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Yang Liu, Wen-ming Jiang, Jie Yang, Yu-xing Li, Ming-can Chen, Jian-na Li

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Experimental study on evaluation and optimization of tilt angle of parallel-plate electrodes using Electrocoagulation device for oily water demulsification

Yang LIU[a,b], Wen-ming JIANG[a,b*], Jie YANG[a,b], Yu-xing LI[a,b], Ming-can CHEN[a,b], Jian-na LI[c]

(a. Shandong Provincial key laboratory of Oil & Gas Storage and Transportation Safety, Qingdao Key Laboratory of Circle Sea Oil & Gas Storage and Transportation Technology, Qingdao 266580, China; b. College of pipeline and civil engineering, China university of Petroleum, Qingdao 266580, China; c. Thermal Energy Engineering, Xi'an jiaotong university, Xi'an 710049, China)

Abstract

Tilt angle of parallel-plate electrodes (APE) is very important as it improves the economy of diffusion controlled Electrocoagulation (EC) processes. This study aimed to evaluate and optimize APE of a self-made EC device including integrally rotary electrodes, at a fixed current density of 120 Am^{-2}. The APEs investigated in this study were selected at 0^o, 30^o, 45^o, 60^o, 90^o, and a special value ($\alpha_{(d)}$) which was defined as a special orientation of electrode when the upper end of anode and the lower end of cathode is in a line vertical to the bottom of reactor. Experiments were conducted to determine the optimum APE for demulsification process using four evaluation indexes, as: oil removal efficiency in the center between electrodes; energy consumption and Al consumption, and besides, a novel universal evaluation index named as evenness index of oil removal efficiency employed to fully reflect distribution characteristics of demulsification efficiency. At a given plate spacing of 4 cm, the optimal APE was found to be $\alpha_{(d)}$ because of its potential of enhancing the mass transfer process within whole EC reactor without addition, external mechanical stirring energy, and finally the four evaluation indexed are 97.07%, 0.11 g Al g^{-1} oil, 2.99 kwhkg^{-1} oil, 99.97% and 99.97%, respectively.

Key words

Electrocoagulation; Tilt angle; Rotary electrodes; Oily water; Demulsification

1. Introduction

On account of the increasing large volumes of oily water produced by oil extraction every day, a growing attention has been directed to the demulsification of oil in water emulsions for recycle or direct discharge. As reported by Ferro and Smith (2007), indicated that global oily wastewater associated with oil and gas fields was estimated at around 250 million barrels per day compared with around 80 million barrels per day of oil recovery. In addition, the oily water is characterized by high oil concentration, high salinity and micron sized oil droplets with high stability. Thus, untreated oily water not only causes pollution of the environment but also jams rock of formation with a consequent affecting subsequent recovery.

Conventional technologies were unfit for demulsification of O/W emulsions due to complex control, high cost, low efficiency, limits and a lot of sludge generation (Asselin et al., 2008; Karhu et al., 2012). Nevertheless, electrocoagulation (EC) is receiving an increasing acceptance by industry in view of its advantages compared to other methods. In essence an EC reactor is an electrochemical cell, wherein chemical reactions occurring as seen in Eqs. (1) - (5) (Chen et al., 2004).

For anode:

$$Al\text{-}3e \rightarrow Al^{3+} \quad (1)$$