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Review and Outlook on Technologies of Well and Completion for CBM in China

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Abstract

China is the world's most populous country with a fast-growing economy that has led it to be the largest energy consumer and producer in the world. Substantial energy demand growth and an appeal for environment protection have increased pressure on China to utilize a wide range of energy sources, especially clean energy. Coalbed methane is a global resource, poised to become a major contributor of clean, abundant energy. China has the third largest proven recoverable coal reserves, which accounts for 13.5% of the world total. In recent years, CBM projects have rapidly proliferated in China. In 2013, CBM production in China reached 2.98 billion m3. Accompanying production increases, however, are challenges, including complex high-rank coalbed geology, wellbore collapse, reservoir damage, and low well production. These challenges play a restraining role in China's effort toward CBM industrialization.

After a background of CBM development in China, this paper will describe state-of-the-art in multilateral horizontal well technology, underbalance-drilling technology, and completion technology. Field results are discussed. Finally, a brief focus on the future technologies associated with CBM development is presented.

1. State-of-the-art of China's CBM Drilling and Completion Technology

This section begins with a review of the current situation of drilling and completion in China CBM industry. Main problems encountered are listed out, and options to solve these problems are analyzed. China is still on the way to find an economic package of solutions comprised of drilling, completion, and stimulation methods that is suitable for the high rank, low-permeability coal seams. This section concludes with some recommendations for change.

2. CBM Multilateral Well Technology

Multilateral drilling was introduced to China in 2004. The large-scale application commenced in 2009. Through drilling practices from 2009 to 2012, CNPC has been capable of utilizing this technology to develop CBM fields. Well construction costs have been reduced dramatically from RMB $15 million at the beginning to about RMB $9 million at present.

Well completions and stimulations for CBM have generally been chosen by trial-and-error, because there has not been much consensus, unlike wells in conventional sandstone. To increase well production, CNPC has proposed a new cost-effective drilling practice named "L-pattern horizontal well". Another alternative considered is to drill the main bore beneath the lower edge of the coal seam and then the laterals upward into the coal seam.

New adaptive equipment, including Electromagnetic MWD, DRMTS, and Truck-mounted drilling machine, has emerged in the last few years. The Electromagnetic MWD system is introduced to meet the needs of the growing number of projects involving under-balanced drilling in the CBM industry. Dynamic azimuth gamma is available with this system, which is capable of precisely determining the upper/lower edge of the seams. DRMTS is a solution for intersection of wellbores between a vertical well and a horizontal well. With the range of up to 70 meters the DRMTS allows for significant trajectory correction prior to intersection. DRMTS has been used in more than 30 first-time intersections in China. CNPC has designed and built its first prototype of truck-mounted drilling machine especially for the domestic CBM industry.

3. CBM Underbalanced Drilling

Due to the low-pressure reservoirs, overbalanced drilling may cause severe reservoir damage, thereby leading an unexpected methane production. Slightly underbalanced drilling helps minimize coal formation damage. Three kinds of underbalanced drilling technologies, including gas drilling, aerated freshwater drilling, and circulated microbubble drilling, have been tested in China. At present, CBM wells drilled with aerated freshwater are becoming more common. This technique is suitable for a formation with pressure coefficient ranging from 0.7-1.0 g/cm^3. In addition, it is free to the influence of formation influx.

A key hardware in underbalanced drilling is the rotating control head, which is able to maintain a pressure seal between drill pipe and casing even as the drill string is turning. For consideration of being suitable for the CBM application, a custom-made rotating control head is designed to operate at 500 psi (3.5MPa) rotating and 1,500 psi (10.5MPa) static.

In aerated underbalanced drilling, the use of expensive air compressors and injection equipment is required, which leads increased costs. An alternative to aerated underbalanced drilling is a special drilling fluid named fuzzy ball. Being able to adjust the density in a range of 0.7-1.0 g/cm3 (the average reservoir pressure coefficient is 0.88 in China), fuzzy ball can be used as a kind of underbalanced drilling fluid. Besides that, fuzzy ball can also solve many problems including lost-circulation control, formation damage, stabilization of multi pressure sequences with one fluid, and possible differential sticking. In the end, a case study on lost-circulation control will be presented.

4. CBM Horizontal Well Completion Technology

In China, borehole collapse is one of the main obstacles for the large-scale development of horizontal wells in the CBM industry. Coalbed collapse will bring high risk for drilling and extraction operations. Three completion tools including slotted PE (polyethylene plastic pipe) screen completion, slotted GRE (Glass Reinforced Epoxy pipe) screen completion, and water swellable packers, which have been widely used to overcome the instability problem, will be introduced in this section.

Key hardware in PE screen completion includes a hydraulic-driven injector and a roll of PE screens with custom-made slots. Running PE screens down to the desired TD involves connecting an anchor at the bottom of the PE screens, running down through the drilling pipe pushed by the injector, and with the arms of the anchor opened and fixed in the seams, pulling the drilling pipe without disturbing the PE screens.

Compared with PE screens, slotted GRE screens could hold much higher compressive strength and provide a larger inner diameter, which would facilitate stimulation operations. Operationally, the benefit of the slotted GRE screen completion is simplicity. Screens are simply run to the depth, similar to the slotted liners. In addition, even more important, there is no potential risk for the post mining operations. In recent years, slotted GRE screen completion is popular in China.

In Australia, wells with slotted liners completion in the openhole often experienced coal fines plugging problems. On average, Pumps needed inspection every 6-12 months. Water swellable packers were used to provide a cost efficient and competent annular isolation of reservoir intervals. The isolation system has proven successful in preventing the coals and fines from the upper sections entering the borehole, reducing the possibility of solids plugging of the pumps, thereby leading an extended inspection period and less need of intervention.

5. Challenges and Future Technologies

China's government, recognizing the value of this resource, named CBM development as one of 16 major projects in the 11th "Five-Year Plan". Production targets are 10 billion m^3 by 2010, 30 billion m^3 by 2015, and 50 billion m^3 by 2020. At present, the average well production from vertical wells is less than 600 m^3/day, and the average well production from horizontal wells is about 7,000 m^3/day. Given what is happening now, it is difficult if not impossible to realize the desired production targets. China has been redoubling its efforts to increase well production and improve the economics of CBM development. Several innovative technologies, which are either currently being tested or already in use, are covered in this section. Some examples include air drilling, special drilling fluids; CBM coiled tubing technique, enhanced CBM, and underground coal gasification.