Development of Oxy-fuel IGCC system

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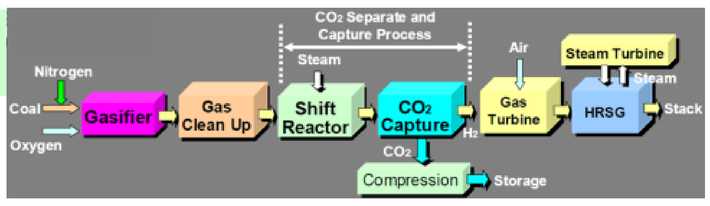
1. Introduction

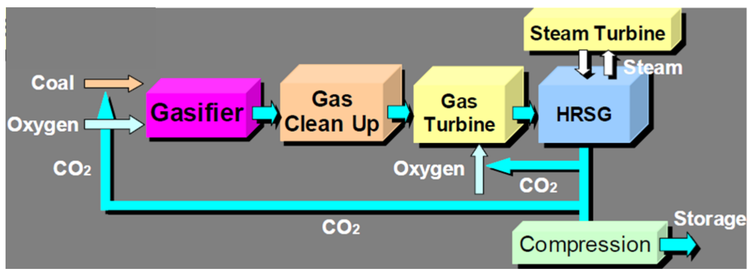
In order to control CO_2 emission, as countermeasure for a global warming problem, CCS (CO_2 capture and storage) technology is studied in various countries, but CCS required great decrease of thermal efficiency. This project plans to develop innovative IGCC system with CO_2 capture, which can keep generation efficiency more than 40%.

2. Proposed system

This system is to gasify coal with mixed gas of recycled CO_2 from flue gas and necessary O_2, just as Oxy-fuel combustion system [1].



(1) Conventional Pre-combustion IGCC system



(2) Proposed "Oxy-fuel IGCC system"

Fig.1 Concept of "Oxy-fuel IGCC system"

