



Pore Scale Experimental Investigation of Increasing the Efficiency of Miscible Injection of Normal Heptane and Hexane in Heavy Oil Fractured Reservoirs Using Ultrasonic Wave Technology (6150)

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Abstract

In this work we investigated the effect of ultrasonic radiation on miscible injection process in fractured reservoirs and also we studied the effect of fractures orientation and length on front propagation and ultimate recovery of this process. The effect of the molecular weight of injected fluid is another subject that studied in this work. In conclusion ultrasonic waves in all of cases causes the increment in ultimate recovery, it also results that the lower molecular weight can be cause greater recovery.

Introduction

Several methods are introduced to implement the enhancement of oil recovery values in the reservoirs. Miscible flooding is also one of these methods in which the main purpose is to overcome capillary forces prevailing in porous media which is the cause of oil droplets trapping.

Observations on the improved recovery of oil after earthquakes [3] have led researchers to focus on any type of sonic waves as an improved recovery tool. Investigation on how elastic waves impact oil recovery has been performed for decades mostly through experimental works on rocks with a focus on oil recovery-based results.[1]

Deformation of pore walls and alteration the radius of pores by ultrasonic waves are two concepts that proposed by Ganiev et al.(1989) to be responsible for increasing the recovery in presence of ultrasonic waves.

Naderi et al. (2011) focused on the pore-scale process to identify the parameters controlling the process and to clarify the physics of the process visually when ultrasonic energy is applied. In this regard, Micromodel is the best way. Micromodel is a small scale artificial model of porous medium which is known as a novel approach for simulating flow and transport in porous media. This provides insight to the pore scale interplay of various aspects of transport phenomena.[2]

In this work, three different porous mediums including one conventional and two other fractured, simulated by glass type micromodel are used. Heptane and Hexane are also used as the miscible fluids, and the process of miscible injection flooding is investigated in presence and absence of ultrasonic waves.

Experimental

• Micromodels

As it mentioned the transparent micromodels are used for flow visualization and simulation of two phase flow in pore scale. In this work six different micromodels were used as the porous medium. Physical and hydraulic properties of micromodels are shown in Table 1. Also a photograph of porous area of the micromodels is shown in Figure 1.

• Test Procedure

The micromodel was cleaned by toluene and water and then heated in an oven at 120°C for 6 hours to remove any organic material left from the last test. Then the model is saturated with oil. Inlet of micromodel is connected to a programmable Quizix pump to inject the miscible fluid with constant flow rate. The unit was then immersed in a bath filled with water to make a suitable environment for ultrasonic application. A camera with a proper lens was focused at pore scale and the images sent to PC for analysis.

The injection rate of miscible fluids is 0.0008 and the images were analysed by image processing softwares such as Photoshop.

Ultrasonic cases, a generator which is able to produce ultrasonic waves at 25 kHz, was used. A schematic of the setup is shown in Figure 2.

