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Study the Effect of Fluid Flow Velocity on Sediment Removal from Formation Water using the Magnetic Method

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Abstract: Oil and gas are major energy sources that continue to maintain their strategic importance in meeting the needs of life and industry, despite the availability of other energy alternatives. With growing global demand and declining proven reserves, there is a need to enhance the production efficiency of discovered fields. Among the newly adopted methods for increasing production and improving operational performance is the use of stratified water injection, which aims to maintain stratified pressure and reduce the environmental impacts resulting from associated water. However, this method faces operational challenges, most notably the accumulation of sediments within injection systems, leading to a decrease in operational efficiency. Techniques for treating these sediments vary between mechanical, chemical, and magnetic. This study focused on the use of magnetic technology due to its high efficiency, low operating costs, and flexibility compared to other methods. A laboratory study was conducted using a water model taken from an Iraqi field to evaluate the effect of fluid velocity on electrical conductivity, an indirect indicator of sediment removal effectiveness. The results demonstrated the ability of magnetic treatment to effectively reduce sedimentation under specific operating conditions, enhancing its potential for application in field settings as an economical and practical solution.

Keywords: Magnetic method; Permanent magnet; Injection systems; Sedimentation; Deposits.

1. Introduction

Oil is extracted from wells in most countries of the world using mechanical production methods, which are the most common method in production wells. This is accompanied by a quantity of gases and formation water in addition to amounts of impurities and solid sediments.Before the oil is pumped to export locations, refineries, and consumption locations, it must be processed to ensure it is ready for refining and consumption and meets the required global commercial specifications[1].The source and quality of the water are important considerations when planning a water injection project to increase oil production[2]. The basic requirements for water injection in the formation, after achieving the application requirements for this method and taking into account design factors, include the availability of sufficient water during the life of the injection project. The amount of water required for an injection project varies depending on the type of project to be implemented. In general, total water requirements range between 150-170% of the pore volume of the layer into which the injection is to be carried out[3]. Since the produced and return water are reinjected, the amount of water required for injection is approximately 50% of the pore volume of the oil reservoir, free of undissolved solids or suspended matter[4]. Its chemical stability and relative inactivity with the compounds and elements present in the injection system are also factors that must be taken into account when designing and implementing injection processes. Sedimentation in injection systems is a significant problem that directly impacts formation water injection processes[5],[6]. Several methods are available to remove it, including mechanical, chemical, magnetic, and other methods.The magnetic method is considered one of the most important of these methods due to its ease of use and low cost. This method relies on the principle of combating salt deposits by passing stratified water through a magnetic field of appropriate intensity[7],[8]. The magnetic field affects the water passing through it, ionizing the ions, meaning it charges some molecules positively (such as calcium (Ca) and magnesium (Mg)) and others negatively (such as carbonates and sulfates).Precipitation generally occurs as a result of the movement of positive and negative ions toward each other at increasing speeds[9],[10]. This results in an increase in the number of collisions between the ions, resulting in the formation of undissolved (precipitated) particles. When this water is exposed to a magnetic field, the magnetic field exerts a powerful influence on the water, affecting the identity of the liquid[11],[12]. The magnetic field not only ionizes the ions, but also directs the positive ions along a specific path and the negative ions along another specific path, preventing the positive and negative ions from meeting each other and thus preventing their precipitation.

2. Materials and Methods

The methodology of this study included evaluating the effectiveness of magnetic treatment in reducing sedimentation within stratified water injection systems. This was achieved through laboratory experiments that measured the effect of fluid velocity on electrical conductivity as a key indicator of sediment removal effectiveness. Water samples were used to simulate actual operating conditions, with both direct as shown in Figure (1) and indirect magnetic treatment techniques applied as shown in Figures (2), (3), and (4). In the direct method, the magnet was installed inside the fluid flow tube, while indirect methods included three main types: the use of a permanent magnet surrounding the tube, an external electromagnet, and the application of an electric field to the flowing fluid. Data were collected from electrical conductivity measurements before and after passing through the magnetic system, with different fluid flow velocities recorded to analyze the relationship between velocity and sediment removal effectiveness. This method aims to identify the optimal operating conditions that achieve the highest efficiency of magnetic treatment, contributing to the provision of economical and effective solutions to address sedimentation problems in stratified water injection systems in field environments.

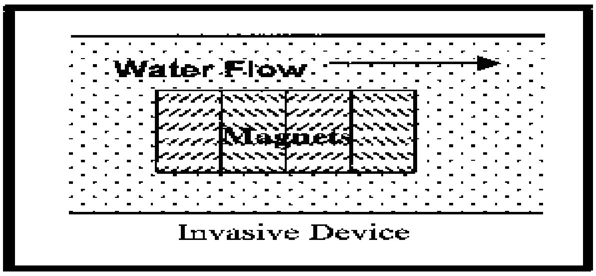

Figure 1. Direct form of applying magnetic technology.

