HYDRAULIC FRACTURING APPLICATION IN SHALE GAS RESERVOIR

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ABSTRACT

Hydraulic fracturing in shale gas reservoir is a newly developing field. Country like China and USA had encouraged research in developing this unconventional energy field. Shale with unique characteristics such as very low permeability, the existing of microfractures, and sensitivity to contacting fluid make it difficult to evaluate and produce. So it needs an optimum fracturing design to produce but there is absence of proper parameter analysis for hydraulic fracture geometry is captured in the literature. This study is carried out to identify the best 2-dimensional fracture propagation model of hydraulic fracturing in shale gas reservoir and to evaluate the response of models by controlling the parameters such as viscosity of fracturing fluid, injection rate and injection time. Meanwhile the study is based on all the research papers, journal and books. Software like MATLAB is used to develop the mathematical code and the parameters are analysed using the code. Besides that, 2-dimensional models are listed out through studies. Then, the best model is chose and mathematical code is developed. From the code, the effect of manipulating the parameters on the outcomes such as average width, fracture length, wellbore width and wellbore net pressure is observed and analysed. The use of 2D fracture propagation model in the hydraulic fracture geometry in shale gas reservoir is verified.

ABSTRAK

Keretakan hidraulik dalam takungan gas syal adalah satu teknik yang baru membangun. Negara seperti China dan Amerika Syarikat telah menggalakkan penyelidikan dalam pembangunkan medan tenaga bukan konvensional ini. Syal dengan ciri-ciri yang unik seperti kebolehtelapan yang sangat rendah, keretakan kecil yang sedia ada, dan kepekaan terhadap menghubungi cecair membuat ia sukar untuk dinilai dan dihasilkan. Jadi ia memerlukan reka bentuk keretakan optimum untuk mengeluarkan gas tetapi ketiadaan analisis parameter yang betul dibentangkan di dalam kesusasteraan. Kajian ini dijalankan untuk mengenal pasti model 2 dimensi peyebaran keretakan hidraulik yang terbaik dalam syal takungan gas dan untuk menilai sambutan model dengan mengawal parameter seperti kelikatan cecair keretakan, kadar penyebaran dan masa penyebaran. Sementara itu kajian ini adalah berdasarkan kepada semua kertas penyelidikan, jurnal dan buku. Perisian seperti MATLAB akan digunakan untuk menghasilkan kod matematik dan parameter akan dianalisis menggunakan kod tersebut. Selain itu, model 2-dimensi akan disenaraikan melalui kajian. Kemudian, model yang terbaik akan dipilih dan kod matematik dihasilkan. Dari kod, kesan memanipulasi parameter kepada hasil seperti lebar purata, panjang keretakan, lebar lubang telaga dan tekanan lubang telaga akan diperhatikan dan dianalisis. Ini adalah untuk mengesahkan penggunaan 2D model penyebaran keretakan untuk mengetahui geometri keretakan hidraulik dalam takungan gas syal.

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CHAPTER 1

INTRODUCTION

1.1 Background

This project is related to study of hydraulic fracturing application in shale reservoir. Over past few decades, depletion of conventional natural gas deposits made oil and gas industry has focused their efforts in exploring and developing unconventional oil, gas, and gas-condensate reservoirs. The increasing of energy demand has increase the development of unconventional shale reservoir (Figure 1.1) from year to year. Shale gas, gas condensate and shale oil has no different than conventional gas. What is unconventional reservoirs? Ultra-low permeability reservoir that cannot be produced at economic rates without stimulation are defined as unconventional reservoirs.

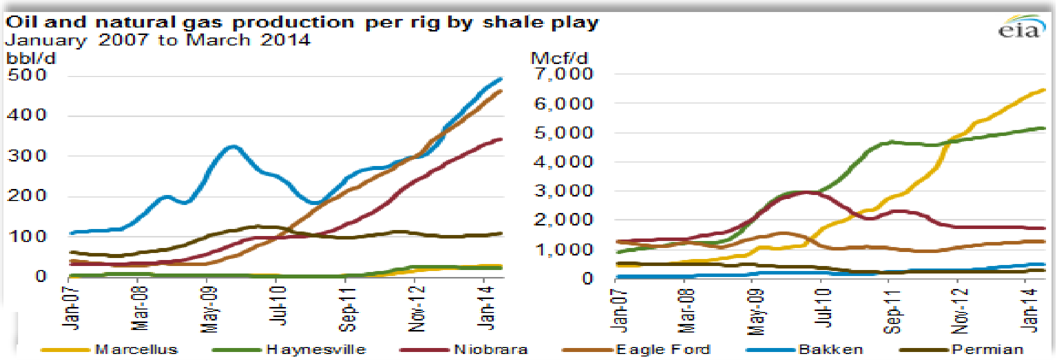

Figure 1.1: Production of oil and gas per rig by shale play. (U.S EIA,2014)

Shale is a fine sedimentary rock that often contain a wide range of hydrocarbons based on source rock maturity. It is made up of clay size weathering debris and categories by its characteristics such as will split along the planes and fissility which mean parallel with the bedding (Figure 1.2). Meanwhile, shale as unconventional resources is more expensive to develop and to produce the gas from it required special technologies. One of the important technologies that is implemented to enable gas production from shale reservoir is hydraulic fracturing. Hydraulic fracturing is a highly technical, and proven method performed to enhance production in a well where the natural reservoir flow characteristics are not good. It is a process of pumping high viscous fluid into the completion interval until fracture is formed by transmitting sufficient pressure.

