Contents lists available at SciVerse ScienceDirect

Chemical Engineering Research and Design

journal homepage: www.elsevier.com/locate/cherd

Flow-field distribution and parametric-optimisation analysis of spiral-tube separators

Lixin Zhao[a,*], *Baorui Xu*[a], *Minghu Jiang*[a], *Feng Li*[a], *Zhengrong Hua*[b]

[a] *Northeast Petroleum University, Daqing 163318, Heilongjiang, China*
[b] *Daqing Oilfield Company Ltd., Daqing 163513, Heilongjiang, China*

ABSTRACT

Here we focus on the analysis of spiral-tube separators; model selection and the basic parameters for numerical simulation are described. Flow-field simulation analyses were performed for spiral-tube separators both with and without holes. The effects of gyration radius, inlet flowrate, the number of spiral coils, and oil-droplet diameter on flow-field distribution and the separation performance of spiral-tube separators were analysed in detail. The simulation results showed that the gyration radius and inlet velocity are the two main factors affecting the separation characteristics of spiral-tube separators. In addition, the size of the holes in a spiral-tube separator also affects the separation results. Some simulation results were verified through experimental studies. This study provides a basis for the flow-field analysis and structural optimisation of spiral-tube separators.

Keywords: Oil–water separation; Separator; Spiral tube; Flow field; Parametric optimisation

1. Introduction

Oily wastewater is a typical organic industrial wastewater that is widely produced and does great environmental harm. At present, a large number of the oilfields in China have moved into a period of high-water-cut crude-oil exploitation. In the process, the water content of the product fluid reaches up to 80–90 percent. A large amount of oily water remains after the oil–water separation (Wang et al., 2005; Chen, 2000), which has resulted in the pollution of water resources and a waste of oil; furthermore, the ecological harm and human health hazards caused by this oily pollutant have aroused serious concern. Therefore, the development of an effective and economical oily wastewater treatment technology to achieve the goals of energy conservation, environmental protection, and water reuse has become a key problem in oilfield operations (Zhao and Li, 2006; Zhao et al., 2008b).

The treatment methods (Gao and Gu, 1999) for oily wastewater can be classified into the following according to their principles: (1) physical methods, e.g. gravity settling, mechanical separation, centrifugal separation, filtration, and membrane separation; (2) physical–chemical processes, e.g. flotation, adsorption, and ionic exchange; (3) chemical processes, e.g. agglomeration, acidification, and electrolysis; and (4) biochemical process, e.g. activated-sludge processes, biological-filtration processes, and oxidation-pond methods. With respect to environmental protection, physical methods are preferred.

The spiral-tube separator has advantageous structural characteristics. It can produce a centrifugal force field and form a secondary flow. Although its structure is relatively simple, the interior flow field is quite complicated. The flow-field distribution of spiral-tube separators and its parametric governing equations were studied in this work.

2. Structure and working principles of spiral-tube separators

A geometric model of a spiral-tube separator is shown in Fig. 1(a), and a geometric parameter sketch is shown in Fig. 1(b). Here the inner diameter, d, is 25.4 mm. The pitch is marked as t, and R is the gyration radius.

* Corresponding author at: College of Mechanical Science and Engineering, Northeast Petroleum University, 199 Fazhan Rd., High-Tech Zone, Daqing 163318, Heilongjiang, China. Tel.: +86 459 6503853; fax: +86 459 6503853.
E-mail address: lx_zhao@yahoo.com.cn (L. Zhao).

Received 7 December 2010; Received in revised form 14 November 2011; Accepted 18 November 2011
0263-8762/$ – see front matter © 2011 The Institution of Chemical Engineers. Published by Elsevier B.V. All rights reserved.
doi:10.1016/j.cherd.2011.11.014