Optimising Oil Recovery Through Polymer Injection: A Case Study Of The Patos-Marinza Oilfield In Albania

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Abstract— **Oil is considered globally as an important energy source. Albania is rich in oil and gas reserves. The main sources of natural energy in a hydrocarbon area, such as water or gas, move the oil from the reservoir to the production wells. Typically, this process contributes only a small portion of a country's crude oil production. Nowadays, developing an injection strategy that has the potential to improve oil recovery has gained considerable attention in the field of research and technology. Enhanced Oil Recovery (EOR) techniques have been optimized and applied in the field with the aim of improving flushing efficiency in oil reservoirs. In the field, practices have shown that polymer solution injections increase oil recovery from 5 - 30% of in-situ production. In Albania, polymer injection was applied by the company Bankers Petroleum in 2013 at the Patos-Marinza oilfield in the Lower Driza layer. The objective of this paper is to present the injection scheme, modeling curves performed with Matlab, analysis for the type of polymer injection production. The data for this paper were obtained from the company Bankers Petroleum Albania, which currently exploits this oilfield. The results achieved by polymer injection are quite satisfactory because they ensure a high oil recovery coefficient. Polymer injections in the Patos - Marinza reservoir are very promising techniques for a long-term economic activity.**

Keywords— Polymer solutions, enhanced recovery, injection, Patos Marinza Oilfield.

I. INTRODUCTION

The Patos-Marinza oilfield is located in the southern part of Albania, east of the city of Fier. It is considered the largest onshore field in Europe in terms of geological oil reserves [14, 20]. The Patos oilfield area was discovered in 1928 by APOV (Anglo Persian Oil Company) and began production in 1939. The Marinza region lies on the southeastern edge of the Adriatic Lowland, Figure 1.

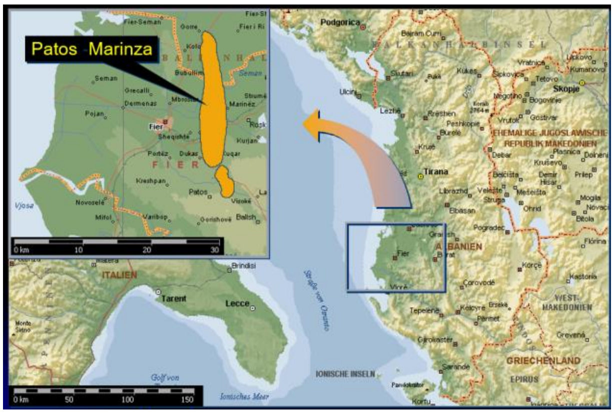

Figure 1. *Location of the Patos-Marinza oilfield*

The main oil-bearing sandstone formations found in this field are: Bubullima, Gurët e Zezë, Marinza, Gorani, Driza, Kuçova and Polovina. The formations of most interest in the northern part of the development area have been Bubullima and Marinza [21, 22]. Above these formations, Driza is estimated to have the largest geological oil reserves (*AKBN, 2005*). Historically, the depth of production in this field has ranged from 200 m to 3200 m vertical depth. The specific gravity of the oil ranges from 30°API to 33°API.

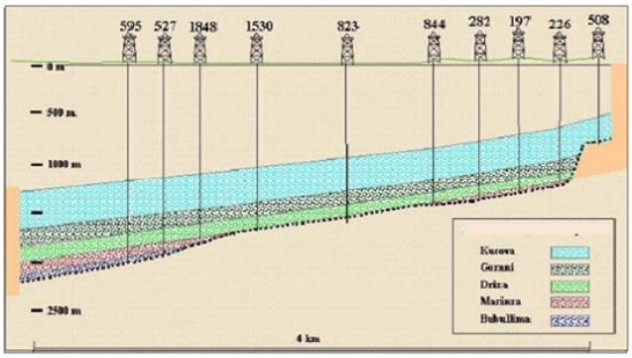

Figure 2. *North-west geological profile of the Patos-Marinza oilfield (AKBN 2005)*

