MOVE THE WORLD FORWARD MITSUBISHI HEAVY INDUSTRIES GROUP

Mitsubishi Heavy Industries Carbon Capture Solution

2024

Mitsubishi Heavy Industries, Ltd.

MITSUBISHI HEAVY INDUSTRIES

Extracts from the technology selection report for Padeswood

MHI's proprietary solvent (KS-1™/KS-21™) offers several advantages over conventional processes, including low utility consumptions, low corrosiveness, and high stabilities. KS-1™ solvent is the most deployed solvent in the world and widely recognised in this industry and KS-21™ is an upgraded proprietary solvent with features of lower operational cost and superior emission performance, even comparing with KS-1™.

Note that the slides below deal with the improvement shown by KS-21™ Vs KS-1™

KS-1™ - is the currently available product, whereas KS-21™ is a further improved version that will be used at Padeswood.

The final slide is a reference to published data showing how KS-1™ is already much improved compared to MEA.

History of KM CDRTM Technology Development

Verification of applicability to
Various carbon emission sources

Present

Development of KS-21™ and Advanced KM CDR™
KS-1™/KS-21™ and Advanced KM CDR™ were tested in
Technology Centre Mongstad (TCM)
Testing was on both cogen and cat cracker exhaust

2021

Plant Barry 500 Mt/d
demonstration project

2011-2014

Technology Centre Mongstad

In-house Pilot Plant in
Nagasaki R&D center

Large absorber flow test at Mihara works

2008

10 Mt/d coal pilot test at Matsushima

2006

Developed proprietary energy
efficient process

2003

1 Mt/d coal in-house pilot test at
Hiroshima R&D Center
(present transferred to Nagasaki R&D Center)

2002

Developed KS-1™
and KM CDR Process™

1994

2 Mt/d pilot plant at
KEPCO's Nanko Power Station

1991

1990

Pilot Plant in
Nanko Power Station

Pilot Plant in Plant Barry

HISTORY OF CARBON CAPTURE TECHNOLOGY DEVELOPMENT

Advanced KM CDR Process™- Overview and Features

- MHI has developed upgraded process **Advanced KM CDR Process™** and upgraded solvent KS-21™.
- **KS-1™ / KS-21™ tested in Technology Centre Mongstad (TCM) carbon capture facility in Norway in 2021 with great success.**
  - ✓ Testing was on both CCGT and cat cracker exhaust
  - ✓ **95-98% carbon capture rate** was maintained for CCGT flue gas during the campaign.
  - ✓ Maximum **99.8%** was achieved for CCGT flue gas, then absorber outlet CO2 % is lower than CO2 content in air.
  - ✓ **KS-21™** showed reduced reclaiming duty and comparable or better energy performance than KS-1™
- **Advanced KM CDR Process™** is a process that enabled cost savings by using **KS-21™**.
- Ready for new commercial projects

Technology Centre Mongstad (TCM) ;
The world's largest and most flexible test centre for developing carbon capture technologies (an annual capacity for handling up to 100,000 tons of CO_2) and a leading competence centre for carbon capture.

Technology Centre Mongstad

Tanaka et al, "Advanced KM CDR Process™ using New Solvent",
14th International Conference on Greenhouse Gas Control Technologies

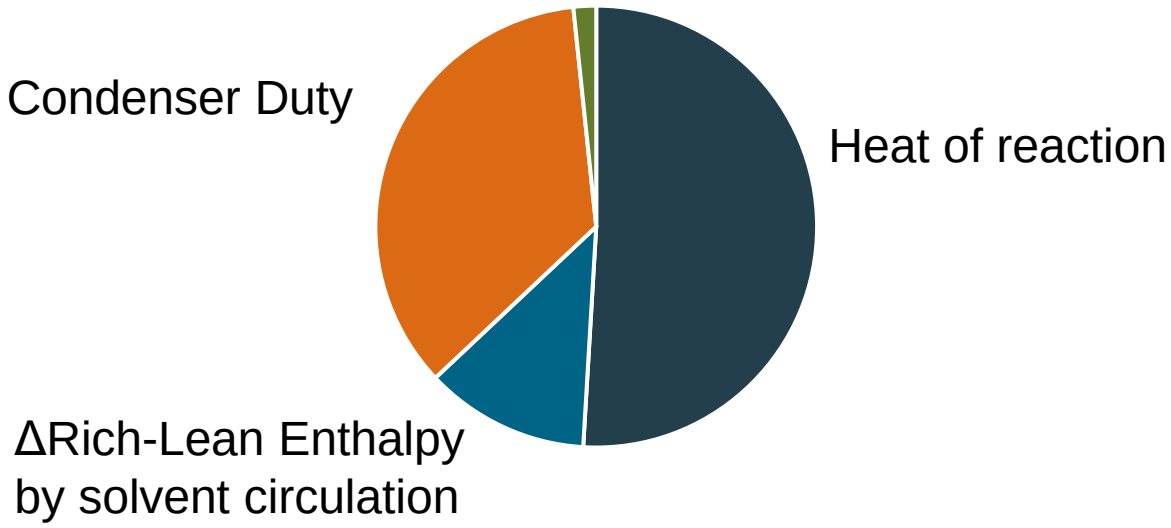
Photograph courtesy of Technology Centre Mongstad

