The effect of addition of polymer on viscosity as fluid of industrial oil and gas injection in EOR method

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Abstract. One EOR injection is polymer injection. In this study we will use FP3300S polymer with a concentration of 500ppm, 750ppm, 1,000ppm, 1,250ppm, 1,500ppm, 1,750ppm, 2,000ppm, 2,250ppm and 2,500ppm. The purpose and objective of this study was to determine the effect of polymer concentration on increasing viscosity, determine the effect of polymer concentration on polymer filtration (compatibility, filtration, screen factor, thermal stability), and to find out how the polymer injection results, the higher the research found. the polymer concentration the higher the viscosity where the highest at the polymer concentration 2,500ppm with 19.38cp, the viscosity required by the polymer as injection liquid is the viscosity of the polymer greater than 2X the viscosity of the oil to be injected, where the oil viscosity is 5.2pp. then while in polymer screening it was found that higher polymer concentrations were not always good for polymer filtration, and polymer injection has been shown to increase recovery factor, recovery factor was obtained at 51.5% water injection and polymer injection was 23.1%, before injection was correct really need to be screened first, to get the most optimal concentration to be injected.

1. Introduction
The lack of exploration activities in Indonesia is not comparable to Indonesia's increasing oil demand, one of them is to meet existing needs [1], the need for exploration activities for oil wells that have been produced, but besides doing exploration, Indonesia can maximize wells that have reached the secondary stage with a water cut of> 90%, or those who have made water injections, for this reason, it is necessary to do the next step is tertiary or EOR [2-12]. One of them is polymer injection, where polymer injection is carried out to expand the swap efficiency area which in injection of water often occurs fingering, injection of polymers is expected to reduce fingering. But to find out the right concentration the need to do research first, so that the concentration used is not too high which can clog the reservoir [13-19].

The purpose and objectives of the study Know the effect of polymer concentration on viscosity changes and compatibility, Know the effect of polymer concentration on Filtrasi changes, Know the effect of thermal tests on changes in polymer viscosity [20]. To find out the results of polymer injection on increasing Recovery Factor, by doing a screening before injection will get the optimum polymer concentration.

2. Methods
The research methodology that will be used to conduct this research is analytical research and experimental research, both of which are to find out the causal relationship between two operational
variables, differences, relationships, and researcher intervention in it. The researcher will analyze the polymer FP 3330 S concentration 500 ppm, 750 ppm, 1000 ppm, 1250 ppm, 1500 ppm, 1750 ppm, 2000 ppm, 2250 ppm, 2500 ppm, see how the effect of polymer concentration on screening is done and how much recovery factor is produced from the polymer injection.

3. Results and discussion

The need for EOR in Indonesia, considering that the wells in Indonesia are mostly those that have reached the secondary stage, or injection of water with a water cut > 90%, because of the need for an EOR, one of them is polymer injection [1,2], but prior to polymer injection it is necessary to do screening first, in order to get the right concentration and the concentration we use is not too low, too low concentrations will not be optimal in pressing oil or expanding the sweep efficiency area, while the polymer concentration that is too high is also not good, in addition to issuing greater costs, can also plug the reservoir, at the initial screening of the need to find the right concentration with a ratio of max polymer viscosity 2x viscosity of oil to be injected.

Table 1. Polymer concentration Vs viscosity and compatibility.

| No | Polymer FP 3330 S | Synthetic Water X | Viscosity (CP) | Compatibility 0 Day | Compatibility 10 Day |
|----|-------------------|-------------------|----------------|--------------------|----------------------|
| 1  | 500 ppm           | 18,000 ppm        | 3.17           | Clear              | Clear                |
| 2  | 750 ppm           | 18,000 ppm        | 3.99           | Clear              | Clear                |
| 3  | 1,000 ppm         | 18,000 ppm        | 5.08           | Clear              | Clear                |
| 4  | 1,250 ppm         | 18,000 ppm        | 6.9            | Clear              | Clear                |
| 5  | 1,500 ppm         | 18,000 ppm        | 8.25           | Clear              | Clear                |
| 6  | 1,750 ppm         | 18,000 ppm        | 9.92           | Clear              | Clear                |
| 7  | 2,000 ppm         | 18,000 ppm        | 12.61          | Clear              | Clear                |
| 8  | 2,250 ppm         | 18,000 ppm        | 15.25          | Clear              | Clear                |
| 9  | 2,500 ppm         | 18,000 ppm        | 19.38          | Clear              | Clear                |

Table 1 shows that the polymer used is suitable for use and continues to the next screening stage, worthy of use because there is no change in 2 weeks in all concentrations, but the value of viscosity needed is only 2x of oil viscosity, that is 5.2 cp. To be more clearly seen in figure 1.

