumping time and therefore the potential for fluid loss will be certain **(Nolte, 1986; Settari, 1985)**. Then Fan and Barree worked to derive a pressure-dependent leakage model for the purpose of studying fluid loss more precisely. They relied on the study of the hydraulic fracture propagation process **(Barree & Mukherjee, 1996; Fan & Economides, 1995; Yew, Ma, & Hill, 2000)**. Van Den Hoek developed this fluid leakage model by means of high permeability fracturing, gave that fluids flow in a non-linear manner. Also, Van Den Hoek's theory resulted that natural fractures have a high impact on fluid loss **(Van den Hoek, 2002)**. Otherwise, Vinod and co-workers studied fluids in low permeability formations through chamber experiments, which showed some beneficial effects for reservoir fracture designs. Where they found that the occurrence of fluid loss, but can be controlled by dynamic machines such as injection (Vinod, Flindt, Card, & Mitchell, 1997). Ditzel, Kohler, and Rodgerson presented and put this previous model in the development stage by assuming the existence of some main considerations such as fracture properties and also the effect of fracture propagation on fluids in fractured reservoirs **(Dietzel & Koehler, 1998; Rodgerson, 2000)**.
This study showed that the failure to control oil and gas leakage in naturally fractured reservoirs affected the safety of the well, which generates pollution in the wells. This study confirmed that gas is the most liquid lost when a safety failure occurs as a result of the presence of failed valves on the surface, which can repair the failure quickly, but the external leakage affected the environment significantly **(King & King, 2013)**. The 2013 study developed from a study presented in 2018 on the Continental Shelf to study the barrier theory to prevent hydrocarbon leakage. This study confirmed the failure of the barrier system theory about preventing hydrocarbon leakage, but this study proved the possibility of hydrocarbon leakage in the fractured reservoirs, which affected the environment and generates risks in the safety of wells. This study developed a leakage rate calculator to assess the leakage potential of the borehole **(Ford et al., 2017).** Treatment of hydrocarbon leakage and hydraulic fracturing continued in naturally fractured reservoirs by Ahmed Farid Ibrahim, Mazher Ibrahim, Pieprzica Chester, Apache Corporation. Hydraulic fracturing was a well stimulation technology to improve natural gas production from narrow gas and shale formations. However, the implementation of the technique is through the soaking process, which is the process of pumping large volumes of water as an injection process into naturally fractured gas formations, and this a study that applied water injection into gas reservoirs by pumping a large amount of water into the well **(Ibrahim, Ibrahim, & Chester, 2019).** In previous studies presented by **(Soleiman Asl et al. 2019 and Yuan et al. 2019),** it led to a decrease in the recovery of the leaked hydrocarbons. This study was expanded the study of the recovery of fracking water and hydrocarbon leakage by using surfactant solutions in fracturing fluids for the purpose of simulating leakage processes after fluid flow, which helped in the recovery of residual oil in fractured reservoirs. The results shown that the use of these solutions helped to enhance the extraction of the relative permeability of

the recovered oil during backflow by reducing phase trapping and water blockage **(Yousefi, Habibi, & Dehghanpour, 2020).** The 2021 study completed the relevant studies from 2013 to 2019 and 2020 on the design of barriers in wells to prevent hydrocarbon leakage, as well as the use of water injection as one of the existing operations at the implementation site. This study developed from the concepts of previous studies, which made it resort to P&A design. This design specialized in increasing the production of hydrocarbons and the level of the shutdown. P&A operations implemented in tens of thousands of people worldwide, especially in the North Sea. They confirmed the development of P&A's process technologies with new operational technologies that may helped decommission hydrocarbon production wells in a safe and cost-effective manner. Monte Carlo methods utilized certainties in production development inputs and outputs to determine hydrocarbon flow paths, allowing a robust comparison of different design options based on the risk of hydrocarbon leakage. (Johnson, **Sefat, Elsheikh, & Davies, 2021)**

