

化学吸收法的CO₂减排研究

Chemical Absorption Technology of CO₂ Abatement

贾莹光
JIA Yingguang

国家电站燃烧工程技术研究中心

National Power Plant Combustion
Engineering Research Center (NPCC)

辽宁省燃煤二氧化碳减排与多污染
物控制开放重点实验室

Liaoning Provincial Key Laboratory of
Coal-fired Carbon Dioxide and Multi-
Pollutants Abatement (LCCA)

Outline



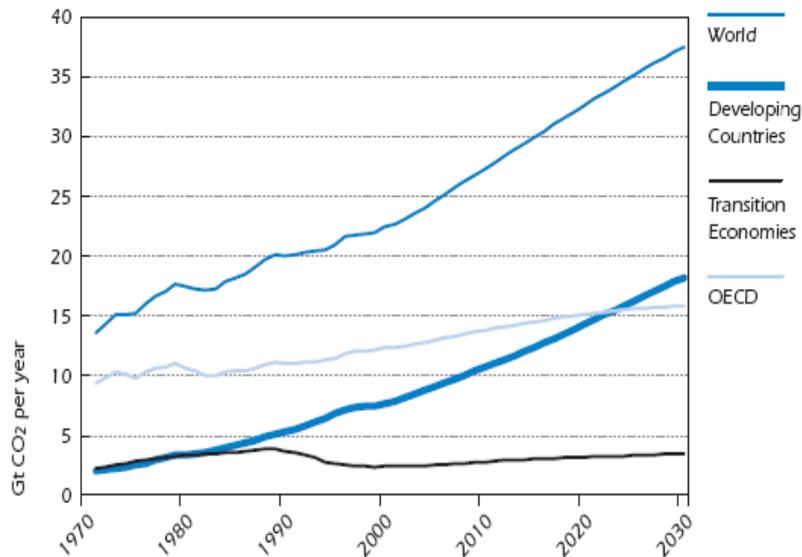
- **1. Main Technology of CO₂ Abatement in the World**
- **2. Research on CO₂ Abatement Technology in China**
- **3. Development of Chemical Absorption CO₂ Abatement Technology Research**
- **4. Contemplations of Chemical Absorption CO₂ Abatement Technology**
- **5. Summary of Chemical Absorption CO₂ Abatement Technology**



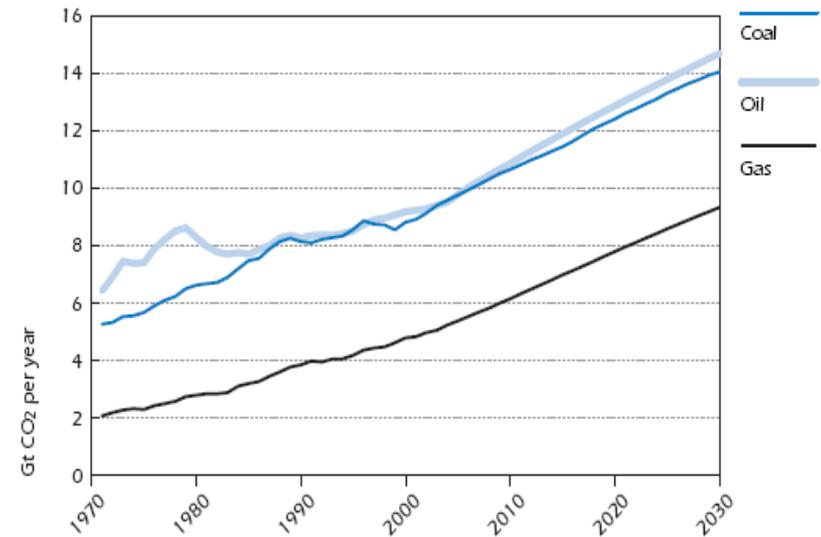
Main Technology of CO₂ Abatement in the World

World CO₂ Emission

CO₂ Emission of Different Areas (1973~2030)



CO₂ Emission of Different Energy 1973~2030)



