Characterization of natural copper ore in anthracite fuelled Chemical-Looping with Oxygen Uncoupling (CLOU)

Daofeng Mei, Haibo Zhao*, Yanfei Fang, Kun Wang, Chuguang Zheng

State Key Laboratory of Coal Combustion, Huazhong University of Science and Technology

* E-mail address: klinsmannzhb@163.com.
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Background

CLOU

Cu-based Oxide
Mn-based Oxide
Perovskite Type Oxide

Coal + Gaseous O₂
Fast Reactions
Main Products: CO₂+H₂O

Key Aspect----Low-cost Oxygen Carriers

Air Reactor (AR)

Fuel Reactor (FR)

Air

Coal

MeOₓ⁻¹+O₂(g) → MeOₓ

MeOₓ

Coal+O₂(g) → CO₂(g)+H₂O(g)

MeOₓ⁻¹

MeOₓ⁻¹+O₂(g) → MeOₓ⁻¹+O₂(g)

H₂O + CO₂

N₂ + O₂


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## Copper ore

<table>
<thead>
<tr>
<th>Samples</th>
<th>Ultimate analysis (wt %)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cu</td>
<td>Fe</td>
</tr>
<tr>
<td>Before calcining</td>
<td>35.49</td>
<td>25.44</td>
</tr>
<tr>
<td>After calcining</td>
<td>48.88</td>
<td>45.00</td>
</tr>
</tbody>
</table>

**Calcined Fresh Particles**

- $R_{OC}$ (wt %): 4.44
- BET ($m^2/g$): 0.217
- Size (mm): 0.125~0.180
- Density ($kg/m^3$): 5353
- Crushing strength (N): 1.53
- XRD phases: CuO, CuFe$_2$O$_4$
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## The coal

<table>
<thead>
<tr>
<th>Proximate (wt %, ad)</th>
<th>Ultimate (wt %, daf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>2.25</td>
</tr>
<tr>
<td>Volatiles matter</td>
<td>10.69</td>
</tr>
<tr>
<td>Ash</td>
<td>20.62</td>
</tr>
<tr>
<td>Fix Char</td>
<td>66.44</td>
</tr>
<tr>
<td>LHV (MJ/kg)</td>
<td>26.17</td>
</tr>
</tbody>
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Fluidized bed

Length: 892 mm
Inner Diameter: 26 mm
Temperature: 800-1000 °C
OC mass: 40 g
Coal mass: 0.3 g
Flow rate: 800 ml/min

Concerned Operating Parameters: Steam Content, Temperature, OC/Fuel Ratio, Cycling number
Gas concentration profiles in 900 °C and N₂ atmosphere

- CO₂ generated rapidly
- Low amount of CO and H₂ were found
- Combustion was finished within 30 mins which is faster than CLC
- O₂ decreases quickly when fuel was added
- Small peaks of O₂ were found initially
- Excessive O₂ was detected
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Influence of OC to Fuel ratio $\Omega_{OC}$

- Time for converting 95% of C in the coal, $t_{0.95}$, decreases with $\Omega_{OC}$
- More O$_2$ residual and higher combustion efficiency can be attained with the increase of $\Omega_{OC}$
- Combustion efficiency reached as high as 96~97%
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Influence of Temperature

- Faster reaction can be reached at higher temperatures, $t_{0.95}=60$~$10$ s
- Concentration of CO and H$_2$ in the exhaust gas increase with the temperature because the volatiles in the coal releases faster at higher temperatures
- CO$_2$ capture decreases with temperature
- Combustion efficiency changes between 98~99%

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Influence of Steam content in flow gas

- Steam is advantageous for the fast reaction.
- However, steam makes the CO$_2$ capture and the combustion efficiency unsteady.
- High combustion efficiency and CO$_2$ capture can be attained.
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Cycling tests

- Stable gas profile and combustion efficiency ranged from 96~98% in the five successive reductions were achieved, which reflected that the OC was stable in the 5 cycling tests.

- Slight agglomeration has been found in the successive tests.
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Conclusion

- Copper ore is promising for using as CLOU material
- Too high oxygen to fuel ratio can reduce the time to 0.95, however, increase the residual O₂ in the exhaust gas, which is NOT economical to the combustion
- Faster reaction can be achieved at higher temperatures, however, decrease the CO₂ capture
- Steam containing in the flow gas can speed up the reaction in FR, however, makes the CO₂ capture and combustion efficiency unsteady
- Agglomeration should be reduced to increase the lifetime of OC
Thanks & Gracias !