

Test results on IHI advanced amine solvents, packing and process at 20 ton-CO₂/day pilot plant



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I H I Corporation

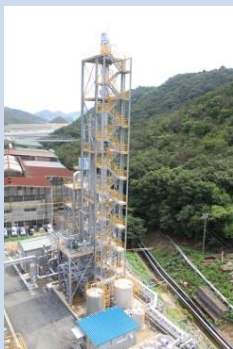
1. IHI CO₂ Reduction Technologies

Wood Biomass



Carbon neutral

Post CO₂ Capture(PCC) (Chemical Absorption)



20t/day Plant

Oxyfuel Demo. Project



Near zero emission

Reduce coal consumption rate

High Efficiency

Co-firing with, Renewables

CO₂ Reduction Technology

Carbon Capture & Storage

High Availability

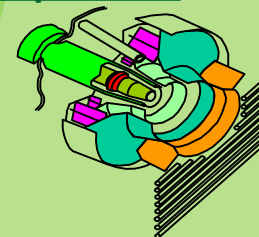
Minimize the occasions of plant stop & start

Flexible Operation

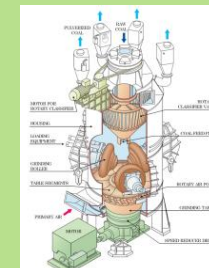
Control System



Low Load Operation

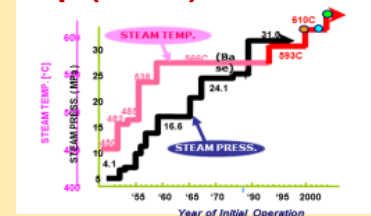


High Load Change Rate

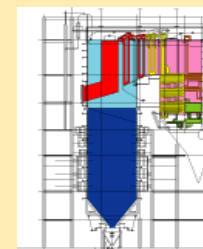


IHI USC/SC Boiler

World's Highest Reheat Temp.(623°C) USC Boiler



IHI's Proven Boiler Design



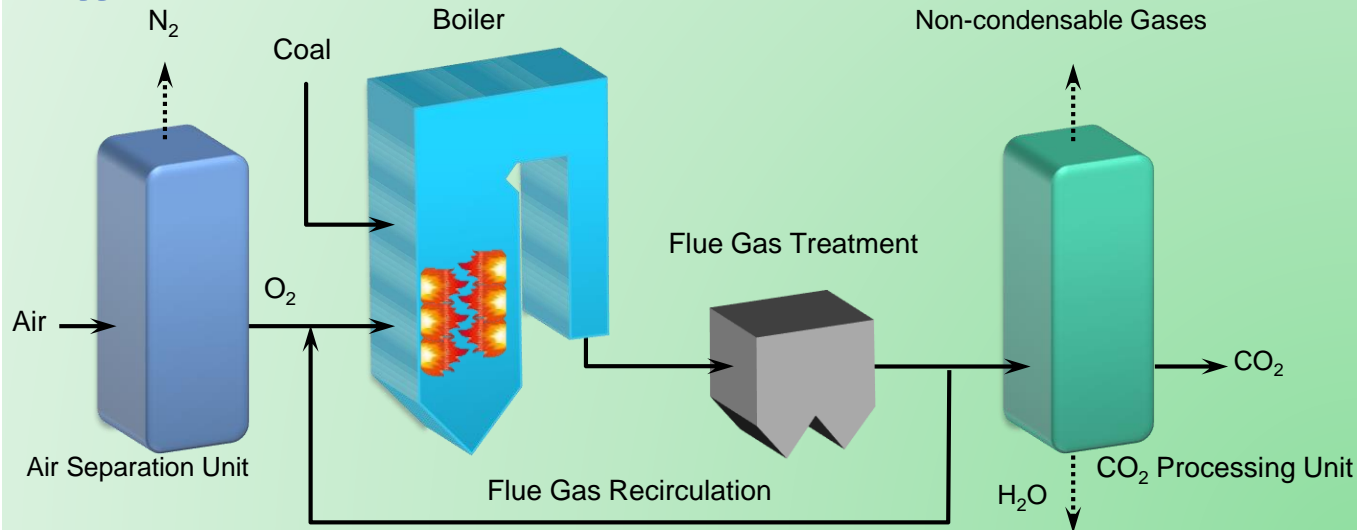
Over 95% Availability, over 19 years operation

IHI CO₂ Capture Technologies

IHI

IHI Is Developing “Oxy-Fuel Combustion” And “Post-Combustion” As CCS Technologies.