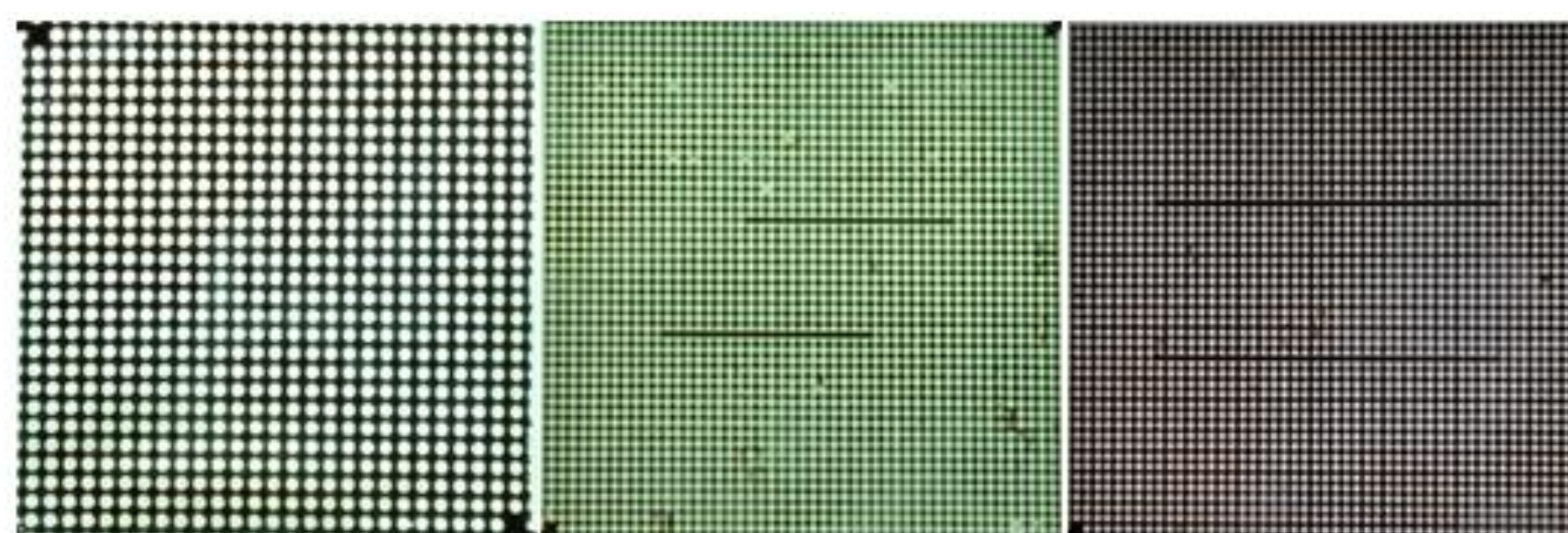


Fig.1. Micromodels Saturated with Oil from right to left(a, b, c)