The recoverable reserves of an oilfield depend on several factors such as: the configuration and size of the oil-bearing zone, pressure and temperature conditions, the bedding regime, the physical properties of the fluid reservoir, and the exploitation system [15, 17]. The indicators characterizing the technical and economic efficiency of the exploitation of reserves vary according to the type of reservoir. Undoubtedly, the amount of energy in the bed and the dynamics of the change in the pressure of the layer also affect this. The factors that determine the injection method are various. These factors are viewed in a complex manner and are closely related to the current and prospective development of oil extraction. Alkaline agents, surfactants, and polymers are the main components of chemical methods that are widely applied in the oil industry [15]. When polymer solutions are injected into the reservoir, the mobility ratio between water and oil becomes more favorable compared to conventional water injections, which leads to a significant increase in volumetric sweep efficiency. Partially hydrolyzed polyacrylamide is one of the most widely used polymer types for injection in the canterial field [4]. Experimental results have shown that this polymer can meet the needs of injection technology in reservoirs with high temperature and salinity. The performance of polymer solution injection is directly related to the properties of the polymer and its interactions with the porous medium [18]. Increasing the salinity of the solution, especially the divalent cations, is a parameter that has the greatest effect on polymer injection and significantly reduces viscosity [10, 11]. The push causes molecules in the solution to stretch, an effect that emphasizes the decrease in mobility at higher polymer concentrations. The behavior of pseudoplastic fluids better interprets polymers used in chemical methods [4]. Pseudoplastic fluids are characterized by a viscosity that decreases with increasing tangential stress. The behavior of the polymer used is very complex because the polymer molecules have a degree of elasticity. Furthermore, the flow in the porous medium is complicated, especially when we have accelerations and decelerations of the fluid passing from the entrance part of the pores into the interior of the porous medium. However, not all of the polymer solution injected effectively participates in oil displacement [7]. Part of the solution is adsorbed by the solid particles of the reservoir rock, reducing the permeability of the reservoir rock. Another important property is the stability of the polymer with respect to injection speed, temperature, and pH [11].

The purpose of this study is to provide a summary of the polymer solution injection process to serve as a guide for pilot projects. This paper is of great importance for the application and popularization of polymer solution injection technology in oil reservoirs.

II. METHODOLOGY

Software programs such as the Matlab Reservoir Simulation Toolbox (MRST), contain modules that provide various applications including enhanced oil recovery. These allow the user to use different computational methods and change any parameters. The model analyzed in this study is:

$$y = \alpha x_1 + \beta x_2 + \gamma x_3 + \delta x_4 \quad (1)$$

Where:

x_1- injection pressure,
x_2 -polymer concentration,
x_3 -injected volume
x_4 -polymer viscosity
y- is the volume of oil produced in well 5467 over the entire observation period of 2540 days.

The coefficients for each input are calculated along with the corresponding errors. In order for the linear approximation to be valid, the coefficients are not found for the entire series, but for small segments of the original series. Several levels of approximation have been tried and those adaptations that best approach the real data obtained in the field are presented.

A. *Polymer injection scheme*

Polymer looding has been used to effectively recover the remaining oil from the reservoir. The injection scheme at this well site consists of an injection well and at least two production wells, which form what is called an injection-production block or Pattern. The application of polymer solution in the Patos-Marinza reservoir began mainly in the D_3, D_4 and D_5 sandstone layers in the southern part of the field, due to the characteristics and physical properties of the reservoir [2, 20]. Polymer injection is now a well-known method applied to almost all the Patos-Marinza sandstone formations. Currently, many wells have been converted from production wells to polymer injection wells.

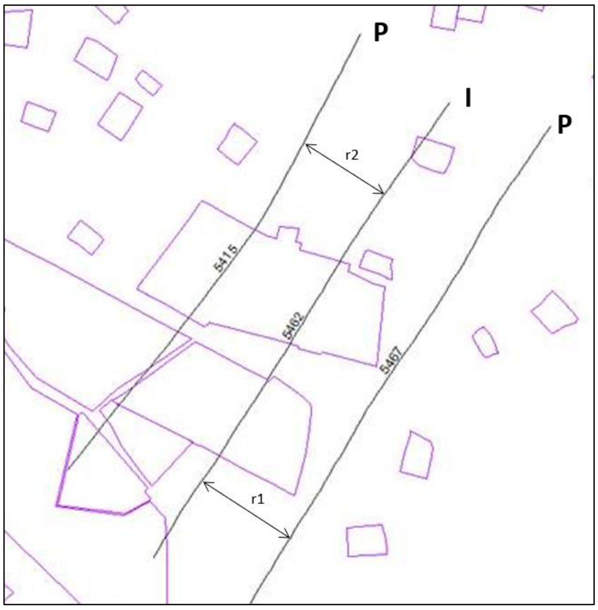

Figure 3. *Polymer injection scheme (Bankers, 2019)*

In the presented scheme, well 5462 is the injection well and wells 5415 and 5467 are production wells as well as the impact this well has on the production wells. Well 5467 is located at 106 meters from the injection well, while well 5415 is at 96 meters.