2.2 THE DAMAGE OF DRILLING AND PRODUCTION OF HYDROCARBONS

John W. Colbert worked on the study of drilling problems in highly fractured reservoirs. John W. Colbert studied the migration of hydrocarbons during drilling, as it shown that hydrocarbons may migrate out of the formation as a result of a hole resulting from the high-pressure fracture in the casing, which made it difficult to control a large proportion of fluids. John W. Colbert worked with the Light Annular Mud Cap Drilling (LAMCD) method and applied the Cogollo Formation in South America and more recently for drilling sour formations in Kazakhstan. LAMCD worked to control and monitor the migrating sour gases as they reach the ring in formations that are highly fractured. This method was shown that closing the fracture dam may lead to counterproductive results and worked on drilling with the throttle closed and high **(Colbert & Medley, 2002)**. Then P. Vieira presented the problems of conventional drilling that apply in naturally limestone fractured reservoirs. P. Vieira confirmed that the traditional drilling technique works on a large loss of drilling fluids in the formation, causing losses, and these losses may cause great damage to the formation. This method was applied in the Shuaiba Formation, a highly fractured limestone reservoir in the Kuwait fields, by the Kuwait Oil Company. UBD drilling technology evaluated the potential of hydrocarbons under Shuaiba formation conditions to eliminate fluid loss and improve the quality of drilling performance. **(Vieira et al., 2007).** In contrast, A. Moreno and S. Rosales, composition assessment performed correctly in naturally fractured reservoirs. A. Moreno and S. Rosales considered that the process of drilling and extracting oil from horizontal wells in fractured reservoirs is a complicated matter. Their studies confirmed that drilling operations in naturally fractured reservoirs generate damage to the formation and affect the fault network system. They worked to stimulate the matrix more to reduce damage to the formation, because the matrix works to push or direct the fracture fluid, its stimulation may contribute more to the production of fluid. Also, they merged all private data and records. This study successfully confirmed the presence of hydrocarbons in the T field in southern Mexico for the first time **(Moreno et al., 2014).** Then Vasilev, Y. Alekshakhin, and G. Kuropatkin discussed the study of naturally fractured reservoirs and their effect on hydrocarbon flow. They explained that the fracture system increases the capacity and conductivity of the reservoir, which generates a large production, however, the fracture system may cause a significant impact on the performance of the reservoirs, such as stopping production or malfunctions in drilling operations. they concluded that fractures may be well, poorly, or moderately conductive, which affected the permeability of hydrocarbons during production, causing poor productivity in naturally fractured reservoirs when poorly conductive fractures form high-conducting fractures, radial flow, have caused rapid depletion in tectonic formations, generating partial penetration, which may transient pressure as well as the impact on fracture size, conduction, and orientation also fractured fish naturally Configurations can be significant and increase the impact of WBS and it is presented in Figure 1 **(Vasilev, Alekshakhin, & Kuropatkin, 2016).**

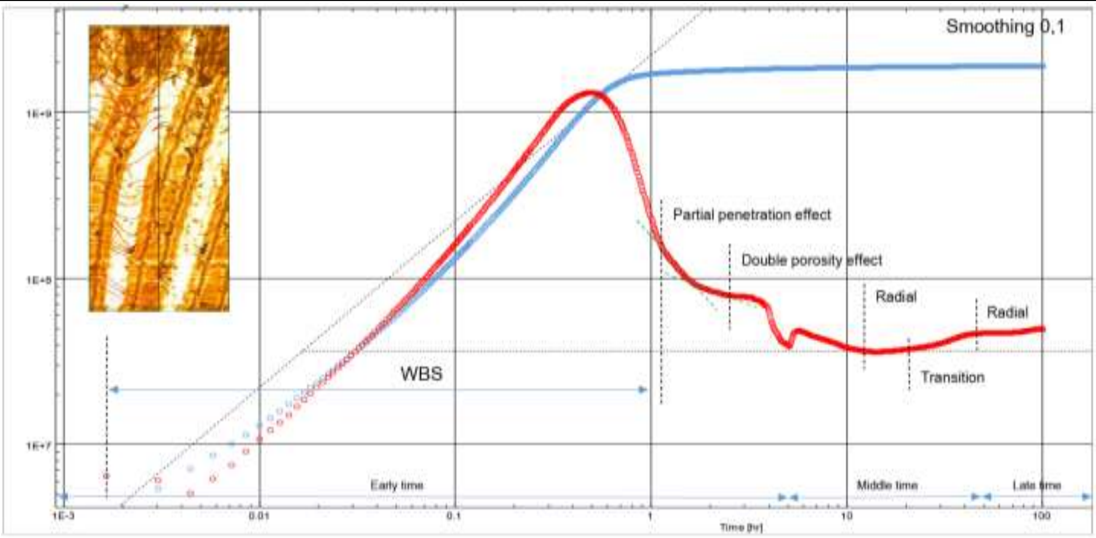

Figure 2. Impact of WBS on directions of transient pressures (PBU)

