Experimental study of biomass particle combustion

Kouchaksaraeia, Maryam; Kær, Søren Knudsen; Yin, Chungen; Hansen, Troels Bruun; Jensen, Peter Arendt; Glarborg, Peter

Publication date: 2012

Document Version
Early version, also known as pre-print

Link to publication from Aalborg University

Citation for published version (APA):
Experimental Study of Biomass Particle Combustion

M. Momeni¹, S. K. Kær¹, C. Yin¹, T. B. Hansen², P. A. Jensen², P. Glarborg²

¹ Department of Energy Technology, Aalborg University, 9220 Aalborg East, Denmark
² Department of Chemical Engineering, Technical University of Denmark, 2800 Lyngby, Denmark

E-mail: mam@et.aau.dk

Abstract

An experimental study was conducted to investigate the combustion behavior of single cylindrical and spherical biomass particles with diameters from 1 to 3mm. Particles with different aspect ratios (similar diameter and volume) were produced for studying the influences of particle shape on the combustion process. The particles were combusted in a single particle reactor at temperatures in the range of 1200°C to 1600°C and oxygen concentration levels in the range of 5 to 20%. A CCD camera was used to record the whole combustion process.

Experimental Setup

- The set up mainly consists of a reactor, a burner, a flame detector and a gas supply system. The burner is a Blue Flame Technology 94 Jet Burner.
- The flow rates are controlled by mass flow controllers (MFCs) of the type EL-FLOW which is connected to a computer. The software LabView 8.6 regulates and controlled the flow.
- The entire combustion process is recorded by using of a high performance camera which is located in the back of the reactor. The camera is an Allied Vision Technologies Stingray F-033 which is able to take 65 images per second in average.

Experimental Procedure

- The temperature and oxygen profiles inside the reactor have been measured by inserting a thermocouple and a suction probe into the reactor in the desired location from the wall to the reactor center.
- A ceramic protection tube is applied to cover the particle and allows it to reach the center before it is ignited. The tube is made of Al2O3 with a thermal conductivity of 30 W/mK. The protection tube is inserted to the reactor first, then the particle on the platinum holder is inserted to the reactor through the protection tube from the opposing hole, and at the end, the protection tube is ejected from the reactor tube. All these steps are done very quickly (<5s) and the heat transfer from the tube to the particle is negligible.

Results and discussion

- The investigated fuel was a low ash content pine wood.
- All the shaped samples were weighed before the tests and there was less than 5% difference.

Three different times can be determined from the resulted video, ignition time, total devolatilization time and burnout time. The criteria for determining the ignition, devolatilization and burnout time are based on the observation from the images captured during the whole combustion process.

Materials and Conditions

- The oxygen concentration changes from 5 to 20%.
- The investigated fuel was a low ash content pine wood.
- A single cylindrical particle with aspect ratio of 4 was combusted at different temperatures and oxygen concentrations.

Acknowledgements

This work was financially supported by DONG energy. The authors would like to thank Paw Jensen for his worth helps in performing the experiment.

Table 1

<table>
<thead>
<tr>
<th>Sample's size and shape information</th>
<th>M (g)</th>
<th>S/V (mm⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spheres</td>
<td>2.0</td>
<td>0.0125</td>
</tr>
<tr>
<td>Cylinder 1</td>
<td>1.65</td>
<td>0.0125</td>
</tr>
<tr>
<td>Cylinder 2</td>
<td>1.41</td>
<td>0.0125</td>
</tr>
<tr>
<td>Cylinder 3</td>
<td>1.31</td>
<td>0.0125</td>
</tr>
<tr>
<td>Cylinder 4</td>
<td>3.0</td>
<td>0.0125</td>
</tr>
<tr>
<td>Cylinder 5</td>
<td>3.0</td>
<td>0.0125</td>
</tr>
<tr>
<td>Cylinder 6</td>
<td>3.0</td>
<td>0.0125</td>
</tr>
</tbody>
</table>

References


Fig 1. Setup

Fig. 2. Temperature and oxygen concentration profiles (T=1200°C, O₂=20%)

Fig. 3. Temperature variation vs. time inside the protection tube and reactor

Fig. 4. Samples

Fig. 5. Effects of particle shape on the conversion time of particles with similar mass (volume) T=1200°C, 02=20%, All refers to spherical particles

Fig. 6. Effects of surrounding conditions on the particle devolatilization time

Fig. 7. Effects of surrounding conditions on the particle burnout time

Fig. 8. Effects of particle shape on the conversion time of particles with similar diameter T=1200°C, 02=20%, diameter of all particles is 3mm