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Research into magnetic guidance technology for directional drilling in SAGD horizontal wells

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Abstract: SAGD horizontal wells are used to enhance oil recovery from heavy oil reservoirs. This technology requires precise separation between the production well and the injection well to ensure the efficient drainage of the reservoir. By studying the attitude of the downhole probe tube and the production well trajectory, an algorithm is proposed for eliminating ferromagnetic interference while drilling injection wells. A high accuracy filter circuit has been designed to correct the detected magnetic signals, which are ultra-weak, frequency-instable, and narrow-band. The directional drilling magnetic guidance system (DD-MGS) has been developed by integrating these advanced techniques. It contains a sub-system for the ranging calculation software, a magnetic source, a downhole probe tube and a sub-system for collecting & processing the detected signals. The DD-MGS has succeeded in oilfield applications. It can guide the directional drilling trajectory not only in the horizontal section but also in the build section of horizontal injection wells. This new technology has broad potential applications.

Key words: Heavy oil, SAGD horizontal wells, directional drilling, magnetic guidance system

1 Introduction

Thermal oil recovery is one of the most effective means for the production of heavy oil and there are several effective methods. These include steam soaking, steam drive, steam assisted gravity drainage (SAGD) (Corbett, 1997) and in-situ combustion, of which SAGD is the most effective (Yang et al, 2010). The SAGD technique is often used for recovering ultra heavy oil and its main well patterns are vertical-horizontal well combinations (Malik et al, 2011; Bao et al, 2012) and twin-horizontal wells (Mendoza et al, 1999). Typical SAGD horizontal wells drilled in the Karamay oilfield in western China have a specified separation of 5.0±0.5 meters between the production well and the injection well (Lin et al, 2009). Due to ferromagnetic interference from the completion tubular string (casing and screen pipe) and the accumulated errors, conventional inclinometers cannot be used to guide the directional drilling trajectory in the SAGD horizontal wells.

In order to meet the field requirement, Vector Magnetics LLC in USA developed the Magnetic Guidance Tool (MGT) (Kuckes et al, 1996; Grills, 2002) and the Rotating Magnet Ranging System (RMRS) (Vandal et al, 2001; Rach, 2004; Al-Khodhori et al, 2008; Loparev, 2008; Oskarsen et al, 2009). The MGT was the first method proposed for directional drilling in SAGD horizontal wells. It has been utilized to drill over 95% of the SAGD horizontal wells in existence (Vandal et al, 2004). The RMRS has the advantages of high precision and wide range. However, its maximum working temperature is only 85 °C, its operations are complicated and its sensors are susceptible to the ferromagnetic interference. The RMRS system has been proven to be effective for well intersection operations in which a vertical well is intersected by a horizontal well (Qiao et al, 2007; Gong and Duan, 2006; Hu and Chen, 2008; Dong et al, 2008). However, the RMRS and the MGT need a lot of detected data, and the magnetic source or the probe tube needs to be run into the production well, so that they are not suitable for the applications in relief-well intersection operations and collision avoidance in cluster-well engineering. Therefore, Vector Magnetics LLC developed the Single Wire Guidance Tool (Mallary et al, 1998) and Wellspot Tool (Jones et al, 1987; Grace et al, 1988; Olberg et al, 1991; Tarr et al 1992; Roes et al, 1998). The authors are also studying new electromagnetic guidance systems for directional drilling (Li et al, 2012; Diao and Gao, 2013), which have not yet been applied in an oilfield.

The magnetic guidance technology of SAGD horizontal well drilling has been developing rapidly in China recently. Yang et al (2010) introduced the directional drilling technology in SAGD horizontal wells and its applications. Gao, Diao, Sun and other researchers have done much investigation into the theory and hardware of RMRS and MGT (Diao and Gao, 2011; Diao et al, 2011a; 2011b; Sun et al, 2011). We have developed a magnetic guidance system for directional drilling (DD-MGS) in SAGD horizontal wells by investigating magnetic ranging theory and methods

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