Muhammad Moawwaz UlHaque and Abdul Saboor developed unbalanced drilling technology to address formation damage in the reservoir and improve the reservoir performance through drilling operations and development of productivity. Unbalanced drilling operations UBD in the Hassi Messaoud field of Sonatrach, where it was drilled with a fluid whose hydrostatic pressure is less than the formation pressure. The unbalanced drilling process enabled the well to recover 40% of the drilling cost **(Bonter et al., 2018).**
Fanhui Zeng, Yu Zhang, and Jianchun Guo introduced more advanced techniques for treating hydrocarbon leakage and flow by hydraulic fracturing to improve the efficiency and performance of the unconventional reservoir. This study presented a high-density crushing technique by making artificial fractures for the purpose of stimulating the matrix and fully extracting all the resources from it. **(Zeng et al., 2021).**

2.3 COMPLEXITY MODELLING DUE TO THE FRACTURES

The Pollard method was a distinctive method of acid stimulation. This method applied in limestone wells for the purpose of evaluating acid treatments in limestone fields. This study was concerned with evaluating acid treatments to know the pressure difference that passes through the skin or between fine spaces and rough cracks, or a pressure difference that occurs due to the resistance to flow in the rough plugging of the cracks. In the Pollard system **(Pollard, 1959)**, the Pollard method was used in 1958 for calculating the coarse pore volume through analyzing well pressure drawdown and build-up tests. It was designed to predict the outcome of acid treatments and the analysis of the Pollard study was expanded by Pirson **(Pirson & Pirson, 1961)** for the purpose of calculating the pore volume system of the matrix and also calculating the impact radius before and after treatment through the well modelling process. The Pollard method developed through tests taken from the laboratory and these tests are applied using electrical isotopes for different porous systems. This method verified the number of wells first and that is knowing the number of wells that have been drilled, if it is sufficient or not, for the purpose of effectively draining a given field or lease. This method was considered inaccurate despite its application in field tests according to some authors' opinions. Warren and Root developed an idealized model for studying fluid flow in heterogeneous reservoirs, as shown in **Figure 2.** The model was composed of rectangular parallelepipeds where the blocks represent the matrix and the space in between represents the fractures. The general assumptions of the model are homogeneity and isotropy of the two porous media, uniform block-size distribution, and occurrence of fluid flow from matrix to fracture and from fracture to well, but not between matrix elements. The flow from matrix to fractures is pseudo steady state. **(Pulido, Samaniego, Rivera, Camacho, & Suárez, 2002)**

