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AN OVERVIEW OF THE POLYMER GEL TECHNIQUE TO IMPROVE THE EFFICIENCY OF WATER FLOODING INTO OIL RESERVOIRS (WITH INTRODUCTION OF A NEW POLYMER)

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ABSTRACT

An important property of polymer gels is that the injected fluid in the fracture area with high permeability moves and can form a solid mass, in result of water and gas permeability because of the formation of this layer will be decreased. In gel polymer techniques first amount of the polymer solution is injected into the reservoir with a low rate, then the cross link solution such as aluminum or magnesium citrate is injected into the reservoir and gel to be figured. Therefore, improves oil recovery and reduces the percent of water production. This study concerns a light review on gel polymer process and this study introduces a new polymer with superior flooding property to water shut - off, too.

Keywords: *Additional Water Production, Polymer Gels, EOR, PVA*

1. INTRODUCTION

One of the common problems in oil wells is excess of water production compare to oil recovery also, some oil companies in the world normally for each barrel of produced oil, are produced three barrels of water including conventional chemical methods to prevent of the excessive water production in oil and gas wells, polymer gel system today is widely utilized in the world and in the Middle East, and has led to successful results. Today, the polymer gel is one of the most useful ways to reduce water cut [1, 2].Polymer gel systems, cement ratio and mechanical methods use to prepare deeper barriers against excessive water,. Gel system for the injection and production wells is often repeated in order to increase oil and gas production [3]. Recent successes in the field of gel polymers, has attracted the attention of many oil experts. In all instances in which the polymer gel used in oil reservoirs, reduces water production and increase of oil production has been clearly observed. In many cases after a few weeks of using the gel polymer technique, large increase in the yield of oil wells has been observed. Many recent successful examples of technology such as MARCIT for this case have been

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utilized. This system was introduced in mid 1980 by Martin Oil Company. In this method, the dry polymer (carbox late / Acryl amide & Cr) was mixed with water. In 2003, another company named LLC has used a new technology called PROD. This technology is very similar to working MARCIT. Since 2001, 30 operators, about 300 oil wells in Kansas by PROB and MARCIT technologies were tested, and positive results about almost all have been reported. In some of these cases in few days (14 days), oil production has increased from about 5 BOPD to 200 BOPD and water production has declined from 1500 BWPD to 100-200BWPD. In some cases, oil production has increased, but the water production has declined. Productive wells include areas with high permeability, generate large amounts of water [4,5]. The gel is injected into the fracture with high permeability. Profile modification or injection gel under the mechanism which is called Conformance Control, injection will divert water to areas not swept and kept and to promote the production of reservoir. This application not only increases the drawdown from the manufacturer, but the cost of water production reduces or eliminates [6]. Polymer gel systems typically are water soluble polymer and a water soluble Cross-linking agent that they are made. This solution, called gel solution after time, semi-solid gel body becomes like a gel blocking flow diverter or treats. Polymer gel system depends on in reservoir conditions such as temperature, Salinity, hardness and PH [7]. In general, since different chemical and physical methods for reducing the amount of effluent was studied, the most successful and most frequently used method of gel polymers is related to copolymers based on poly acryl amide [8, 9]. Gels are networks of polymer that have property of their vehicle maintenance. They are soft and elastic, which tend to be very active in terms of drought. Infinite molecular weight and cross linked gels are causes the formation of a cross linked three-dimensional network, which is insoluble in the solvent. [10]. the solvent gel networks, water or aqueous solutions are called hydro gel. Hydro gels super absorbent polymer dilute solutions of electrolytes in water or pure water will be a ble to dispose of it in a different context, the absorption process are temperature and PH [11]. The first hydro gel generation with swelling capacity based on Hydroxyl Alkyl Methacrylate monomers was 40-50% in 1950. Although the first report on the production of hydro gel was presented in 1950 [12]. In this investigation we follow to state the main role of polymer gel in oil industry, and we emphasis that with using nano gels, the future of gel polymer techniques could be changed. Basic parameter during gelling process in order to EOR will mention, and to be proposed a polymer with extreme property for this case.