Main Problems in CO₂ Abatement

CO₂ Capture

Low-concentration CO₂ Capture
in Traditional Energy Consumed

&

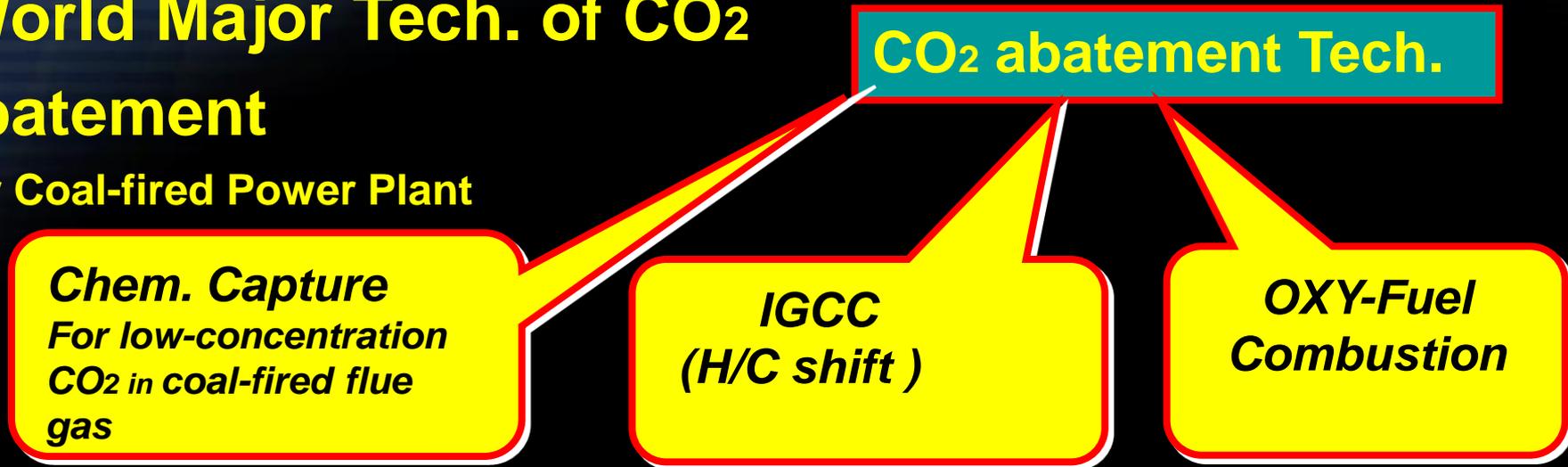
CO₂ Storage

Further Utilization &
storage of Captured CO₂



World Major Tech. of CO₂ abatement

For Coal-fired Power Plant



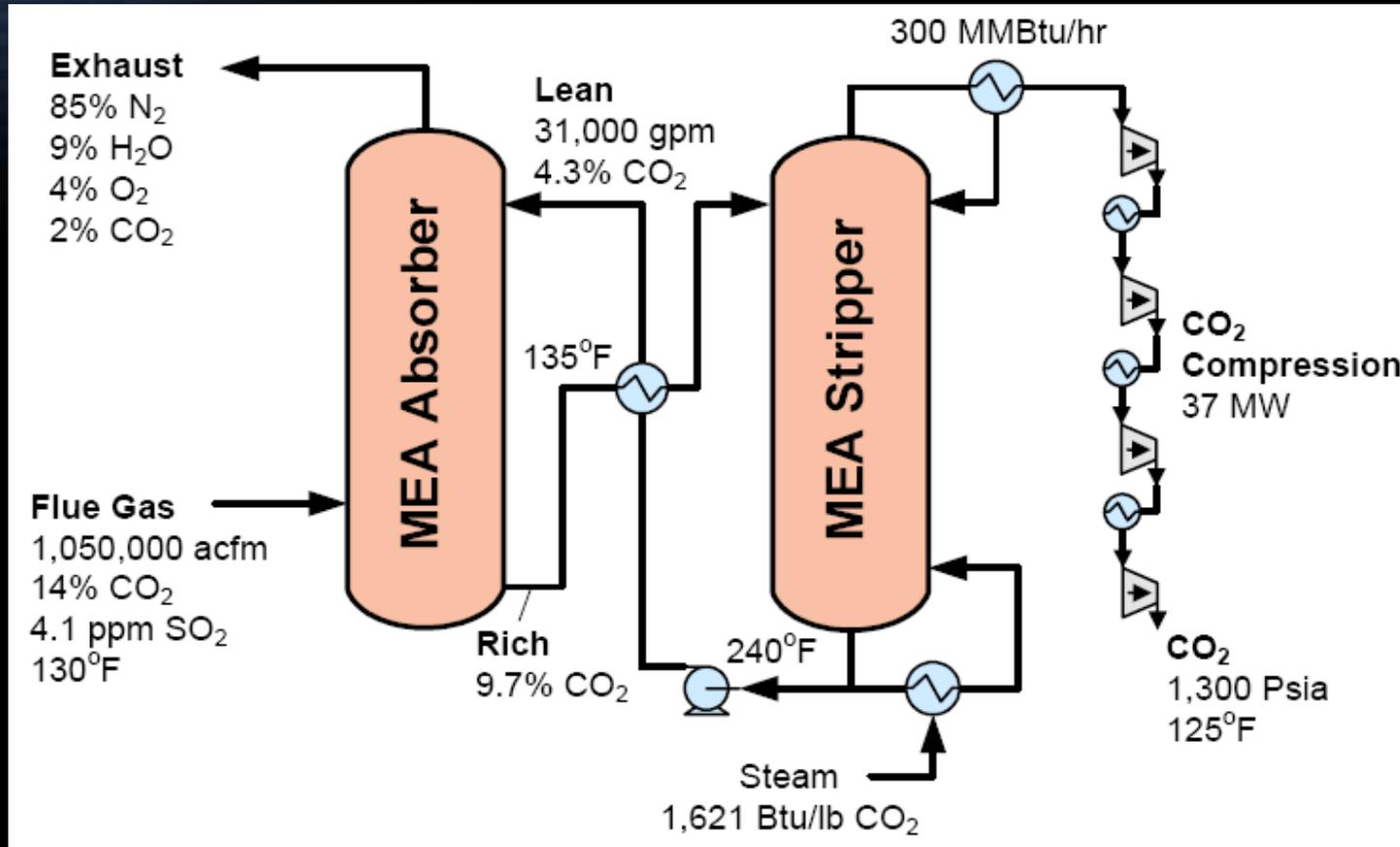
CO₂ Storage Tech.

- **Used for Resource**
- *Inject into oil fields or coal seams with EOR or ECBM Tech.*
- **Embedding**
- *Embed In deep ocean, geological storage*

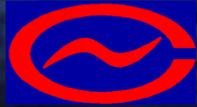


Main Technology of CO₂ abatement in the world

CO₂ Capture by Ammonia or Amine (MEA) Chemical Absorbent



MEA CO₂ Capture System



Excellences & Shortages of Chem. CO₂ Capture

Excellences

- *Mutually process & high reliable;*
- *High efficiency & stable running;*
- *Simply system with less maintenance;*
- *Easy refine of boiler system in current power plant for CO₂ abatement.*