Figure 1.2: Shale split into flakes, fissility (Merriman et al, 2003).

High conductivity proppant is filled into the fracture to hold the fracture open after treatment completion. The proppant will be transported down with fracturing fluid in many forms such as gel, foam or slick water based on the composition required for the fracturing. Besides all of this, the primary function of hydraulic fracturing is to help in flow of oil and gas from the formation to the wellbore (Figure 1.3). From a reservoir development point of view, to produce more hydrocarbons, having a reasonable understanding of hydraulic fracture geometry is crucial. This will help in determining well spacing and devising field development strategies design (Bennett et al, 2005).

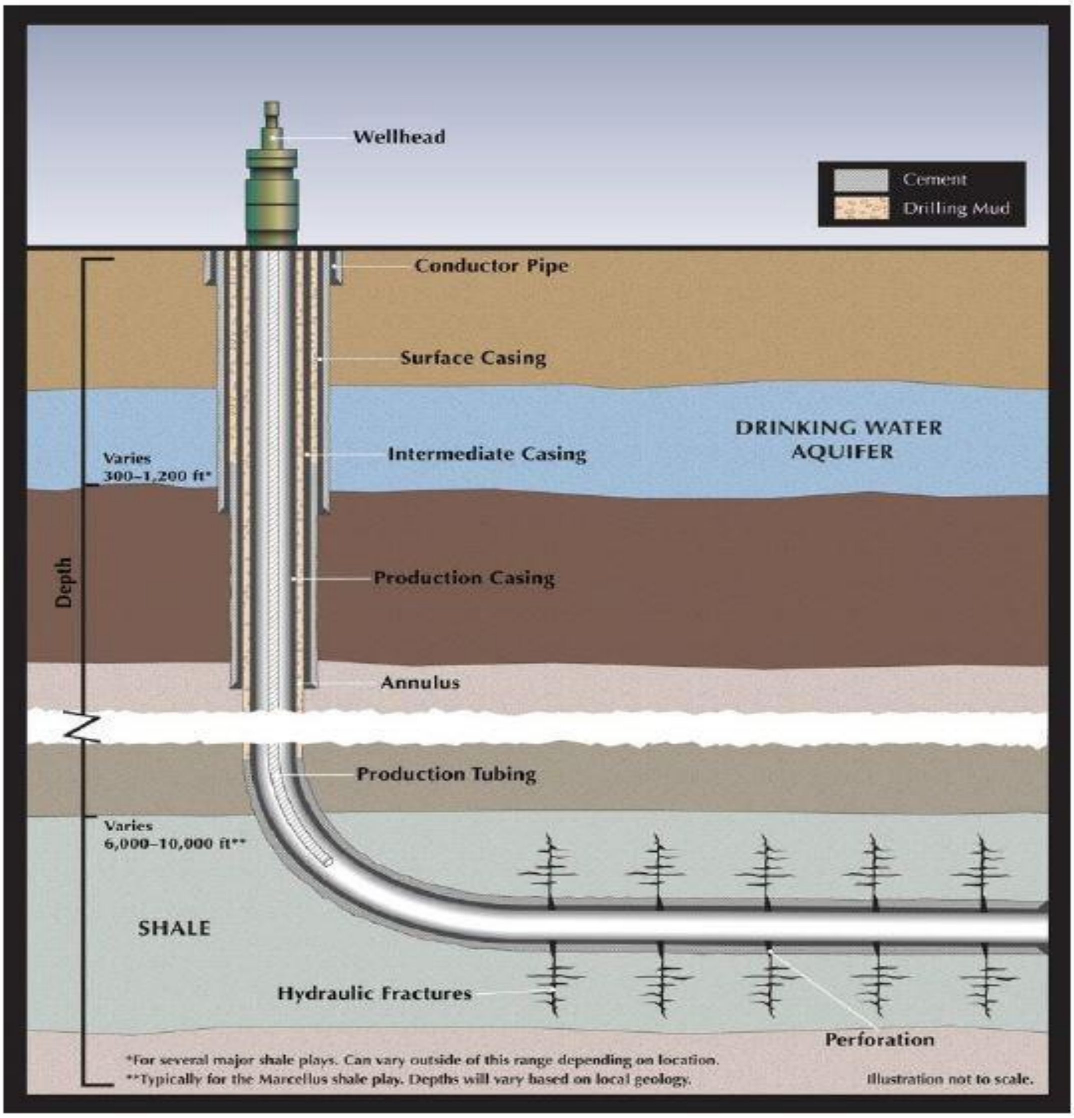

Figure 1.3: Hydraulic Fracturing. (C.Clark et al,2013).