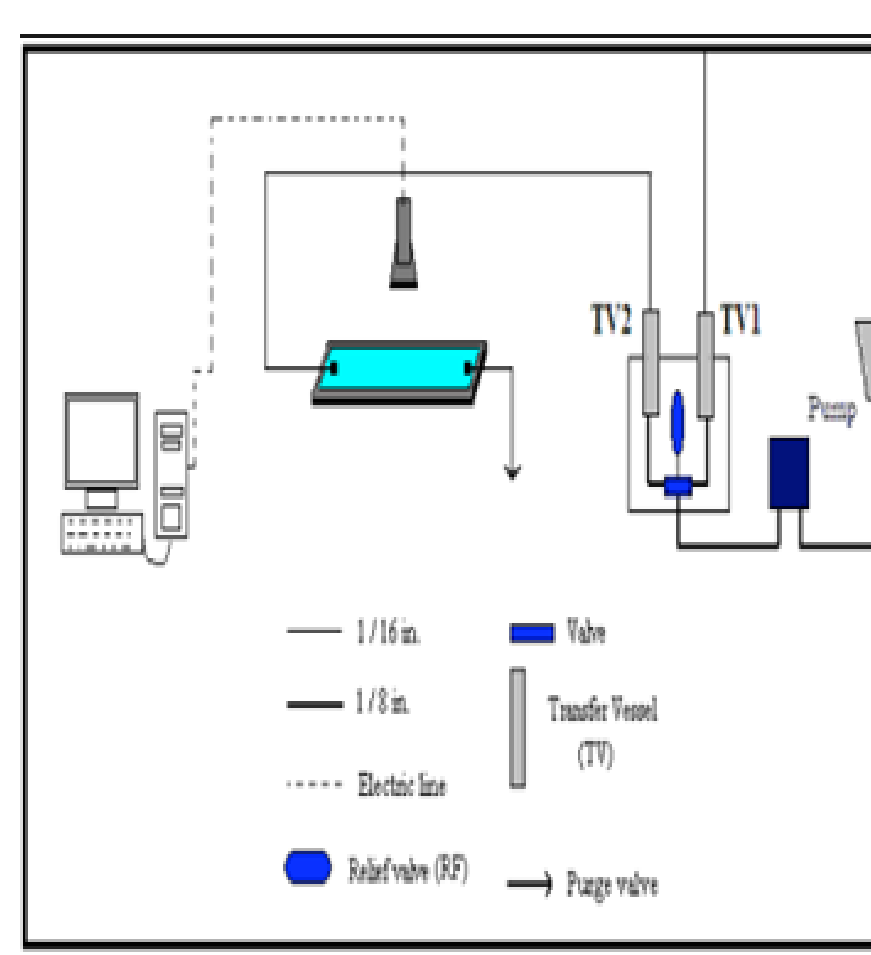


Fig.2. Schematic of Micromodel Setup

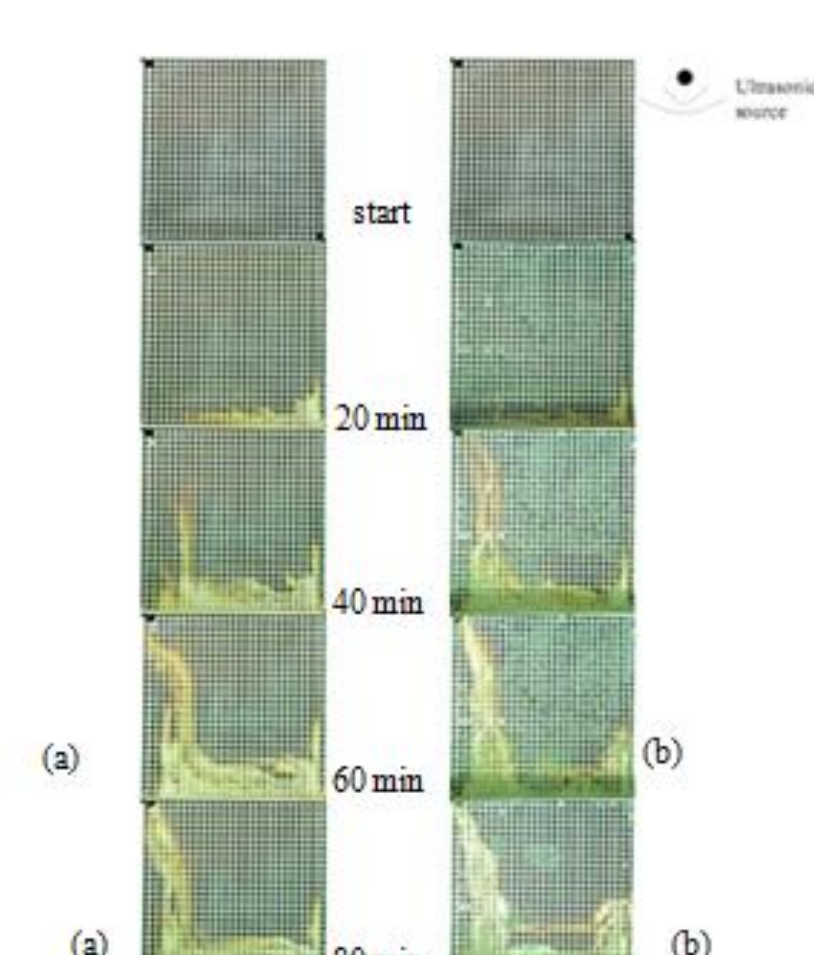


Fig.3. Injection of Heptane in homogeneous micromodel, a(absence of ultrasonic waves),b(presence of ultrasonic waves)

