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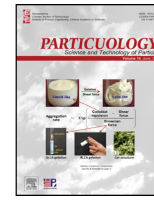
PARTIC-1089; No. of Pages 9
ARTICLE IN PRESS

Particuology xxx (2018) xxx–xxx

Contents lists available at ScienceDirect

Particuology

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



Agglomerate behavior in a recirculating fluidized bed with sheds: Effect of ring baffles

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ARTICLE INFO

Article history:
Received 7 October 2016
Received in revised form
30 September 2017
Accepted 30 October 2017
Available online xxx

Keywords:
Radioactive particle tracking
Fluidized bed
Fluid coker
Baffles

ABSTRACT

The radioactive particle tracking technique was used to study the effect of internal ring baffles on wet agglomerate motion inside a cold flow recirculating fluidized bed. The study found that using such a baffle on its own or above the regular sheds helps reduce the fouling of the stripper section by increasing the residence time that the agglomerates spend above the baffle, thereby reducing the release of the vapors below the baffles that cause fouling of the sheds. Adding down-comers, or flux tubes, to the ring baffles degrades the performance of the baffles. Reducing the length of the flux tubes, so that they do not reach the bottom of the baffle lip results in a further degradation in baffle performance.

1 Introduction

Fluid coking™ (Fig. 1) is a thermal process used to crack heavy oils (Speight, 2006). Oil is sprayed onto a downward-flowing fluidized bed of hot coke particles, where it heats up and cracks into smaller vapor molecules. The down-flowing coke particles are then transported to a fluid bed burner where they are reheated.

Oil vapors are recovered from the moving bed of coke-particles by steam stripping before the coke particles are conveyed to the burner. The stripper section of the coker involves a system of baffles (sheds) that distribute steam into the flowing bed and displace the hydrocarbon vapors from the voids between the coke particles; they also reduce gas back-mixing through the sheds.

Most of the injected liquid is confined (Farkhondehkavaki, 2012) within wet agglomerates ranging from 1 to 20 mm in diameter (Ali, Courtney, Boddez, & Gray, 2010; Gray, 2002; Weber, Briens, Berruti, Chan, & Gray, 2006). Because significant heat is required in converting liquid bitumen to cracked vapor, heat transfer from the bed through the agglomerate imposes limitations; specifically, the liquid is at a much lower temperature than the average bed temperature (Gray, McCaffrey, Huq, & Le, 2004; House, 2007; House, Saberian, Briens, Berruti, & Chan, 2004). This liquid therefore reacts much more slowly. Some agglomerates subsist and reach the stripper region, where their liquid continues to react and release hydrocarbon vapor products.

In 2011, Wyatt et al. (2011) from Exxon-Mobil, patented a new type of ring baffle (Fig. 2(a)) to help reduce fouling of the stripping section of the fluid coker sheds. These attachments are located at different heights along the reactor and can restrict the open area by up to 70%. The baffles can be equipped with down-comers (also called flux tubes), which are vertical tubes that are attached to the ring baffle Fig. 2(b). Wyatt et al. (2011) proposed using baffles as an addition to the stripper sheds, but they did not intend to use them as substitutes for the stripper sheds.

Most of the hydrocarbon vapor is released within and below the stripper shed region, and rises through the sheds, where they may crack and cement coke particles on the shed surfaces. Widespread fouling thickens the sheds and narrows the open space between adjacent sheds through which coke flows (Fig. 3); this reduces the stripping efficiency and can cause premature shutdown of the reactor. Observations of commercial fluid cokers have shown that fouling is more pronounced in the top shed row. Raising the coker temperature reduces stripper fouling, but reduces the yield of valuable liquid product.

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https://doi.org/10.1016/j.partic.2017.10.008

Please cite this article in press as: Careaga, F. J. S., et al. Agglomerate behavior in a recirculating fluidized bed with sheds: Effect of ring baffles. *Particuology* (2018), https://doi.org/10.1016/j.partic.2017.10.008

