GAS CONDENSATE BANKING: A REVIEW OF THE PHENOMENON, ACCUMULATION, MITIGATION METHODS AND NEW BREAKTHROUGH

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RESEARCH HIGHLIGHTS

This research presents a review related to condensate banking problem by describing the condensate phenomenon; condensate accumulation; current mitigation methods and its limitation. Then a new breakthrough method based on wettability alteration is introduced with an explanation on its mechanism and example of chemicals used. Next, new research ideas using nanoparticles as a wettability alteration agent is presented, and it is believed to be better than the chemical treatment alone as it modifies the wettability surface from two aspects: surface free energy and surface roughness – while chemical treatment only reduced the surface free energy. In a nutshell, there is a significant gap of study in using nanoparticles as the wettability alteration agent in gas condensate reservoirs.

RESEARCH OBJECTIVES

Gas condensate reservoirs happen at pressures less than 2,000 psia and temperature below 100 °F and probably can occur at any higher temperatures and pressures within reach of the drill string (1). The trend to drill deeper in many areas has led to the discovery of reservoirs with higher pressures and temperatures. Gas condensate reservoirs also contain a large volume of gas reserves as well as appreciable amounts of light density, high API quality condensate. The increasing everyday consumption of energy makes it very important to maximize the exploration and production from such reserves (2).

METHODOLOGY

The phase behavior of gas condensate reservoirs revealed that with production and the continuous decline of the reservoir pressure, the heavy components in the gas stream would start to condense and form liquid condensate (3). This liquid condensate will form and accumulate in the area very close to the wellbore where the pressure drop is maximum, and the flowing pressure will be minimal compared to the reservoir pressure (4).

When the drawdown pressure hit below the dew point pressure, a small drop of condensate is formed and accumulated in the near wellbore region. As the accumulation occurs, the liquid saturation will also increase and the gas relative permeability is reduced, hence affecting the productivity (5, 6).

RESULTS

The problem of condensate in gas wells have been well discussed and several techniques have been proposed to resolve this issue, which has been summarized in Table 1.

Table 1: Summary of condensate banking mitigation methods.

Techniques	Description
Gas injection	<ul style="list-style-type: none"> Natural gas, nitrogen or carbon dioxide gas are pumped into the reservoir to increase the $P_{\text{reservoir}} > P_{\text{dew-point}}$ (7, 8). Limitations: cost of injection is high and there is a market for natural gas.
Horizontal wells	<ul style="list-style-type: none"> Increase the contact area between the reservoir and the wellbore, hence, improving the wells productivity index and delay the condensate banking (2, 9). Limitation: temporary solution.
Hydraulic fracturing	<ul style="list-style-type: none"> Improve the well's productivity by creating conductive paths to increase the contact between the reservoir and the wellbore (10, 11). Limitation: temporary solution.

Interfacial
tension
reductions

- Reduce the interfacial tension between liquids and gases using solvents. In return, it will improve the gas relative permeability and increase the productivity of both gas and condensate (12, 13).

- Limitation: frequent solvent treatment is needed.

Wettability
alteration

- Using chemical treatment to modify the rock surface wettability from liquid-wet to neutral-wet (6, 14).

- Limitation: still at research stage (15, 16).

FINDINGS

Wettability alteration of rock surfaces can be achieved through pumping fluorinated chemicals such as fluorinated surfactants, fluorinated polymers or fluorinated polymeric surfactants in a solvent mixture. Wettability alteration chemicals were found to be effective in changing the wettability of rock surfaces from liquid wetting (oil, water or condensate) to intermediate wetting or even preferentially gas wetting with these liquids (14, 17). On top of that, another research group (14, 18), used a non-ionic polymeric fluorochemical in a glycol alcohol solvent mixture. They claimed that the gas relative permeability was increased as the chemical treatment alters the wettability of a water-wet sandstone to neutral-wet.

Recent direction of research is to use the surface modified nanoparticles and fluorinated nanofluid system to change the wettability of rock surface. The main inspiration for this recent direction is the water repellence phenomenon noticed on the lotus leaves (19, 20). The superhydrophobic surface on these natural lotus leaves was achieved by combining the surface topography (surface roughness) and the surface chemical compositions (to lower the surface energy). The change of the surface topography or creating surface roughness has been achieved by utilizing nanoparticles and the surface free energy is reduced by using fluorine functional groups.

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