



OTC 19435

On the Performance of Class 2 and Class 3 Hydrate Deposits During Co-Production With Conventional Gas

George J. Moridis, SPE, Matthew T. Reagan, SPE, and Keni Zhang, SPE, Lawrence Berkeley National Laboratory, University of California

This paper was prepared for presentation at the 2008 Offshore Technology Conference held in Houston, Texas, U.S.A., 5–8 May 2008.

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Abstract

Recent numerical studies have provided strong indications that it is possible to produce large volumes of gas from natural hydrate deposits at high rates (in excess of 10 MMSCFD) for long times by depressurization-induced dissociation of hydrates. Of the various factors that can adversely affect the production potential of hydrates, low temperatures have one of the strongest negative impact. These can be caused by low initial temperatures, increasing stability of the hydrate (as defined by the deviation between the temperature of the deposit and the equilibrium temperature at the reservoir pressure), and by an advanced stage of dissociation (a strongly endothermic reaction) when substantial amounts of hydrates remain. The reasons for the production decline include a reduction in the rate of the hydrate dissociation at lower temperatures and the evolution of flow restrictions in the vicinity of the well caused by the formation of hydrate and/or ice in the vicinity of the wellbore. The latter is caused by continuous cooling, and is the reason why large amounts of gas that may have been released in the reservoir in the course of earlier dissociation cannot be easily recovered.

We investigated the possibility of alleviating the problem of low production at low temperatures in Class 2 and Class 3 deposits by means of co-production with gas from conventional reservoirs. Large-scale numerical simulations involving injection-production multi-well systems indicate that, by routing some of the pressurized hot conventional gas through Class 2 hydrate reservoirs at rates that do not exceed 50% of the total production rate, it is possible to achieve a significant increase in hydrate dissociation and gas production. This occurs mainly because of the enhanced relative permeability of the gas phase and the increased effective permeability of the hydrate interval, which facilitates gas flow and further dissociation. The thermal effect on dissociation appears to be limited. Co-production appears to confer no benefits to the performance of Class 3 deposits when the production well is kept at a constant pressure.

Introduction

Background. Gas hydrates are solid crystalline compounds in which gas molecules (referred to as guests) occupy the lattices of ice crystal structures (called hosts). Under suitable conditions of low temperature T and high pressure P , the hydration reaction of a gas G is described by the general equation



where N_H is the hydration number. Hydrate deposits occur in two distinctly different geologic settings where the necessary conditions of low T and high P exist for their formation and stability: in the permafrost and in deep ocean sediments (Sloan and Koh, 2008). Methane is by far the predominant gas in natural gas hydrates. Pure CH_4 -hydrates concentrate methane volumetrically by a factor of 164 at standard P and T conditions (STP), and have a N_H ranging from 5.77 to 7.4, with $N_H = 6$ being the average hydration number and $N_H = 5.75$ corresponding to complete hydration (Sloan and Koh, 2008).

Although there has been no systematic effort to map and evaluate this resource and current estimates vary widely (ranging between 10^{15} to 10^{18} m³ STP), the consensus is that the worldwide quantity of hydrocarbon gas hydrates is vast (Collett, 1995; Milkov, 2004; Klauda and Sandler, 2005). Although they are currently deemed uneconomical, given the sheer magnitude of the resource, ever increasing global energy demand, and dwindling conventional fossil fuel reserves, hydrates are emerging as a potential energy source even if only a limited number of deposits might be suitable for production and only a fraction of the trapped gas can be recovered (Makogon, 1987; Dallimore and Collett, 2005; Boswell, 2007). This study is part of a wider effort (Moridis et al., 2008) that seeks to evaluate the technical and economic feasibility of commercial gas