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The Possibility of Enhanced Oil Recovery by Using Magnetic Water Flooding

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One of the most important challenges in heavy oil reservoirs is the enhancement of oil recovery. In the last two decades, a new technology, called magnetic water technology, has been used in different industries such as concrete. In this technology, by passing water through a magnetic field, some of its physical properties change. In this research, the effects of magnetic water on enhanced oil recovery (EOR) have been studied. A magnetic treatment device was used for the production of magnetic water. Three tests were taken with normal water, weak magnetic water, and strong magnetic water. The results of the experiments showed that the breakthrough event will shorten with an increasing level of magnetism in water. Although the total recovery is approximately the same, it can be concluded that EOR has a reverse relation with the amount of magnetism in water.

Keywords: enhanced oil recovery, magnetic treatment device, magnetic water, water flooding

1. INTRODUCTION

The effects of magnetic fields on water were discovered in the early 1900s by Danish physicist Hendrick Antoon Lorenz. He received the Nobel Prize in 1902 for his discovery of the effects of magnetic fields on water (Gehr et al., 1995). This technique consists of exposing water to a magnetic field. The changes in the structure of water when exposed a magnetic field are important in various applications. For instance, it has been reported that water gives rise to many phenomena when it is magnetized, such as an increase in the compressive strength of concrete (Su and Fang, 2003; Botello-Zubiate, 2004; Fathi et al., 2006; Alimi et al., 2009; Afshin et al., 2010), in the precipitation process of calcium carbonate (Kney and Parsons, 2006), and reduction of the corrosion rate of steel (Bikul'chyus et al., 2003).

The change in various physical properties of water in applied magnetic fields has been reported. Ghauri and Ansari (2006) investigated the effect of an applied magnetic field on water viscosity between 298 and 323 K. A higher absolute viscosity has been observed in the presence of applied magnetic field, which has been explained on the basis of stronger hydrogen bonds(Ghauri and Ansari, 2006). Kitazawa et al. (2001) reported an enhanced water vaporization rate and an enhanced oxygen gas dissolution rate into water after the magnetization process.

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Toledo et al. (2008) examined the effect of a static apparent magnetic field, which indirectly calculated on liquid water. The results showed that the viscosity increased when the water was submitted to the magnetic treatment. The same tendency was observed for surface tension and enthalpy. They concluded that an increase in these physical and chemical properties means an increase in the molecular interactions (Toledo et al., 2008).

Amiri and Dadkhah (2006) showed that the surface tension of water approaches a certain value after a few treatment cycles. This trend of surface tension to become constant after treatment in magnetic fields was also reported by other researchers (Cho and Lee, 2005).

Pang and Deng (2008) also studied the influence of a magnetic field on the microscopic structures and macroscopic properties of water. They showed that the magnetic fields increase the soaking degree and hydrophobic property of water, depress its surface tension ability, diminish the viscosity of water, enhance the plastic flow of water, and increase the refraction index, dielectric constant, and electric conductivity of water after magnetization.

2. EXPERIMENTAL SETUP

An enhanced oil recovery system was used to measure the oil recovery as shown in Figure 1. The accumulators and core holder were put in an oven to simulate the reservoir temperature. The postulating fluid was injected to the core plug by means of a high-performance liquid chromatography pump after selecting the appropriate valve. First, the core was saturated with brine and then the reservoir oil was injected into the core. Thereby, the core was prepared for water flooding. Three tests were made with normal water, weak magnetic water, and strong magnetic water.

3. RESULTS AND DISCUSSION

Figure 2 shows the recovery values of normal and magnetic waters. This curve indicates the recovery percentage vs. pore volume of injected water. The breakthrough for the normal water occurred 69 min after the start of the test; the breakthrough time for the weak magnetic water and strong magnetic water was reduced to 66 and 55 min, respectively.