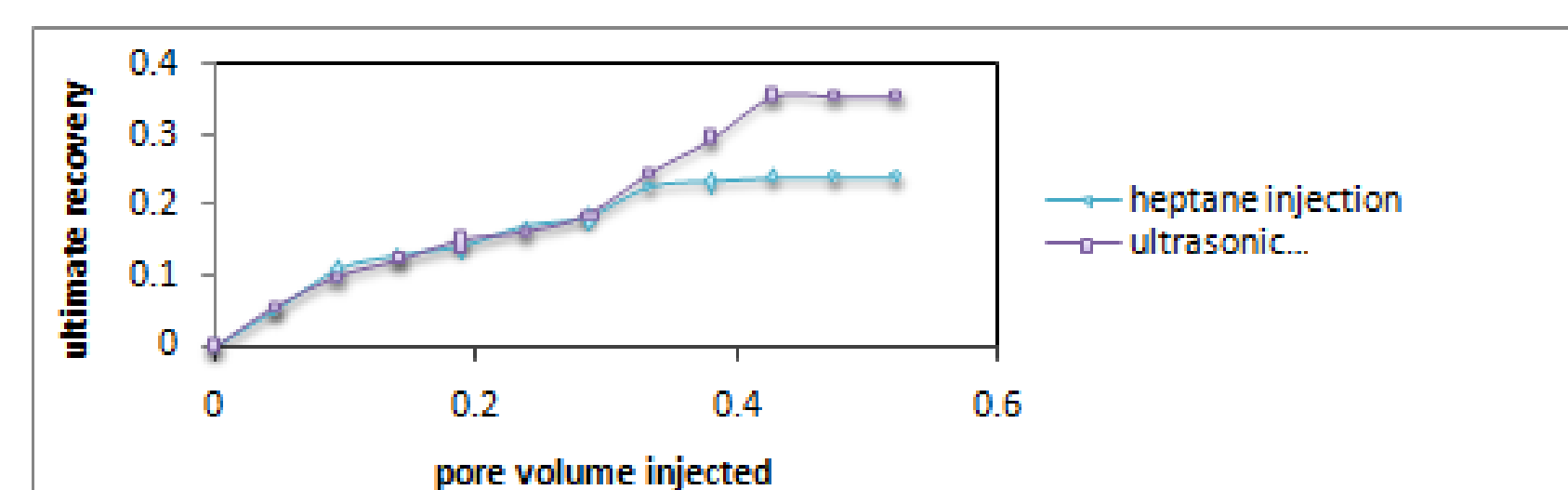


Fig.4. Effect of Ultrasonic Radiation on the Ultimate Recovery (heptane injection, model a)

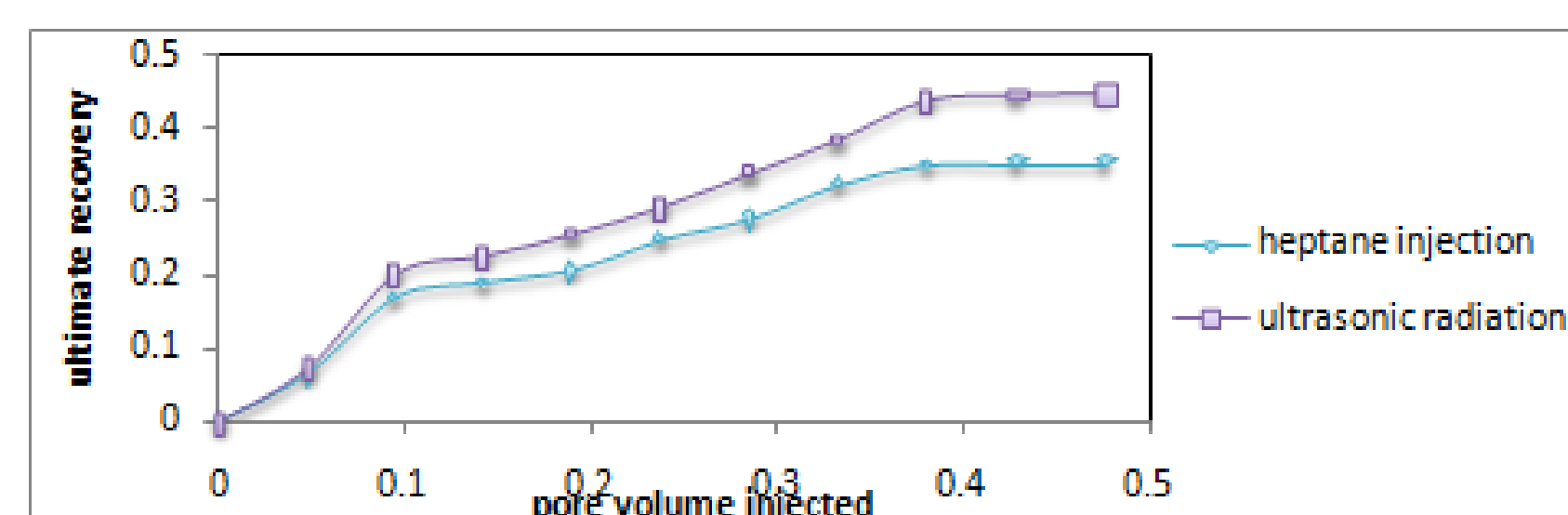


Fig.5. Effect of Ultrasonic Radiation on the Ultimate Recovery (heptane injection, model b)