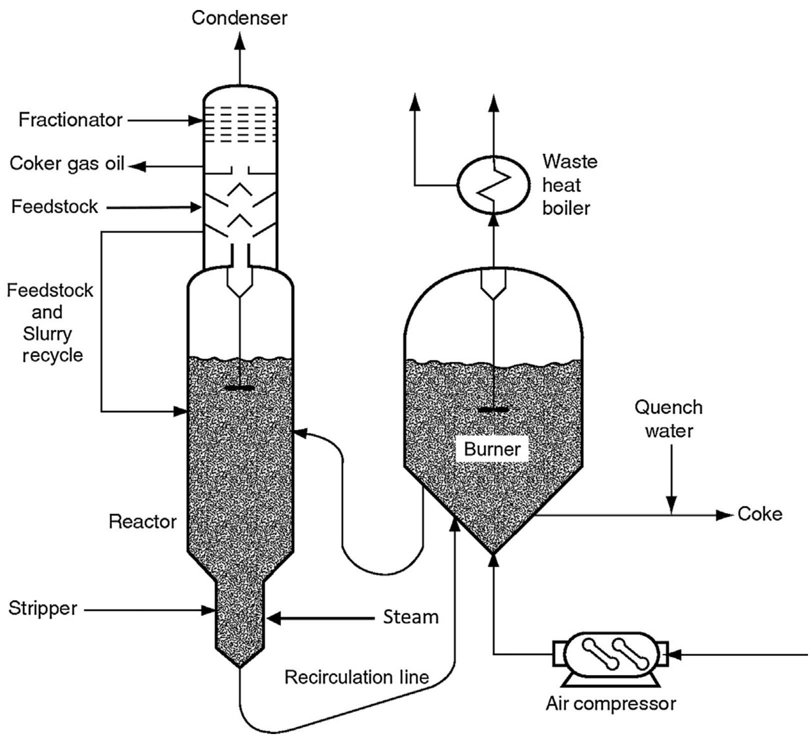

Fig. 1. Schematic of a fluid coker system.

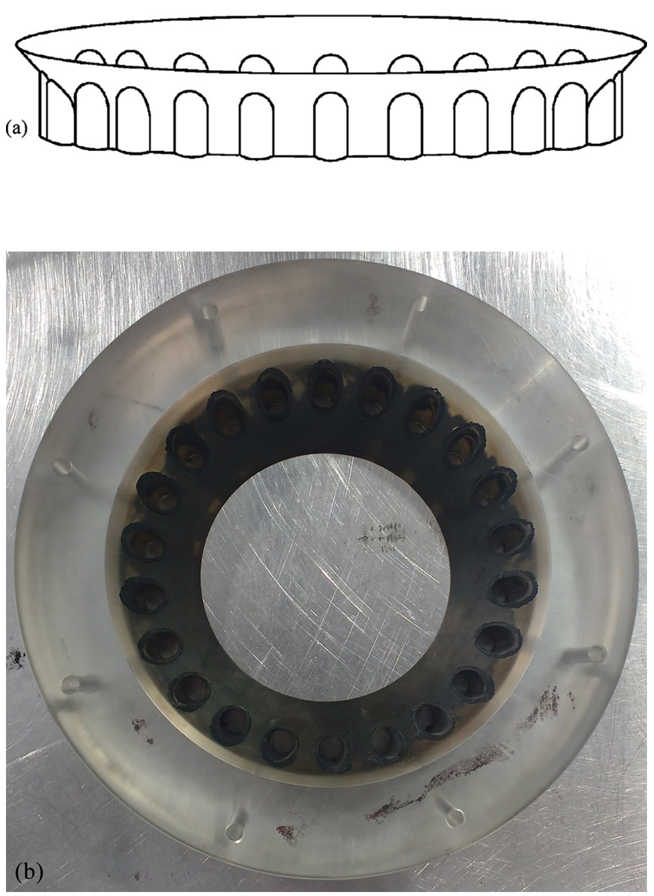

Fig. 2. (a) Side-view schematic of a ring baffle, (b) top view photo of a ring baffle with flux tubes used in Wyatt et al. (2011).

It is therefore of value to study how agglomerates flow through the stripper zone. Of special interest is the amount of vapor released below the top stripper row because this vapor causes fouling.

The radioactive particle tracking (RPT) technique provides the instantaneous position of a radioactive tracer-agglomerate within a fluidized bed: as an example, Upadhyay and Roy (2010) used RPT with tracers of different densities to study particle segregation in non-recirculating fluidized beds. Sanchez et al. (Sanchez Careaga, Briens, Berruti, McMillan, & Gray, 2015; Sanchez & Granovskiy, 2013) showed that RPT can be used to track model agglomerates in a cold flow recirculating fluidized bed that contained stripper sheds.

The objective of this study was to use RPT in a cold flow recirculating fluidized bed to determine how the motion of the agglomerates is affected by:

- the presence of ring baffles,
- the presence of flux tubes, and
- the length of the flux tubes.

The release of vapors from agglomerates can then be estimated by combining the RPT results with a coking reaction model.

2 Materials and methods

2.1 Materials

Fluid coke, provided by Syncrude Canada Limited, was used as the fluidized material. Its particle density is 1450 kg/m^3 and its Sauter-mean diameter is 140 μm. A bed mass of 19 kg was used in the laboratory scale fluid bed.

An epoxy/gold tracer-agglomerate prepared as recommended by Godfroy (1997) was selected as the radioactive source. When irradiated in a nuclear reactor (for this study, the material test reactor at McMaster University in Canada), gold is partially converted into isotope ^{198}Au with a half-life of 2.69 days (Larachi, Chaouki,