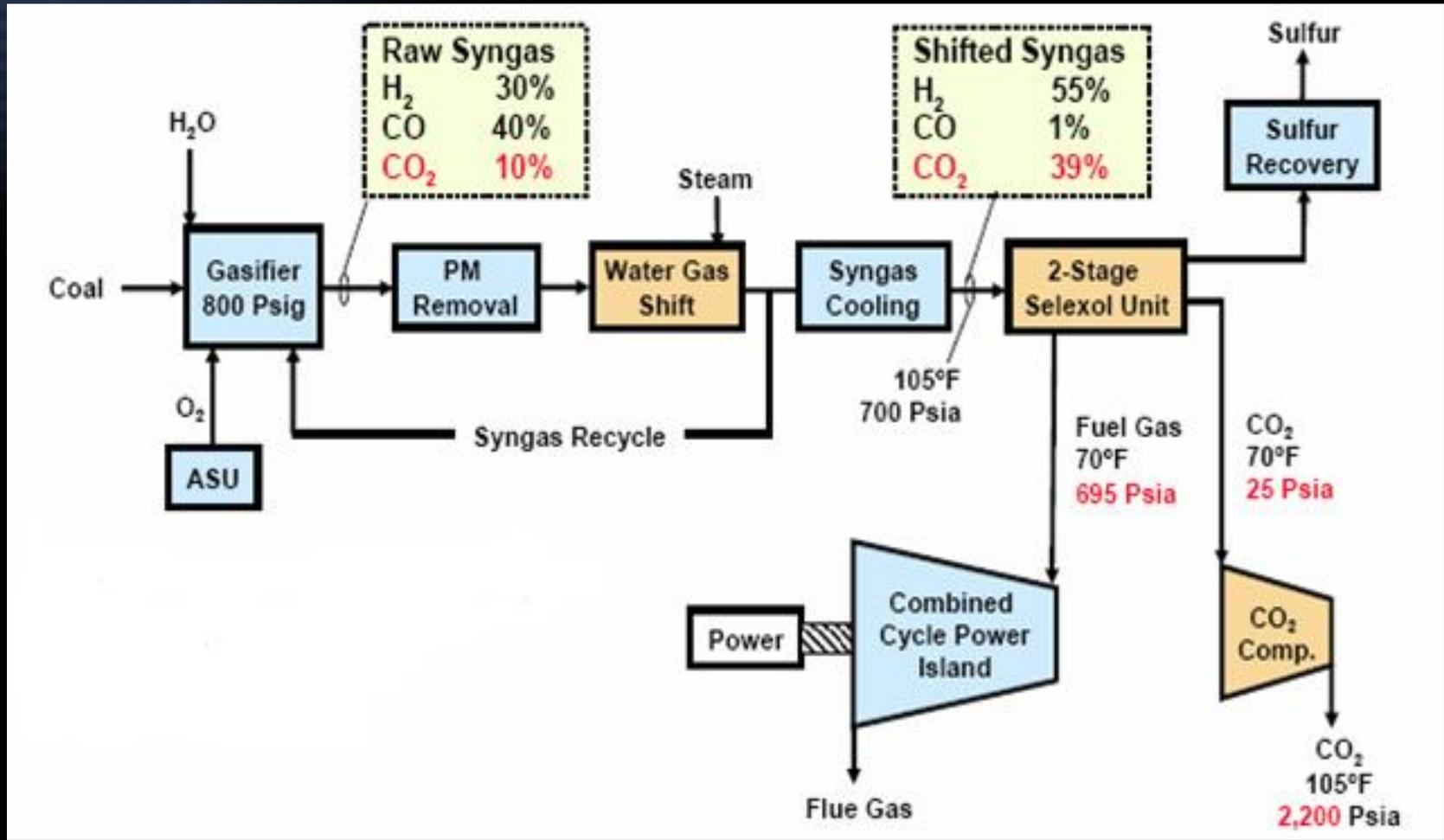
Shortages

- *High energy consumed for absorbent regenerated ;*
- *Corrosion of process equipments;*
- *High degradation of amine absorbent;*
- *High running cost .*

Main technology of CO₂ abatement in the world



IGCC System



Flow Chart of IGCC Power Plant with CO₂ Capture Technology



Main technology of CO₂ abatement in the world

Characters of H/C Shift--IGCC

- 1 . CO₂ removal before combustion, improved generation efficiency ;
- 2 . High concentration of CO₂, is good for CO₂ removal by other process;
- 3 . High quality CO₂, because of the special process of pollutants removal;
- 4 . Realized Co-production process with Hydrogen production.

Excellences

- *Multi-pollutants emission control can be realized ;*
- *Improve the concentration of CO₂, help to be absorbed and separated;*
- *Low cost of Comprehensive CO₂ abatement.*