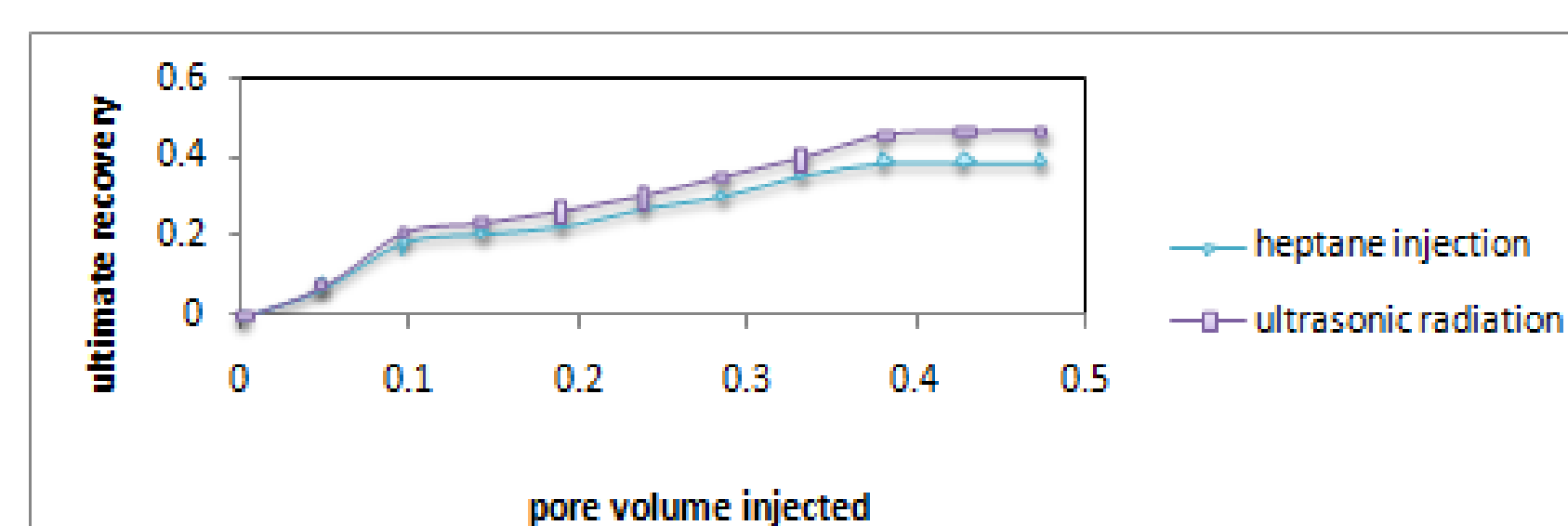


Fig.6. Effect of Ultrasonic Radiation on the Ultimate Recovery (heptane injection, model c)