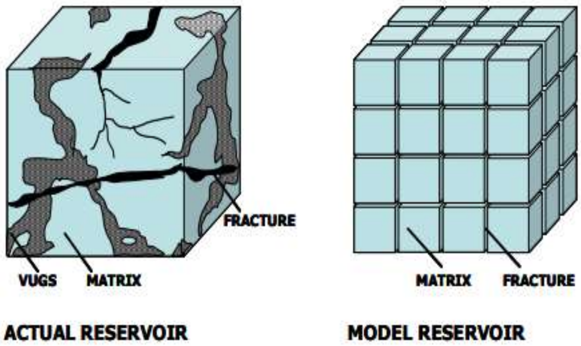

Figure 3 Warren and Root model for the naturally fractured reservoirs

Then Mavor and Cinco **(Mavor & Cinco-Ley, 1979)** worked on expanding the model of fracture reservoir for Warren and Root for the purpose of calculating the wellbore and skin storage, as well as calculating the reservoir and wellbore conditions, as well as evaluating and improving the analysis of field data. This study worked on knowing the behaviour transient pressure of naturally fractured reservoirs by reading and analyzing the results of previous studies of the reservoir. Complete analytical derivation was made for the double porous systems in the Laplace space **(Mavor & Cinco-Ley, 1979)**. Kazemi **(Kazemi, 1969)** created an ideal model for the specific cases for the model of Warren and Root. Whereas, Kazemi **(Kazemi, 1969)** also clear that the model of Warren and Root was very perfect to describe the unsteady-state flow where the value of the interporosity flow coefficient is based on the flow regimes which occur from matrix to fracture. Three hypothetical cases were simulated by Kazemi **(Kazemi, 1969)** also analysed the build-up and drawdown responses. This study followed by De Swaan **(De Swaan O, 1976)** who developed the unstable state theory which explains well pressure responses to naturally fractured reservoirs that form fractures that have high permeability and tight matrix mass. De Swaan **(De Swaan O, 1976)** demonstrated these analytic solutions to an ideal that describe inter-porous transient flow by means of geometries different from those of Kazemi. Najurieta **(Najurieta, 1976)** extended the theory that explains the transition period. In contrast, Dreier et al. **(Dreier, Ozkan, & Kazemi, 2004)** introduced two quadruple porosity models for naturally fractured reservoirs in 2004. this model includes a triple-fracture network with a single matrix system. These models are used to analyze and investigate pressure-transient characteristics of quadruple-porosity systems. The theory mostly used in the well-test analysis is Warren and Root theory with different types of matrix-to-fracture flow regimes, wellbore storage, and skin; such that the parameters (ω) and (λ) are valid for describing those reservoirs.

Then, Laura has developed the previous studies based on the simulation method where Laura depended more on Warren and Root equations and the Gilman model. Laura has used the IMGS program in the modeling of the naturally fractured reservoirs by depending on the shape factor, matrix permeability, and fracture permeability, in a line with interporosity flow coefficient and storativity ratio. Laura has resulted that the data of well test were accurate but the fracture reservoirs have been needed more studies and development assumptions. **(Perez Garcia, 2006).** As contrary of Laura, **Chen, Z. (2007)** have used a mathematical theory of homogenization that has been used to construct a dual-porosity model of multidimensional, multicomponent, multiphase flow in naturally fractured reservoirs. There are N chemical components in a completely compositional model, each of which can exist in any or all of the three phases: gas, oil, and water. The development of a broad strategy to integrate gravitational effects is given special emphasis. Also, they have modeling Naturally fractured reservoirs through interporosity flow coefficient and storativity ratio to model the dual-porosity. Forces, pressure gradient effects, and mass transfer effects between phases are all factors to consider. Under homogenization by a homogenizer, generic equations describing the interactions between matrix and fracture systems are produced. These impacts must be scaled with caution. Numerical investigations are carried out using this dual-porosity compositional model. **(Z. Chen, 2007)**

However, **Wang, X. D., Zhou, Y. F., & Luo, W. J. (2010)** have discussed horizontal wells in dual media reservoirs which require a thorough understanding of the associated fluid fluxes. The majority of current research has focused on dual-porosity media rather than dual-permeability media. A unique Laplace-domain solution for the slightly compressible fluid flow in the 3-D dual-permeability medium in which the horizontal well is running at a constant rate of production is achieved in this study using both integral transformation and sink-source superposition. The restricted examination examined the major asymptotic properties of diagnostic curves of dimensionless downhole pressure. Using the Laplace numerical inversion, the impact of dual-permeability media factors such as mobility ratio, storativity ratio, and inter-porosity flow parameter on downhole pressure are investigated. The novel approach presented in this paper incorporates and enhances prior findings, and can therefore be utilized as a foundation for either pressure transient analysis or formation behavior evaluation for a typical horizontal well reservoir.