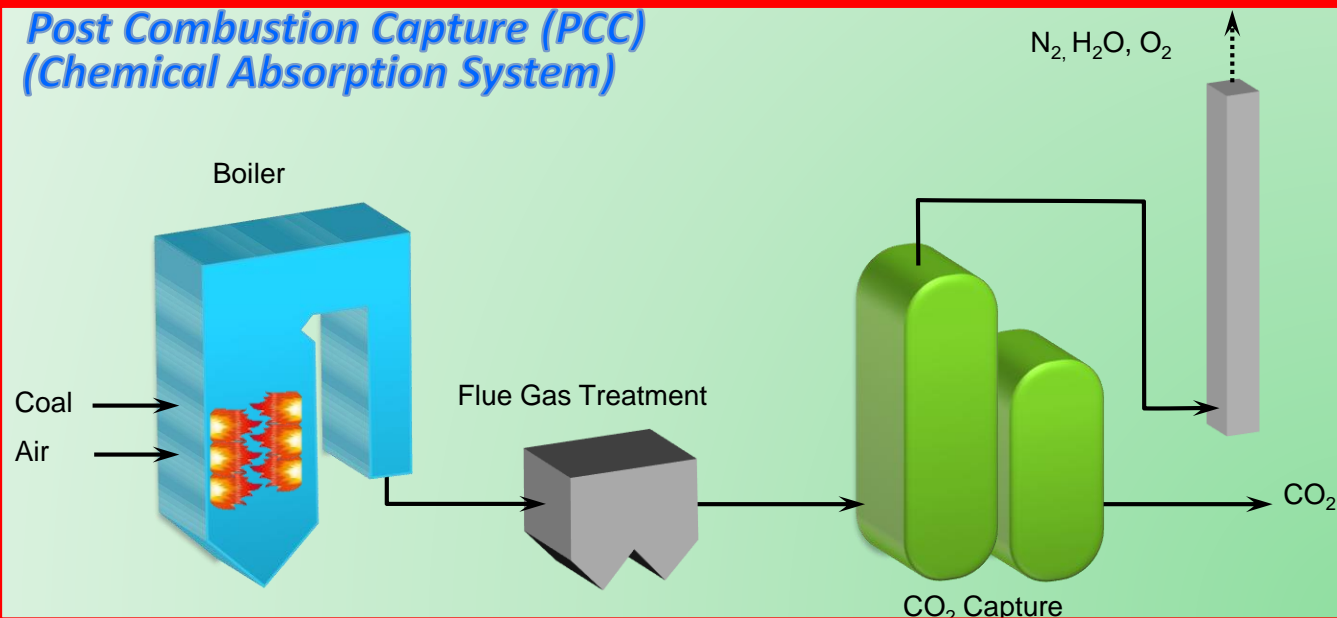
Oxyfuel Combustion



Features

- Lower CO₂ capture cost for full capture
- Byproduct reuse such as N₂ resulting from air separation for O₂
- Achievable of CO₂ capture rate up to 98%
- Applicable to both existing and new power plants

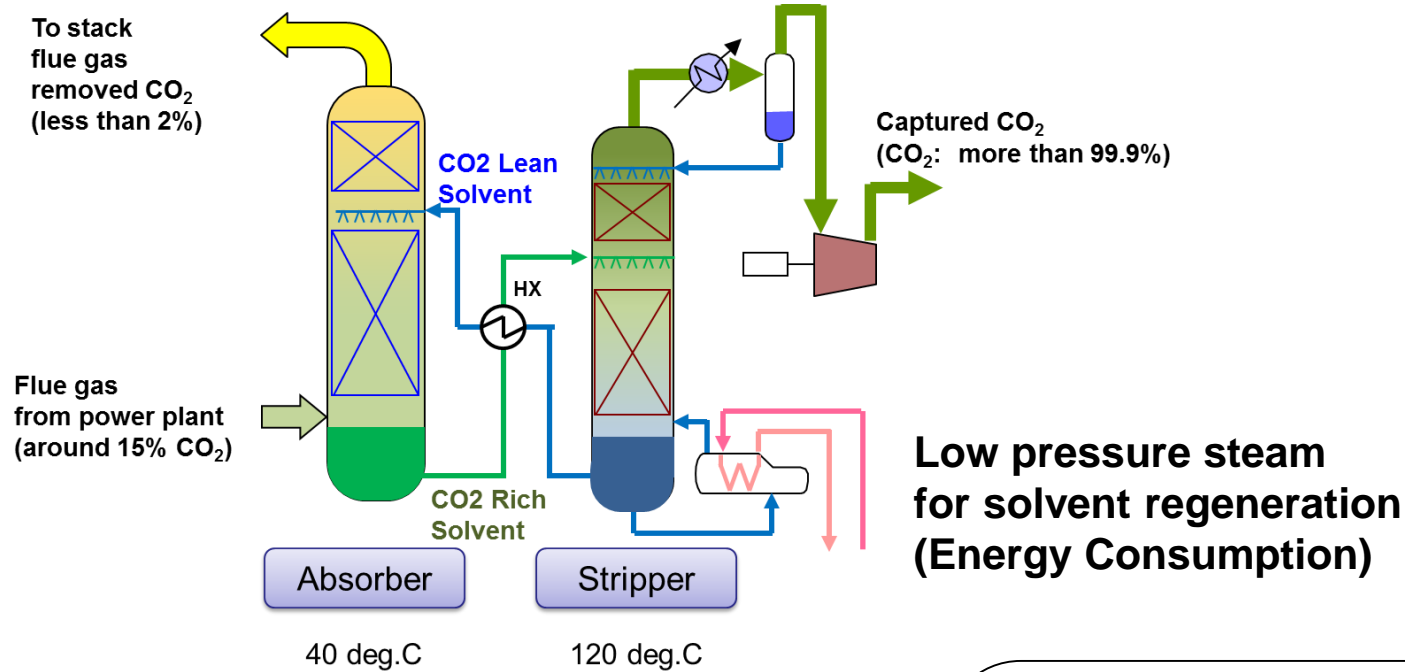
Post Combustion Capture (PCC) (Chemical Absorption System)



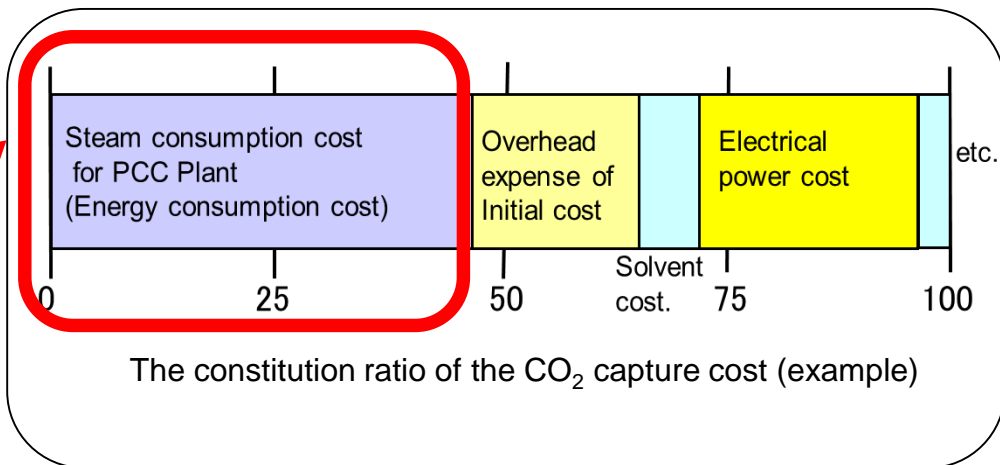
Features

- Flexible design for both full capture and partial capture
- Sequential scale up by increasing the number of PCC module
- Applicable to not only Coal fired boiler but also the other use such as NG-GTCC and Biomass power plant.
- Applicable to both existing and new power plants

2. IHI PCC Technology (PCC: Post Combustion Capture)



The energy saving technology is necessary



(Note) Source: FY2002 NEDO survey report (02004342 and 02004343)