2. DISCUSSION

In general, polymeric gels are a water-soluble polymer gel, network Cross-link agent and solvent (water). When the water-soluble polymer is combined with metal Ion or organic factors as network operating mechanism, the resulting gelant to be produced. An important property of polymer gels is an area with low permeability and fluid into the gap in time as there are solid masses of water and gas permeability, resulting in the formation of these layers will be decreased while the permeability of oil does not change much. Estimated economic costs in

comparison with other methods indicate that the polymer injection costs, including the cost of facilities and equipment is more affordable than other enhanced oil recovery methods. it is expect one tones of polymer can recover up to 600 tons of additional oil (15%). Polymer solution is injected into the heterogeneity reservoir with permeability of 20 mm Darcy or more. Each region of permeability in reservoirs with high permeability zone varies flow with the span oil wells and displaced streams water or gas to the mouth of the well. To reduce the impact of this problem can be found in areas with higher permeability, the changes to be applied [13]. First amount of the polymer solution is injected into the reservoir to speed up the absorption of the polymer solution in layer of the sand Polymer partly within the reservoir rock and the mass transfer inside the reservoir causes; A layer of polymer absorption to solid substrate is sand reservoir which causes Properties of reservoir rocks than those who change their own oil EOR was one of the important parameters Be changed, and this causes the polymer adsorption. Amount of residual oil trapped in sand and hard substrate wettability properties of displacement due to be released. Cross-link such as aluminum or magnesium citrate solution is injected, so that to be attracted the polymer solution into the reservoir and is formed a Cross-link polymer matrix. This matrix made in the reservoir, causes some changes in the structures of solid sand layers and passing direction of fluid water flood in the fracture of reservoir is narrowed. Now that non-uniformity of reservoir structure, in some extent, has improved, its mobility by injection of natural gas or water in the reservoir has been decreased in order to sweep crude oil relocation, further percent of oil can be recovered by reducing oil viscosity. [14]

2-1 Polymer gel proceeds

Polymers begin the reaction with connection factors after injection in formation and translocation in that position and become gelatin state. At first gelatin process is considered as follows:

$$K(P)_{aq} + L(X)_{aq} \leftrightarrow (G)_{aq} \quad .$$

In this equation P, X and G (in order of their places) are represent of the polymer connection factor . aq subtitle shows that P, X and G are all in water solutions. K and L are stochiometrically parameters of gelatin reaction. After injection fluid, fluid moves from directions and holes that have more permeability and plug that place. As a result directions with high permeability that water can reach itself to production well interval have been plugged and water is forced to find its direction through the zone with low permeability to the well way and consequently conning water will be delayed. It is needed to know that gel injection must be done properly. According to the situation and purpose of gel injection, a distance from the well that its permeability must be decreased, will be different. Sometimes it's needed to be injected to a distance and often just in some meters around the well, injection process is done. In the fracture reservoir, gel injection must be done until longer depth and distances.

2-2 Advantage of gel polymer system in connection with other methods

Gel is simply made by adding solutions and chemical connection factors to polymer hydrous solutions. To some extent, gel is cheap because 70-80 percent of them consist of water with chemical brackets with low prices. Presented reports from the use of gel injection in the oil zones indicated that this system is not harmful for the environment and in relation to reservoir rock is insensitive and is suitable with all equipments and reservoir materials. Polymer is injected like a solution and it can penetrate in the reservoir and reduce permeability near the well bore. Injected solution can move towards well bore up and down. Gel comes out from the well by water injection or conventional acid in spiral tubes and in this way the well becomes clean. According to the experimental studies, high resistivity and suitable benefit in gel injection connection is expected. Gel polymer system can make a permanent non-permeable wall in the reservoir matrix and upwards WOC and in the well bore area so that it prevents vertical movement.

2-3 -Characteristics of using gel polymer in preventing water lose

As it was said, gels are 3 dimensional polymer grids that in common grouping of material state (solid, fluid, gas) must put them in semi-solid grouping. These polymers with high elastic grade consist of water from to 98 to 99 percent that have been trapped by polymer grade in their 3 dimension structure. As it was mentioned above, different polymer system have been developed that can use them to prevent and control water penetration to production well and unwanted production. But what becomes important in polymer solution injection and doing gelling reaction are rheological and mechanical characteristic, temperature and is salty (the value of ions gel PH and is chemical and thermal stability in different situation in reservoir) that must keep its stability for a long time what comes next that gels properties are examined under different reservoir situation.