(X.-d. Wang, Zhou, & Luo, 2010)

With the dual-porosity model, **(He et al., 2017)**have suggested a new way to calculate interporosity flow functions (also known as transfer functions) and form factors between the fracture and low-permeability matrix in naturally fractured reservoirs. To derive the analytical solution for shape factors in the transient pressure diffusion equation, the differential form of the single-phase seepage equation and the analytical solution for the pressure diffusion equation was used. The restrictions originating from the process of deducing interporosity flow function and form factors under numerous assumptions have been eliminated, and the no-linear pressure gradients in the matrix can be properly explained, thanks to the use of this technique. The pseudo-steady state theory, in which no-linear pressure gradients in the matrix cannot be adequately represented, is largely responsible for the deficiencies of the interporosity flow function and form factors. Under no pseudo-steady-state hypothesis, the interporosity flow function, constant shape factors, and time-varying shape factors considered threshold pressure in one, two, and three-dimensional fractures are determined for low permeability fractured reservoirs. Incompressible fluid productivity forecast and transient well-testing applications benefited from the newly developed analytical solution. The field case study revealed that those form characteristics can give more accurate parameters for compressible fluid productivity prediction as well as a more appropriate theoretical foundation for well-testing interpretation. **(He et al., 2017)**

In the exploitation of tight oil reservoirs, multistage hydraulic fracturing for horizontal wells has been widely used. Due to a significant interaction of rock and fluids in nanoscale pores, complex fracture networks with different sizes have been produced, and hydrocarbon flowing in the matrix exhibits a Pre-Darcy feature. The numerical simulation of tight oil reservoirs required the modelling of intricate fracture networks as well as the Pre-Darcy effect. Microseismic events are utilised to limit the sites of fractures in this article, and stochastic fracture networks are used to replicate actual fracturing networks according to the related probability density functions (PDFs). The numerical simulation for tight oil reservoirs was built using an embedded discrete fracture model (EDFM) framework that took into account complicated fracture networks and the Pre-Darcy effect. Finally, using the developed fracture network generation and tight oil numerical simulator, the effects of fracture network features such as isolated fractures, linked fracture networks, and the Pre-Darcy effect on well output were explored. The findings showed that isolated fractures without a direct link to the wellbore had little impact on well performance. When isolated fractures join to a wellbore, the effect becomes more visible, and an increase in fracture length and conductivity can improve well performance, especially when fractures are located off streamline lines. Similarly, an increase in fracture network features (number, length, and conductivity) can improve well performance, and fractures perpendicular to a horizontal wellbore can create the highest flow rate when compared to alternative fracture orientations. The fluid flow was influenced by fracture network connectivity, and there are strong correlations between well output and two suggested metrics that may be used to quantify the flow characteristics in fractured reservoirs. **(L. Li et al., 2021)**

5. SUMMARY AND CONCLUSIONS

This studies have comprehensively identified and critically appraised papers that either in development stage or followed other technical method. The work assessed their performance and highlighted errors that may have been made in their formulation. Previeus studies summarized the main issues that occur in the naturally fractured reservoirs. The first section is introduced 15 studies and total of 10 studies hydrocarbons leakage correlations were isolated and critically reviewed. In the second section, presented 17 studies and total of 7 studies production and drilling processes damages correlations were isolated and reviewed. This third section is focused on the modelling of the naturally fractured reservoir and shown 15 studies and total of 10 modelling NFR were isolated. This study avoided giving an encyclopedic overview of every work on the subject, instead of focusing on current obstacles, highlighting those areas of interest and importance. The following conclusions may be formed as a result of this:

a) This review paper is concluded that difference of fracture properties can effect on the hydrocarbons flow paths.
b) Dual porosity effected on the hydrocarbons flow movements
c) This review paper considered that high of fracture pressure can cause loss of hydrocarbons which effect on storage hydrocarbons in the source.
d) The production previous process focuses on the pressure control more that fracture effect that some production processes get problems in their methods.
e) This review paper confirmed that the large discrepancy between permeability and porosity can cause fluid loss of hydrocarbons which effect on the modelling of the natural fractured reservoirs.