Development of PCC Technology

IHI

IHI's key technologies of PCC for energy saving

- High Efficiency Heat Recovery
- Higher CO₂ Loading Operation in Rich Amine

Advanced Process

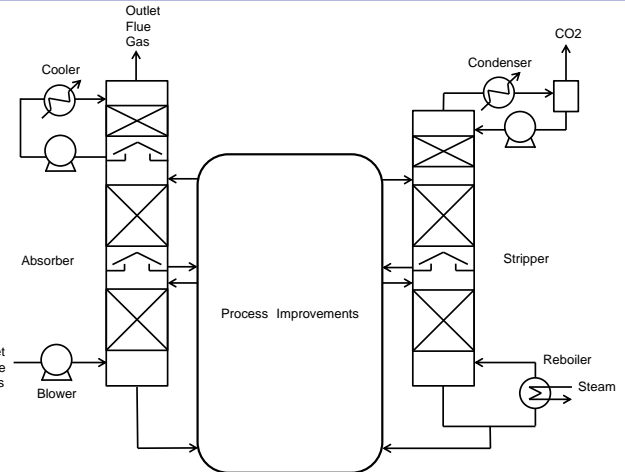
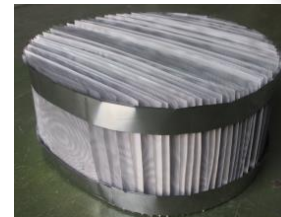
Post Combustion Capture Technology

Advanced Solvent

Advanced Packing System

- High CO₂ Cyclic Capacity
- Low Reaction Heat
- High Desorption Performance

Bench-scale Test



Flow Diagram of Advanced Process



- High Absorption Performance
- Low Gas Pressure Drop

Absorption Column Test

Development of Solvent

IHI

Development and demonstration on the basis of theoretical and analytical studies by collaboration with Waseda University

IHI Solvent (ISOL-X)

Operation and assessment

Feedback of test results

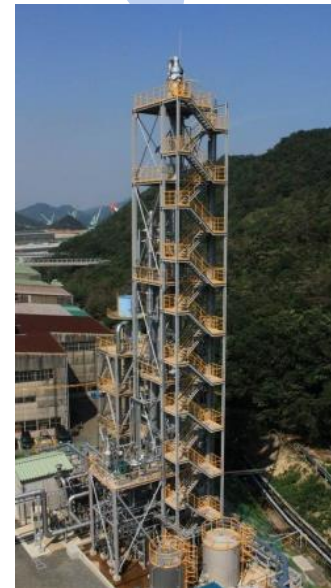
- Energy efficiency of CO₂ capture by bench scale test stand and Pilot plant

Detailed evaluation

- Measurements of physical properties absorption rate, desorption ratio, heat of reaction, specific heat



Bench scale test stand
(50kg-CO₂/day)



Pilot plant
(20t-CO₂/day)



Evaluation apparatus for solvents

Screening on the basis of theory and analysis

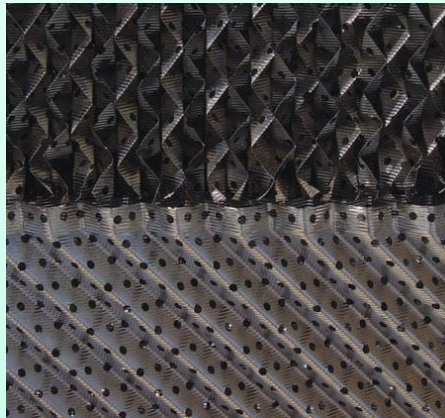
- reaction analysis
- molecular dynamics simulation
- evaluation of properties

Improvement of absorption rate higher than conventional packing
by modifying configuration, materials of thin plates

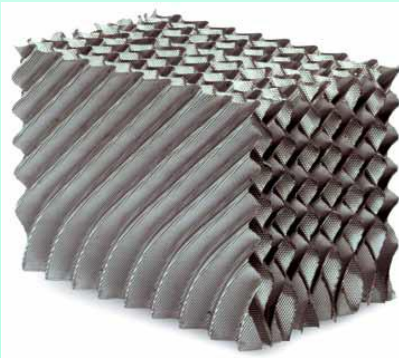
Conventional Structured Packing



Mellapak, MellapakPlus
http://web.ist.utl.pt/ist11061/de/Equipamento/Structured_Packings.pdf



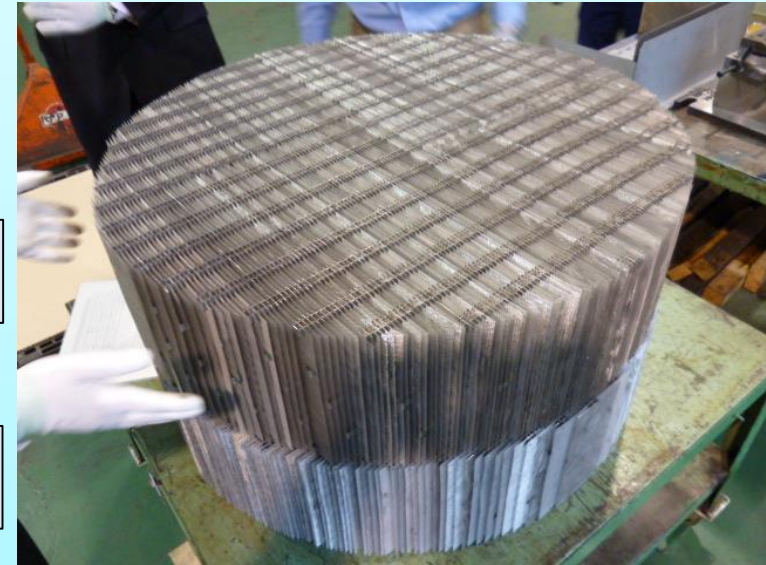
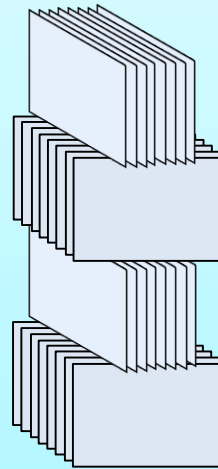
FLEXIPAC
<http://www.koch-glitsch.com/Document%20Library/KGSP.pdf>