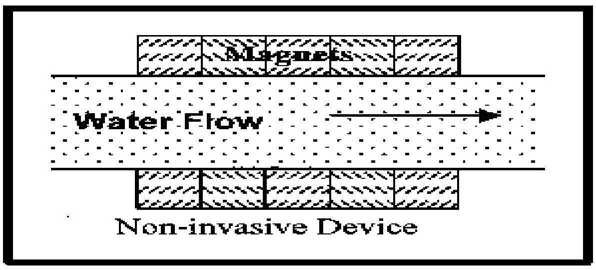

Figure 2. Permanent magnet.

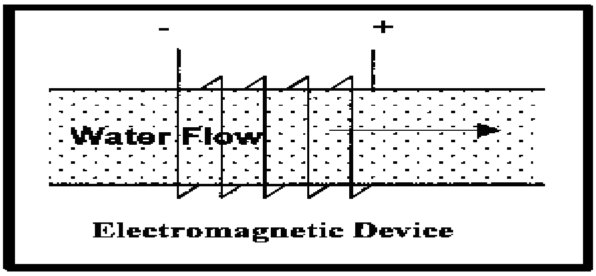

Figure 3. Electromagnet type.

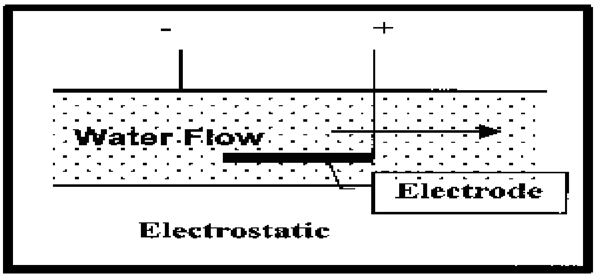

Figure 4. Application of an electric field to water.

3. Results and Discussion

The laboratory study was conducted in an Iraqi producing field using mechanically and autonomously produced wells. The produced fluids are transported to sub-collection stations for production measurement and then treated at the main stations before being pumped to the treatment unit. Stratified water samples were collected from the pump discharge line at the injection unit and subjected to chemical analyses as illustrated in Table (1). The analyses included measuring the concentrations of basic ions such as chloride, sulfate, calcium, and magnesium, in addition to hydrocarbons and trace metals. The study aimed to evaluate the effect of fluid flow velocity on the effectiveness of magnetic technology in removing sediments under different operating conditions in terms of temperature and magnetic field strength. The results showed that changing flow velocity significantly affects the efficiency of magnetic treatment, indicating the importance of controlling operational conditions to achieve optimal performance of this technology as shown the relathinships in Figures (5), (6), and (7).

Table 1. Results of chemical analysis of formation water.

ION	mg/l
Cl^-	9688
Co_3^{--}	-
HCO_3^-	523
SO_4^{--}	758
NO_3^-	148
Ca^{++}	1398
Mg^{++}	374
Na^+ and k^+	4503
Fe^{++} and Fe^{+++}	0.28

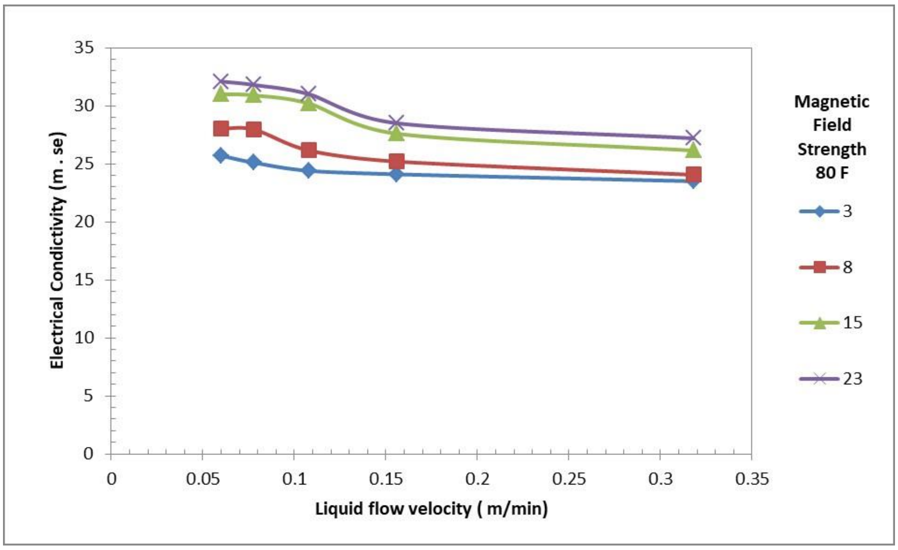

Figure 5. The effect of flow velocities on the electrical conductivity of formation water at different magnetic strengths and temperature 80 ˚F.

