DGMK-Fachbereichstagung: Thermochemische Konversion – Schlüsselbaustein für zukünftige Energie- und Rohstoffsysteme, 23-24.05.2019, Dresden

Plasma-gestützte Biomassevergasung mit Fokus auf Konversionsgrad und Reaktionskinetik

Plasma-assisted Biomass Gasification with a Focus on Conversion Degree and Reaction Kinetics

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Motivation

Involving non-thermal plasma (NTP) into biomass gasification, the following advantages can be achieved:

- Generated highly energetic electrons contribute to molecular structure cleavage
- Generated radicals, charged elements and etc. oxidize the target molecules and lead to better reaction kinetics

The major motivation of this investigation is to study the NTP influence on syngas-based carbon conversions and hydrogen releases.

Approach

In this work, a direct comparison between plasma and thermal biomass steam gasification under similar experimental conditions (energy input, gas temperatures, mass flow rates etc.) has been conducted.

In plasma cases, ca. 1 kW electrical power will be fed into reactions, while in thermal cases a similar amount of thermal energy will be introduced by a steam superheater. Besides, the primary steam temperatures in both cases are optically measured. The measurement results shown no substantial deviations. Therefore, the water steam gas temperatures in both cases are similar.

Test conditions and facility

The plasma-assisted steam gasification/reforming tests (CH_mO_n + H_2O + plasma → H_2 + CO + CO_2 + CH_4) take place at the following major conditions:

- Reactor wall temperatures: 700 – 950 °C
- Mass flow rate of feedstock: 0.1 – 0.2 kg/h
- Total steam mass flow rate: 8 kg/h

Figure 1 presents the applied test facility for plasma-assisted and thermal gasification and reforming investigation.

Analysis Methods

The results are analyzed by the following two key performance parameters:

Carbon conversion X_C: is calculated from a carbon balance between products (CO, CH_4 and CO_2) and fuel.

$$X_C = (\dot{m}_{C,CO} + \dot{m}_{C,CH4} + \dot{m}_{C,CO2})/\dot{m}_{C,fuel}$$

Hydrogen release Y_H: is determined from a hydrogen balance between products (H_2 and CH_4) and fuel without the hydrogen production from water dissociation.

$$Y_H = (\dot{m}_{H,H2} + \dot{m}_{H,CH4} - \dot{m}_{H,plasma})/\dot{m}_{H,fuel}$$

