

Kinetic Modeling of Tar Formation in an Updraft Biomass Gasifier

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ABSTRACT

As the depreciation of the fossil fuels in the world, it is obligatory to discover new fuels to the highly industrialized society. With increasing requirements of the energy, it is globally focused on the use of renewable energy. Biomass can be used as an alternative energy source to replace fossil fuels, which contribute to the greenhouse gas emission. Therefore, biomass is a major renewable energy source as of today.

Nowadays, converting biomass into biofuel is a major goal. So, the gasification process can be used as such an effective way to convert biomass into syngas. Even if the major goal of the gasification is to produce syngas such as H_2 , CO , intermittently, many byproducts are generated such as NO_x , SO_2 , fly ash and tar. The formation of tar in the gasifier is a problematic situation. The formation of tar mainly depends on temperature, residence time, type of biomass and gasifying medium.

Modeling is an effective method to optimize the gasifier operation. Also, it can be used to determine the relationship between operational parameter limits and explain trends in output products. By using Aspen Plus process simulation tool, a kinetic model was developed to predict the tar formation of updraft gasifier considering the main chemical phenomena biomass pyrolysis, reduction and combustion. The results were compared with the experimental data from the literature to validate the model. According to the developed model, the tar content and the composition could be estimated with respect to the equivalence ratio (ER) and pyrolysis zone bed height. When the ER is increasing the formation of tar is trending to decrease. The pyrolysis zone bed height beyond 1.3 cm does not show a significant impact on the tar content.

It is possible to use the developed model to minimize tar content by operating at a suitable temperature (by controlling the ER) and by keeping an applicable residence time (by maintaining a suitable bed height). Further, this model can be used to optimize the tar formation with different biomass types and gasifying mediums when the temperature profile of the gasifier is available.

Keywords: Biomass, Updraft Gasifier, Tar, Kinetic Modeling

NOMENCLATURE

Abbreviation

ER

Equivalence Ratio

PFR

Plug Flow Reactor

Description

Symbol

$C_7H_8O_2$

Guaiacol

$C_8H_8O_3$

Vanillin

C_6H_6O

Phenol

$C_7H_6O_2$

Salicylaldehyde

$C_6H_6O_2$

Catechol

C_7H_8O

o-Cresol

$C_{10}H_8$

Naphthalene

$C_{14}H_{10}$

Phenanthrene

C_6H_6

Benzene

C_5H_6

Cyclopentadiene

C_9H_8

Indene

C

Concentration (mol/m^3)

k

Reaction rate constant (1/s)

r

Reaction rate ($\text{mol/m}^3\text{s}$)

R

Universal gas constant (J/mol K)

T

Temperature (K)

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