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Experimental investigation of asphaltene adsorption in porous media due to solvent injection and effects on relative permeability

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ABSTRACT

While reduction in rock permeability due to deposition of asphaltene fraction of crude oil imposes negative effects on oil production rate from producing formation, there is no clear understanding about adsorption of asphaltene and the resulting effects on rock-fluid properties such as relative permeability.

This work reports the results obtained from a series of experimental investigations to address the adsorption of asphaltene in porous media and the consequent impacts on relative permeability and recovery of waterflooding.

Experiments are implemented by means of a designed experimental rig for specific set of water salinity, asphaltene concentration, clay content and composition of injected fluids. Waterflooding is performed in sand-pack prior and after the dynamic adsorption step to measure relative permeability and evaluate the change in recovery factor of waterflooding. Adsorption level is measured from spectrophotometry analysis of injected asphaltene solution and collected samples using the developed material balance calculations for asphaltene. In addition, the extracted sand at the end of experiment is analyzed to clarify the distribution of adsorbed asphaltene along the sand-pack.

Obtained results show that the salinity of water phase acts as a resistive force to adsorption. However, waterflooding experiments and the corresponding relative permeability curves show the possible improvement in displacement performance and recovery factor of waterflooding under effect of asphaltene adsorption at certain conditions. Longer breakthrough time, more favorable transient flow and reduced residual saturation during waterflooding indicate the positive effects of asphaltene on recovery factor.

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1. Introduction

The asphaltene fraction of crude oil contains polar molecules, which can act as surfactant and affect the interfacial tension between the oil and water phases. Asphaltene deposition on rock surfaces is known to reduce the permeability of porous media and cause formation damage (Hematfar et al, 2015). Nevertheless, many aspects of dynamic adsorption of asphaltene, including the mechanisms and effective parameters are not known and their consequent effects on rock-fluid properties and immiscible displacement require further investigation.

Asphaltene adsorption can be considered an interfacial phenomenon which involves the interaction between rock surface and asphaltene containing fluid, e.g., crude oil or water. Therefore, interfacial tension (IFT), contact angle, wettability, relative permeability, end-point saturations, waterflood performance and oil recovery can all be affected by the surface active properties of asphaltene and its adsorption on reservoir rock surfaces.

This work investigates the adsorption of asphaltene in porous media and its effects on two-phase relative permeability as well as on efficiency of waterflooding as an oil recovery method. Experiments are implemented to evaluate the contributing mechanisms of modification in two-phase flow properties, i.e., breakthrough time, end-point saturations, relative permeability and recovery factor due to asphaltene adsorption. A parametric analysis workframe is developed to understand the individual contribution of each parameter on asphaltene adsorption and to see whether it intensifies or restricts the adsorption level on sand particles. This is achieved by means of an experimental setup designed for dynamic flooding tests in sand-pack.

The objectives of this work are: (1) to study the influence of water phase salinity, presence or absence of clay in porous media and change in composition due to solvent co-injection on feasibility and extent of asphaltene adsorption in porous media, (2) to measure the amount of dynamically adsorbed asphaltene in porous media by means of spectrophotometry tests, (3) to

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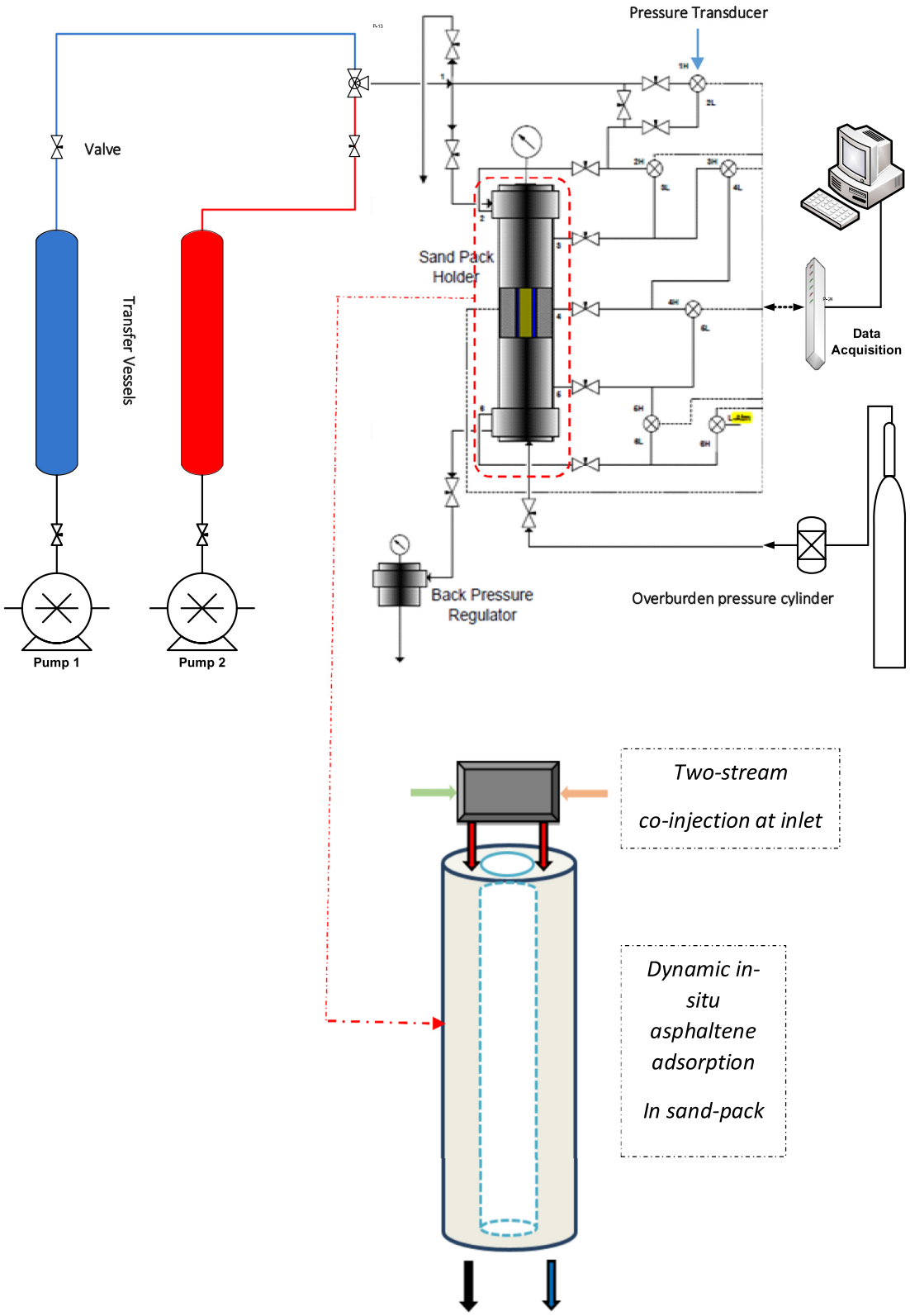

Fig. 1. Experimental rig designed for dynamic flooding.

evaluate the influence of asphaltene adsorption on two-phase flow variables and waterflooding efficiency via measurement of relative permeability, and 4) to determine the distribution of adsorbed asphaltene through porous media.

During each waterflooding and dynamic adsorption experiment, parameters and variables including permeability, pressure drop, production volumes, and end-point values for relative permeability curves are measured.

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