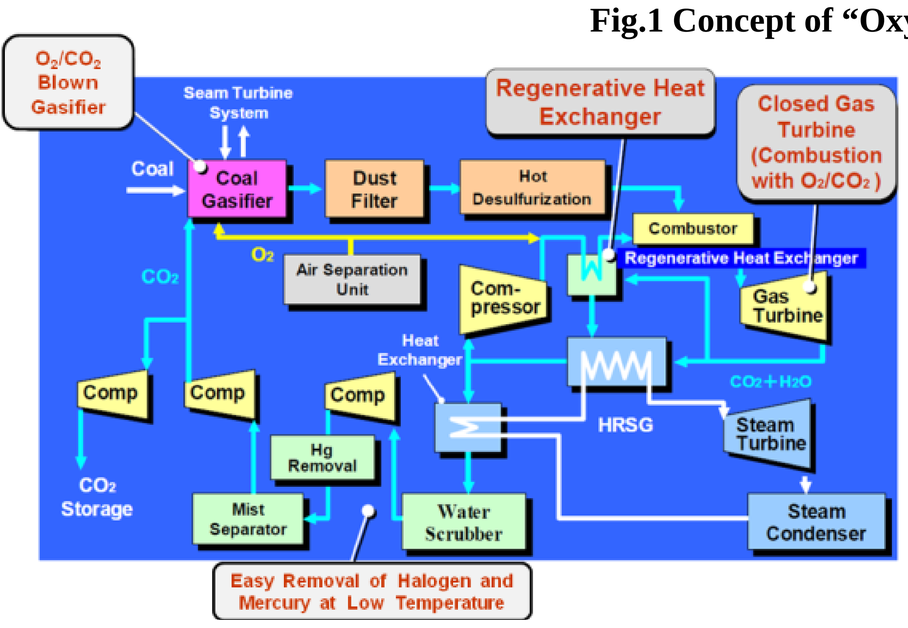


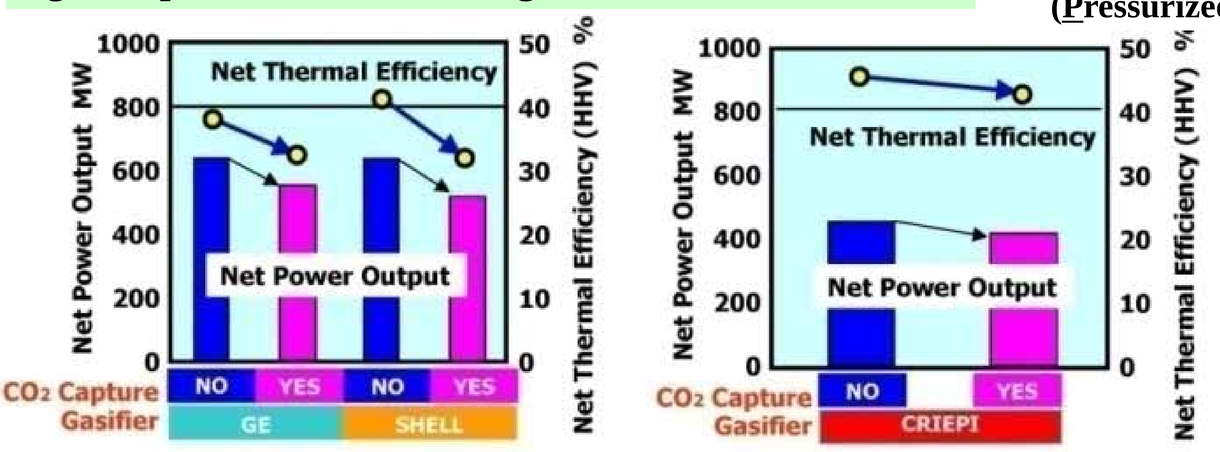
Fig.2 Detailed schematic diagram of "Oxy-fuel IGCC system" [1]

This system has following merits and keeps high generation efficiency at 42% [1] .

1) Simplified system without CO_2 separation unit.

2) Improvement of gasification performance.

3) Introduction of regenerative heat exchanger utilizes high temperature GT exhaust gas.



(1) Conventional Pre-combustion **(2) Oxy-fuel IGCC**

Fig.3 Comparison of efficiency drop by CO_2 capture [1]

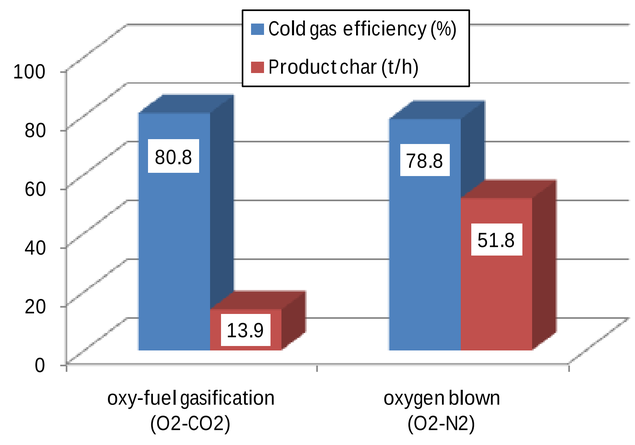


Fig.4 CO_2 is expected to reduce amount of char[1]

3. Experimental confirmation (3TPD gasifier)

Type	Pressurized Entrained Flow
Fuel Feed	Dry Feed System
Capacity	3 t/Day
Pressure	2 MPa
Fuel Types	Coal (Including Low Rank Coal)
Gasifying Agent	Air, O_2-enriched Air, O_2, Steam

CO_2 supply system (Newly constructed)

Fig.5 3TPD gasifier and CO_2 supply system

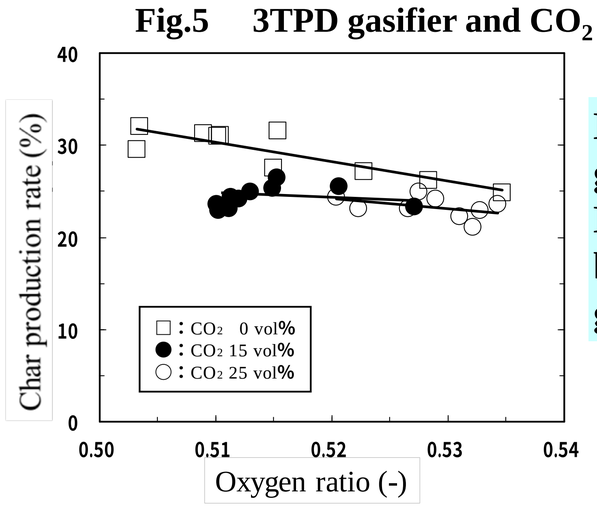


Fig.6 Added CO_2 reduced Char production[2]

Extra CO_2 added to 3TPD coal gasifier reduced char production rate. But reduction rate is not so high because of temperature drop inside gasifier.