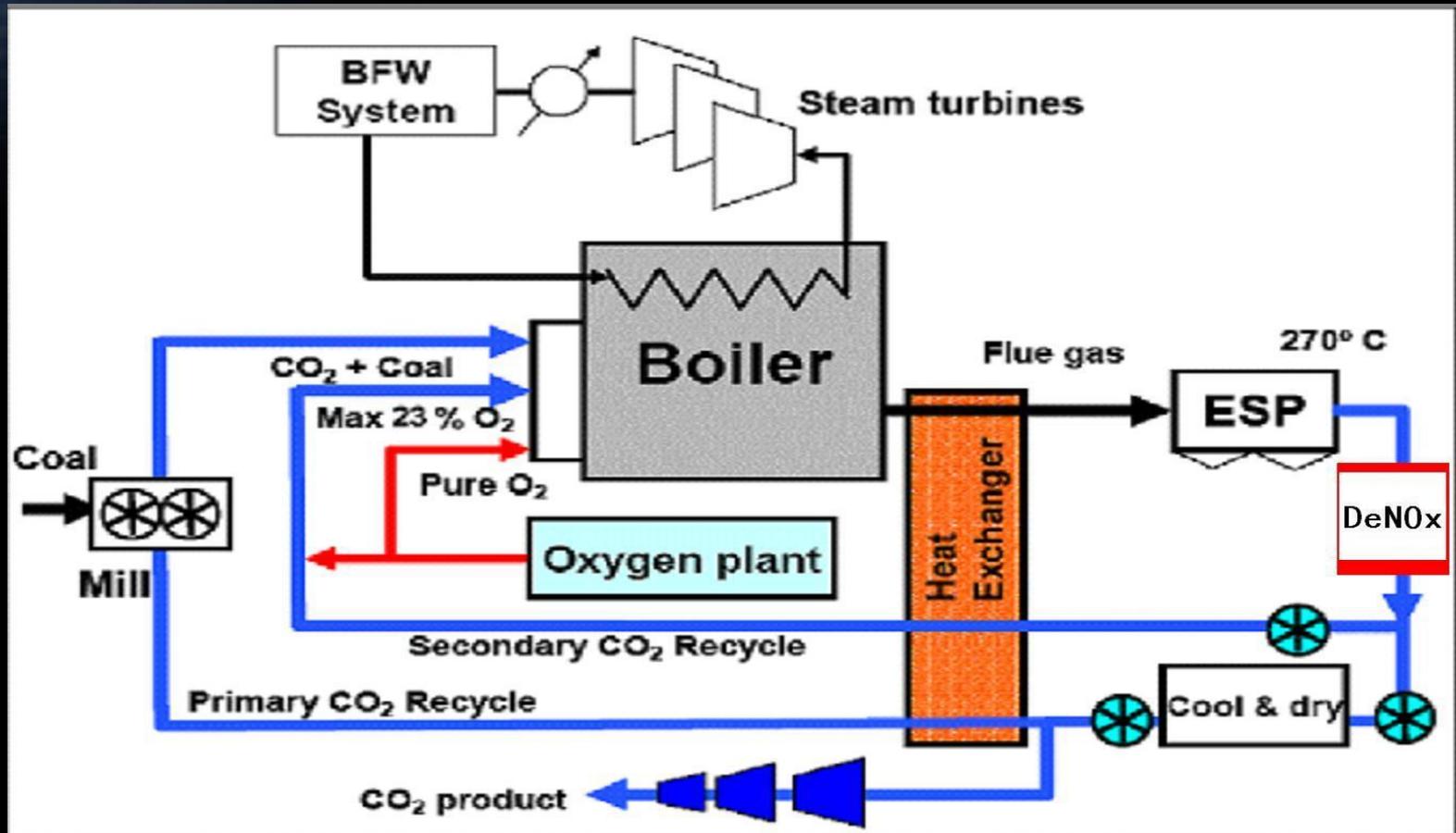
Shortages

- *More complex system, difficult technology to realize;*
- *Produced CO₂ need to be removed by other chem. process ;*
- *Investment & area are great to realize multi-production and zero-emission.*

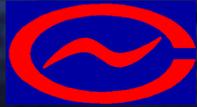


Main technology of CO₂ abatement in the world

OXY-Fuel Combustion

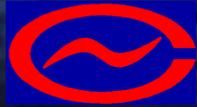


OXY-Fuel Process Frame



Characters of OXY-Fuel Combustion Technology

- ♥ CO₂ of over 95% concentration in flue gas can be separated directly;
- ♥ SO₂ removal efficiency reaches above 90%, FGD equipments can be reduced;
- ♥ De-NO_x equipments can be reduced for the production of NO_x reduced (25-50%), saving the cost;
- ♥ Can be realized directly in existing PC boilers with small risk.



Research on CO₂ abatement technology in China

CO₂ abatement situation in China today

- **Energy Constitutes:** production & consume fossil energy in china are about 10% of the total energy all over the world every year, which equals to 10% the total CO₂ emission in the world. In China today, coal holds 62%, oil & gas hold about 24% in energy structure. In the air pollutions of China, 85%of CO₂ & 60% NO₂ come from fired coal. density of CO₂ emissions is 26% higher than the average level of the world.

Facing tasks: with fast development of China economy, energy consume and CO₂ emission are increasing continuously. So CO₂ and other pollutants abatement are needed.

Abatement Approach:

- **Energy conservation & efficiency Improvement ;**
- **Development of CO₂ capture & utilization technology;**
- **Formulate relative laws and regulations.**



CO₂ abatement research in China today

Traditional technology

MEA Absorption
Pressure Swing Adsorption

New technology

Ammonia Absorption
for multi-pollutants

IGCC Engineering
OXY-Fuel Combustion



Chemical Absorption for CO₂ Removal

Chemical CO₂ capture with MEA etc.

Mainly focus on original process shortages, such as heavy corrosions, degradation and High energy consumed for absorbent regenerated, developed with antioxidants、 activator and inhibitor. Results has been used in Petro-Chem. fields.

Chemical CO₂ capture with ammonia

Under the frame of U.S.-China Fossil Energy Protocol Annex IV, NPCC and NETL have cooperated to research on CO₂ absorption in flue gas by ammonia of PC boiler.

Development of Chemical Absorption CO₂ Abatement Technology Research



Under the frame of U.S.-China " Fossil Energy Technology Development & Utilization Cooperation Protocol" was signed by Ministry of Science and Technology of China (MOST) and the U.S. Department of Energy (USDOE), National Power Plant Combustion Engineering Research Center (NPCC) and the U.S. Department of Energy National Energy Technology Laboratory (NETL) signed Annex-IV-A of the protocol mentioned above on August 31, 2001 in Beijing, which includes "CO₂ emission reduction by spraying ammonia & production of long-lasting NH₄HCO₃ " project cooperation protocol of "Energy and Environmental Technology".