2-4 -Rheological characteristic

Gels are very elastic and their rheological properties in relation to polymer solutions that are made of them are very different. By examining viscometer behavior of previous and next polymer solution from gelling process, it is observed that in zero shear rate, there is some remaining tension or yield stress like Bingham plastic for provided gels form poly acryl amide with width physical connection of chromium ion. It is also observed that viscometer behavior depends on shear environment that gel is made in it (porous media). Gels that are made in low shear rates are viscometer, from gels that are existed under high shear rates. Any way gels structure is destroyed under produced tension. [15]

2-5- Gelling time

To put gel in its place in reservoir for water plugging loss, gelling system must provide enough time before gelling reaction so that penetration in matrix reservoir could be done. In a state that the purpose is water plugging , penetration near the well bore, gelling time does not make a limitation in that work but at the time when it is needed that water plug operation from radius type or crossover flow

plug between heterogeneous layers long , depth (over 4000 meters) to be done. Gelling time is the only salient operation characteristic for the operator person or researcher. As fig.1shown gelatin time is strongly depended on temperature, and in Arnius equation and determination of activation energy can be guessed gelatin time will be changed with temperature. Polymer density has many effects on gelling time in polymer solution. Gelling time reduces by increasing polymer in polymer solution. Furthermore mechanical gel strength increases by increasing effective width connection in grid and can produce a strong gel. In equation,

$$t_{hr} = 10^{-7} e^{\frac{111000}{RT}}$$

R is gas constant, equivalent (0.0987cal/g mol) and T is absolute temperature in terms of Kelvin. As it is observed in above equation increase of every ten degree in reservoir temperature causes that gelling time divide in to half.

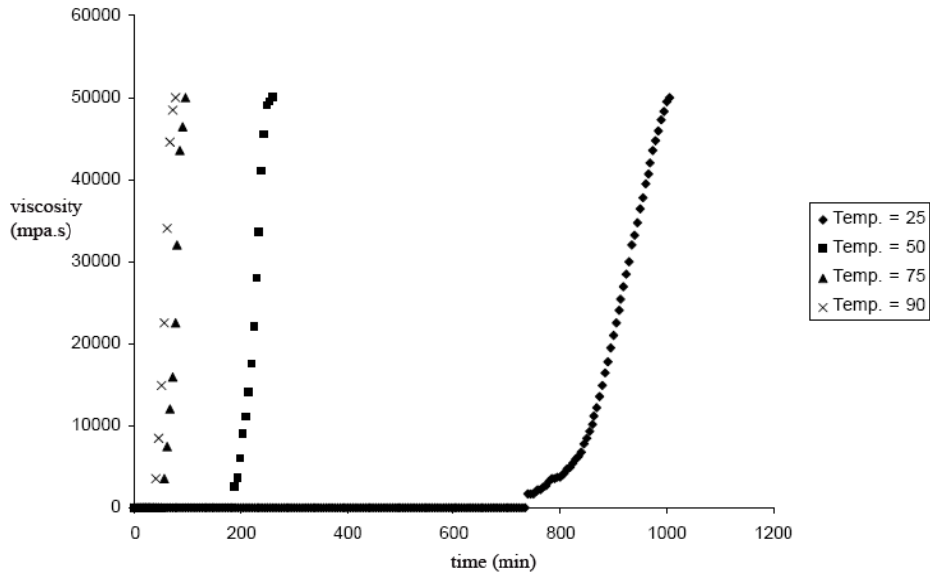

Fig.1. Effect of temperature on the gelatin behavior [16]

2-6 Gelling behavior

Environment temperature increase and width connectors density are the most important factors that affect on gelatin time. Furthermore some other parameters affect on gelatin time. Losing gels water against increasing incoming pressure on them and increasing shear stress may lose its water like waste state. Of course the results show that increasing of incoming pressure gradient on gel causes losing water in gel but it doesn't have many effects on gall duty as water penetration plug and accordingly prevents water loss. What is important in these results? Is gel injection that is ready to be sent into production well? In this state, stress increase (with increase of injection rate) causes losing water and gelling time will be decreased with. Therefore it's usually suggested that some holes are filled

by prepared gel in some places, that there is not gel washing risk, by injection rate decrease and losing water decrease gels influence or penetration increase into holes in this state, and then a strong gel is produced by injection rate decrease and losing water increase in the gel near the well or somewhere that injection is finished so that it prevents washing risk by water.

2-7 Residues

Gels generally show residue's tension and transformation in relation to the time. This residue's tension causes gel transformation and volume water loss. Consequently trapped water in the gel exit from it and although gel produces more mechanical strength, its water loss plug makes water loss difficult. Of course, the results show that (holes measurements are not big in reservoir matrix) gel shrinkage or water loss doesn't have any effects on water plug decrease. But anyway this issue must be taken in to consideration. Therefore a gel is called mechanical stable that shows the least residue's value against PH temperature changes and it salty or being water reservoir.

3- POLYVINYL ALCOHOL (PVA)

PVA is a water soluble hydrophilic polymer and is the largest volume synthetic resin produced in the world [16]. Excellent chemical resistance, physical properties, and biodegradability lead to the development of so much produced based on this polymer. PVA is used as an emulsifier and as a stabilizer for colloidal suspensions as a sizing coating in the textile and paper industries and as an adhesive too. The degree of hydrolysis influences the polymer behavior in the solution. The viscosity of solution, surface tension and other properties can be related to the degree of hydrolysis.

