Condensate Flooding Experiments

Using Teledyne ISCO Syringe Pumps

University of Texas, USA

Syringe Pump Application Note
AN26

Overview

Gas reservoirs typically display a significant decrease in production over time. Much of the production loss is due to condensate and water blocking. Gas condensates typically reside in the reservoir at pressures above the dew point in a single gas phase. As the gas is produced and flows to the well, the pressure drops below the dew point and liquid begins to form or "drop out" of the gas phase. The liquid becomes trapped in the pores of the formation and blocks the flow of gas to the well, thus decreasing the production rate.

The pressure gradient tends to be exponential to proximity of the well bore, so that the dew point is reached here with maximum effects due to blockage. Because the bulk of the damage is localized to a relatively small volume near the well bore, it is possible to treat a small volume and reverse some of the damage. A method is presently being researched to restore some of the lost well productivity.

Research

Core flooding experiments are being conducted to assess the effectiveness of various treatment methods to reverse well damage caused by condensate and water blockage. The experiments are conducted by flowing gas condensate mixtures through cores at actual reservoir conditions.

Experimental Procedures

The core flooding experiments are conducted in several phases:

1. Initial permeability (methane, nitrogen)
2. Initial relative permeability to gas (condensate)
3. Treatment (liquid solution)
4. Post treatment relative permeability to gas (condensate)
5. Final permeability (methane)