Montz-Pak
<http://amacs.com/wp-content/uploads/2012/09/AMACS-Montz-Brochure.pdf>

- Thin corrugated metal plates
- High performance of liquid spreading

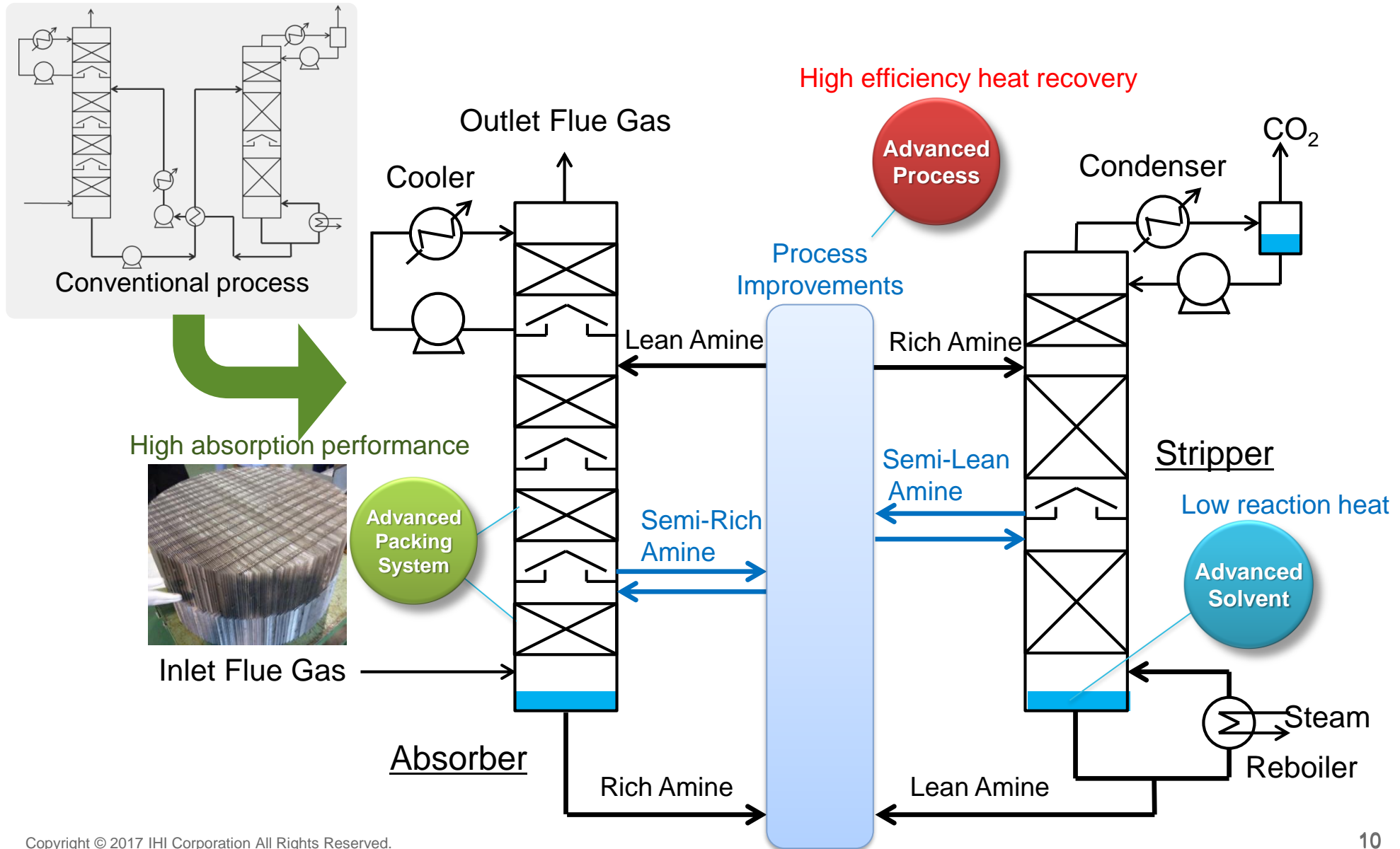
IHI Advanced Packing



- Thin parallel metal plates
- Lower pressure drop per unit surface area
→ Increase number of plates
- Tendency to decrease absorption performance by Inhomogeneous liquid spreading

Improvement of the efficiency

by designing IHI's process on the basis of process-simulation technology



3. 20 ton-CO₂ /d pilot plant tests

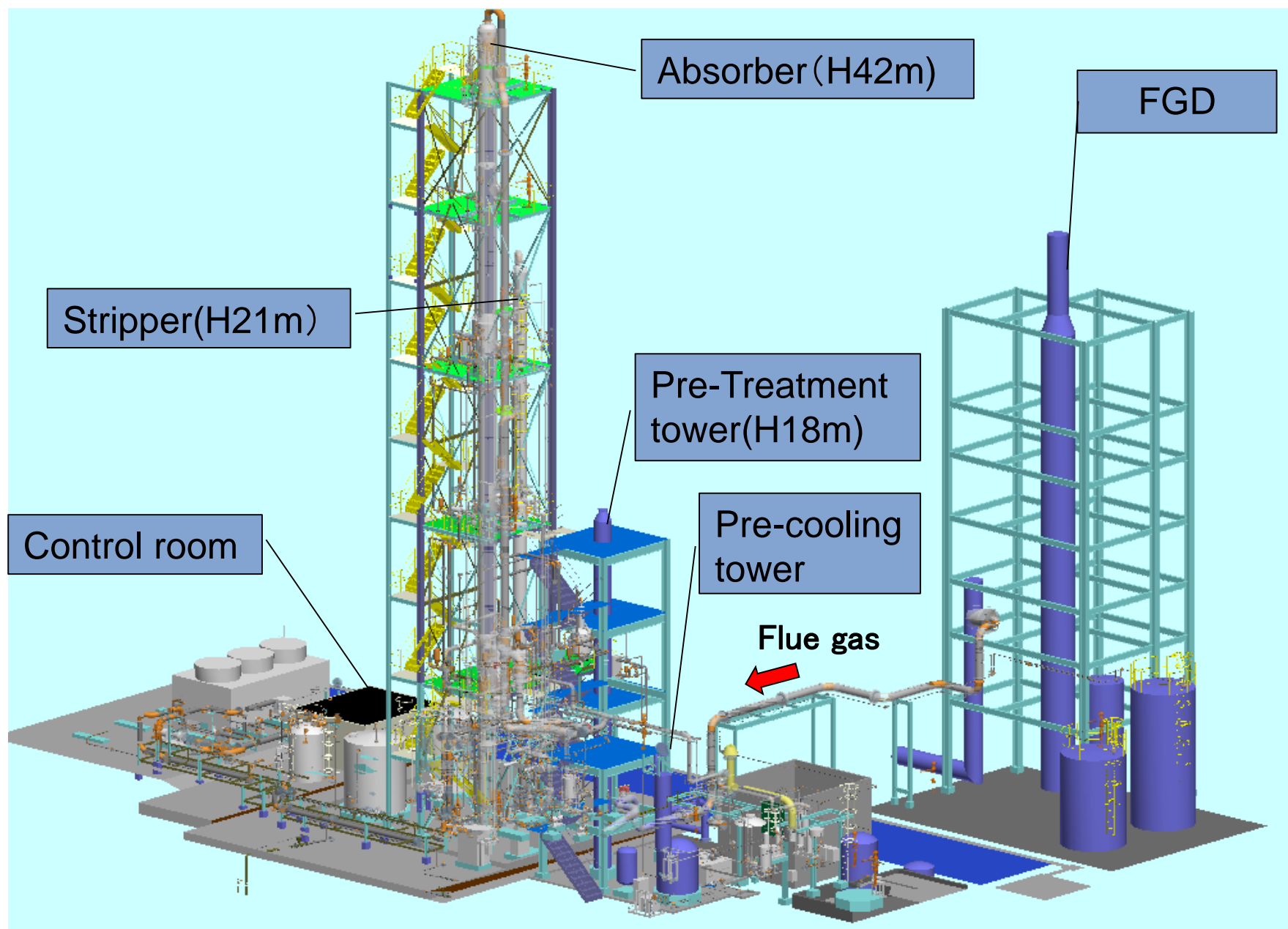
20 ton-CO₂/d Pilot Plant located at IHI's Aioi Works in Japan