Development of Chemical Absorption CO₂ Abatement Technology Research



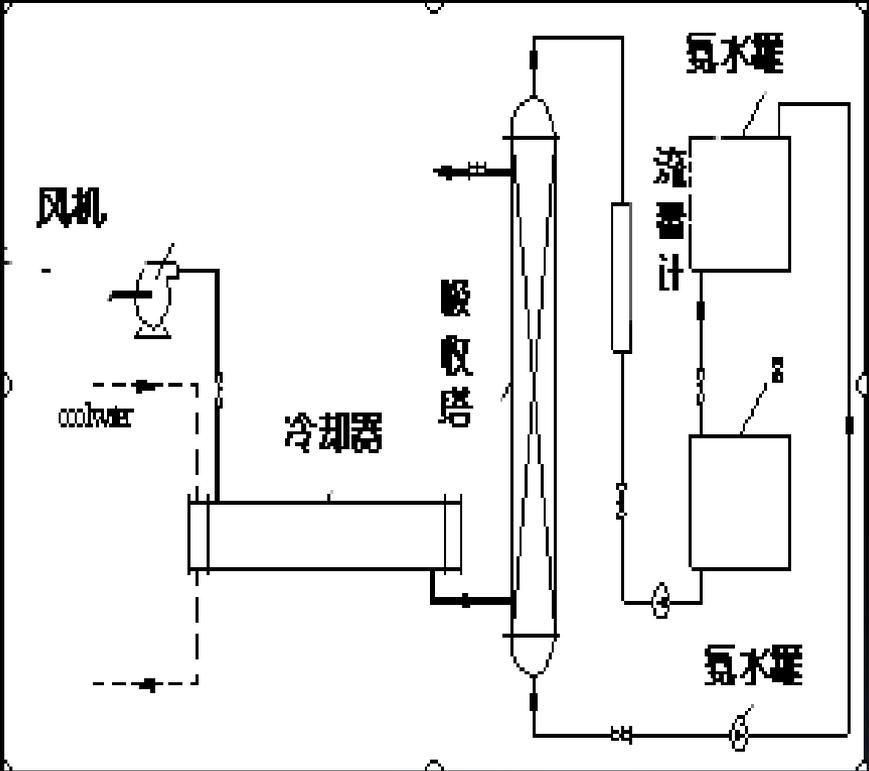
According to the protocol, the design and establishment of true CO₂ capture by spraying aqueous ammonia in coal-fired flue gas test facility has completed by NPCC. It adopted mono packing absorption tower as the main facility, completed the test study of CO₂, NO_x, SO₂ and other pollutants absorption by spraying aqueous ammonia by using this test facility.



Development of Chemical Absorption CO₂ Abatement Technology Research



Mono Tower Process Frame



Picture of Mono Tower Process



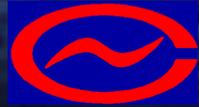
Conclusions of Mono Tower Process Research

CO₂, SO₂ in coal-fired flue gas can be absorbed by aqueous Ammonia, in order to reduce the pollution;

The absorption product can be turned into the mixture of NH₄HCO₃, (NH₄)₂SO₄ etc. in the solution, which can be regarded as Compound Fertilizer;

The concentration of aqueous ammonia and molar has great influence on absorption rate, concentration 10% aqueous ammonia to 55% absorption rate, And 15% concentration to 78%, 20% concentration to 93% .

Development of Chemical Absorption CO₂ Abatement Technology Research



In April 2004, Annex-IV of Research on CO₂ Capture and Abatement Protocol was signed by Ministry of Science and Technology of China (MOST) and U.S. Department of Energy (U.S. DOE) in Washington U.S.A. , which revealed to establish a long-term cooperation institute, U.S.-China “Coal-fired CO₂ and Multi-pollutants Abatement United Laboratory” ; NPCC is responsible for establishing tri-tower, NETL provides CO₂ regeneration facility, and build up integrate CO₂ control test platform; cooperate on the study of CO₂ control, study and develop the integral technology on multi-pollutants removal of coal-fired power plant.

Development of Chemical Absorption CO₂ Abatement Technology Research

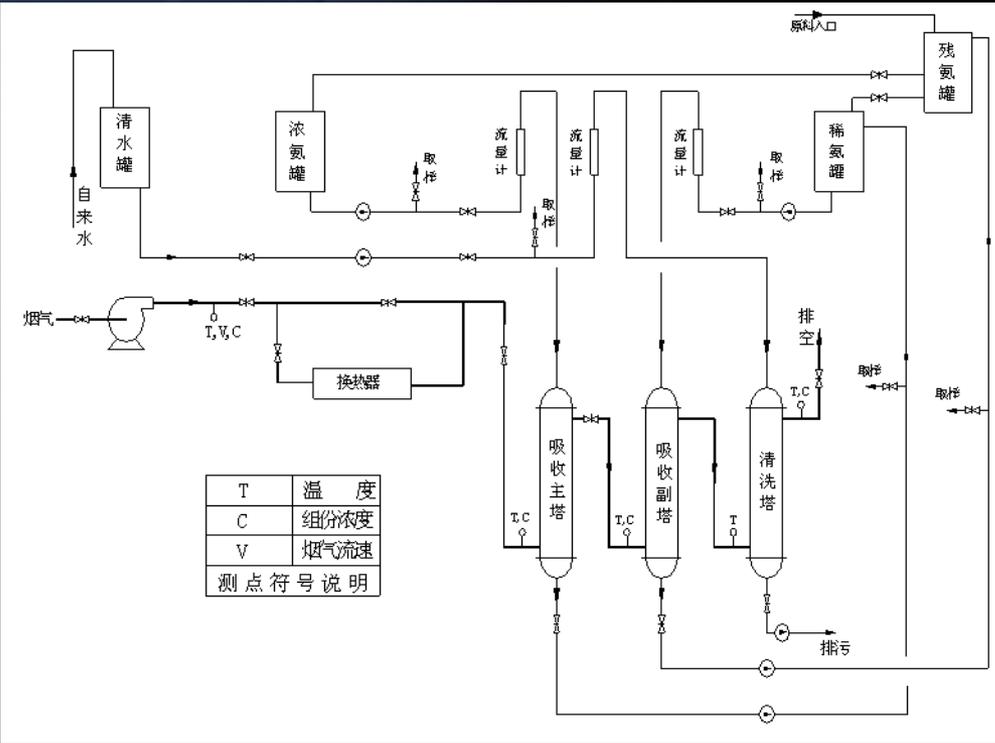


Completed Tasks by NPCC

- **Designed and established test platform of CO₂ capture in flue gas by tri-tower;**
- **Researched on CO₂ capture in coal-fired flue gas by tri-tower test platform;**
- **Studied on integration technology of multi-pollutants removal in flue gas;**
- **Engineering project of CO₂ capture in flue gas from coal-fired power plant;**
- **Established “Liaoning Provincial Key Laboratory of Coal-fired Carbon Dioxide and Multi-Pollutants Abatement” in NPCC.**