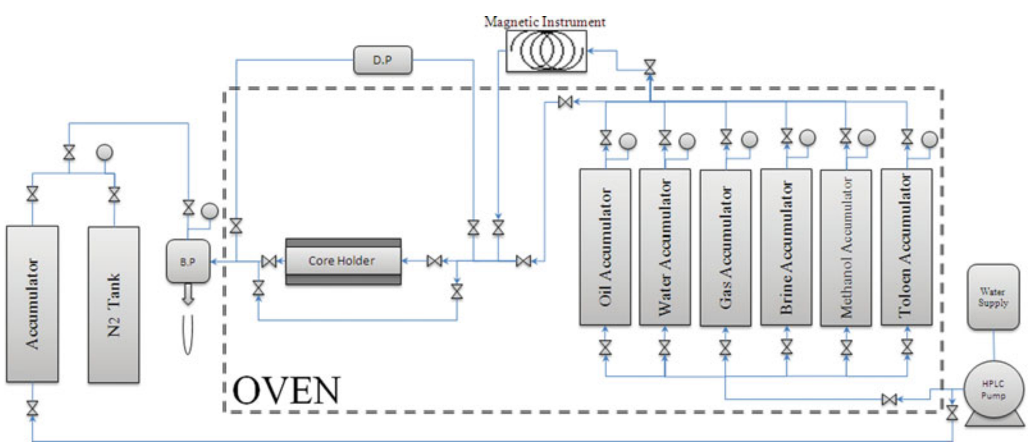

FIGURE 1 Experimental setup.

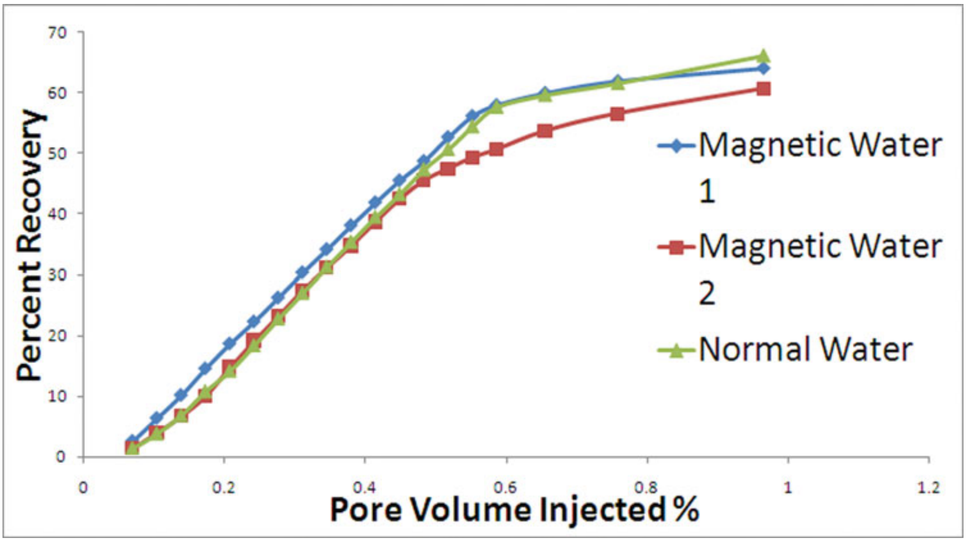

FIGURE 2 Recovery values of normal and magnetic waters.

The recovery amounts of magnetic water were lower than that of normal water. The total recovery for normal water, weak magnetic water, and strong magnetic water was 43.6, 42.2, and 40%, respectively. Despite the existence of a small decline in the amount of total recovery, they are all in the same range. The effect of a magnetic field on the water that causes water to pass thorough porous media should be investigated.

The reason for this phenomenon can be explained as follows:

1. Viscosity reduction of magnetic water. Pang and Deng and Toledo et al. highlighted the reduction of water viscosity as a result of magnetic field (Pang and Deng, 2008; Toledo et al., 2009). The mobility ratio is defined as permeability divided by viscosity. Therefore, viscosity has an inverse effect on the mobility ratio. Thus, the mobility ratio of magnetic water is greater than that of normal water and results in earlier breakthrough.
2. Change in the molecular arrangement in magnetic water. Toledo et al. (2009) showed that an external electric field reduces the cluster sizes. In the other words, the number of molecules in the water clusters decreases from 13 to 5 or 6. It increases the activity of the water molecules and may prompt the influence of water in porous media at a microscopic level and cause the observed event.
3. The reduction in surface tension of magnetic water has reported by many researchers. Cho and Lee (2005) highlighted that the surface tension of the treated water was reduced by approximately 8% compared to that of the no-treatment case. Amiri and Dadkhah (2006) showed that the surface tension of water decreases to a certain value after a few treatment cycles. Decreasing the surface tension of magnetic water can affect the bulk flow of water and result in earlier breakthrough.

