Hydra-Cell® Diaphragm Pump Technology for Minimizing Shear Effects in EOR Polymer Solutions

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Introduction

Polymer flooding is a mature technology and continues to be the dominant form of chemical enhanced oil recovery (EOR). However, many industry insiders know that the intended viscosity of a polymer solution and the actual viscosity injected in the reservoir tend to vary significantly. This is primarily due to shear effects (polymer degradation) in equipment and piping systems.

With the typical lifetime from reservoir screening to pilot EOR projects being two to four years, operators cannot afford operational inefficiencies and increased CAPEX / OPEX in their projects and must reliably inject what was designed. A main cost driver for larger-scale projects is the price of polymer, and degraded polymer affects overall recovery and reserves. Cost savings with low shearing pumps are crucial to the overall economics of polymer EOR projects.

Hydra-Cell model T100K, manufactured by Wanner Engineering, Inc., Minneapolis, Minnesota, USA.

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Experimental Setup

Wanner Engineering's Hydra-Cell T100K triplex diaphragm pump was tested, with a patent-pending collection system and method, to minimize shear effects and characterize viscoelastic response from a medium molecular weight polymer solution (12 MDalton). Dr. Vladimir Alvarado and his team conducted the experiment at the University of Wyoming.

Experimental measurements included rheometer measurements, nuclear magnetic resonance (NMR) measurements, and dynamic light scattering (quality control checks).

- Rheometer measurements included flow sweep, frequency sweep, and strain sweep measurements to collect dynamic viscosity and complex modulus rheology data.

- NMR measurements included T_2 distributions and diffusion coefficients.

These measurements ensured experimental quality and stability.

Summarized below are the parameters at which the T100K's effect on polymer was tested. It should be noted that the T100K can achieve a maximum flow rate of 45 gpm at 3000 psi.

Table 1 | Experimental pressures, flow rates, and polymer viscosities tested (at 10 s^{-1})

Run #	Pressures (psi)	Flow Rates (gpm)	Polymer Viscosity (cp)
1	500	8 - 24	17
2	1000	8 - 34	13
3	500, 1500	8 - 34	35
4	500, 1500	8 - 34	110
5	500, 1500	2 - 34	60
6	500, 1500	8 - 34	5

Results and Discussion

On average, the Hydra-Cell T100K demonstrated a 1% to 5% degradation of polymer viscosity. Experimental results show a maximum percent difference between the storage tank and pump discharge solution viscosity was less than 5%, observed at 34 gallons per minute through the T100K. Results further demonstrate no consistent trend between the percent decrease in viscosity and either the discharge pressure or the pump flow rate.

The experimental system and piping did have a non-negligible impact on polymer solution viscosity reduction, suggesting that polymer degradation through the T100K is most likely even less than the measured 1% to 5% viscosity reduction.

Overall, Wanner Engineering's Hydra-Cell T100K has demonstrated a marked improvement and decrease in polymer solution viscosity degradation over what is generally seen in oilfield projects (10% to 15%).

Run #1 | Viscosity reduction

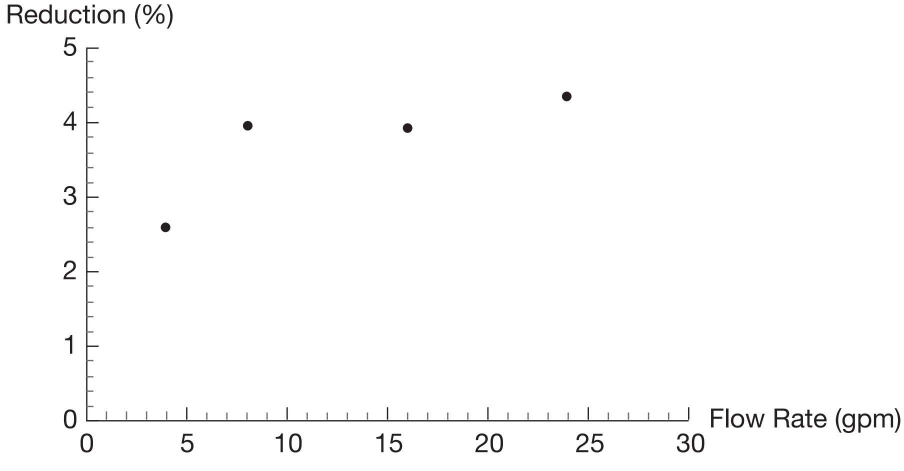

Figure 1 – Run #1 sample data. This run shows a 1% to 5% viscosity reduction increasing with flowrate and independent of pressure. Subsequent runs showed similar results.

Conclusions

The Wanner Engineering Hydra-Cell T100K is an excellent choice for polymer EOR applications. Operators will save money on polymer injection costs due to the reduction of polymer usage via less degradation in the Hydra-Cell pump. They also have the advantage of injecting polymer slugs that match design specifications without having to overdose their solutions, aiding in reduced OPEX and increased reserves.

Operators will see immediate cost savings in operational expenses compared to triplex plunger pump counterparts. Unlike plunger pumps, the Hydra-Cell hydraulically actuated diaphragm pumps do not have packing or seals to repair and replace. The Hydra-Cell's plungers do not contact the process liquid and require no external lubrication, ending the need for lubricating equipment installation and underground lubricant disposal tanks or pump lubricant drains. Additionally, the T Series can run dry without damage if the pump is accidentally starved. Over the course of three years, operators are expected to save more than $40,000 on pump maintenance alone versus a plunger pump.

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About the Author

Vladimir Alvarado is a Professor of Chemical & Petroleum Engineering at the University of Wyoming, College of Engineering and Applied Science in the Department of Petroleum Engineering. His specialization is Enhanced-Oil Recovery, Transport in Porous Media.

Education:
Master in Exploration and Production, IFP School, Paris, France, 2002
Ph.D. Chemical Engineering, University of Minnesota, Minneapolis, MN, 1996
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Summary of Research Activities
Dr. Alvarado's research focuses on Enhanced-Oil Recovery (EOR) activities including screening methods for assisting decision making. A combination of data mining and analytical simulation assists the creation of simplified decision spaces. Monitoring techniques for EOR operations such as time-lapse seismic and tracer tests are another area interest. Uncertainty propagation and upscaling are two pillars of feasibility analysis for monitoring techniques.

Recent ventures include involvement with experimental and modeling initiatives to investigate flow of dispersions (emulsions) through porous media. Observation of flow phenomena (jamming, drop breakup, etc.) in glass pore-throat models helps to formulate single-pore models as well as network models for these flows in porous media.

While current simulation models do not account for some important phenomenology, planned modeling strategies such as Lattice-Boltzmann techniques will hopefully handle several of the most important events at the pore scale. This research focuses on understanding the flow mechanisms for the development of EOR and well-conformance strategies based on dispersions. The ultimate objective of this research is to create robust reservoir simulation models for dispersion flows.

Publications:
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