Figure 4. *Patos-Marinëz oil operations and production system* [20]

The figure shows the cascade system in the well fields, which consists of the "mother solution" distribution network and the diluted emulsion pipelines (mother solution + water).

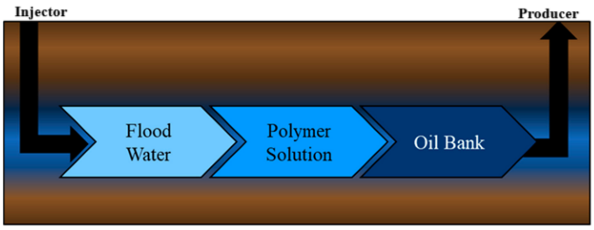

Figure 5. *Schematic of the polymer flooding process for enhanced oil recovery* [18].

B. Creation of the polymer solution

The polymer solution is created in a plant at the central station. The plant serves to mix the powdered polymer with water, thus forming a viscous liquid with certain parameters based on technical specifications. The preparation of the polymer solution must avoid precipitates and guarantee a perfect flooding fluid. Prior to this process, preliminary tests are carried out to calculate the ratios of polymer to well water.

Figure 6. *Hopper, the device where the polymer is mixed with water (Photo: author 2022)*

The hopper is the device where the powdered polymer is mixed with water and the Mother Solution is produced. Considering the type of fluids in the Patos-Marinza well and the characteristics of the reservoir, the water for preparing the polymer solution must have the following properties:

- Chlorides should be less than 100mg/liter;
- Ca and Mg cations should be less than 10mg/liter;

Figure 7. *Deposit where the polymer solution is transferred, Patos-Marinza oilfield (Photo: author 2024)*

After preparation in the main process (PSU600), the mother solution passes into two deposits, where their mixing occurs all the time, while one of the deposit is filling, the other is being emptied and conversely, which in a way serves as a conservation.

Figure 8. *The PDU unit remotely monitors fluid filtration to improve injection quality (Photo: author 2022)*

The PDU has many functions such as setting the water and polymer ratio parameters to inject into the wells with the concentration that best suits the layer. The PDU shows the injection amount for each well for 24 hours and for the entire pad where the polymer solution is injected. It is connected to the pump and to do this, the policy will be pushed with high pressures according to the conditions determined by the study of the layers.

Figure 9. *Coil Box Device (Photo: author 2024)*

The coil box is used to reduce the pressure of a well, in case we have many wells in a pit and we want one of the wells to have low pressure, by means of the coil box we make it possible to reduce the pressure to the values we want without affecting the other injection wells. A pump is installed in each injection well that serves to inject the polymer solution into the reservoir.

Figure 10. *Injection well at the Patos-Marinëz oilfield (Photo: author 2024)*

III. RESULTS AND DISCUSSION

The natural energy of the reservoir is depleted over time as the pressure in the reservoir drpos with the production of hydrocarbons. Secondary oil recovery techniques such as gas and water injection lose their effectiveness as the pressure decreases [11]. Therefore, pressure is a very important parameter for the production of hydrocarbons from a reservoir. The figure below shows the polymer injection pressure curve at the Patos-Marinza oilfield, well 5467.