4. CONCLUSION

1. The breakthrough for normal water, weak magnetic water, and strong magnetic water occurred at 69, 66, and 55 min, respectively.

2. The total recovery for normal water, weak magnetic water, and strong magnetic water was 43.6, 42.2, and 40%, respectively, which are all within the same range.
3. It can be concluded that by improving the level of magnetism in water, the fingering phenomena will take place faster.
4. The experiments show that the change in water properties under a magnetic field does not cause a meaningful effect on the enhanced oil recovery (EOR) process.

5. RECOMMENDATIONS

1. Due to the reduction in water cluster sizes in a magnetic field, increasing the activity of magnetic water has improved. In this article we observed a greater influence of magnetic water in porous media with respect to normal water. Therefore, it is highly recommended to study effects of this phenomena on acidizing.
2. Corresponding to acceptable conclusion in magnetic concrete research, it is recommended that these experiments be performed in well cementing.
3. In spite of petroleum, water is a polar liquid. Therefore, the use of magnetic technology in separator units for more efficiency should be studied.
4. The effect of magnetic water on drilling mud should be investigated.
5. Changes in water due to the application of a magnetic field is still controversial, because the reported results have low reproducibility. However, it does have applications in low-permeability reservoirs and changing the reservoir rock wettability and can be used in combination with other EOR methods.

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REFERENCES

Afshin, H., Gholizadeh, M., and Khorshidi, N. (2010). Improving mechanical properties of high strength concrete by magnetic water technology. *Scientia Iranica*. 17:74–79.

Alimi, F., Tlili, M. M., Ben Amor, M., Maurin, G., and Gabrielli, C. (2009). Effect of magnetic water treatment on calcium carbonate precipitation: Influence of the pipe material. *Chem. Eng. Process*. 48:1327–1332.

Amiri, M., and Dadkhah, A. (2006). On reduction in the surface tension of water due to magnetic treatment. *Colloid. Surface. Physicochem. Eng. Aspect*. 278:252–255.

Bikul'chyus, G., Ruchinskene, A., and Dennis, V. (2003). Corrosion behavior of low-carbon steel in tap water treated with permanent magnetic field. *Protect. Met*. 39:443–447.

Botello-Zubiate, M. (2004). Influence of magnetic water treatment on the calcium carbonate phase formation and the electrochemical corrosion behavior of carbon steel. *J. Alloy. Comp*. 369:256–259.

Cho, Y., and Lee, S. (2005). Reduction in the surface tension of water due to physical water treatment for fouling control in heat exchangers. *Int. Comm. Heat Mass Transfer.* 32:1–9.

Fathi, A., Mohamed, T., Claude, G., Maurin, G., and Mohamed, B. A. (2006). Effect of a magnetic water treatment on homogeneous and heterogeneous precipitation of calcium carbonate. *Water Res*. 40:1941–1950.

Gehr, R., Zhai, Z. A., Finch, J. A., and Rao, S. R. (1995). Reduction of soluble mineral concentrations in $CaSO_4$ saturated water using a magnetic field. *Water Res*. 29:933–940.

Ghauri, S. A., and Ansari, M. S. (2006). Increase of water viscosity under the influence of magnetic field. *J. Appl. Phys.* 100: 066101-2.

Kitazawa, K., Ikezoe, Y., Uetake, H., and Hirota, N. (2001). Magnetic field effects on water, air and powders. *Phys. B Condens. Matter.* 294–295:709–714.

Kney, A. D., and Parsons, S. A. (2006). A spectrophotometer-based study of magnetic water treatment: Assessment of ionic vs. surface mechanisms. *Water Res.* 40:517–524.

Pang, X., and Deng, B. (2008). The changes of macroscopic features and microscopic structures of water under influence of magnetic field. *Phys. B Condens. Matter.* 403:3571–3577.

Su, N., and Fang, W. C. (2003). Effect of magnetic field treated water on mortar and concrete containing fly ash. *Cement Concr. Compos.* 25:681–688.

Toledo, E. J. L., Custodio, R., and Ramalho, T. C. (2009). Electrical field effects on dipole moment, structure and energetic of $(H_2O)n$ cluster. *J. Mol. Struct.* 915:170–177.

Toledo, E. J. L., Ramalho, T. C., et al. (2008). Influence of magnetic field on physical–chemical properties of the liquid water: Insights from experimental and theoretical models. *J. Mol. Struct.* 888:409–415.