Coal Mining Methane Abatement Seminar

KAWASAKI VAM Abatement System

Kawasaki Heavy Industries, Ltd.
Gas Turbines & Machinery Company
Gas turbine Division

4th September, 2012
InterContinental Hotel, Sydney, Australia
Who is Kawasaki?
Kawasaki Heavy Industries, Ltd. (KHI) - a leading global manufacturer of transportation & industrial equipment
【Kawasaki Gas Turbine】

- Started development of industrial Gas Turbine in 1972.
- Accumulated order of over 10,000 engines

【Product Line-up】

- Base Load Model : 1.5MW - 30MW
- Stand-by Model : 0.2MW - 4.8MW

【Application】

- Cogeneration
- Stand-by Gene-set
- Pump Drive
- Mobile Gene-set
- Combined-cycle System
Lean Methane Fueled Gas Turbine

Catalytic Combustion & Re-generative Cycle Gas Turbine
**Cycle of Lean Methane Fueled Gas Turbine**

**【Simple Cycle GT】**

- Flammable Fuel (Natural Gas)

  - Suctioned Air
  - Gas Compressor
  - Combustor
  - Power Converter
  - Turbine

**【Lean Methane Fueled GT】**

- Lean Methane Fuel (VAM)

  - Suctioned Lean Fuel to compressor
  - Catalytic Combustor
  - Power Converter
  - Recuperator
  - Turbine

- Large pressurization work required
- Nonflammable

**Key Point.1**
- Injecting compressed Fuel to combustor

**Key Point.2**
- Indispensable equipment for system establishment

**Key Point.3**
- Flammable Fuel

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6
What is Catalytic Combustion?

Feature of Catalytic Combustion:

- Can burn (oxidize) lean methane/air mixture (less than 5% v/v; out of flammable range) at low temperature (lower than 900°C)
- Resulting in no NOx emissions and no flame (flameless combustion)
Catalytic Combustion & Re-generative Cycle Gas Turbine based on Proven Technologies

Catalytic Combustion & Re-generative Cycle Gas Turbine

Catalytic Combustor
Only practical use machine in the world
1,500kW-class Catalytic Combustion GT: M1A-13X

Recuperator
The long time use results with the practical use machine
600kW-class Re-generative cycle GT: S7A

Gas Turbine
Abundant operative results
1,000kW-class GT: M1A-01
Layout of Lean Methane Fueled Gas Turbine

Lean Methane Fuel (2%CH4)

Gas Turbine

Reduction Gear

Catalytic Combustor

Starting Combustor

Exhaust Gas

Recuperator

Starting Combustor

1

2

3

4

5

6

7

8
### Projected Performance

#### Generator Output

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generator Output [1]</td>
<td>800 (kWe)</td>
</tr>
</tbody>
</table>

#### Utilization of VAM & Drainage Gas

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utilization of VAM &amp; Drainage Gas</td>
<td>22,000 (mN³/hr)</td>
</tr>
</tbody>
</table>

#### GHG Reduction

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>GHG Reduction [2]</td>
<td>48,000 (tCO₂e/year)</td>
</tr>
</tbody>
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[Note.1] ISO Condition (15°C, 1atm, sea level: 0m)

[Note.2] Availability of operation: 97%.
Assembling of Practical Test Engine

- Generator
- Reduction Gear
- Gas Turbine (Rotor Ass’y)
- Recuperator
- Catalytic combustor
Test Facility at KHI Akashi Factory
Construction of the Gas Turbine Gene-set

- Fuel Gas
- Fuel/Air Mixer
- Methane Sensor
- Intake Air Filter
- Intake Air
- Ventilation Fan
- Generator
- Gas Turbine
- Starting Combustor
- Recuperator
- Catalytic Combustor
- Methane Sensor
- Ventilation Exhaust
- GT Exhaust Gas

size: 7,700(L) x 2,980(W) x 5,140(H)
weight: 27,000kgf
Practical Test Results

Inlet Methane Concentration [%]

Power output

Power input

Speed [%], Power [kW], Catalytic Outlet Temperature [°C]

Warm-up

Power Generation

17:00 17:30 18:00 18:30 19:00 19:30 20:00

Power Generation
Kawasaki’s Proposed VAM Abatement System

Combination of the Lean Methane Fueled Gas Turbine and Catalytic Oxidizer
Fugitive methane abatement system

Gas Turbine Gene-set

- Ingest VAM & Drainage Gas mixture as a fuel (methane concentration approx. 2%)
- Generate electricity: 800kW
- VAM mixture abatement: 22000Nm³/Hr

VAM Oxidizer

- Oxidize huge VAM by Catalytic Oxidizer
- Preheat VAM through the heat exchanger
- Increase VAM temperature by mixing with GT exhaust gas for starting and assisting

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Legend:
- VAM
- Drainage Gas
- Catalytic Oxidizer
- Heat Exchanger
- Exhaust Gas
- Fan
- Generator
- Gas Turbine
- Power Converter
- Recuperator
Feature of KHI’s Abatement System

- No grid electricity required for operation (except startup period)
- No water required for operation
- Small footprint
- Shorter startup- and shutdown-time
- Quick response for fluctuation in $\text{CH}_4$ concentration
- Low operation temperature due to catalytic oxidation
  - Gas turbine gene-set: $900 \, ^\circ\text{C}$ max
  - Oxidizers: $600 \, ^\circ\text{C}$ max
Kawasaki Gas Turbine places importance on "Efficient Energy Use", "Eco-friendly" and "Reliable Product Care for Total Life Cycle" as a philosophy of our products. To enhance this philosophy, we have introduced a new title for our products..."GREEN Gas Turbines".

"Get Reliable Eco-friendly Energy Now"