4. Numerical simulation & reaction analysis

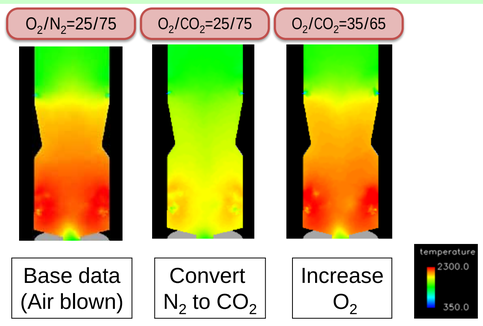


Fig.7 Estimation of temperature profile inside a gasifier

CRIEPI's original numerical simulation code clarified the effect of high CO_2 concentration on temperature profile inside a gasifier.
When O_2 concentration becomes higher, temperature drop inside gaifier will be cleared.

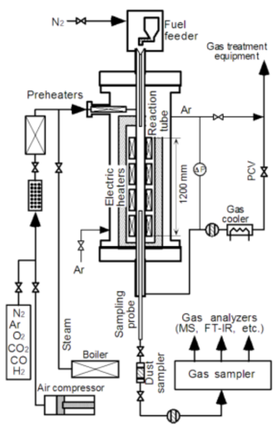


Fig.8 Schematic diagram of PDTF (Pressurized Drop Tube Furnace)

L-H model based reaction model was established from data acquired with drop tube (PDTF). This model can estimate complicated reaction in CO_2/O_2 gasification. This model is planed to be installed to numerical simulation code this year.

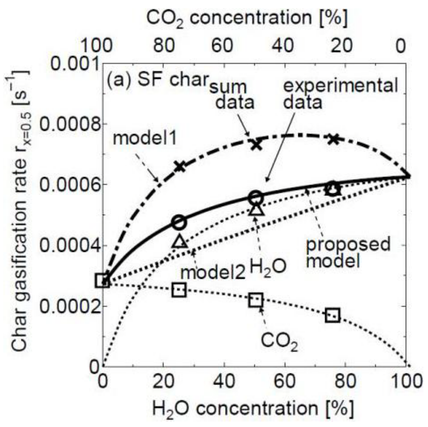


Fig.9 Evaluation of gasification reaction[3]

5. Development of countermeasure for carbon deposition in hot-gas cleanup system

Evaluation apparatus for de-sulfurization

$CO+H_2O \leftrightarrow H_2+CO_2$ (Shift reaction)

$2CO \leftrightarrow CO_2+C$ (Boudouard reaction)

$K_B=P_{(CO2)}/P_{(CO)}{}^2$

Bleeding line for syngas

Honey cam sorbent for de-sulfurization

Fig.8 Newly installed experimental apparatus for hot-gas clean up system

$H_2O\uparrow \rightarrow CO_2\uparrow$

$CO+H_2O \leftrightarrow H_2+CO_2$

$2CO \leftrightarrow CO_2+C$

$CO_2\uparrow \rightarrow C\downarrow$

Experimntal data proved that addition of CO_2, H_2O(Steam), GT exhaust gas (mixture of CO_2 and H_2O) prevent carbon deposition.

5. Project update

[1] Shirai, H. et.al.,Proc. Clearwater conference, 2008, 44 (3), 610
[2] Kidoguchi,K. et.al., Proc. of ICOPE2011, 2011
[3]Umemoto,S. et.al., Proc. of the 27th Annual International Pittsburgh Coal Conference, 2010

- Increase of CO_2 concentration reduced char production rate.
-Addition of CO_2 and H_2O prevented carbon deposition in hot gas cleanup system.

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