AAPG Datapages/Search and Discovery Article #90234 © 2015 AAPG Asia Pacific Region, Geoscience Technology Workshop, Opportunities and Advancements in Coal Bed Methane in the Asia Pacific, February 12-13, 2015, Brisbane Australia

Challenges of Solids Management in Thinly Bedded Coal Seam Gas Reservoirs

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Abstract

The coal seam gas (CSG) reservoirs are rapidly developing in recent years worldwide particularly in the Asia Pacific region. These reservoirs are located in different geological settings with different reservoirs characteristics. CSG reservoirs in Australia are typically thin and interbedded with thick layers of sandstone, siltstones and shales and are generally in shallow depth adjacent to fresh aquifers. Well completions, in general development of such CSG fields often are required low technology, and cost approaches due to limited lateral extension and high reservoir heterogeneity. In contrast to conventional gas reservoirs where water production and decrease of reservoir pressure will result in lower gas flow and could eventually lead to well abandonment, in CSG wells extracting gas from coal beds often requires a dewatering stage by pumping out the water held in the seam, to reduce the level of water saturation and formation pressure, to allow the gas to be released by desorption from the coal surface. Dewatering decreases pore pressure, so does the reservoir stresses. Pressure depletion and high drawdown pressures during dewatering stage in CSG wells could increase the risk of wellbore and perforation instability in the form of solids and fine production caused by rock failure under a high effective stress environment even before onset of gas production.

Introduction

In thinly bedded CSG reservoirs, solids production from coals may not be a concern but sanding or solids production from interbeded rocks can be the main source of solids production with adverse effect on well reliability and productivity, integrity and cost. Where the interbeded clastic rocks are clay rich with a high percentage of water sensitive clay minerals such as smectite, clay swelling and grain dispersion will be expected when the rocks are exposed to low salinity water generated from coal dewatering. This in turn could reduce the overall rock strength, due to the loss of cementation in the rock matrix, hence increasing the risk of rock failure under low hole pressure (and high drawdown) conditions at early stage of the well life. This is in contrast with the conventional gas reservoirs where many gas wells will be sand free in early to middle of their lives and sanding may become an issue only when the reservoir become heavily depleted with or without water production.

Well Completions and Solids Control Challenges

Various completion techniques have been utilized worldwide to develop CSG reservoirs. These techniques range from vertical well multi-seam completion either open hole or cased and perforated with stimulations, to multiple lateral wellbores drilled into single coal seam. Common stimulation techniques include open-hole under ream, cavity creation and hydraulic fracturing. A practical and cost effective well completions for thinly bedded CSG reservoirs are vertical and low angled deviated wells completed either open hole undreamed to larger holes for stimulation or cased and perforated with multi zone hydraulic fracturing stimulation for the thicker seams. The low cost open hole completion options have the disadvantage of high risk of solids production from the thick non-pay intervals and will likely encounter a higher workover costs and failure of lift pumps due to frequent shut-ins and solids production. The option of casing, cementing and stimulating would be expected to significantly reduce the production of solids in CSG wells. Although cased and stimulated completions have the benefit of the isolation of the non-reservoir interval, hydraulic fracturing stimulation could be practically challenging with the numerous small thin seams present.

Open hole designs with pre-perforated liner have generally been seen as a cost effective way for moderate permeability coal seams. Cost effective downhole solids control options are limited in the case of thin coal beds, because of high exposure to fine grain solids production from heterogeneous interbeded rocks. Given the high percentage of expected fine grain sand, silt and fine productions, sand control screens would not be effective as they are likely to plug and not able to exclude the solids down hole due to a wide grain size distribution and high uniformity coefficients. Screens are also expensive and to be successful, it is likely complex methods such as gravel packing would be required which would result in a step-change in cost, resources and services.

One major parameter in the favor of solids control is that the main source of solids in thin CSG reservoirs is the non-pay. The ideal and cost effective well design is therefore a one that can isolate non-pay zones and limit solids production without adversely affecting well productivity. Identification of the non-pay zones, which are vulnerable to solids production, is therefore the key to well design and a full geomechanical and petrological evaluation will be therefore required.

Use of swellable packers in open holes to isolate different coal measure units and weak zones to mitigate solids production has been considered as an option and was tried by an operator in one CSG field in Australia. In parallel with the field trial, a systematic rock mechanics testing and geomechanical evaluation was also carried out to identify the mechanisms of solids production and the main solids producing zones in pilot wells. Results of rock mechanics testing with petrological and mineralogical examinations along with field observation reveal that the major source of produced solids is smectite rich mudstones and sandstones. Isolation of solids prone non-pay zones by swellable packers may be successful only if the weak and smectite-rich rocks are limited to a very few sections of the open hole. This approach may not be successful in mitigating solids production in long open holes with numerous individual thin coal seams and the presence of thick, water reactive non-pay zones across the target coal measures. Nevertheless, the use of swellable packer has been effective by insolating non-coal bearing aquifers from the target coal measures. In contrast, pilot wells with cased and perforated completion have shown the benefit of the isolation of the non-reservoir interval while acid stimulation and controlled hydraulic fracturing have enhanced the well productivity comparable with wells completed open hole. Production monitoring from pilot wells is in progress. Initial evaluations indicate the option of casing, cementing, perforating and stimulating with short fracturing for skin removal is a likely optimum completion to combat the solids production problem; to reduce well intervention cost and maintaining the overall well productivity.