Development of Chemical Absorption CO₂ Abatement Technology Research



Picture of Tri-Tower Facility



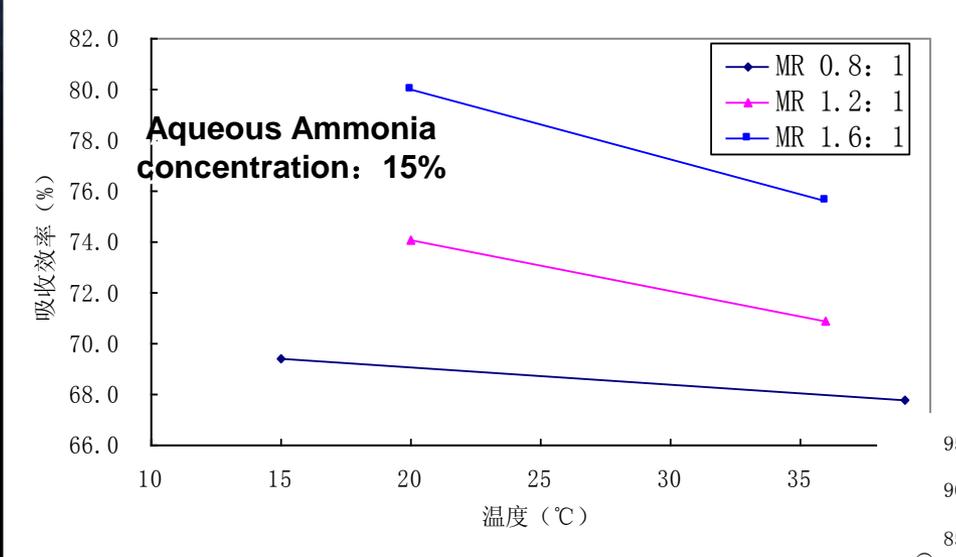
Tri-Tower CO₂ Capture Facility Frame

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Development of Chemical Absorption CO₂ Abatement Technology Research

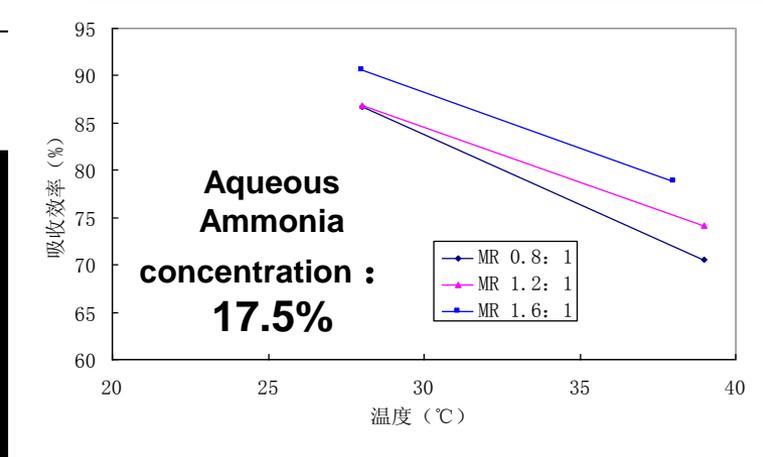


Test results and analysis of CO₂ capture by tri-tower



Temperature

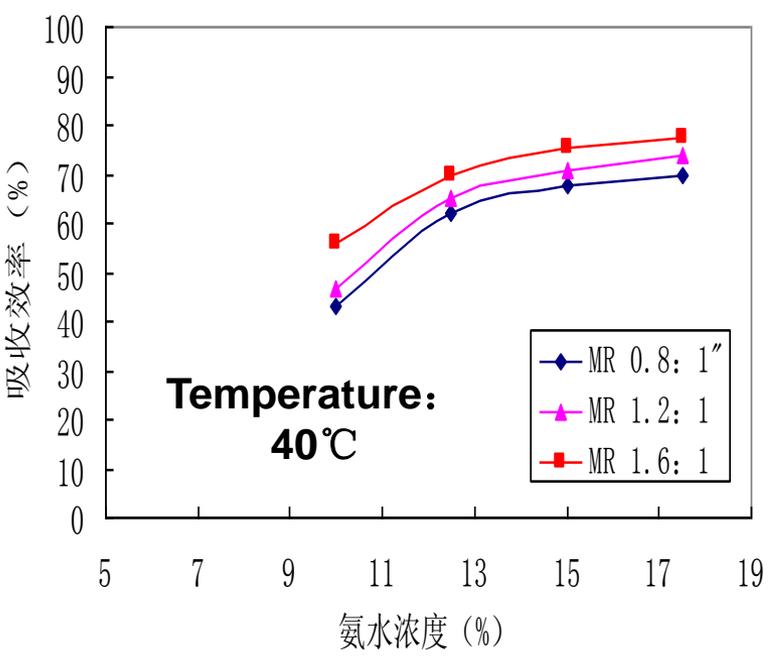
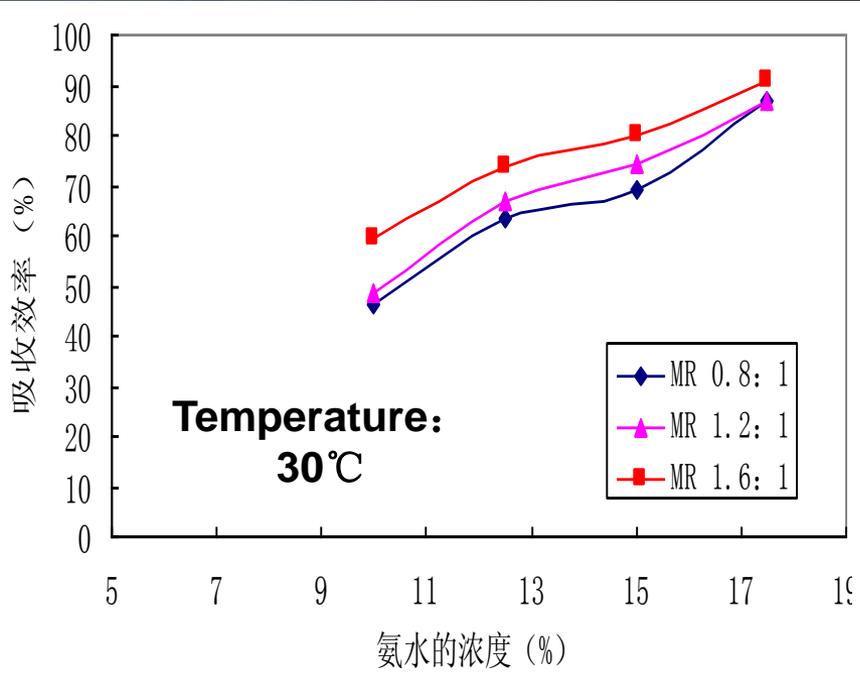
Low temperature is good for CO₂ Capture by aqueous ammonia in Coal-fired flue gas, temperature Influences much on absorption of high concentration aqueous ammonia.