Thus, the purpose of this research is to choose 2-dimensional model and manipulate the parameters involved to understand the optimum application of hydraulic fracturing to help overcome the challenges faced in developing shale gas reservoir. There are 2 major models that is Perkins, Kern & Nordgren (PKN) model, and the Khristianovich & Zheltov, Geertsma & deKlerk (KGD) is studied from existing literatures. The parameters that will be analyse here are 1) viscosity of fracturing fluid, 2) injection rate, and 3) injection time. Mathematical equation or code will be used based on selected model to evaluate the parameters with different value of data. All the data will be reviewed and collected by research studies.

1.2 Problem Statement

Production of shale reservoir has been always challenging for the oil and gas industry as the shale sedimentary rock have various unique characteristics. Among the unique characteristic of the shale is the low permeability of the rock strata. Most of the hydrocarbons are deposited within the low permeability medium rock of the shale reservoir, and the presence of natural fractures will be only way to transmit the fluid. Consequently, their very low, matrix permeability, makes unstimulated, conventional production impossible. The characteristics of the natural fractures such as size, interconnectivity, and amount of cementation typically determine the overall productivity of the reservoir. On the other side, the existing of micro fractures and sensitivity to contacting fluid make it difficult to evaluate and produce. To achieve economical production, in a shale gas reservoir almost all the wells need to be hydraulically cracked. These stimulations process are believed to reenergize and recombine the natural fracture matrix.

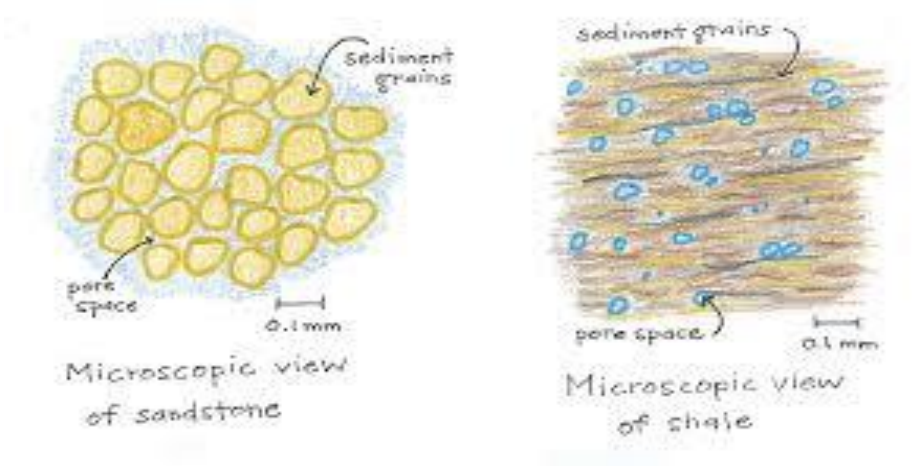

Figure 1.4: Comparison between sandstone and shale rock characteristics. (Sturgis, 2014)

Thus, to achieve the optimum production, analysis of parameters involved in hydraulic fracturing design is important. This will help operates to enhanced their production with reasonable cost and time. From literature study, effective 2-

dimensional fracture propagation model and its parameters are studied to evaluate hydraulic fracture application.

1.3 Objectives

The objectives of this project can be summarized a below:

1. To study and identify the best 2-dimensional fracture propagation model to be used in shale gas reservoir hydraulic fracturing design.
2. To analyse the 2-dimensional fracture propagation model parameters impact on hydraulic fracturing and how it helps in increasing the production of shale gas reservoir.

1.4 Scopes of Project

This study covered the following aspects:

1. Reviewing existing hydraulic fracturing method and challenges faced in producing shale gas reservoir.
2. Identifying and selecting best 2-dimensional fracture propagation model based 2 main type of models as below which is further breakdown into 6 types of sub models in our study:
    - Perkins, Kern & Nordgren (PKN) Geometry
        - PKN-C, PKN-N & PKN-α
    - Khristianovich & Zheltov, Geertsma & deKlerk (KGD) Geometry
        - KGD-C, KGD-N & KGD- α
3. Developing selected 2-dimensional fracture propagation model into mathematical code using MATLAB software

4. Analysing parameters as below in the developed mathematical code of selected 2-dimensional fracture propagation model to justify the efficiency of the model in hydraulic fracturing design of shale gas reservoir.
   - Viscosity of fracturing fluid
   - Injection rate
   - Injection time

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