New Solvent KS-21™ Features

Parameters Relative to KS-1™	KS-1™	KS-21™
Volatility	100	50-60
Thermal degradation rate	100	30-50
Oxidation rate	100	70
Heat of reaction	100	85

Lower solvent consumption & amine emission

Breakdown of Reboiler heat duty



Largest portion of reboiler duty

Some comments on the advantages of MHI's KS-1™ over MEA

KS-1 Vs MEA

("*Result of the 60 tpd CO2 capture pilot plant in European coal power plant with KS-1", Kamijo et al, Energy Procedia 37 (2013) 813 – 816*)
https://www.sciencedirect.com/science/article/pii/S1876610213001823#:~:text=The%20MHI%20test%20results%2C%20utilizing,and%20significantly%20lower%20amine%20emissions.

It was found that KS-1™ can achieve a lower heat consumption,

MEA: ~1.5[kg-steam/kg-CO_2]>> KS-1™: app 1.2 [kg-steam/kg-CO_2], with a lean solvent flow rate approximately 25% lower than MEA 30wt% as shown in the Figure below

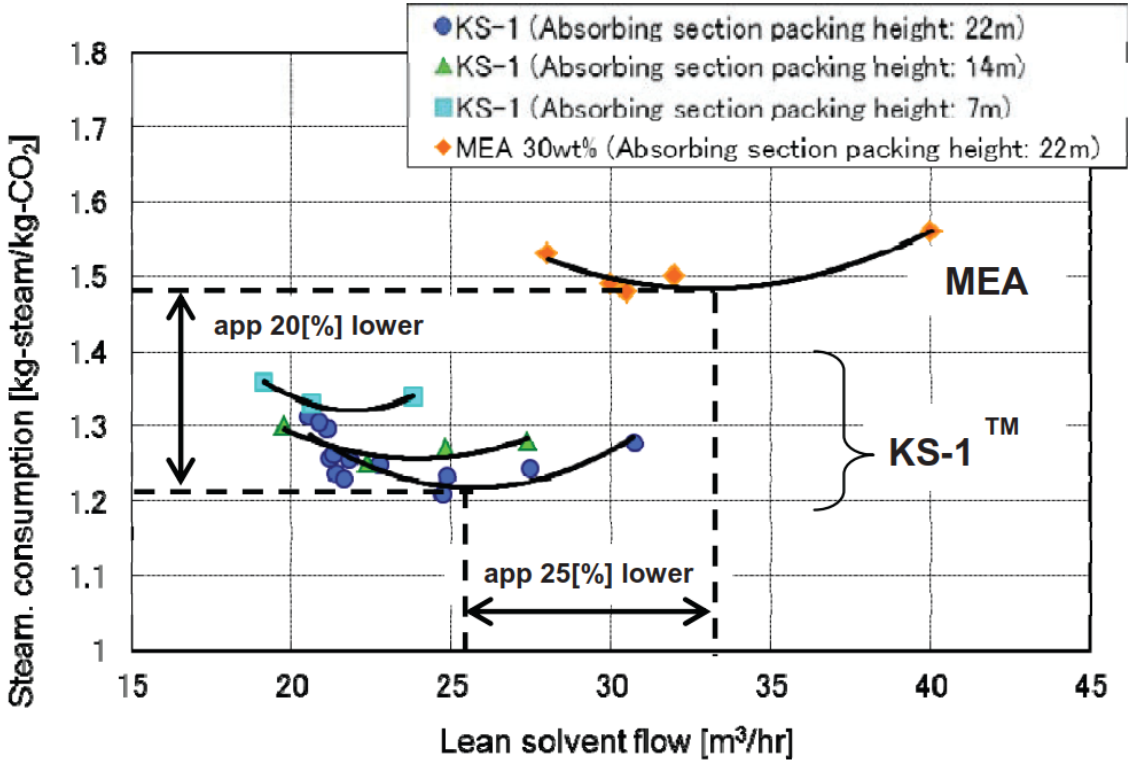


Figure 3. Parameterized performance test result.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