Figure 1. Polymer concentration vs viscosity.
Like Figure 1 the higher the concentration of the polymer the higher the viscosity value, but at the polymer concentration > 2,000 ppm get the value of viscosity 2x oil viscosity and concentration > 2000 is not recommended for concentrations polymer injection.

Furthermore, it is necessary to conduct a filtration test to find out whether the concentration used by filtration is not > 1.2, because if the filtration ratio > 1.2 will cause blockages in the reservoir.

![Polymer Concentration Vs Filtration Ratio](image1.png)

**Figure 2.** Polymer concentration vs filtration ratio.

The ratio filtration experiment as shown in figure 2, the polymer concentration of 2,500 ppm obtained a filtration value ratio > 1.2, that at this concentration it was not feasible to do the injection because it could blockages the reservoir, the safest maximum concentration in this study was 1,750 ppm polymer concentration.

Furthermore, the pH measurements that have been carried out in the FP 3330 S 1,500 ppm + synthetic X concentration, the acid value of the ph is 6.68 but the value is close to the neutral ph, is 7. Then proceed with the thermal test.

![Viscosity Polymer Vs Day](image2.png)

**Figure 3.** Polymer viscosity vs days.
The results as in figure 3 thermal test conducted for 2 months in which the polymer is stored in an oven, which aims to see how resistant the polymer is to heat for 2 months, because the polymer injected is not only 1 day or 5 days in the reservoir, it runs for months. The thermal test carried out obtained results, on day 1 to day 15 the polymer's viscosity decreased, but the decrease was not significant and the days of 15 to 60 days the viscosity of the polymer had experienced stability.

After all, stages were carried out on the FP 3330 S polymer, the concentration chosen to be injected was a concentration of 1,500 ppm because all the factors tested at the screening test were the best polymer concentrations because they met all existing standards.

Before doing core flooding, it must know the nature of the rock, where the rock used is birea rock, get length 5.56 cm, diameter 3.81 cm, Section area 11.39 cm2, bulk volume 63.37 cc, Wdry core 133.88 gr, Wwet core 146.22 gr, brine density 1.00260 gr / cc, PV water 12.31 cc, porosity 19.4%, permeability 159.44. After knowing the rock specifications, performing core flooding, core flooding gets the results as in figure 4 below.

![Figure 4. Core flooding.](image)

We can see figure 4 the results of the core flooding polymer carried out, 51.5% water flooding, 23.1% polymer injection, and 7.5% pre-flush from Soi 54.44% and 45.56% Swi, with the results of core flooding, it was proven that incomplete polymer increasing recovery factor is quite large with a ratio of 1.2 PV, although polymer injection is quite large there is still a Sor of 17.5% which can be lifted with other technologies.

4. Conclusion

The higher concentration of the polymer the higher viscosity, in this experiment the lowest viscosity value was 3.17 cp in a 500 ppm polymer concentration, this concentration is the lowest concentration in this study, and the highest is 19.38 cp in the polymer concentration of 2500 ppm, where this is the highest concentration in this experiment. Compatibility in polymer experiments experienced stability for two weeks in all concentrations, this experiment the PH value produced from acid polymers tends to be neutral, can be categorized safely for injection. In the filtration test, a polymer solution of 2500 ppm the clump was marked with an FR value of 1.548. The thermal test that has been carried out for two months found that the polymer viscosity decreased slightly. Recovery Factors obtained in water injection were 51.5%, polymer injection 23.1% and finally free flush total Recovery Factor 82.1%.