6. REFERENCES

1) Aguilera, R. (1974). Analysis of naturally fractured reservoirs from sonic and resistivity logs. Journal of Petroleum Technology, 26(11), 1233-1238.
2) Aguilera, R. (1999). Recovery factors and reserves in naturally fractured reservoirs. Journal of Canadian Petroleum Technology, 38(07).
3) Barree, R., & Mukherjee, H. (1996). Determination of pressure dependent leakoff and its effect on fracture geometry. Paper presented at the SPE Annual Technical Conference and Exhibition.
4) Beckner, B. L. (1990). Improved modeling of imbibition matrix/fracture fluid transfer in double porosity simulators. Stanford University,
5) Bonter, D., Trice, R., Cavalleri, C., Delius, H., & Singh, K. (2018). Giant oil discovery west of Shetland-challenges for fractured basement formation evaluation. Paper presented at the SPWLA 59th Annual Logging Symposium.
6) Colbert, J. W., & Medley, G. (2002). Light annular MudCap drilling-A well control technique for naturally fractured formations. Paper presented at the SPE Annual Technical Conference and Exhibition.
7) Dietzel, H., & Koehler, M. (1998). Stimulation of a low permeability natural fractured reservoir in the North-West German carboniferous. Paper presented at the SPE Rocky Mountain Regional/Low-Permeability Reservoirs Symposium.
8) Dreier, J., Ozkan, E., & Kazemi, H. (2004). New analytical pressure-transient models to detect and characterize reservoirs with multiple fracture systems. Paper presented at the SPE International Petroleum Conference in Mexico.

9) Ford, E. P., Moeinikia, F., Lohne, H. P., Arild, Ø., Majoumerd, M. M., & Fjelde, K. K. (2017). Leakage calculator for plugged and abandoned wells. Paper presented at the SPE Bergen One Day Seminar.
10) Gilman, J., Bowzer, J., & Rothkopf, B. (1995). Application of short-radius horizontal boreholes in the naturally fractured Yates Field. SPE Reservoir Engineering, 10(01), 10-15.
11) Hawez, H., Sanaee, R., & Faisal, N. (2021). Multiphase Flow Modelling in Fractured Reservoirs Using A Novel Computational Fluid Dynamics Approach. Paper presented at the 55th US Rock Mechanics/Geomechanics Symposium.
12) Ibrahim, A. F., Ibrahim, M., & Chester, P. (2019). Developing new soaking correlation for shale gas wells. Paper presented at the Unconventional Resources Technology Conference, Denver, Colorado, 22-24 July 2019.
13) Jaffré, J., Mnejja, M., & Roberts, J. E. (2011). A discrete fracture model for two-phase flow with matrix-fracture interaction. Procedia Computer Science, 4, 967-973.
14) Johnson, C., Sefat, M. H., Elsheikh, A. H., & Davies, D. (2021). Development of a Probabilistic Framework for Risk-Based Well Decommissioning Design. SPE Journal, 1-18.
15) Kazemi, H. (1969). Pressure transient analysis of naturally fractured reservoirs with uniform fracture distribution. Society of Petroleum Engineers Journal, 9(04), 451-462.
16) Kazemi, H., Merrill, L., Porterfield, K., & Zeman, P. (1976). Numerical simulation of water-oil flow in naturally fractured reservoirs. Society of Petroleum Engineers Journal, 16(06), 317-326.
17) King, G. E., & King, D. E. (2013). Environmental risk arising from well-construction failure—differences between barrier and well failure, and estimates of failure frequency across common well types, locations, and well age. SPE Production & Operations, 28(04), 323-344.
18) Lima, B. E. M., & De Ros, L. F. (2019). Deposition, diagenetic and hydrothermal processes in the Aptian Pre-Salt lacustrine carbonate reservoirs of the northern Campos Basin, offshore Brazil. Sedimentary Geology, 383, 55-81.
19) Lima, B. E. M., Tedeschi, L. R., Pestilho, A. L. S., Santos, R. V., Vazquez, J. C., Guzzo, J. V. P., & De Ros, L. F. (2020). Deep-burial hydrothermal alteration of the Pre-Salt carbonate reservoirs from northern Campos Basin, offshore Brazil: evidence from petrography, fluid inclusions, Sr, C and O isotopes. Marine and Petroleum Geology, 113, 104143.
20) Moreno, A., Rosales, S., Reséndiz, T., Ramírez, E., Tellez, F., Losada, M., . . . Añez, A. (2014). Old Problems, New Challenges: Evaluating a Horizontal Well in Naturally Fractured Carbonate Reservoirs. Paper presented at the SPE Latin America and Caribbean Petroleum Engineering Conference.
21) Najurieta, H. (1976). A Theory for the Pressure Transient Analysis in NFR. paper SPE, 6017.
22) Nelson, R. (2001). Geologic analysis of naturally fractured reservoirs: Elsevier.
23) Nolte, K. (1986). Determination of proppant and fluid schedules from fracturing-pressure decline. SPE Production Engineering, 1(04), 255-265.
24) Onajite, E. (2017). Practical Solutions to Integrated Oil and Gas Reservoir Analysis: Geophysical and Geological Perspectives: Elsevier.
25) Ordonez, A., Peñuela, G., Idrobo, E.-A., & Medina, C. (2001). Recent advances in naturally fractured reservoir modeling. CT&F-Ciencia, Tecnología y Futuro, 2(2), 51-64.
26) Pirson, R. S., & Pirson, S. J. (1961). An extension of the Pollard analysis method of well pressure build-up and drawdown tests. Paper presented at the Fall Meeting of the Society of Petroleum Engineers of AIME.
27) Pollard, P. (1959). Evaluation of acid treatments from pressure build-up analysis. Transactions of the AIME, 216(01), 38-43.