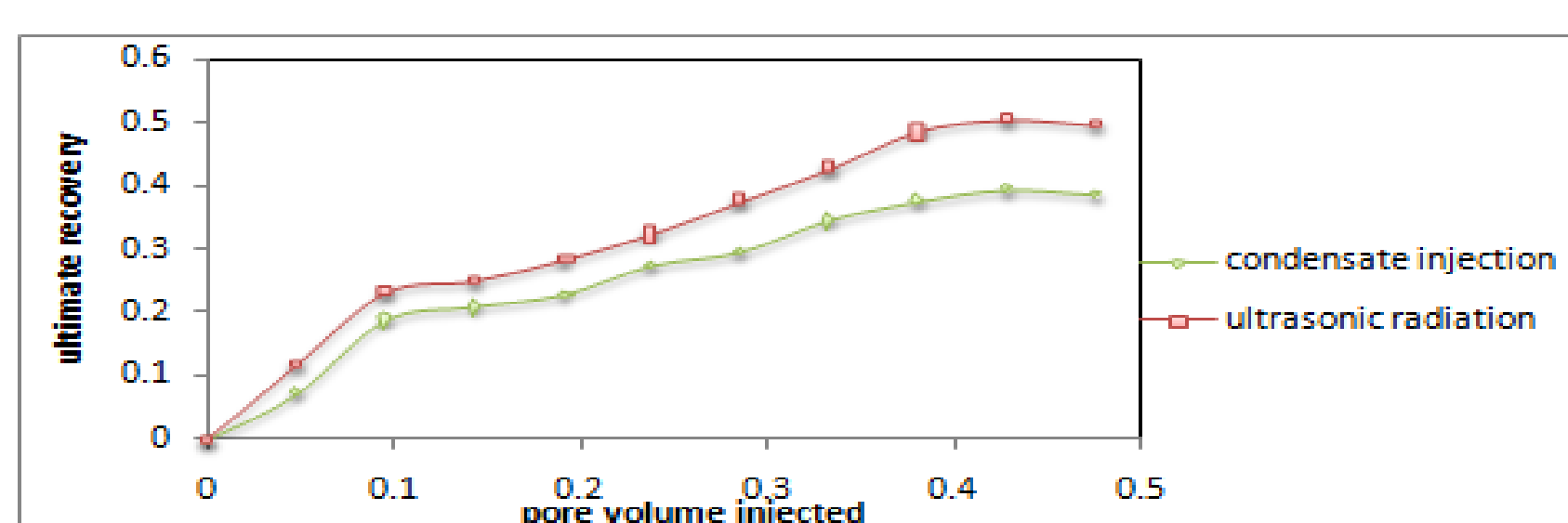


Fig.7. Effect of Ultrasonic Radiation on the Ultimate Recovery (hexane injection, model a)

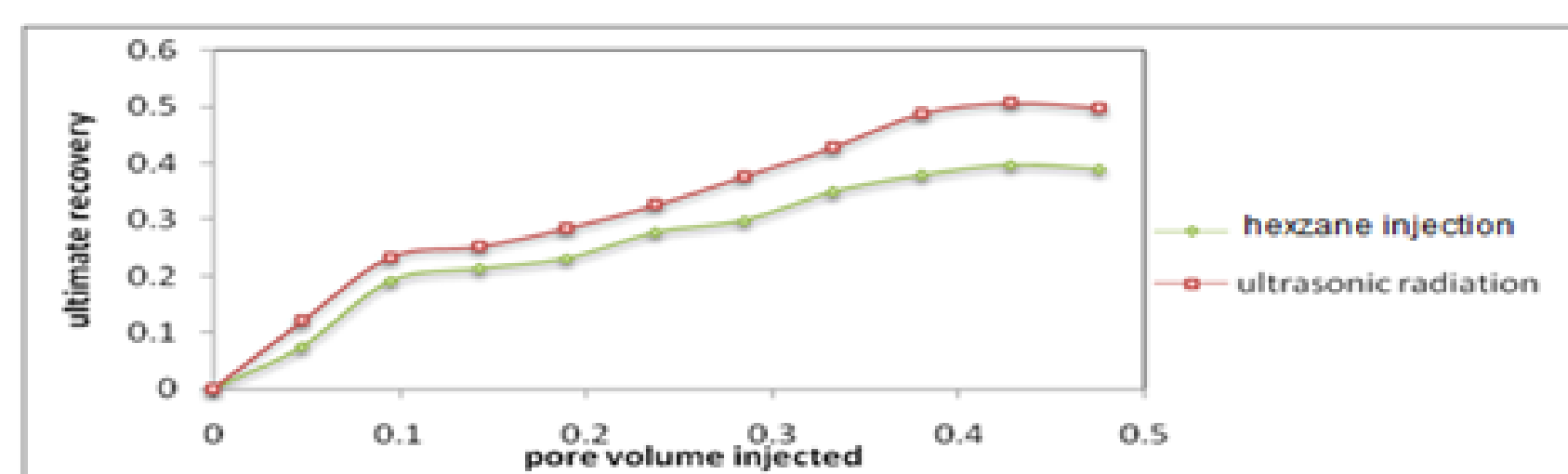


Fig.8. Effect of Ultrasonic Radiation on the Ultimate Recovery (hexane injection, model b)

