Research and Application of Multiscale Fiber Toughener BCE-230S

Shuang ZOU 1,2,3, Jian-Long ZOU 1,2,3, Tian-Yi ZHANG 1,2,3, Jian-Guo ZENG 1,2,3, Kun-Peng YANG 1,2,3, Kang-Wei AO 1,2,3, Bao-Hui ZHAO 1,2,3

1. CNPC Tianjin Bo-Xing Engineering Science&Technology Limited Company, Tianjin, China; 2. CNPC Key Laboratory of Drilling Engineering; Laboratory of Cementing Technology, Tianjin, China; 3. National Engineering Laboratory of Petroleum Drilling Technology, Tianjin, China

ABSTRACT

Aiming at the problems of high brittleness, low tensile strength, poor impact resistance and fracture resistance of oil well cement stone, three kinds of inorganic fibers with high modulus, high strength and good dispersibility were selected to toughen the cement stone according to the toughening mechanism of the fiber and the demand of practical engineering application. The optimum ratio of three kinds of fibers was determined by orthogonal test, and the multiscale fiber toughener BCE-230S was invented. Effects of different additions and different ages on mechanical properties of oil well cement were investigated. The experimental results show that the BCE-230S has good toughening effect on oil well cement. When the fiber content is 5%, under the condition of 80 °C curing 7 days, compared with blank control, the tensile strength increased by 23.17%, the compressive strength increased by 2.42%, the elastic modulus decreased by 16.54% and the impact power increased by 22.57%. This toughener has been applied in low permeability wells a dozen times in Jidong Oilfield, with high cementing quality and smooth fracturing.

KEY WORDS: Multiscale; Fiber; Cement stone; Mechanical properties; Toughen.

INTRODUCTION

The long-term effective interlayer isolation capability of the cement sheath in the wellbore is not only the premise for developing and increasing production in oil and gas fields, but also for guaranteeing the long-term production life of oil and gas wells. (Liu, RG, Zhou, SM, Tao, Q Yan, PY, Ding, SD, 2015). However, set cement is a brittle material with inherent microscopic defects, such as, poor deformation capacity, low tensile strength, poor impact resistance, and poor fracture resistance (Li, M, Yang, YJ, Guo, XY, 2015; Cheng, RC, Bu, YH, Wang, Rh, 2006). In the processes associated with subsequent construction, such as pressure testing, perforation, fracturing and mining, due to the influence of temperature and pressure changes, impact, vibration, etc., the cement sheath is prone to rupture, resulting in a loss of mechanical integrity. It will result in annulus pressure, annular gas migration, and the well may even be abandoned (Zou, S, Zou, JL, Zhao, BH, Shi, LL, Yang, KP, Liu, AP, 2017; Zou, S, Zou, JL, Zhao, BH, Shi, LL, Yang, KP, Liu, AP, 2017; Hua, SD, Yao, X, 2007). Therefore, it is particularly important to improve the mechanical properties of oil well cement. Cement-based material is a kind of multiphase composite material (Zhang, C, Cao, ML, Xu, L, 2014), which has different microstructure in different scales. These microstructures will directly affect its macroscopic mechanical properties. It is found that the process of destruction of cement-based materials is mainly from the internal cracks developing and expanding into macroscopic cracks. According to the multiscale structure characteristics and destruction process of cement-based materials, the continuous propagation of micro-cracks is the root of the destruction. Multiscale fibers can be used to suppress the crack propagation at different scales, which can effectively improve its mechanical properties (Zhang, C, Cao, ML, 2014; Pereira, EB, Fischer, G, 2012).

In view of the above problems, BCE-230S, a multiscale fiber toughener for oil well cement, was made up of three different scales of inorganic fibers with high modulus, high strength and good dispersion. This toughener can improve the mechanical properties of oil well cement without affecting the construction safety. At present, it has been applied in low permeability fracturing wells in Jidong Oilfield for more than 10 times with high cementing quality, smooth fracturing in the late stage.

EXPERIMENT

Materials

Materials included API G class cement from the Shengwei cement plant of Shandong. Dispersing agent CF40S, retarder BXR-200L, fluid loss additive BCG-200L, and defoaming agents G603 were provided by the CNPC Tianjin Bo-Xing Engineering Science&Technology Limited Company. The basic parameters of three fibers are shown in Table 1, and their microscopic morphology is shown in Fig. 1, 3 and 5. And their dispersion in water is shown in Fig. 2, 4 and 6. 15g fiber and 100g water were used in each dispersion experiment.

Methods

The performances of the cement slurries were determined according to API RP-2-10B-2013. The compressive strength of cement stone was...