Basic co-firing characteristics of ammonia with pulverized coal in a single burner test furnace

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Objective of this study

Direct and blended combustion of ammonia in **pulverized-coal-fired power plant** is expected one of the promising technology regarding CO\textsubscript{2} reduction.

What is the significant challenge of ammonia as a fuel?

Ammonia (NH\textsubscript{3}) contains N atom.
- It can be **main source of fuel-NOx**.

If NOx emissions from combustion furnace increase;

- More quantity of NH\textsubscript{3} for flue-gas denitration (de-NOx)
- Improvement or addition of denitration equipment

In this study, we examined the basic blended-combustion characteristics of pulverized coal and ammonia using a single-burner combustion test furnace.
Outline of the test furnace

View of the single burner

Typical conditions of the experiment

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combustion load</td>
<td>760 kW</td>
</tr>
<tr>
<td>(Coal consumption)</td>
<td>(≒100 kg/h)</td>
</tr>
<tr>
<td>Furnace size</td>
<td>Φ0.85m × 8m</td>
</tr>
<tr>
<td>Set exhaust O₂</td>
<td>4.0 %</td>
</tr>
<tr>
<td>Staged air / Total air</td>
<td>30 %</td>
</tr>
</tbody>
</table>

Flow rate of NH₃: Max. 30.0kg/h → Max. 20.3% (LHV basis) of the total load
NH₃ injection into the coal burner

Ammonia injection pipe is inserted into the pulverized-coal burner.
Ammonia is injected into the pre-OFA zone through the measurement port.
Experimental conditions

Experimental parameters
① Percentage of NH₃ blending (Max. 20%(LHV basis))
② Position of the side port where NH₃ is injected

Typical coal properties
Common bituminous coals were used for the experiment.

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Coal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>MO1</td>
</tr>
<tr>
<td>Moisture (AD)</td>
<td>%</td>
<td>2.8</td>
</tr>
<tr>
<td>Ash (dry)</td>
<td>%</td>
<td>12.6</td>
</tr>
<tr>
<td>Volatile matter (dry)</td>
<td>%</td>
<td>35.4</td>
</tr>
<tr>
<td>Fixed carbon (dry)</td>
<td>%</td>
<td>52.1</td>
</tr>
<tr>
<td>Nitrogen (dry)</td>
<td>%</td>
<td>1.74</td>
</tr>
<tr>
<td>LHV (dry)</td>
<td>MJ/kg</td>
<td>29.2</td>
</tr>
</tbody>
</table>
When NH$_3$ was injected into the pulverized-coal burner

- Co-firing rate ≤ 10% $\iff$ Exhaust NOx was much the same as coal combustion.
- Co-firing rate ≥ 10% $\iff$ Exhaust NOx increased as input NH$_3$ increased.
Effect of NH$_3$ injection position

Exhaust NO$_x$ concentration were decreased by injecting NH$_3$ through the side port, compared with injecting NH$_3$ into the coal burner.
Streamwise distributions of $O_2$ & $NO_x$

- In the case of $NH_3$ injection into the burner, NOx generation in the flame is low but it increases after the staged-air injection.
- In the case of $NH_3$ injection at 1.0 m from the burner, NOx is decreased after $NH_3$ injection and is not much regenerated after the staged-air injection.
Unburned carbon concentration in the fly ash is slightly high in the case of NH$_3$ injection into the burner.

Unburned NH$_3$ concentration is increased by injecting NH$_3$, but is enough low considering the detection limit.

NH$_3$ injection through the side port has an advantage regarding the unburned carbon in the fly ash as well as NOx.
Exhaust N$_2$O concentration

N$_2$O concentration was increased when NH$_3$ was injected into the burner, but is negligibly low to work as global warming gas.
Conclusions

Basic co-firing characteristics of pulverized coal and ammonia was investigated using single-burner test furnace. Main conclusions are below.

(1) Effect of NH₃ co-firing rate to NOx generation in case of injecting NH₃ into the coal burner
- Co-firing rate ≤ 10%  ⇒  Exhaust NOx was much the same as coal combustion.
- Co-firing rate ≥ 10%  ⇒  Exhaust NOx increased as input NH₃ increased.

(2) Effect of position of the side NH₃ port
- When NH₃ was injected at 0.6 m or 1.0 m from the pulverized-coal burner, NOx in the flue gas was decreased compared with the case injecting NH₃ into the coal burner.
- By injecting NH₃ into low O₂, high NOx region, fuel-NOx generation is suppressed and NH₃ possibly works also as reductant for existing NOx.

(3) Effect of NH₃ injection to unburned content
- When NH₃ was injected into the burner, unburned carbon in the fly ash slightly increased probably due to the lower flame temperature.
- Unburned NH₃ concentration was enough low even in the cases of NH₃ co-firing.
Acknowledgement

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Thank you for your attention!