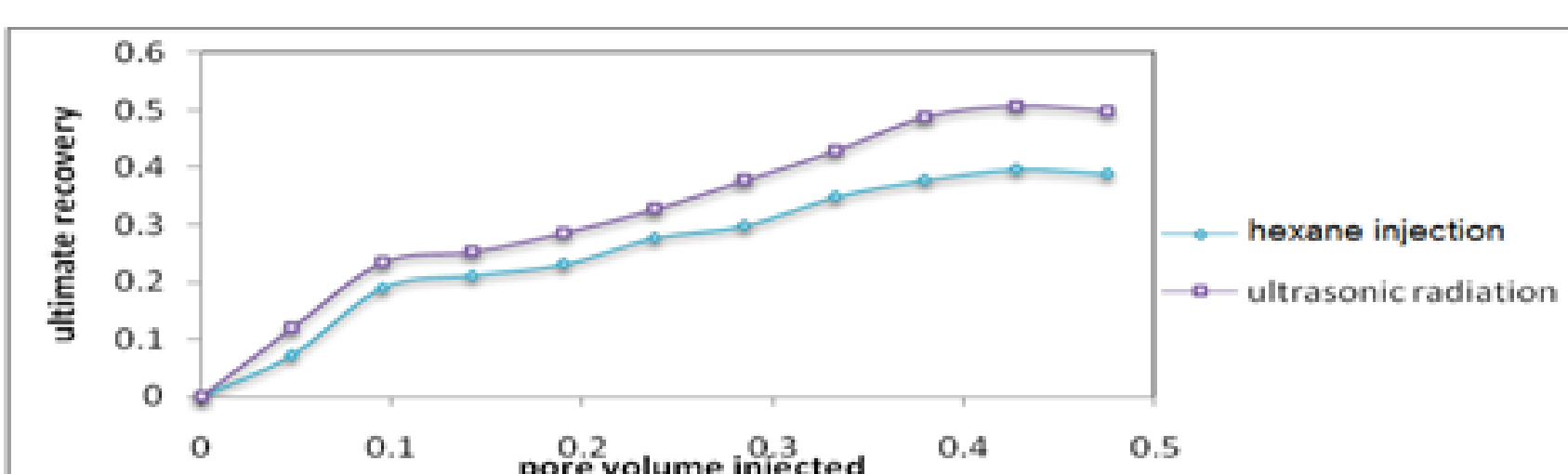


Fig.9. Effect of Ultrasonic Radiation on the Ultimate Recovery (hexane injection, model c)

Results and discussion

The displacement in non-ultrasonic cases was slow in the beginning but gradually became faster, regarding to this fact that the rate was constant during the experiment, changing in area swept could be due to front movement. The homogenous micromodel was used to study the effect of ultrasonic radiation on front propagation. Fig.3(a) and 3(b) present a snapshot of similar experiments of injection the Heptane in homogenous micromodel that saturated with Sarvak oil in presence and absence of ultrasonic radiations.

As seen in presence of ultrasonic waves the oil recovery increases and by image analysis this increment was about 8%. The cause of this increment could be the effect of ultrasonic radiations on asphaltene clusters. One of the major factors primarily responsible for asphaltene deposition is variation of composition of crude oil, and this is the main process in miscible injection methods. Subjection of the crude oil to ultrasonic radiation decrease the size of asphaltene clusters.[5] So the ultrasonic waves could be the cause of better propagation of miscible fluids in porous area.

In conclusion, independent of the type of micromodels and injected miscible fluids ultrasonic radiation improved the sweep efficiency.

Fig.4 to Fig.12 show the effect of ultrasonic radiation on the ultimate recovery of different models on the injection of different fluids.

As seen in figures, because of that the orientation of the fractures is 45 degree with the flow direction they cause to propagate the injected fluids in porous area and help them to have a better contact with crude oil and the result is increment in ultimate recovery. Base on this discussion greater length of fractures would be caused greater recovery and you can see it in figures.

Also it can be resulted from this figures that the hexane as the miscible fluid had greater ultimate recovery and it could be because of its lower molecular weight of the that cause the reduce the weight of the crude oil and increase the movability.

Conclusions

this experiments proposed to investigate the effect of ultrasonic radiations on ultimate recovery of conventional and fractured reservoirs, also study the effect of fracture types on the miscible injection recovery is the other target.

In presence of ultrasonic waves the oil recovery increases and the cause of this increment could be the effect of ultrasonic radiations on asphaltene clusters. Also it resulted that orientation and length of fractures had a undeniable effect on the ultimate recovery of miscible injection methods because of its effect on propagation of the injected fluid. In this experiment another result was that the molecular weight of injected fluid has a reverse impact on increment of the recovery.

References

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