28) Pulido, H., Samaniego, F., Rivera, J., Camacho, R., & Suárez, C. (2002). Decline Curve Analysis for Naturally Fractured Reservoirs with Transient Interporosity Flow.
29) Settari, A. (1985). A new general model of fluid loss in hydraulic fracturing. Society of Petroleum Engineers Journal, 25(04), 491-501.
30) Van den Hoek, P. (2002). A simple and accurate description of nonlinear fluid leakoff in high-permeability fracturing. SPE Journal, 7(01), 14-23.
31) Vieira, P., Qutob, H. H., Chopty, J. R., Al-Saleh, A. M., Larroque, F., & Ismael, H. (2007). Kuwait Employs Underbalanced Drilling Technology To Improve Drilling Performance While Simultaneously Evaluating the Reservoir. Paper presented at the SPE Offshore Europe Oil and Gas Conference and Exhibition.
32) Vinod, P., Flindt, M., Card, R., & Mitchell, J. (1997). Dynamic fluid-loss studies in low-permeability formations with natural fractures. Paper presented at the SPE production operations Symposium.
33) Warren, J., & Root, P. J. (1963). The behavior of naturally fractured reservoirs. Society of Petroleum Engineers Journal, 3(03), 245-255.
34) Yousefi, M., Habibi, A., & Dehghanpour, H. (2020). Surfactant in Fracturing Fluid: Enhancing Imbibition Oil Recovery or Blocking Pore Throats? Paper presented at the SPE Improved Oil Recovery Conference.
35) Zeng, F., Zhang, Y., Guo, J., Diao, S., Ren, W., & Zheng, B. (2021). Investigation and field application of ultra-high density fracturing technology in unconventional reservoirs. Paper presented at the Asia Pacific Unconventional Resources Technology Conference, Virtual, 16–18 November 2021.
36) Perez Garcia, L. E. (2006). Integration of well test analysis into naturally fractured reservoir simulation. Texas A&M University,
37) Chen, Z. (2007). Homogenization and simulation for compositional flow in naturally fractured reservoirs. Journal of mathematical analysis and applications, 326(1), 12-32.
38) Wang, X.-d., Zhou, Y.-f., & Luo, W.-j. (2010). A study on transient fluid flow of horizontal wells in dual-permeability media. Journal of Hydrodynamics, 22(1), 44-50.
39) Li, L., Guo, X., Zhou, M., Chen, Z., Zhao, L., & Wang, S. (2021). Numerical modeling of fluid flow in tight oil reservoirs considering complex fracturing networks and Pre-Darcy flow. Journal of Petroleum Science and Engineering, 207, 109050.
40) He, Y., Chen, X., Zhang, Y., & Yu, W. (2017). Modeling interporosity flow functions and shape factors in low-permeability naturally fractured reservoir. Journal of Petroleum Science and Engineering, 156, 110-117.

NOMENCLATURE

$Ø_f$	Fracture porosity
K_m	Matrix permeability
K_f	Fracture permeability
$Ø_m$	Matrix porosity
ω	The Storativity ratio
λ	Interporosity flow coefficient
σ	The shape factor
r_w	Wellbore radius
C_m	Matrix compressibility
C_f	Fracture compressibility