Exploratory Research on Water-channeling Self-healing Agent for Cementing

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ABSTRACT

A novel water-channeling self-healing agent with core-shell structure was developed to solve the water-channeling problem induced by micro-cracks after cementing. The core of water-channeling self-healing agent is a kind of water-absorbent resin with rapid swelling rate as 1900 in 30 s. When the core get wrapped by the outer layer, it can absorb non-water for 3 h at 90 °C in water. After the cement get hydrated, the shell is destroyed. And it get the ability of water-channeling self-healing. The core experiment shows that the micro-crack could be healed by the self-healing agent in 40 min under the condition of 2 MPa pressure difference at 90 °C. The conventional density cement slurry containing 4 %BWOC water-channeling self-healing agent performs good rheological properties, controllable fluid loss high compressive strength, and normal thickening linearity which inds that this agent is potential to meet the requirements of shallow well cementing.

KEY WORDS: Cementing; annulus channeling; slurry; water-channeling; self-healing

INTRODUCTION

The purpose of cementing is to seal the oil, gas and water layers in the wellbore to protect the production layer, to prevent formation fluid channeling during drilling, stimulation and production, to strengthen the wellbore and support casing to extend the life of wells and increase oil and gas production (Zhao, 2011). Tiny cracks which could act as channel aisle always appear in cement sheath induced by factors such as creeping, fracturing and perforation.

In the presence of annulus channeling, exploitation measures such as zonation testing and slice mining are hard to take which would lead to hard-to-recover reserves reducing oil and gas production. Reservoir energy loss would also occur via annulus channels reducing productivity. Meanwhile high-pressure formation water could enter the reservoir through annulus channels polluting oil and gas resources, and even causes serious damage such as reservoir water flooding. Besides, subjected to erosion and corrosion by the formation fluid would reducing the strength and service life of the casing (Lu, 2017; Ma, 2005). Self-healing agent could expand by reacting with the fluid pass by to effectively block the channel caused by cement sheath damage(Comet, 2010; Ismagilova, 2017; Li, 2012; Zhang, 2015). At present, oil and gas-channeling self-healing agents have been widely studied and applied(Johnson, 2019; Langley, 2018; Nafikova, 2019; Song, 2017; Tian, 2016). The study of water-channeling self-healing agent is still in the initial period(Bu, 2016; Ismagilova 2016).

The difficulty in the preparation of the water-channeling self-healing agent is that the agent should just possess swelling ability after cement setting rather during cementing, otherwise it would lead to unsatisfactory displacement and low cementing quality. The water-channeling self-healing agent with core-shell structure was prepared in two media via four-step reactions. Firstly, a high-speed, high-absorption water-absorbent resin was synthesized as core material, and then the core was wrapped with a shell material to obtain a waterproof structure. The shell of the agent could not be destroyed during displacement. However, it would be destroyed while cement hydration period due to the change of pH and temperature. After the shell is destroyed, the core would be exposed to water passing by in the micro cracks and finally block the micro cracks by water swelling. Moreover, even if the shell is not completely destroyed after the cement setting, the agent also possesses self-healing ability with holes in shell. These holes are the channel of water to core, and the huge tension generated by the rapid absorption of the core material can also damage the outer shell, thereby the purpose of expanding and blocking micro cracks is achieved.

THE PREPARATION OF COREMATERIAL

A quick-absorbent porous dry gel, a kind of hydrogel, is used as the core material to improve the response speed of the water-channel self-healing agent and achieve rapid sealing. The porous hydrogel has mutually intersecting pores as water adsorption channel made the diffusion speed faster than ordinary hydrogel. Since the gel preparation of the structure is simple and easy to control, it is the main way to improve the response rate. The preparation methods of porous hydrogel mainly include pore forming agent (adding pore former and emulsion template technology), phase separation (freezing technology and radiation polymerization) and interpenetrating polymer network technology (IPN).

The preparation method of the core material is prepared by pore forming agent via pore forming agent and IPN technology are