CHAPTER

2

WETTABILITY ALTERATION APPROACH TO IMPROVE CONDENSATE RECOVERY FROM RESERVOIRS

Muhd. Hafeezuddin, Issham Ismail, Luqman Norrani, and Jeffrey O. Oseh

2.1 INTRODUCTION

Gas condensate reservoirs consist of both gas and condensate. When a gas well is being produced, its reservoir pressure decreases isothermally, and this will result in the formation of condensate in the reservoir near the wellbore region. This can happen when the reservoir pressure drops below the dew point of the phase envelope with constant temperature, and subsequently some heavy components in the gas stream will start to condense and eventually it results in a liquid condensate. This phenomenon is called condensate banking in a retrograde condensate reservoir. The condensate formation will clog the connected pore spaces, leading to a reduction in the reservoir permeability (Hassan et al., 2020a; Hassan et al., 2021a). When the reservoir permeability is affected, fluids cannot flow in between the pore spaces into the bottom hole of the respective well. This condition is not ideal because it will cause a significant loss of revenue since the well cannot be produced as expected (Delavarmoghaddam et al., 2009).

Many methods are made available to address this issue in the oil and gas fields. The most common methods utilised to address condensate banking are gas cycling, hydraulic fracturing, matrix acidising, and horizontal well drilling. The methods mentioned previously are effective for a certain period only and have many downsides compared to the wettability alteration method for a given reservoir (Goda & Behrenbruch, 2011; Zhou & Li, 2011).

The top two essential properties in a reservoir are the rock's wettability and the interfacial tension between two immiscible fluids. The majority of the variables affecting fluid flow in a porous medium are influenced by wettability, which is defined as a liquid's capacity to come into contact with a solid surface. On the other hand, interfacial tension is the force that exists between the two fluid interfaces of immiscible matter. The contact angle between the fluid and the rock's surface is the factor that regulates the rock's wettability (Sayed & Al-Muntasheri, 2016). Interfacial tension can be reduced, and the rock's wettability changed to a preferable gas-wet state by injecting wettability-altering chemicals (Wang et al., 2018; Zhou & Li, 2011).

The condensate reservoir produces both gas and liquid in the form of condensate. As the reservoir pressure reduces, more condensates will be formed, and during the production phase, the condensate will accumulate near the wellbore and clog the pores. This will prevent the gas and liquid from flowing through the pores to the rat hole. As previously mentioned, there are many methods that can be used to avoid the formation of condensate banking in a reservoir, such as gas cycling, hydraulic fracturing, and drilling horizontally (Denney, 2007; Hassan et al., 2019; Hassan et al., 2021b). However, it is proven that injecting chemicals, especially wettability alteration chemicals, into a reservoir yields high deliverability of the well (Al Ghamdi et al., 2013; Al-Nakhli et al., 2019; Sayed & Al-Muntasheri, 2016; Sayed & Al-Muntasheri, 2017). The rock surface is liquid wet (condensate wet) during the accumulation. Wettability alteration chemicals can change the surface of the rock layer from liquid wet (condensate/oil wet) to preferential gas wet (water wet) (Wang et al., 2013). The change of rock wettability might cause the condensate that accumulates in the pore spaces to increase its' contact angle, and eventually the condensate banking can be removed (Torheim, 2020; Wang et al., 2018).

The effectiveness of injecting wettability-alteration chemicals to remove condensate banking is discussed in this article. The research work has been designed to alter the wettability of a reservoir from liquid wet (very light crude oil) to gas wet (water). Secondly, a wettability alteration chemical is used to treat the sandpack to increase the permeability of the very light oil. A contact angle experiment was conducted to observe the wettability of the core sample before and after the treatment with chemicals WA A, WA B, and WA C followed by a sandpack test to measure the relative permeability of fluid before and after treatment with one of the chemicals. WA A, WA B, and WA C are used instead of their actual chemical names due to confidentiality.

This research work aims to increase the gas deliverability in condensate reservoirs clogged by the condensate banking issue. When the reservoir pressure falls below the dew point, some wells will experience a significant decline in gas deliverability. Many rich gas-condensate reservoirs with permeability less than 500 mD are classic examples. Viscous forces alone will not improve gas well deliverability in these reservoirs (Mott et al., 1999). Carbon dioxide (CO_2) and propane injection are two strategies for removing liquid from around the wellbore via phase behaviour effects. Both have been put to the test in the field with mixed results. Furthermore, the impact of solvent injection around the wellbore for condensate liquid removal is only temporary. Wettability alteration is an effective strategy for improving gas well deliverability. Gas can flow efficiently in porous media if the wettability of the wellbore region can be changed at least to preferable gas wetting (water wet).

2.2 CHALLENGES FACING BY RETROGRADE GAS CONDENSATE RESERVOIRS

When reservoir pressure drops below the dew point of the hydrocarbons in a reservoir, the heavier hydrocarbons start to condense into liquid droplets.