Coal Conversion and CO$_2$ Utilization

China Coal Research Institute

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Agenda

- Coal Conversion Technologies and CO$_2$ Emissions
- Approaches for CO2 Emissions Reduction and Utilization through Coal Conversion
- Demonstration Projects of Coal Conversion and CO$_2$ Utilization demonstration projects
I. Coal Conversion Technology and CO2 Emissions

Routes of Coal Conversion

Coal \[\rightarrow\] Process

Feed coal \[\rightarrow\] Gasification, Purification, Conversion

CO + H\(_2\) \[\rightarrow\] CO\(_2\), Sulfur recovery

Remove CO\(_2\) \[\rightarrow\] CO\(_2\), Sulfur

Gasification Purification, conversion

CO + H\(_2\) \[\rightarrow\] Synthetic ammonia, Natural gas, Petroleum and chemical product

Synthesis

H\(_2\) \[\rightarrow\] Methanol, Dimethyl ether, Petroleum and chemical products

Liquefaction

Dimethyl ether \[\rightarrow\] Olefin
(1) Ammonia and Urea Production from Coal

- The comprehensive coal consumption in ammonia production is 1.3~1.7 tons of standard coal equivalent per ton of NH₃, a level of below 1.5tce/tNH₃ can be achieved if technology permits.

- Volume of carbon dioxide emissions is about 2~3t/tNH₃.
(2) Methanol Production from Coal

- The comprehensive coal consumption in methanol production is 1.42～1.59 tons of standard coal equivalent per ton of methanol. Energy conversion efficiency can reach 43～48%, or even 50% in some large projects.

- CO₂ emissions are 2.37～3.52 tons of carbon dioxide per ton of methanol (0.119～0.176 t/GJ), among which 0.079～0.117 tons are discharged in the processing and 0.040～0.059 tons in the public process.
(3) Dimethyl Ether Production from Coal

- The comprehensive coal consumption here is 2.18~2.40 tons of standard coal equivalent per ton of dimethyl ether. Energy conversion efficiency can reach 41~45%.

- CO₂ emissions are 3.8~5.48 tons of carbon dioxide per ton of dimethyl ether (or, 0.133~0.190t/GJ), among which 0.090~0.129 tons are discharged in the processing and 0.043~0.061 tons in the public process.
The comprehensive coal consumption is 4.28~5.20 tons of standard coal equivalent per ton of olefin.

CO$_2$ emissions are 6.40~9.15 tons of carbon dioxide per ton of olefin, among which 4.27~6.10 tons are discharged in the processing and 2.13~3.05 tons in the public process.
(5) Direct Liquefaction of Coal

- The comprehensive coal consumption is 2.57~3.01 tons of standard coal equivalent per ton of coal in direct liquefaction of coal; energy conversion efficiency stands at 50~58%.
- CO₂ emissions are 4.14~6.85 tons per ton of oil product (or, 0.096~0.157 t/GJ), among which 0.067~0.110 tons are discharged in the processing and 0.029~0.047 tons in the public process.
(6) Indirect Liquefaction of Coal

- The comprehensive coal consumption is 3.24～3.87 tons of standard coal equivalent per ton of coal in indirect liquefaction of coal; energy conversion efficiency stands at 38～43%.

- \(\text{CO}_2\) emissions are 5.52～8.49 tons per ton of oil product (or, 0.128～0.197 t/GJ), among which 0.085～0.131 tons are discharged in the processing and 0.043～0.066 tons in the public process.
（7）Natural Gas from Coal

- The comprehensive coal consumption is 1.97~2.25 tons of standard coal equivalent per cubic kilometers of natural gas; energy conversion efficiency stands at 55~63%.
- CO\(_2\) emissions are 3.2~5 tons per cubic kilometers of natural gas (or, 0.086~0.145t/GJ), among 0.057~0.097 tons are discharged in the processing and 0.029~0.058 tons in the public process.
The comprehensive coal consumption is 0.64~0.79 tons of standard coal equivalent per cubic kilometers of hydrogen; energy conversion efficiency stands at 55~68%.

CO₂ emissions are 1.02~1.82 tons per cubic kilometers of hydrogen (or, 0.078~0.139t/GJ), among 0.057~0.097 tons are discharged in the processing and 0.029~0.058 tons in the public process.
Energy Efficiencies of Conversion Technologies, %

![Energy Conversion Efficiency Chart]

- CTM: 43%
- CTD: 41%
- DCL: 38%
- ICL: 43%
- CTNG: 55%
- CTH: 55%
- O2 SC: 43%
- IGCC: 45%
Carbon Dioxide Emissions of Conversion Technologies, \( \text{tCO}_2/\text{GJ} \)
Carbon Dioxide Emissions of Conversion Technologies, tCO$_2$/t coal
II. Approaches for CO$_2$ Emissions Reduction and Utilization through Coal Conversion

- Approaches for CO$_2$ Emissions Reduction
  - Choosing the right direction for product development
  - Improving technology
    - Raising coal conversion efficiency
    - Raising the efficiency of catalysts
    - Improving the efficiency of pumps
    - Recycling waste heat
    - Rationalizing the process flow
  - Developing coal poly-generation technology
Approaches for CO₂ Utilization

- Producing chemical products as raw materials
  - Since CO₂ produced in the coal chemical processing are of high concentration and high pressure, it’s helpful for capture and utilization; Priority can be given to deploying capture and storage technologies in the coal chemical industry and IGCC power plants.
  - Producing urea while making coal-ammonia; emissions can be decreased to 0.71t/t.
  - Producing chemical products such as K₂CO₃, acetic acid
  - Underground fire extinguishing

- Raising oil-gas recovery
  - EOR, ECBM
III. Demonstration Projects of CO₂ Utilization in Coal Conversion

- **Shenhua Group CCS Demo. Project**: 100,000t/a, in operation, deep aquifer sequestration
- **Yankuang Cathay Coal Chemicals CO₂ Ltd. (YCCC), Yancon Lunan Chemical Fertilizer Plant**: Producing Urea, Acetic acid, potassium carbonate; CO₂ emissions were reduced by 3.6 million tons.
- **ENN Group Algae Carbon Sequestration Biological Energy**
- **New Materials Preparation with CO₂, ZHONGKEJINLONG Chemical**: 320,000t/a, under construction, 22,000t/a CO₂ resin, in operation
- **Degradable Plastic Preparation with CO₂, China National Offshore Oil Corporation (CNOOC)**: 2100t/a
Possibility of being used for EOR

- CO₂EOR Research and Demonstration, Jilin Oilfield, PetroChina
  - 0.8-1 Mt/a; Phase I is completed; Phase II is under construction; EOR

- CO₂ EOR for Coal-bed Gas, China United Coalbed Gas Holding Limited
  - 40t/d, pilot project

- CCS and Oil Displacement Demo. Project, Shengli Oil Field, SINOPEC Corp
  - 8000t/a, in operation, EOR
Thank you!