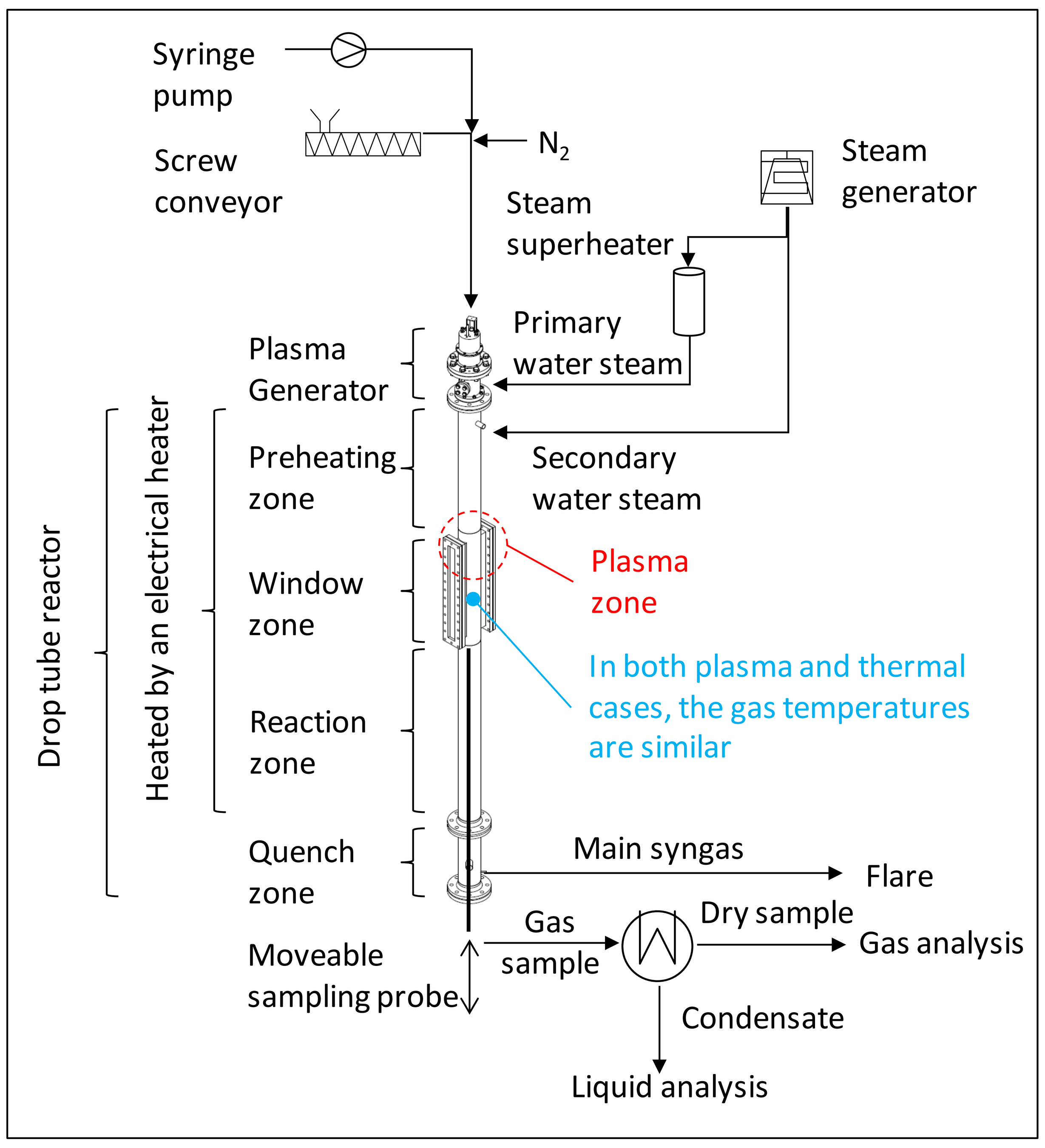


Figure 1. An overview of the simplified test facility

Results

Figure 2 summarizes the experimental results using wood, charcoal, toluene and isopropanol as fuel. The NTP influence has been quantitatively determined.

Conclusions

This work shows that the non-thermal plasma has promoted both conversion degrees and reaction kinetics.

Acknowledgement

This work has been supported by the Campus Future Energy Systems (Campus FES) under the grant „Biomassevergasung in Mitteltemperaturplasmen"

