Detailed Deposition Characteristics around Burner Plane in an Impinging Entrained-Flow Coal Gasifier

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June 6, 2018
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1. Introduction

The gasification processes in the OMB gasifier are complicated. This work focuses on the deposition behaviors around burner plane.
Based on a bench-scale OMB gasification platform and the advanced visualization techniques, detailed deposition characteristics in the gasifier has been studied.
2. Experimental platform

Properties and conditions

Table 1 Properties of coal and CWS

<table>
<thead>
<tr>
<th>Proximate analysis (wt%, air dry basis)</th>
<th>Moisture</th>
<th>3.47</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Volatile matter</td>
<td>31.13</td>
</tr>
<tr>
<td></td>
<td>Fixed carbon</td>
<td>57.57</td>
</tr>
<tr>
<td></td>
<td>Ash</td>
<td>7.83</td>
</tr>
<tr>
<td>Ultimate analysis (wt%, air dry basis)</td>
<td>Carbon</td>
<td>72.56</td>
</tr>
<tr>
<td></td>
<td>Hydrogen</td>
<td>4.58</td>
</tr>
<tr>
<td></td>
<td>Nitrogen</td>
<td>1.02</td>
</tr>
<tr>
<td></td>
<td>Sulfur</td>
<td>0.78</td>
</tr>
<tr>
<td></td>
<td>Oxygen</td>
<td>9.76</td>
</tr>
<tr>
<td>Properties of CWS</td>
<td>Average particle size (μm)</td>
<td>40.1</td>
</tr>
<tr>
<td></td>
<td>Mass concentration</td>
<td>61%</td>
</tr>
<tr>
<td></td>
<td>Viscosity (mPa·s)</td>
<td>288.5</td>
</tr>
<tr>
<td></td>
<td>Density (kg·m⁻³)</td>
<td>1129</td>
</tr>
</tbody>
</table>

Table 2 Operating conditions of CWS gasification

<table>
<thead>
<tr>
<th>Burner</th>
<th>CWS flow rate (kg/h)</th>
<th>O₂ flow rate (Nm³/h)</th>
<th>O/C (mol/mol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burner 1</td>
<td>10</td>
<td>4.13</td>
<td>1.0</td>
</tr>
<tr>
<td>Burner 2</td>
<td>10</td>
<td>4.13</td>
<td>1.0</td>
</tr>
<tr>
<td>Burner 3</td>
<td>10</td>
<td>4.13</td>
<td>1.0</td>
</tr>
<tr>
<td>Burner 4</td>
<td>10</td>
<td>4.13</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Table 3 Ash fusion temperature

<table>
<thead>
<tr>
<th>Properties and conditions</th>
<th>DT</th>
<th>ST</th>
<th>HT</th>
<th>FT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ash fusion temperature</td>
<td>1435K</td>
<td>1521K</td>
<td>1583K</td>
<td>1608K</td>
</tr>
</tbody>
</table>
3. Deposition behaviors around burner plane

Detailed deposition behaviors

- **Droplet**
  - Without breakup (Deform) → Rebound → Deform and rebound without adherence
  - Breakup → Rebound → Breakup and rebound without adherence
  - Adhere partially → Rebound → Breakup with partial rebound and partial adherence

- **Particle**
  - Without breakup → Rebound → Rebound completely without breakup and adherence
  - Adhere → Adhere completely without breakup and rebound
  - Breakup → Rebound → Breakup and rebound completely without adherence
  - Adhere partially → Breakup with partial rebound and partial adherence

- **Detachment**
  - Detach completely
  - Breakup and detach
  - Detach after impact
  - Multi-mode detach

Adhered particles
3. Deposition behaviors around burner plane

- 3.1 Droplet deposition behaviors
  - 3.1.1 Droplet deform and rebound without adherence

Features:
- Impact
- Deformation
- Rebound
- Without adherence
- Without breakup
3. Deposition behaviors around burner plane

- 3.1 Droplet deposition behaviors
  - 3.1.2 Droplet breakup and rebound without adherence

Features:
- Impact
- Deformation
- Breakup
- Rebound
- Without adherence
3. Deposition behaviors around burner plane

3.1 Droplet deposition behaviors

- 3.1.3 Droplet breakup with partial rebound and partial adherence

**Features:**
- Impact
- Deformation
- Breakup
- Rebound
- Adherence
3. Deposition behaviors around burner plane

- 3.2 Particle deposition behaviors
  - 3.2.1 Rebound completely without breakup and adherence

Features:
- Impact
- Rebound
- Without Deformation
- Without breakup
- Without adherence
3. Deposition behaviors around burner plane

- **3.2 Particle deposition behaviors**

  - 3.2.2 Adhere completely without breakup and rebound

**Features:**
- Impact
- Adherence
- Without deformation
- Without rebound
- Without breakup
3. Deposition behaviors around burner plane

- **3.2 Particle deposition behaviors**
  - ✓ 3.2.3 Breakup and rebound completely without adherence

Features:
- Impact
- Breakup
- Rebound
- Without adherence
- Without deformation
3. Deposition behaviors around burner plane

3.2 Particle deposition behaviors
✓ 3.2.4 Breakup with partial rebound and partial adherence

Features:
- Impact
- Breakup
- Rebound
- Adherence
- Without deformation
3. Deposition behaviors around burner plane

- **3.3 Detachment behaviors**
  - 3.3.1 Detach completely under the impulsion of gas flow

- Adhered particles are still **on gasification** until the carbon is consumed out.
- Adhesive force **decreases**.
- Particles detach: Adhesive force < Impulsive force of the gas flow.
3. Deposition behaviors around burner plane

- **3.3 Detachment behaviors**
  - 3.3.2 Breakup and detach partially under the Impulsion of gas flow

- Adhered particles are still on gasification until the carbon is consumed out.
- Adhesive force decreases.
- Particles detach: Adhesive force > Impulsive force of the gas flow > internal force of the adhered particle.
3. Deposition behaviors around burner plane

3.3 Detachment behaviors

3.3.3 Detach after the impact of other particles

- Adhered particles are still on gasification until the carbon is consumed out.
- Adhesive force decreases.
- Particles detach: Adhesive force < Impulsive force of the particle A.
3. Deposition behaviors around burner plane

3.3 Detachment behaviors

3.3.4 Multi-mode detach

- Roll up: Adhesive force < Impulsive force

- Adhere again: Adhesive force > Impulsive force

- Partial detach: Impulsive force > internal force

- Particle → Slag: Carbon is consumed out

- Melt: Temperature > FT
4. Conclusions

1. The droplet deposition behaviors are divide into three modes:
   1) Deform and rebound without adherence.
   2) Breakup and rebound without adherence.
   3) Breakup with partial rebound and partial adherence.

2. The particle deposition behaviors are divide into four modes:
   1) Rebound completely without breakup and adherence.
   2) Adhere completely without breakup and rebound.
   3) Breakup and rebound completely without adherence.
   4) Breakup with partial rebound and partial adherence.

3. The detachment behaviors of the adhered particles are divide into four modes:
   1) Detach completely.
   2) Breakup and detach.
   3) Detach after impact.
   4) Multi-mode detach.
Thanks for your attention!