Specifications

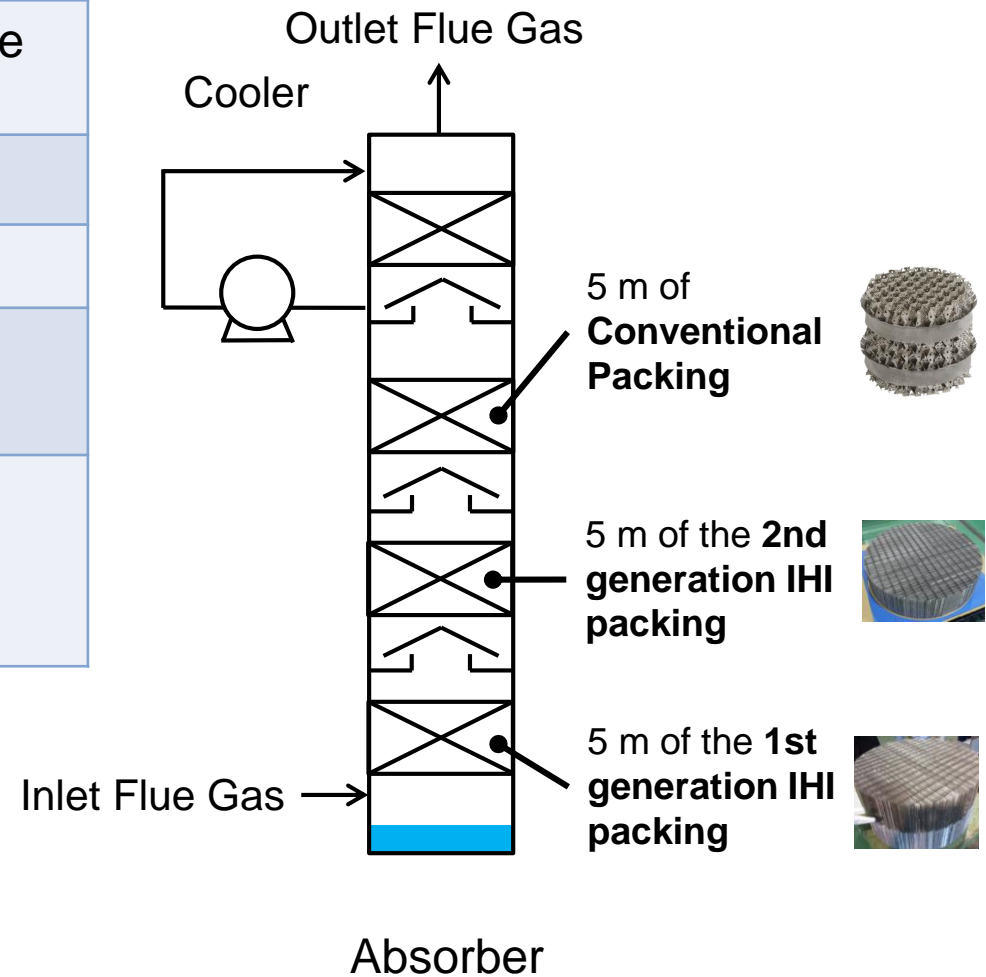
Item	Specification
Source Gas	Flue Gas of Coal-Fired Boiler or Propane Gas Boiler
Captured CO ₂	20 ton-CO ₂ /d
CO ₂ Capture Ratio	90%
Flue Gas Flow Rate(Normal)	Max 4,000m ³ /h-wet
Inlet CO ₂ Concentration (Dry)	14-15%
Solvent Flow Rate	Max 24m ³ /h
Steam Flow Rate	Max 2,500kg/h
Packing Height of Absorption Section	5/10/15m

