High Efficiency Cryogenic Power Generation System

Features

- In an LNG gasification terminal, Boil Off Gas (BOG) is frequently used for Gas Engine In-house Power Generation. The proposed system is to utilize recovery heat of engine cooling water and exhaust hot gas for a propane Rankine cycle. LNG is used for condensation of propane gas of the Rankine cycle turbine exhaust.
- Furthermore, middle pressure gas can be made by the natural gas (NG) expander turbine from high pressure vaporized LNG at the propane turbine condenser. The power of the two turbines of the Rankine cycle and expander makes a common power generator and increases the thermal efficiency by approximately 11% without additional BOG fuel. The turbine unit consists of one common skid and is compact.
- Open Rack Vaporizers (ORV) in the LNG terminal can be reduced since the Rankine cycle can be used as an ORV.
- All heat exchangers in the system are simple shell and tube type. No special equipment is required.

Basic Concept or Summary

The figure below shows the system flow utilizing gas engine cooling water return and exhaust hot gas. Propane turbine inlet gas is pressurized by the cryogenic liquid propane pump and heated by sea water and hot water made by gas engine exhaust and the cooling water return. The turbine exhaust propane is cooled and condensed by LNG. The LNG becomes natural gas (NG) after the propane condenser, the NG is heated by sea water and power is recovered by the expander.

The figure on the right shows the mechanical configuration of the Rankine cycle and expander turbines. The Propane turbine consists of 2 (two) cascaded single stage radial turbines. The NG expander is a single stage radial turbine. Each turbine is connected with high speed pinion gears and drives a low speed wheel shaft with the generator. Mechanical configuration is very reliable and can be packaged on one steel base frame including the oil unit.
Effects or Remarks

- Power generation thermal efficiency (LHV based): The Cryogenic Power Generation System can add 11.4% thermal efficiency without additional fuel in the gas engine resulting in 57.0% total power generation efficiency.

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<thead>
<tr>
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<th>In/Output (kW)</th>
<th>Thermal Efficiency(%)</th>
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<tbody>
<tr>
<td>Gas Engine Fuel</td>
<td>29,600</td>
<td></td>
</tr>
<tr>
<td>Gas Engine Generator Output</td>
<td>13,500</td>
<td>45.6</td>
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<tr>
<td>High Eff. Cryogenic Power System</td>
<td>3,370</td>
<td>11.4</td>
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<tr>
<td>Total Power System</td>
<td>16,870</td>
<td>57.0</td>
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- The above gas engine combined system will produce more power than LNG terminal power demand. The extra power can be sold to the grid or neighboring industries and day and night operation can be varied to suit demand. Investment pay back, depending on power price, is approximately 7-8 years.
- The figure below shows the system overview.

![System Overview](image)

- Domestic and overseas patent pending, under examination.

Installation in Practice or Schedule

**Domestic**

Large LNG terminals: Although configuration differs slightly, the Cryogenic Power Generation System (4MW) was installed in 1985. The above system is more advanced and efficient than existing.

**Overseas**

To be proposed for existing LNG terminals in Asia: Singapore, Malaysia, Taiwan etc.

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