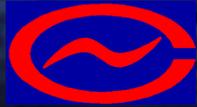
Development of Chemical Absorption CO₂ Abatement Technology Research



Absorbent Concentration



Concentration is the most important factor in absorption test. High concentration is good for CO₂ capture.



Conclusions of Research on CO₂ Capture by Tri-Tower Process

- 1. Low temperature is good to CO₂ removal, the absorption rate is 3%-11% higher on 30°C than on 40°C;**
- 2. Better absorption in high concentration of aqueous ammonia, the absorption efficiency can reach 91% in the concentration of 17.5%;**
- 3. The removal rate increased 2%-5%, compared with mono-tower;**
- 4. Solve the problem of ammonia slip in emission, the ammonia slip can be controlled below 5 ppm, reached the standard.**



Characterization of Aqueous Ammonia Absorption Process

Compared with the technology of CO₂ capture by aqueous ammonia and MEA, conclusion is shown as following:

- The absorption ability increases twice or more of aqueous ammonia technology;
- 49%~64% reduction of regenerated energy loss of absorbent and desorption
- The added cost of absorbent is only 1/6 of MEA technology;
- CO₂ removal technology can be integrated with other pollutant removal technology, saving cost and space of investment and establishment.

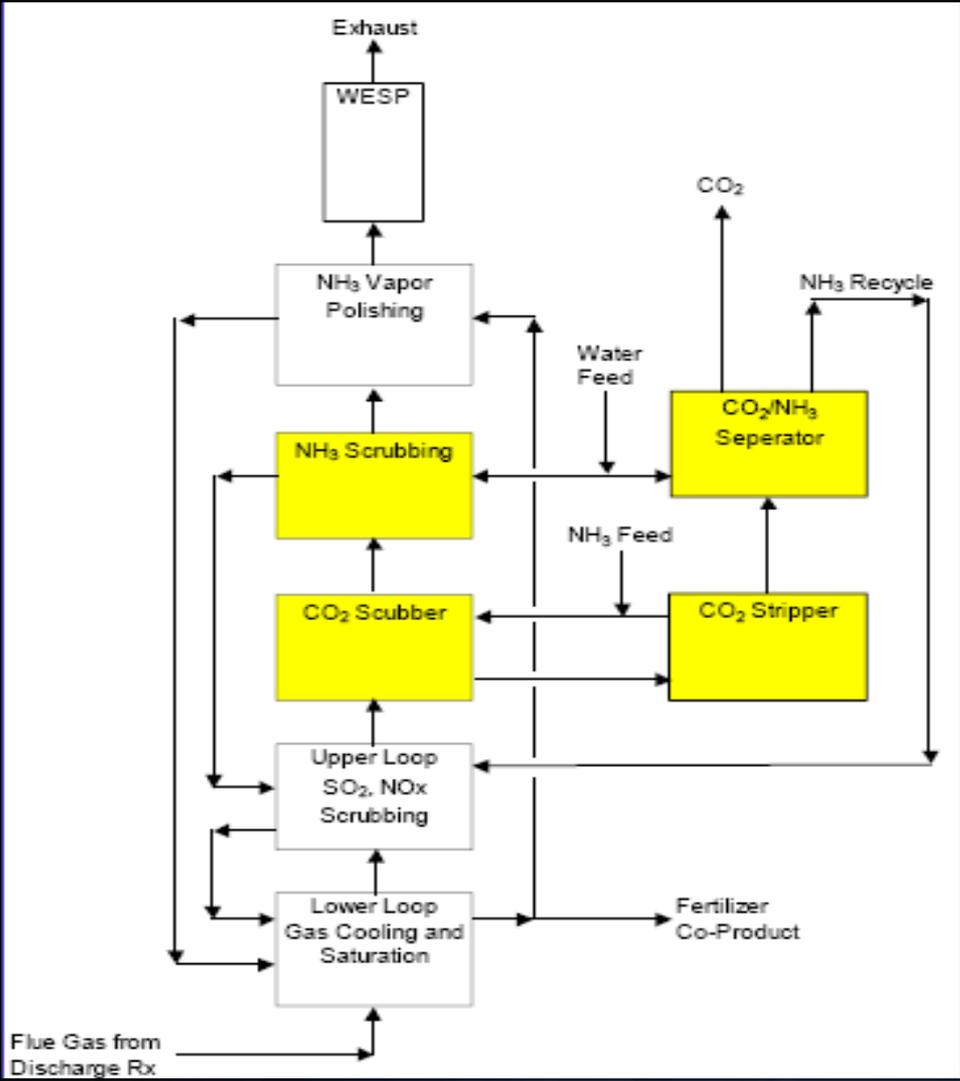
Development of Chemical Absorption CO₂ Abatement Technology Research



