Calcium Phosphate Cement Slurries for Thermal Production Wells

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ABSTRACT

Calcium phosphate cement slurries used for thermal production wells cementing adapt to the soft formations and steam huff and puff were investigated. Calcium phosphate cement slurries were developed with density of 1.50 g/cm³ and 1.90 g/cm³, respectively. The properties of cement slurries and set cements were also studied. The results indicate that calcium phosphate cement slurries can meet the requirements for thermal recovery wells cementing. The long-term compressive strength of the set cement at 300 °C was not retrogressive and compressive strength after curing for 28d at 300 °C was more than 16 MPa and 24 MPa for cement with density of 1.50 g/cm³ and 1.90 g/cm³, respectively. The conclusion of X-ray diffraction (XRD), scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS) of calcium phosphate cement samples indicate that the crystalline phases leading to high-temperature strength retrogression did not exist.

KEY WORDS: Cementing; Heavy oil; Calcium phosphate cement slurry; High temperature stability of long-term strength.

INTRODUCTION

Nowadays, the proven and probable reserves of heavy oil resources of China reached 20.6 × 10⁸ tons accounting for more than 20% of total oil resources in China (Lu, 2010). Thermal recovery technology as the most effective way of heavy oil exploitation is currently the largest and most mature applied EOR techniques of the world. Thermal recovery technology in China, mainly used in Liaohe, Shengli, Xinjiang and Henan oil fields, predominantly via steam huff and puff also with continuously applied steam flooding, electric heating and SAGD technology could benefit 1500×10⁴ tons of oil every year (Wang, 2010). Cement slurries used for thermal recovery of heavy oil should return to the ground from soft formations with low fracture pressure, and set cement strength should also meet the requirements of high-temperature steam injection which is typically greater than 300 °C. There are two major methods for wells cementing adapt to thermal recovery of heavy oil: (1) Modify oil-well cement to improve the thermal resistance of set cement while maintain the seal integrity of cement sheath under diversification conditions of temperature and stress, e.g. FlexSTONE IHT cement and ThermaSTONE thermal response cement of Schlumberger, Steam Seal foam cement, Tuned Light ™ cement, Lifeseal foam cement, Corrosa Cem cement, SteamCem cement, Therma Cem cement and Life Cem cement of Halliburton in which Steam Seal foam cement and Tuned Light ™ cement and Lifeseal foam cement used for significant loss situation at wells drilling, CorrosaCem cement used for CO₂ corrosion existing underground, Lifeseal foam cement and LifeCem cement can self-repair slight cracks ensuring the seal integrity of the cement sheath via adding self-healing materials. However, the results of bonding capacity of set cement under simulated conditions showed that bonding performance between cement strength and casing declined with the increase of steam huff and puff cycle times at 260 °C (Sugama, 2006). (2). Using special cement and modified cement mechanics to meet the requirements of well cementing for thermal recovery can meet the requirements casing performance increased with the increase of steam huff and puff cycle times at 260 °C (Sugama, 2006). In this paper, the retarder and fluid loss additive for calcium phosphate cement and calcium phosphate cement slurries were developed with density of 1.50 g/cm³ and 1.90 g/cm³, respectively. The long-term compressive strength of set cement at 300 °C was investigated.

EXPERIMENTAL

Materials. All materials were provided by the Boxing Company of China National Petroleum Offshore Engineering Co., Ltd.

Method. The performances of calcium phosphate cement slurries were determined according to API RP-2-10B-2013. Ultrasonic compressive strength curves were recorded by Chandler Engineering 6262 Static Gel Strength Analyzer. XRD spectra were recorded by D8 Advance X-ray Diffractometer System. SEM photographs and EDS spectra were determined by 1530VP Field Emission Scanning Electron Microscope.

RESULTS

Thickening performance of calcium phosphate cement slurries. The thickening time as a function of retarder BCR-600S content of