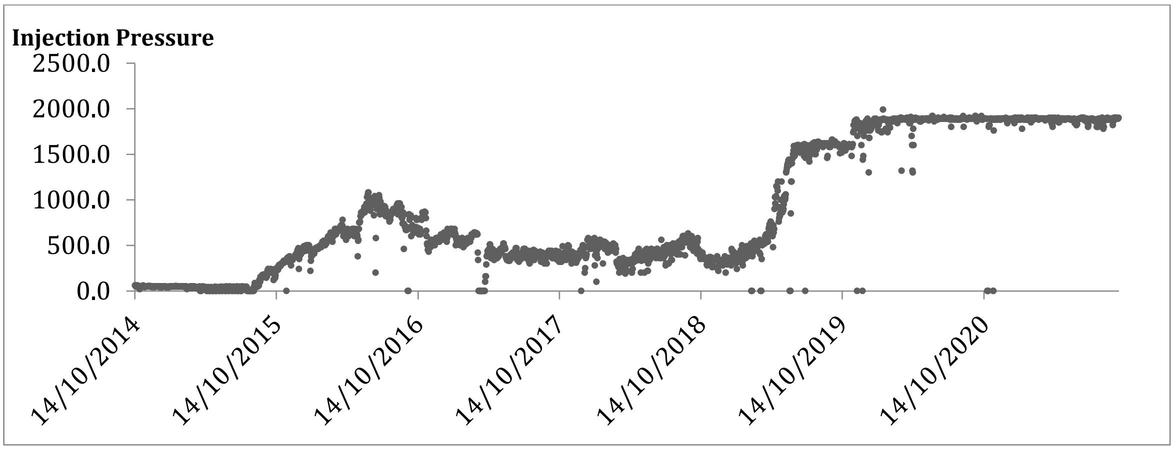

Figure 11. *Polymer injection pressure curve as a function of time (author)*

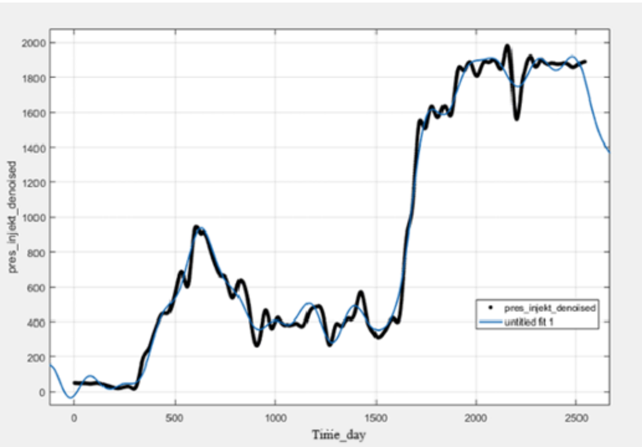

Figure 12. *Injection pressure as a function of time, performed with Matlab (author)*

At the beginning of the application of the polymer injection method, the injection pressure increased to a value of 1040 psi, and over time the pressure values begin to increase further in the area near the injection well until they reach a value of 1850 psi, figures 11 and 12. Pressure drop analysis shows that an increase in the polymer concentration in the solution increases the pressure drop. This effect is explained by the fact that an increase in polymer concentration results in a high resistance factor, which is directly related to an increase in viscosity and a decrease in permeability. Although data shows that the higher the injection pressure, the higher the oil production, we must keep in mind that the injection pressure depends on factors such as: surface technology, formation fracture gradient, and formation type [19].

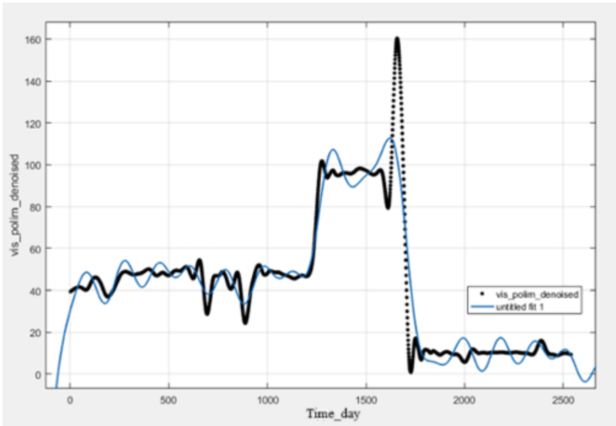

Figure 13. *Polymer viscosity as a function of time, (author)*

The polymer concentration value provides the highest oil production, and the maximum production flow rate is 1.5 kg/m^3. Values below and above give lower flow rates. The fact that higher concentrations give lower oil production values is explained by the fact that the polymer solution loses injectability with increasing viscosity. On the other side, water flow and production decrease with increasing polymer viscosity values. During injection, it is also observed that with increasing polymer viscosity, the permeability reduction increases, because of polymer being adsorbed by the grains of the rock formation [6, 7].

