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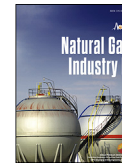

Research Article

An electrochemical adsorption method for the reuse of waste water-based drilling fluids☆,☆☆

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Abstract

The harmful solids and nano-particles with particle size smaller than or equal to 10 μm can be hardly removed by means of the existing solid–liquid separation. And on drilling sites, they are mostly buried after a harmless treatment, but the resource utilization ratio is low and the risk of secondary pollution still exists. In this paper, a technical idea was proposed to carry out a reclamation treatment on the waste water-based drilling fluids by means of electrochemical adsorption. Firstly, a laboratory test was carried out to investigate the effects of voltage, adsorption time, bentonite concentration, pad spacing and inorganic salt concentration on electro adsorption results by applying voltage on electro adsorption electrode. Then, the adsorption capacity of 4 common inorganic salts (NaCl, KCl, $CaCl_2$ and Na_2CO_3) to the solid particles in the simulated drilling fluid was investigated on the electro adsorption electrode at different concentrations. Finally, after an optimal electro adsorption condition was determined, the waste polysulfonate drilling fluid of a certain domestic oilfield was taken as a sample to verify such treatment effect. And the following research results were obtained. First, by means of electrochemical adsorption, the inferior solid particles in waste drilling fluids are removed through adsorption, and thus the waste drilling fluid is reclaimed and the resource reutilization ratio of drilling waste is increased while its treatment volume and cost in the late stage is decreased. Second, the optimal electro adsorption condition of simulated waste drilling fluid with 5% bentonite and 2 g/L NaCl is adsorption voltage of 36 V, adsorption time of 5 min and pad spacing of 5 cm. And third, more than 90% of the inferior solids with a particle size range of 1–10 μm are removed after the sample is treated by means of the electrochemical adsorption. It is indicated that this proposed method plays a remarkable role in removing the inferior solids in the waste polysulfonate drilling fluids.

Keywords: Waste water-based drilling fluid; Electrochemical adsorption method; Inferior solid; Nano-particle; Removal rate; Reclamation and reuse; Resource utilization ratio

1. Introduction

Waste water-based drilling fluid and drill cuttings are mainly treated via on-site solidification and landfill or natural evaporation, and sometimes reuse. Thus, the recycling rate is low and environmental risk is high. The existing treatment methods, if handled improperly, may cause soil and groundwater pollutions, and even be judged as "seepage pit and infusion" treatment of pollutants by the environmental protection authorities by laws. With the implementation of the

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new Environmental Protection Law, the traditional solidification and landfill treatment will gradually be prohibited. If water-based drilling waste generated during exploration and development is not timely and effectively disposed, legal sanctions and fines will be imposed. In recent years, new technologies, like chemical de-stabilization solid–liquid separation and treatment while drilling, have been developed in China for treating drilling wastes generated in different drilling fluid systems [1–4]. These technologies have been successfully applied. Moreover, the suspended treatment technique of waste drilling fluid has rapidly emerged and been applied on sites. However, in most on-site applications, the valuable components in the waste drilling fluid were not recycled. The existing solid–liquid separation techniques/equipment like shale shaker and centrifuge fail to remove harmful solids and ultrafine particles with size of less than or equal to 10 μm.

Foreign researchers started the work on electrosorption technology earlier and the technology has been widely used, especially in water treatment [5–8]. In as early as the 1960s, Ayronaci et al. used porous activated carbon as electrode to remove salt from water [9–12]. With the continuous development of electric power and electrode materials, the application of electrosorption technology has become more widespread. It is applied not only to the removal of inorganic salts, heavy metals and acid radicals in waste water [13,14], but also to the removal of organic pollutants and certain colloidal particles [13–17]. Its application in the treatment of waste drilling fluids has not yet been reported.

In this study, the electrosorption technology was used to recycle waste drilling fluids (namely, adsorption of hazardous solids in waste drilling fluids). Inferior solids in waste drilling fluids are removed without adding chemical treatment agents and ultimately the performance of the recycled drilling fluid is improved. This study provides a new way for recycling waste drilling fluids.

2. Experiment

2.1. Materials and instruments

Experimental agents include sodium chloride (analytical reagent), potassium chloride (analytical reagent), sodium carbonate (analytical reagent), calcium chloride (analytical reagent), sodium hydroxide (analytical reagent), and high quality bentonite (industrial grade).

Experimental instruments include Model 101 Electric Blast Drying Box (Beijing Ever Bright Medical Treatment Instrument Company), AL104 Electronic Balance (MettlerToledo, Switzerland), GJS-B12K High Frequency High Speed Mixer (Qingdao Haitongda Special Instrument Factory), Sension5 Portable Conductivity Meter (Hach Company, US), PHS-3C Microcomputer pH Meter (Shanghai Kangyi Instrument Co., Ltd.), Mastersizer 2000 Laser Particle Size Analyzer (Malvern Instruments, UK), and Small Indoor Electrosorption Device (self-developed).

2.2. Electrosorption static experimental device

The electrosorption experiment on drilling fluid was carried out in an electrosorption device, which comprises three parts: a power supply controller, an insulated electrolytic cell and a plug-in electrosorption plate, as shown in Fig. 1.

2.3. Experimental method

1) Put the prepared drilling fluid (5% bentonite drilling fluid) into the electrolytic cell, and insert the electrosorption plate into the corresponding slot; adjust the voltage, and start timing when the target experimental voltage is reached. When the experiment time is over, the solid particles adsorbed on the electrosorption plate are scraped into a beaker of known quality, and are then sent to an oven for drying and weighing. The amount of solid particles adsorbed under the experimental conditions is calculated by difference subtraction.
2) Record the change of conductivity and current before and after drilling fluid adsorption during the experiment. The amount of drilling fluid used in each experiment is 2 L. The area of the immersed plate in the drilling fluid is 92.4 cm^2 (12 cm (length) × 7.7 cm (width)).

3. Results and discussions

The single factor experiment was conducted to examine the influences of voltage, adsorption time, bentonite concentration, plate spacing and inorganic salt. After the optimal electric adsorption conditions were determined, waste polysulfonate drilling fluid used at an oil field in China was used to verify the effect of electrosorption treatment.

3.1. Voltage and electrosorption time

Electrochemistry has many functions such as electrolysis and electrosorption. The decomposition voltage of water is usually between 1.3 and 1.6 V. Researches show that the electrosorption technology is usually used with a voltage less

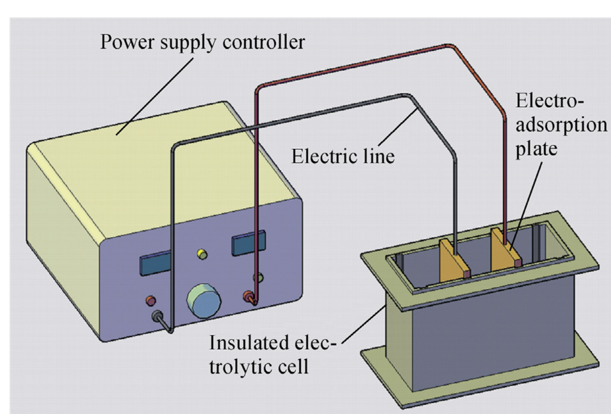

Fig. 1. Schematic diagram of electrosorption experimental device.

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