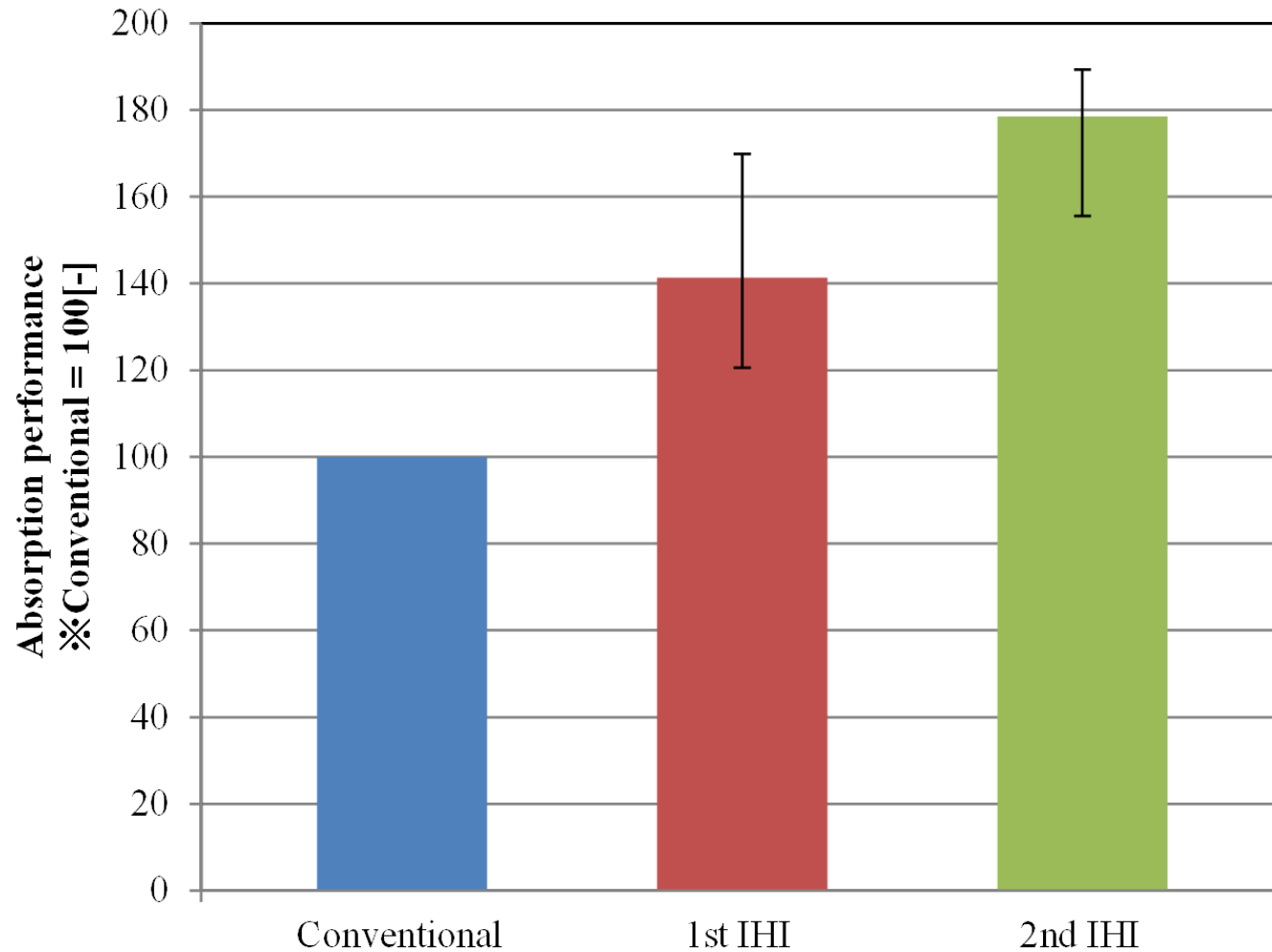
20 ton-CO₂/d Pilot Plant



Test conditions

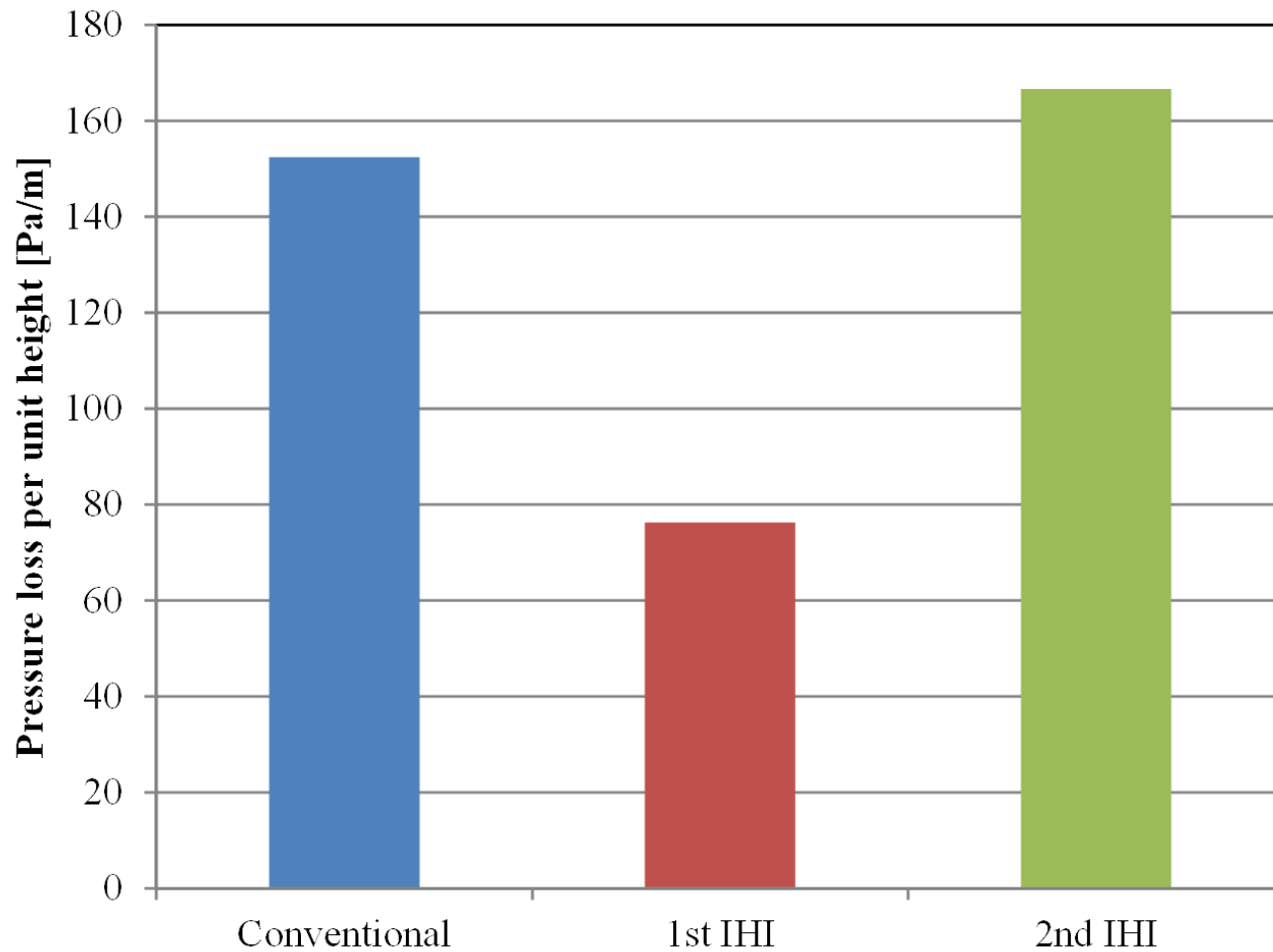
Source Gas	Flue Gas of Propane Gas Boiler
Amine solvent	ISOL-160 series
Liquid to Gas ratio	3.0 L/Nm ³
CO ₂ concentration of flue gas	5 %
Liquid and gas temperature at absorber inlet	40 degC