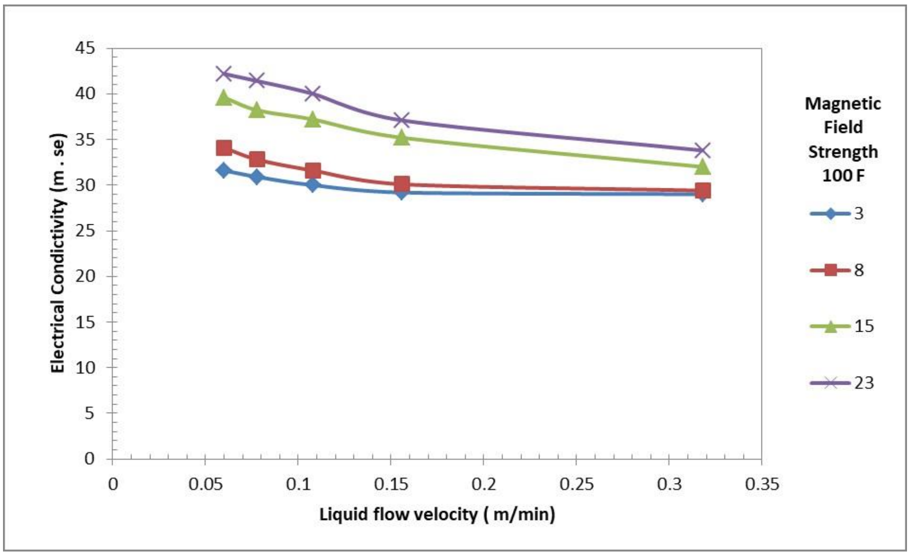

Figure 6. Effect of flow velocities on the electrical conductivity of formation water at different magnetic strengths and temperature 100 ˚F.

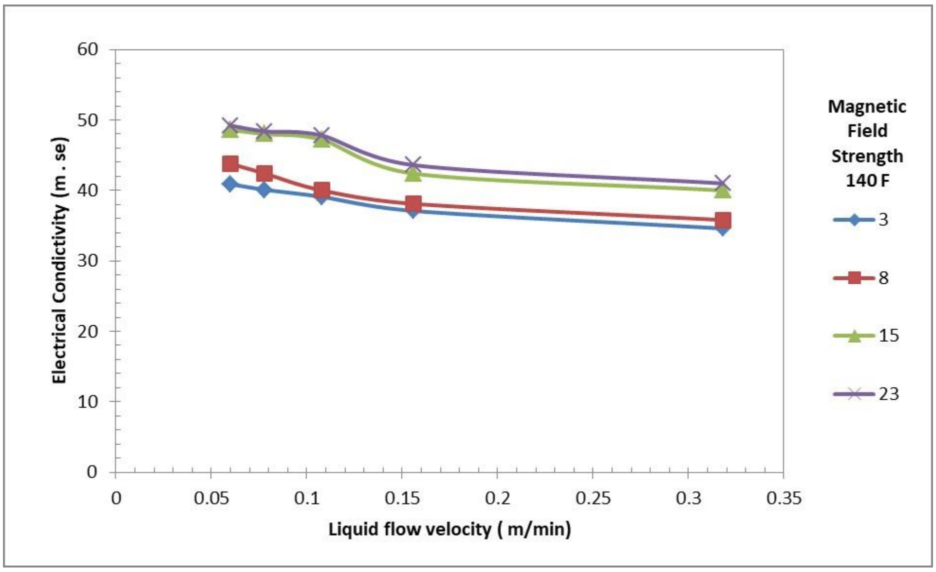

Figure 7. Effect of flow velocities on the electrical conductivity of formation water at different magnetic strengths and temperature 140 ˚F.

4. Conclusions

Laboratory results demonstrate that the magnetic method is effective in preventing deposits on the walls of the reservoir water injection system equipment. The electrical conductivity of water increases with increasing magnetic field strength at a given flow velocity, and this conductivity is proportional to temperature and magnetic field strength, especially at 23 mT. The technical suitability of the magnetic method lies in its effectiveness in preventing deposits at high flow velocities and in maintaining the fluid's magnetic properties for a reasonable period, reducing the need for additional magnetic devices. This method also improves water properties, contributing to enhanced oil production. The effectiveness of the magnetic method can also be controlled by the magnetic field strength, exposure time, and reservoir water temperature. It has been shown that the method's effectiveness increases with increasing magnetic field strength and exposure time, and water temperature also has a positive effect on increasing effectiveness. From an economic perspective, the magnetic method is relatively low-cost compared to other methods, making it a suitable choice for field applications.

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