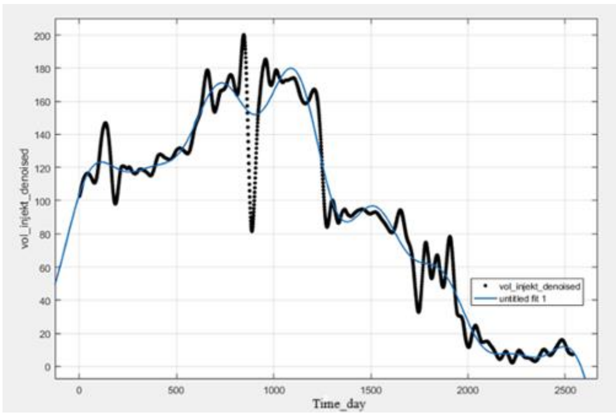

Figure 14. *Injected volume as a function of time, (author)*

After the injection process, for a period of 520 days, we began to receive the first positive responses of increased fluid production in well 5467. This increase in fluid production in the well was achieved as a result of the increase in the volume injected into the injection well. The decrease in the injected volume results in an overall decrease in oil production.

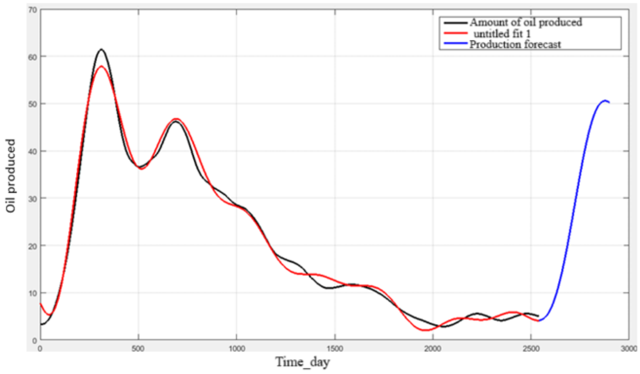

Figure 15: *Forecast and Amount of Oil Produced by Polymer Injection for Well 5467 (author)*

The forecast made from the graph above shows that the oil flow rate, after day 2550, will increase to 36.1 m^3/day, and then will decrease again. As a result of the injection of 160.3 m^3/day of polymer solution, we have obtained 36.1 m^3/day of oil and 153.9 m^3/day of water, in total over 200 m^3 of fluid (oil+water). Whereas on day 2535 we obtained a flow rate of 4.7 m^3/day of oil and 30.4 m^3/day of water by injecting a volume of 6.4 m^3/day of polymer solution and it clearly seems that the trend is towards further decline. In practice, it may happen that the flow rate of the fluid increases, but on the condition that it is reinjected at high flow rates. Under these conditions, the time has come to increase the injection rates again to obtain higher flow rates. In this case, we would aim to predict the change in flow rate in the production wells depending on several variables such as: injection pressure, polymer solution concentration, injected fluid volume and polymer solution viscosity and saturation pressure. The importance of these parameters is emphasized, because changing one of them, in almost every case, would reflect changes in the fluid flow (oil+water). Both injection and production efficiency are being monitored to verify the maximum recovery values with the secondary method.

IV. CONCLUSIONS

Bankers Petroleum Albania applies polymer injection as a method of action in the reservoir in the Patos-Marinza oilfield, due to the physical characteristics of the reservoir and the possibility of being cost-effective. The Patos Marinza oilfield is continuously under study for the conversion of new polymer injection wells and for reactivation of old wells. The selection qualities for this category of wells are:

- Low reservoir pressure drop
- High initial production
- Rapid production decline
- Low water production percentage
- Low Gas/Oil Ratio
- Viscosity should be low 500-2500 cp

Well 5467 is a fully operational producing well and after the injection process since July 2015, production has increased. This increase was also influenced by the injection of polymer solution into well 5462.

The basic mechanism of polymer injection is to increase the viscosity of water in order to reduce the mobility ratio between the displacing and displaced phase, which would lead to higher values of the sweep coefficient in the layer.

The use of polymer injection in the Patos-Marinza well is a successful technique in several ways for the oil company, which ensures high oil recovery coefficient at low cost.

ACKNOWLEDGMENT

The researcher thanks the Polytechnic University of Tirana and Bankers Petroleum Albania Ltd for their cooperation in providing data for the realization of this paper. Also, the researchers who contributed to the development of this research, which made this study possible, for their cooperation and willingness to contribute with their knowledge.

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