Relative absorption performance of each packing type

- The performance of 2nd IHI packing was 1.8 times higher than conventional packing.

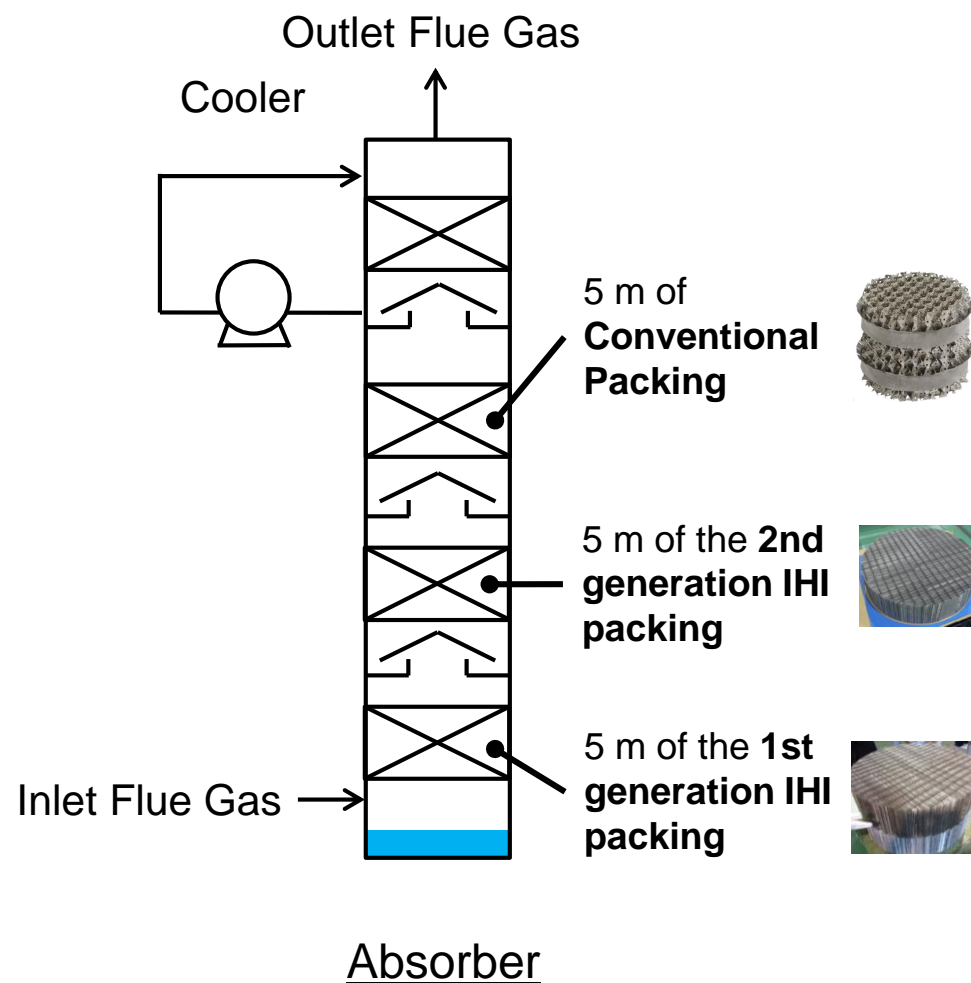


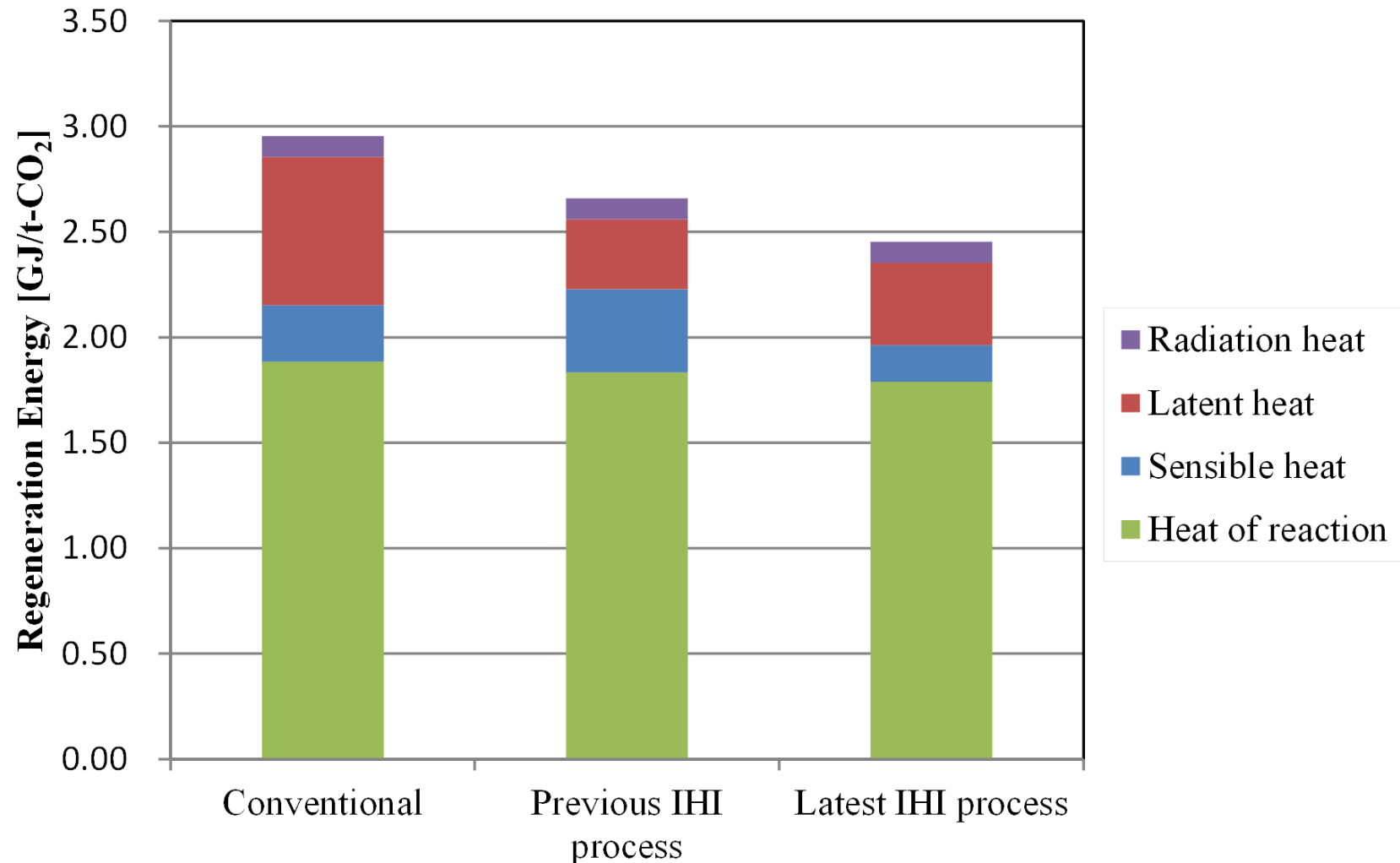
Pressure loss per unit height of each packing type

- 2nd IHI packing and conventional packing were almost same pressure drop per unit height.

Test conditions

Source Gas	Flue Gas of Propane Gas Boiler
Amine solvent	ISOL-160 series
CO ₂ concentration of flue gas	14 - 15 %-dry
Liquid and gas temperature at absorber inlet	40 degC
Packing height of absorber	15 m (3 different types of packing in each 5 m section)
CO ₂ capture capacity	20 ton-CO ₂ /d
CO ₂ capture ratio	90 %





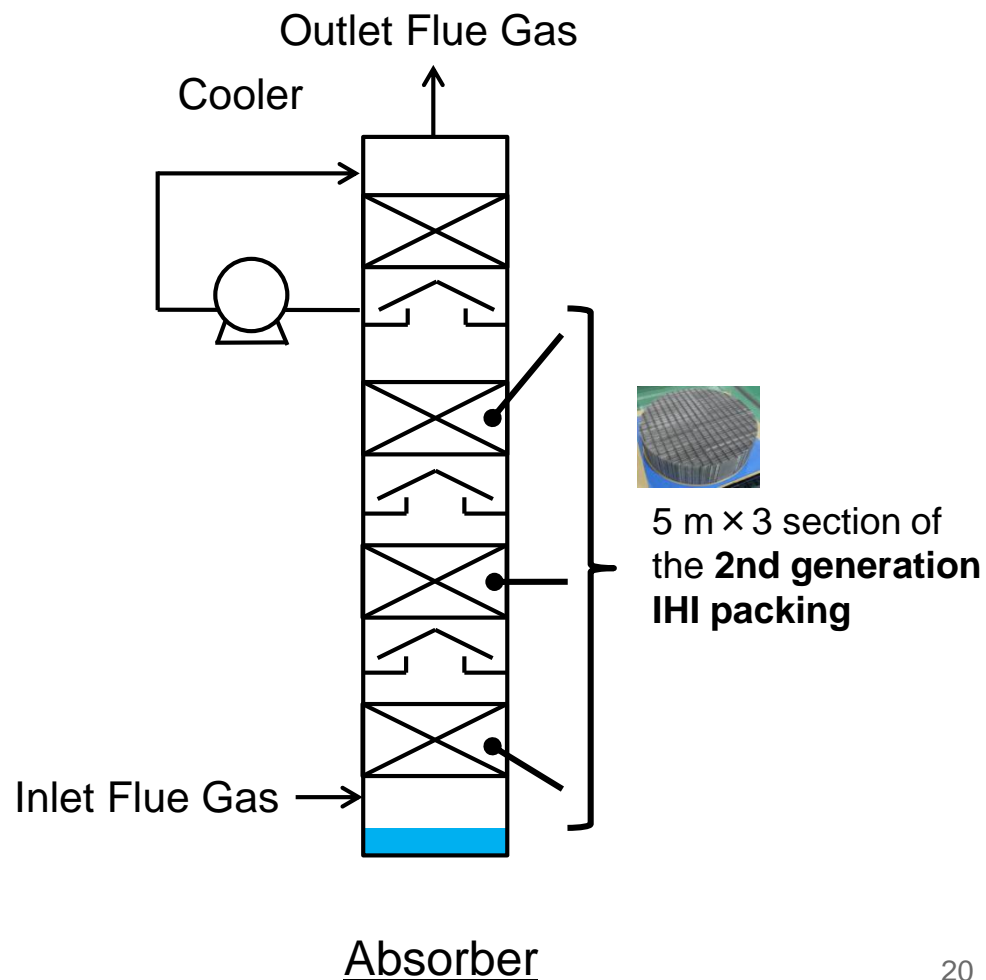
Regeneration energy of each process

- The regeneration energy of the latest IHI process accomplished less than 2.4 GJ/t-CO₂ excluding the radiation heat.

- The absorption performance of the 2nd generation IHI packing was 1.8 times higher than the conventional packing with almost the same pressure loss per unit height.
- The regeneration energy of the latest IHI process achieved less than 2.4 GJ/t-CO₂ excluding the radiation heat.

5. Future works

We are testing a new solvent with lower heat of reaction at PCC pilot plant in Aioi Works with the 2nd generation IHI packing and latest IHI process.



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Thank you for your attention !

IHI

Realize your dreams