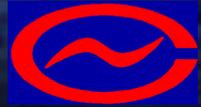
Research on integration technology on multi-pollutants removal in flue gas

Comprehensive program of multi-pollutants control in coal-fired flue gas has provided by NETL

Integrated Multi-Pollution Abatement Process Frame



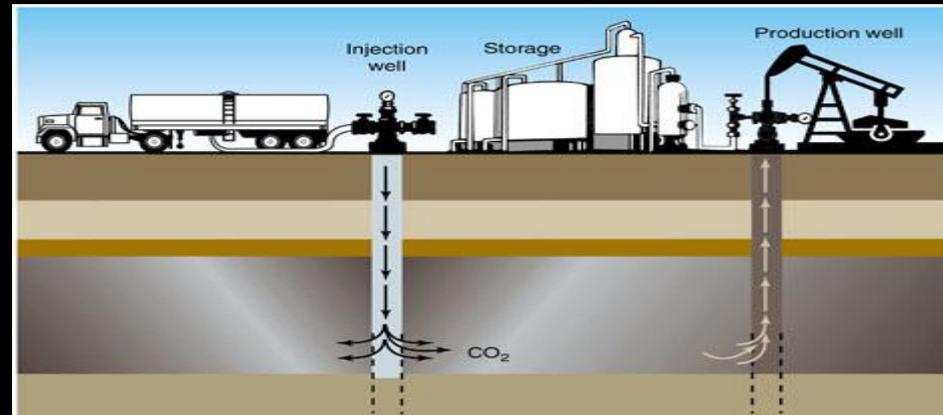
Development of Chemical Absorption CO₂ Abatement Technology Research



Engineering works of CO₂ capture in coal-fired power plant

Base on the result of CO₂ capture test with U.S. NETL, aimed to CO₂ EOR application, NPCC wrote “Study report of CO₂ separation and EOR of flue gas in coal-fired power plant.” the conclusion shows as following:

Project improvement of CO₂ control and integration technology on multi-pollutants removal in flue gas of 100MW coal-fired power plant, the budget of project investment cost is 75,000,000 Yuan, the total project cost is 83,500,000 Yuan, unit cost is 835 Yuan per ton. The price of recycled CO₂ is 680 Yuan per ton, Sulfur ammonium is 700 Yuan per ton, NH₄NO₃ is 1600 Yuan per ton, based on the budget above, power plant can run with profit.



Development of Chemical Absorption CO₂ Abatement Technology Research



Cooperation between NPCC and Norway Silica Tech ANS (ST)

- To research on CO₂ capture and control, China National Power Plant Combustion Engineering Research Center (NPCC) and Norway Silica Tech ANS (ST) signed a purchase order for running CO₂ capture tests in 2006 under the arrangement of Norway government and NETL. Project application was responsible by Silica Tech ANS (ST), and all of test work was responsible by NPCC.
- **Test Condition:**
 - ➔ Flue gas contains 3-4% CO₂ by concentration (coal-fired CO₂ concentration is 12-14%);
 - ➔ Flue gas temperature: 30 ° C;
 - ➔ Aqueous Ammonia as absorbent, concentration: 17.5 % w/w;
 - ➔ NH₃/CO₂=2;
 - ➔ Tri-tower technology system.

Development of Chemical Absorption CO₂ Abatement Technology Research



Research on new absorption material

A new kind of absorption material has been researched in our laboratory. It is a hydrophobic amine material that could be coating on solid surface. Silicone or ceramic could be used as new material carrier. So fluid or fixed bed process is suitable for it.

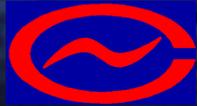


Contemplations of Chemical Absorption CO₂ Abatement Technology

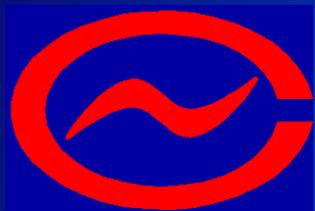


- **Complete the study and development of CO₂ removal process by using aqueous ammonia;**
- **Based on the Annex-IV of U.S.-China Frame Protocol, continue to cooperate with U.S. side;**
- **Establish 100MW level demo-facility to EOR by CO₂;**
- **Establish demo-project of CO₂ capture, storage and utilization in coal-fired power plant;**
- **Study and development of chemical absorption method for CO₂ separation systematic technology by IGCC facility;**
- **Demo-project of chemical absorption method for CO₂ separation system by IGCC facility.**

Summary of Chemical Absorption CO₂ Abatement



- **The research on CO₂ control by chemical process in China needs to keep pace with the international technology development, further communication and cooperation with advanced institutions based on the current CO₂ cooperation system;**
- **Further international communication, especially with U.S. and European countries, making full use of U.S.-China Fossil Energy Cooperation Protocol signed by Ministry of Science and Technology of China (MOST) and U.S. Department of Energy (USDOE);**
- **China has got some results on CO₂ chemical absorption material and system technology.**
- **Establish a demo-project aimed to utilize CO₂, and then improve demo-project of study on CO₂ capture and storage step by step, after got some experience.**
- **Strengthen the study of CO₂ Separation technology & study application of the integration technology on multi-pollutants removal.**



谢谢
THANK YOU