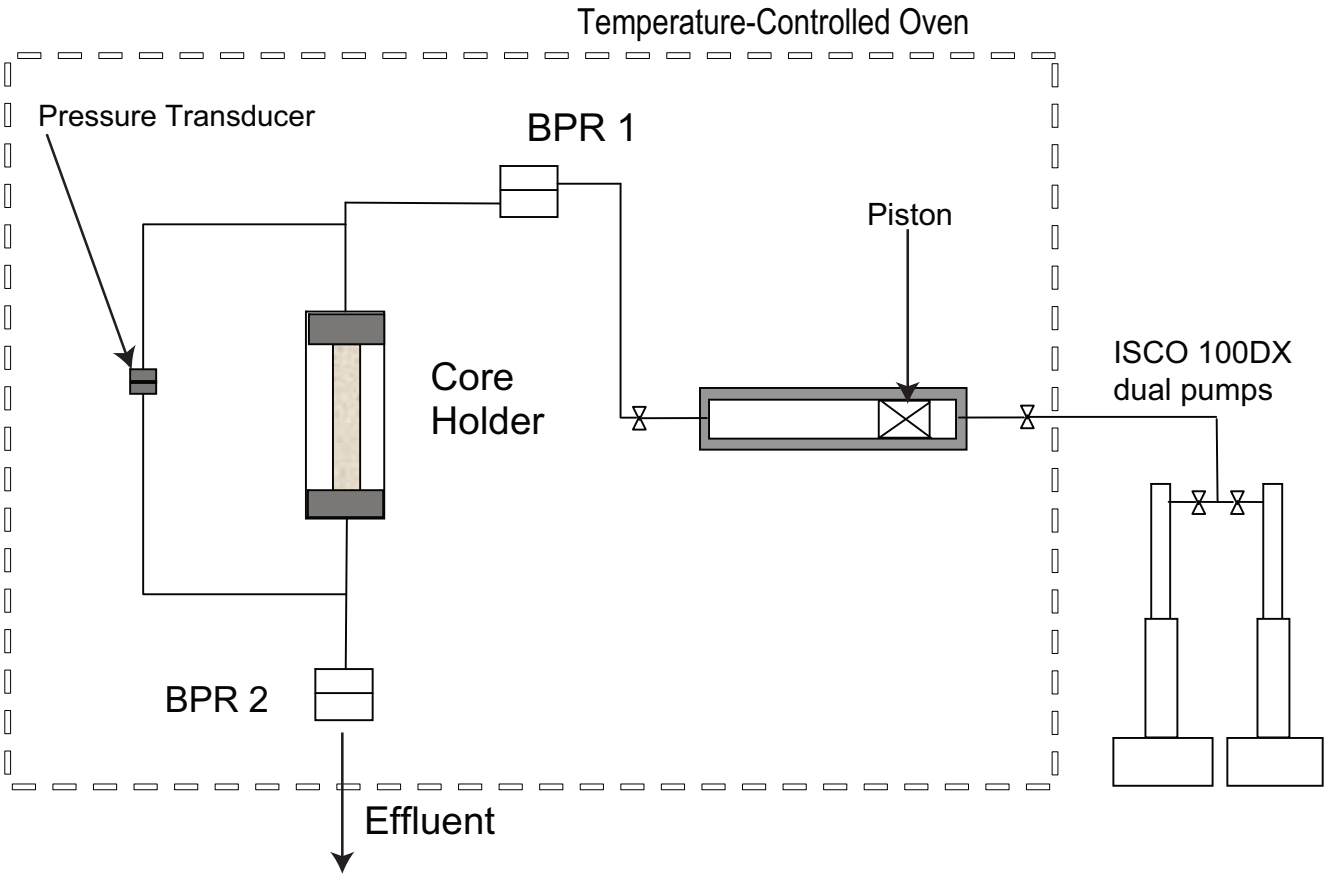

Figure 1: Experimental setup

All fluids are loaded into an accumulator for injection. Each accumulator is fitted with a piston that seals one side from the other. The injectant is loaded into one side, and water on the other side. Water is then pumped into the accumulator to displace the piston, which pushes fluid into the core. To simulate reservoir conditions, the condensate must initially be a single-phase fluid and thus be at equilibrium above the dew point. So the injected fluids are initially at a pressure and temperature above the dew point (typically >4,000 psi), and with the use of back pressure regulators "flashed" to pressures typical of well bottom hole flowing pressures (500 – 2,500 psi). When the fluid is flashed to the bottom hole pressure, liquid hydrocarbon drops out of the gas phase. This is designed to simulate what happens as gas in a reservoir approaches the well bore.

Condensate floods are conducted under the same conditions before and after the core is treated. The effectiveness of the treatment is evaluated by measuring the pressure drop across the core before and after treatment and comparing the pre and post treatment relative permeabilities.

Experiments have been conducted on cores with permeabilities of less than 1 mD and in propped fractures with permeabilities in the 100 D range. This requires a pump able to accurately dispense continuous, pulseless flow in the range of 10 to 2,000 cc/hr and at pressures in excess of 5,000 psi.

ISCO Syringe Pump

A dual pump system using ISCO model 100DX pumps with an electric valve package was selected for the application [see note]. The test system is basically comprised of a core holder, two back pressure regulators, an accumulator, pressure gauges, and the pump. The core holder, back pressure regulators, and accumulator are installed inside an oven.

The pump is connected to the water side of the accumulator, and serves two main purposes during the experiment:

It is used in the **constant pressure** mode while fluids are equilibrating and heating. For a condensate mixture to be a single gas phase fluid, it must equilibrate for long periods of time (overnight) at a pressure above the dew point. The 260DX is put into constant pressure mode at a pressure above the dew point, thus ensuring that the condensate equilibrates at a sufficient pressure. Liquid treatment solutions expand when they are heated; the pump in constant pressure mode allows the solutions to be heated overnight without over-pressuring the system. The most important application for the 1000DX is to pump condensate solutions through cores.

The pump is run in **continuous flow** mode to flood the core with the various fluids. It is essential that the pump flow rate be accurate and constant, and exhibit no pressure pulse during change-over so that accurate pressure drops can be measured. This is very important when flooding cores with low permeability (<25 mD), because pressure spikes can take a long time to dissipate.

Note:

The 100DX model pump, which was used during the original experiment, is discontinued. Current model 260x is the recommended replacement for the older100DX model.

September 28, 2012; revised November 7, 2023
Product model names have been updated in this document to reflect current pump offerings.

Teledyne ISCO
P.O. Box 82531, Lincoln, Nebraska, 68501 USA
Toll-free: (800) 228-4373 • Phone: (402) 464-0231 • Fax: (402) 465-3091
www.teledyneisco.com