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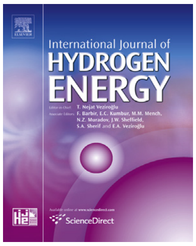

Determination of residence time distributions in different high pressure gasification processes by radioactive tracers

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ABSTRACT

High-Pressure Partial Oxidation is a key technology for the usage of flare gases and heavy oil residues. At the test plant of TU Bergakademie Freiberg, it is possible to gasify different gaseous and liquid fuels at pressures up to 100 bar (g). Information on residence time distributions can be gained by using radioactive tracers. The results of measurements for different reactor geometries and feedstocks will be discussed in this paper. Results of radioactive residence time measurements depend strongly on reactor geometry and require different evaluation methods.

Introduction

The production of synthesis gas is one of the first steps in the conversion of different feedstocks to liquid fuels like methanol or gasoline. Feedstocks might be gaseous (e.g. natural or flare gas), liquid (e.g. heavy oil residues) or solid (e.g. coal or biomass). At TU Bergakademie Freiberg in Germany, a High-Pressure Partial Oxidation (HP POX) test plant with 5 MW thermal power has been installed and operated

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together with Lurgi GmbH (part of Air Liquide Group) for the conversion of gaseous and liquid fuels. It is designed for three different modes: the so-called ATR-mode (Autothermal Catalytic Reforming), the Gas-POX-mode (Partial Oxidation of natural gas) and the MPG-mode (Multi-Purpose Gasification), see also [1,2].

The first one is a process for the catalytic conversion of natural gas and can be run at pressures of up to 70 bar (g). The Gas-POX-mode is also used for natural gas processing, but no catalyst is applied and operating pressure may reach up to 100 bar (g). In MPG-mode, high-viscosity liquids can be gasified at pressures of up to 100 bar (g). In all modes, the feedstock is processed with oxygen and steam. A schematic view of the partial oxidation (or gasification) reactor is given in Fig. 1. The geometry of the reactor of the test plant can be changed according to the different modes, as can be seen for the ATR-mode and the MPG-mode in Fig. 6.

Because of high investment costs for such processes, design studies with the help of computational fluid dynamics (CFD) are of increasing importance. Validation of such studies is very complicated due to high pressures and temperatures within the reactor and the poor accessibility for (e.g. optical) measurement equipment. The use of a radioactive tracer has been determined as a possible way for obtaining information on flow conditions within the reactor since it has some advantages compared to other methods. Usually, only small amounts of tracer material are required. Thus, the properties of the process materials are not influenced. Also, radioactive tracers have a very high detectability, even through e.g. massive walls. If the half-live is small enough, there will be no remaining radiation in the product or in the process equipment after a relatively short time period. The results of

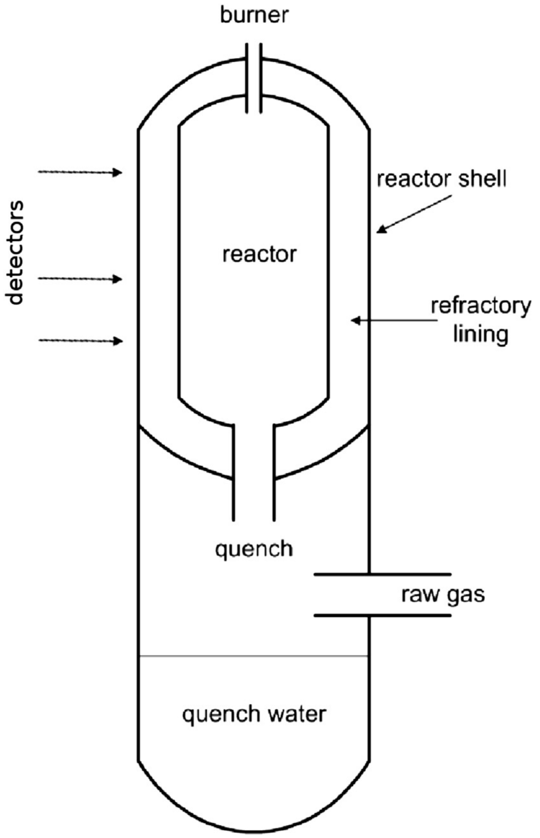

Fig. 1 – Schematic view of the reactor of the HP POX test plant.

Fig. 2 – Detectors installed at the reactor (encased in the yellow lead bricks) [6].

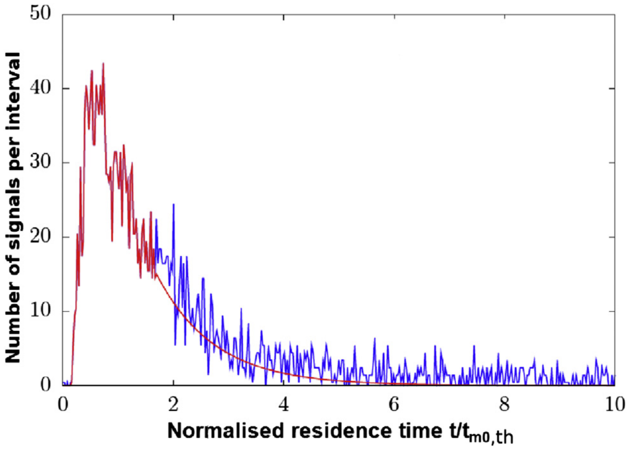

Fig. 3 – Signal with noise (blue line) and exponential extrapolation (red line), normalised by theoretical mean residence time $t_{m0,th}$. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)