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Dry-Gas Reinjection in a Strong Waterdrive Gas-Condensate Field Increases Condensate Recovery—Case Study: The Sleipner Ty Field, South Viking Graben, Norwegian North Sea

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Abstract

The Sleipner Øst Ty Field is a strong waterdrive gas-condensate field, with in-place volumes of $59 \times 10^9 \text{Sm}^3$ gas and $52 \times 10^9 \text{Sm}^3$ unstabilized condensate. The reservoir consists of deep-water turbidite sandstones and associated mudstones, which act as baffles to flow. The reservoir qualities are very good, with high porosity and with permeability in the range of 100 to 1000 mD.

The first production in the area started up from the Sleipner Øst Ty Field in 1993. The initial reservoir pressure of 244 bar was only one bar above the dew-point pressure. Massive dry gas reinjection started in 1996, and the reservoir pressure increased during the next two years causing an increase in the condensate to gas ratio. During the injection period, which lasted until 2005, $29 \times 10^9 \text{Sm}^3$ of dry gas was injected. The main focus during these years was to obtain good vertical and areal sweep of the dry gas in order to vaporize the dropped-out condensate. Chemical gas tracers were injected and analyzed for in the production wells to monitor the movement of the dry gas through the reservoir. This knowledge was used to identify unswept areas, and to change the drainage pattern by doing well interventions and drilling infill wells.

The injection was stopped primarily due to high probability of trapping gas. Compositional reservoir simulation showed that from 10 to 20% of the injected dry gas volume could be trapped in the northern region, which has no producers. The risk of not being able to back-produce the injected dry gas was considered high, since the saddle area separating the producers in the south from the injectors in the north was partly water flooded.

The gas cycling programme has increased the condensate recovery factor substantially; from the originally planned 50% by pressure depletion, to the current estimated ultimate recovery of 81%. At present, the condensate recovery factor is 76%.

Introduction

The Sleipner Øst Ty Field is located in production license PL046 in the Sleipner Area in the southern part of the Viking Graben, Norwegian North Sea, **Fig. 1**. It was discovered in 1981 by the exploration well 15/9-9, and appraised and developed during the next 12 years. The production started in 1993 from the Sleipner A platform, a fully integrated gravity base platform, and a connected subsea template with two producers. Water depth in the area is 82 m. The field is operated by Statoil ASA with their license partners ExxonMobil Exploration & Production Norway AS, Total E&P Norge AS and Norsk Hydro Produksjon AS.

The field was originally planned to be produced by pressure depletion, but a revised drainage strategy recommended dry gas reinjection to increase the condensate recovery. Hence, as soon as plateau production was achieved and gas sales commitments were fulfilled, a recycling programme of the surplus dry gas was started. The first two years the injected volumes were small. It was not until the large, neighbouring gas-condensate field Sleipner Vest came on stream in 1996 that massive gas reinjection was possible. Since the initial reservoir pressure was only one bar above the dew-point pressure, condensate started to drop out in the reservoir immediately after start-up of production in 1993. The dry gas reinjection has been important both to revaporize this dropped-out condensate and to keep the pressure high in order to prevent further condensate drop out in the reservoir.

This paper will present how the reinjection of dry gas into the Ty reservoir has increased the condensate recovery substantially compared to a pure depletion drainage strategy. The strong aquifer has given important pressure support during the production history. When the injection period ended, blowdown of the field was accelerated to maximize the recovery.