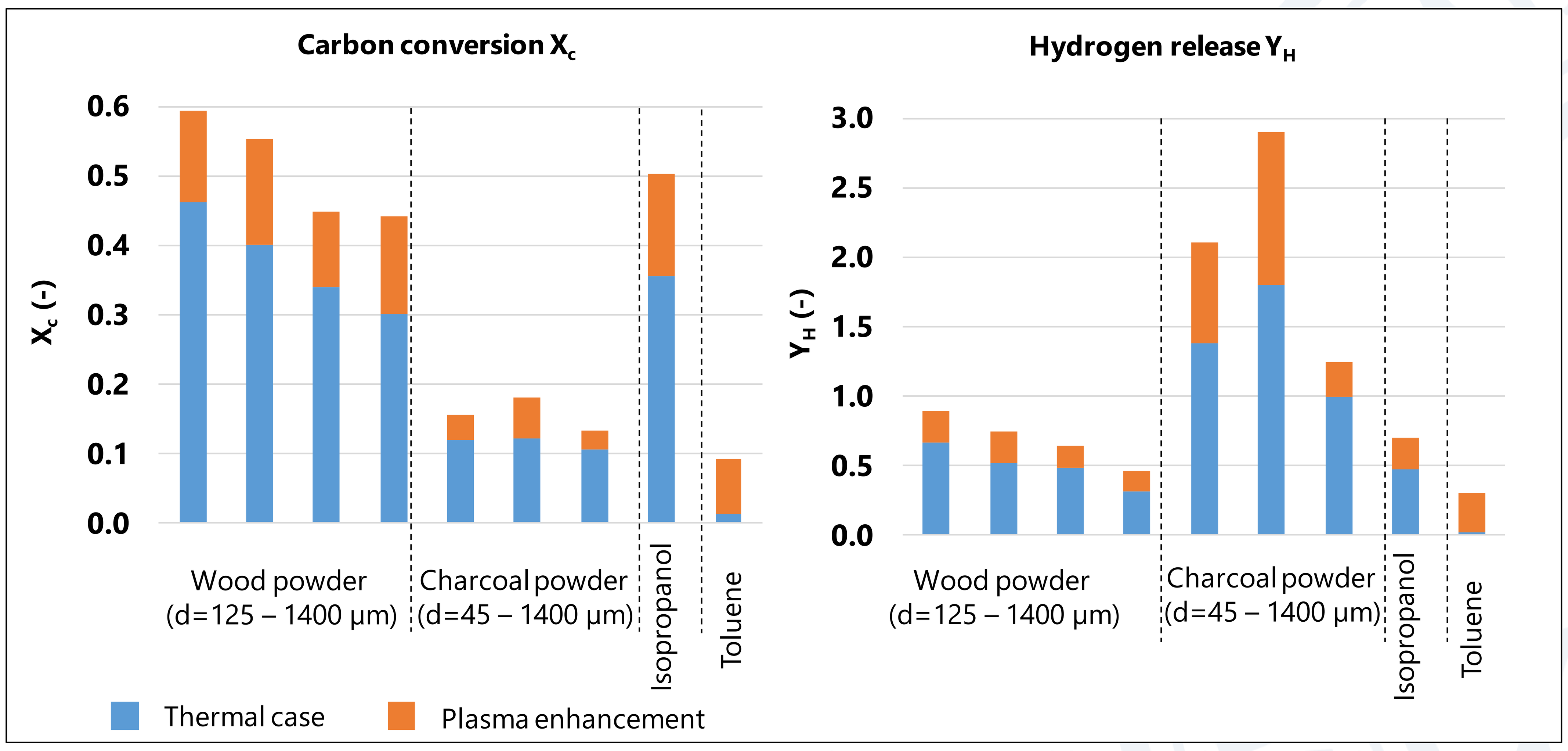
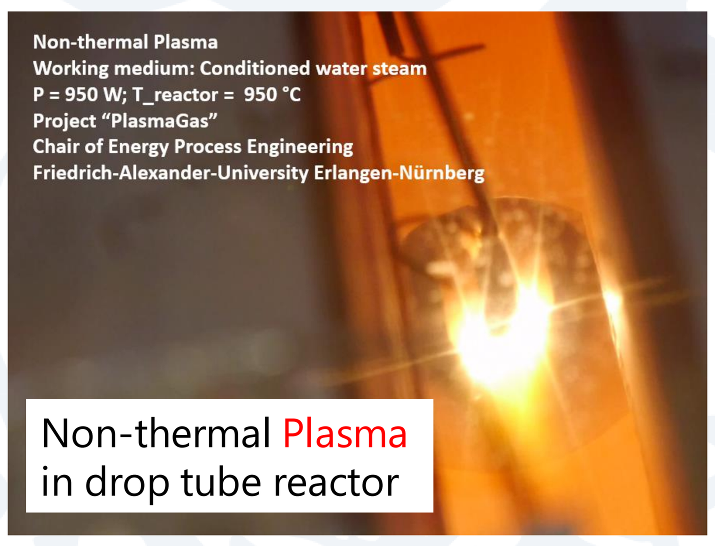


Figure 2. Carbon conversions and hydrogen releases from thermal (blue) gasification/reforming with non-thermal plasma enhancement (orange)



Non-thermal Plasma in drop tube reactor

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