3-1 Laboratory measurement procedure

To investigate the effect of salinity and temperature on this polymer solution, a number of experiments in different conditions were conducted. First, Polyvinyl Alcohol with the degree of hydrolysis of 87% and degree of polymerization 1700 was prepared in Sina Company, Arak petrochemical. Then, solution was made in different concentrations, and the viscosity of each solution was measured accurately in the same condition. In next step, NaCl with different concentrations was added to solution in order to make a solution with required salinity.

3-2 Results and Discussions

3-2-1 Effect of salinity and temperature on PVA solution

As expected, experimental results confirmed that with adding NaCl to PVA solution, its viscosity not only decreases with increasing salinity, but increases and therefore, this polymer will be stabile at high salinity. It is significantly important that PVA is not decomposed at high concentrations of NaCl. Maximum viscosity has been observed at 1.2 wt% NaCl. Therefore, in oil reservoirs with high salinity, this polymer could act as water shut off and it can be used. Figure (2) illustrates the viscosity of PVA NaCl solution in different concentrations. To

evaluate the effect of temperature on PVA polymer solution, some other experiments were done. In this case, PVA solution in various concentrations was prepared and the solution was heated up to 482 ^{0} F, and it was observed that PVA solution could sustain temperature up to 482 ^{0} F without missing its property and our experiments indicated that this polymer is stable at high temperatures, confirming previous study showing thermal decomposition of PVA takes place at temperature above 480 ^{0} F. The same was done for HPAM solution and it was observed that thermal decomposition of HPAM takes place above 250 ^{0} F.

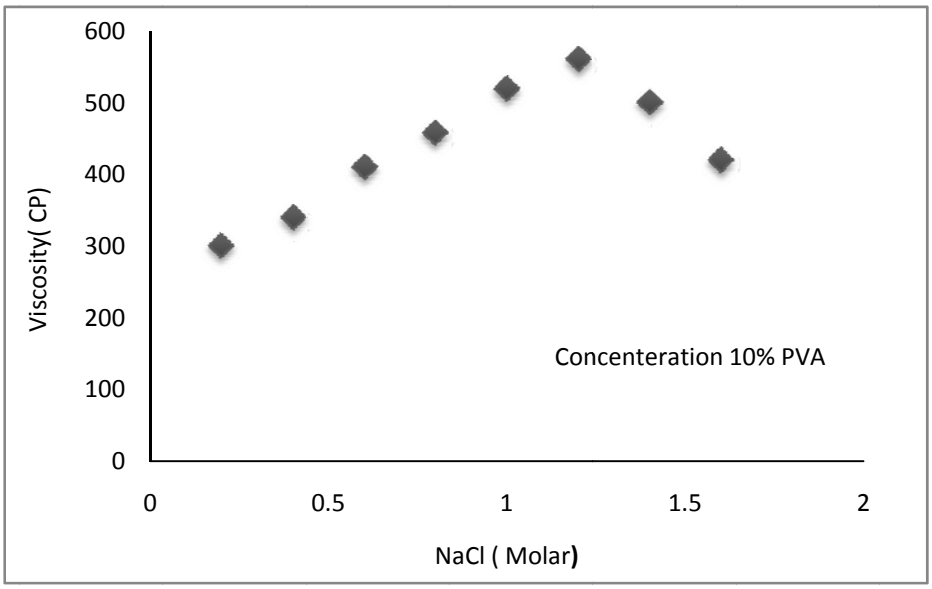

Fig.2. Effect of NaCl additions on viscosity of PVA solution.

4- CONCLUSIONS

In this review study various parameter in relation to gel polymer in EOR process have been expressed and as mentioned , gel polymer play an important role in EOR , and with structural changes that during water flooding in reservoir provides can complete the water flooding process by reduce of the injected water permeability . Our estimates shows that oil exploitation can reach to 50 percent of primary oil from calcareous reservoirs by using gel polymer. In this study a polymer with superior flooding to gel polymer in EOR process has been introduced and we strongly believe that Polyvinyl Alcohol (PVA), as a gel polymer, would be stable in extreme conditions of high salinity and high temperature (above 480 ^{0} F) therefore, it can be used for reservoirs with high salinity and temperature.

Abbreviations

EOR: Enhanced Oil Recovery
BOPD: Barrels of Oil Per Day
BWPD: Barrels of Water Per Day
PVA: Poly Vinyl Alcohol
HPAM: Hydrolyzed Poly Acryl Amid

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