References

[1] Arvirianty 2019 RI Target Produksi Minyak 1 Juta Barel/Hari Di 2022 (Jakarta)
[2] Green D W and Willhite G P 1998 Enhanced Oil Recovery, SPE textbook series Society of Petroleum Engineers, Richardson, Texas
[3] Rukman D, Kristanto D and Aji V 2011 Teknik Reservoir: Teori dan Aplikasi
[4] Fattahanisa A, Setiati R and Kasmungin S 2018 Penentuan Komposisi Surfactan Nals Ampas Tebu Dengan Pertimbangan Kestabilan Surfactan Dan Uji Kelaukan Fasa in Prosiding Seminar Nasional Cendekiawan 103-109
[5] Ristawati A, Setiati R and Kasmungin S 2018 Pengaruh Konsentrasion Surfactan Nals Ampas Tebu Dan Salinitas Tinggi Pada Hasil Uji Kelaukan Fasa in Prosiding Seminar Nasional Cendekiawan 111-115
[6] Septoratno 2000 Enhanced oil recovery (Bandung: Institut Teknologi Bandung)
[7] Abadli F 2012 Simulation Study Of Enhanced Oil Recovery By Asp (Alkaline, Surfactant And Polymer) Flooding For Norne Field C-Segment Norwegian University Of Science And Technology
[8] Aladasani A and Bai B 2010 Recent Development And Updated Screening Criteria Of Enhanced Oil Recovery Techniques Spe, 1 1–24
[9] Pramadika H, Fauzani Y, Kasmungin S and Fajarwati K 2018 Karakterisasi Surfactan Sebagai Fluida Injeksi Pada Lapangan X in Prosiding Seminar Nasional Cendekiawan 361-364
[10] Haryoko B T 2014 Kajian Optimasi Kelaukan Fasa dan Analisa Numerik Pada Injeksi ASP (Alkali Surfactan Polimer) (Universitas Trisakti)
[11] Hermeidi A 2015 Karakteristik Fluida Reservoir
[12] Jerauld G R and Rathmell J 2015 Wettability and Relative Permeability of Prodhoe Bay: A Case Study in Mixed-Wet Reservoir SPE 28576
[13] Arina A and Kasmungin S 2015 Studi Peningkatan Produksi Minyak dengan Metode Injeksi Polimer Ditinjau dari Bermacam Salinitas Air Formasi In Seminar Nasional Cendekiawan
[14] Pramadika H and Kasmungin S 2016 Peningkatan Perolehan Minyak dengan Injeksi Air dengan Penembahan Polimer Konsentrasion Rendah Skala Laboratorium in Prosiding Seminar Nasional Cendekiawan
[15] Tobing M L Edward 2012 Pengaruh Adsorpsi Statik Batuan Reservoir Minyak Terhadap Viskositas Polimer Polyacrylamide LEMIGAS.
[16] Tobing M L Edward 2012 Peningkatan Perolehan Reservoir Minyak Dengan Injeksi Polimer Skala Laboratorium LEMIGAS Jakarta.
[17] Wibowo B E, Buntoro A, Natsir M 2007 Upaya Peningkatan Perolehan Minyak Menggunakan Metode Chemical Flooding Di Lapangan Limau IATMI Yogyakarta
[18] Widyrso A, Swadesi B, Wibowo A W and Sudarmoyo 2006 Studi Laboratorium Pengaruh Injeksi Polimer Dengan Berbagai Konsentrasion Terhadap Peningkatan Perolehan Minyak Pada Reservoir Karbonat IATMI.
[19] Danisworo R, Kasmungin S and Astra A 2017 Karakterisasi Surfactan Polimer Pada Salinitas 15.000 ppm dan Suhu 85 C in Seminar Nasional Cendekiawan Jakarta 2460 – 8696
[20] Arachchilage P, Gayani W P, Spilker K K, Tao E B, Alexis D, Linnemeyer H and Dwarkanath, V 2018 Evaluating the Effect of Temperature on Surfactant Phase Behavior and Aqueous Stability to Forecast Optimum Salinity at High Temperature In SPE Improved Oil Recovery Conference Society of Petroleum Engineers