DEVELOPMENT AND SPREAD OF GHP
WITH A POWER-GENERATING FUNCTION
(FUSION OF AIR-CONDITIONING AND POWER GENERATION)

Main author

T. Sakai

Commercial & Industrial Market Development Dept.
Osaka Gas Co., Ltd.

JAPAN
ABSTRACT

A gas heat pump (GHP) air-conditioner is a gas air-conditioning system in which an outdoor compressor is driven by a gas engine to operate a heat pump to provide air-conditioning. As the advantages of energy saving, low electric power consumption and running costs have been recognized, the use of GHP units has been increasing every year. As of the end of the FY2004, the installed capacity of GHP units in the Osaka Gas service area amounted to 3.10 million kW (an increase of approximately 110% over the previous fiscal year).

We have recently developed the GHP with power-generating function (High Power Multi). Equipped with a small generator with 1-kW class output, High Power Multi has the feature of lower electric power consumption and running costs, compared to GHP without a power-generating function (conventional GHP). We launched the sale of High Power Multi with the variation of the type from 35.5kW to 56kW type in October, 2003. All GHP manufacturers are going to commercialize High Power Multi in the FY2005, a variation is due to be expanded to 35.5kW – 84kW type.

Furthermore, we are also tackling development of GHP with a power-generating function that enlarges power generation capacity of High Power Multi, and supplies generated power out of an outdoor unit by the grid connection. This system is under development aiming at commercialization of the spring of 2006.

In this paper, we show the overview and spread of High Power Multi. Then we introduce the development of GHP with power-generating function (GRID CONNECTION TYPE). Finally a future prospect is described.
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1. INTRODUCTION

A gas heat pump (GHP) air-conditioner is a gas air-conditioning system in which an outdoor compressor is driven by a gas engine to operate a heat pump to provide air-conditioning. As the advantages of energy saving, low electric power consumption and running costs have been recognized, the use of GHP units has been increasing every year. As of the end of the FY2004, the installed capacity of GHP units in the Osaka Gas service area amounted to 3.10 million kW (an increase of approximately 110% over the previous fiscal year).

We have recently developed the GHP with power-generating function (High Power Multi). Equipped with a small generator with 1-kW class output, High Power Multi has the feature of lower electric power consumption and running costs, compared to GHP without a power-generating function (conventional GHP). We launched the sale of High Power Multi with the variation of the type from 35.5kW to 56kW type in October, 2003. All GHP manufacturers are going to commercialize High Power Multi in the FY2005, a variation is due to be expanded to 35.5kW – 84kW type.

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2. OVERVIEW AND SPREAD OF HIGH POWER MULTI

2.1 Overview

2.1.1 System Outline

Figure 1 shows the structure of the gas heat pump air-conditioning system with power-generating function. In this new system, the generator and the converter are additionally installed in the conventional gas heat pump air-conditioner. High-frequency AC power produced by the generator is converted into DC power by the converter, and its DC power is supplied to the outdoor unit cooling fan and pump. With continuous commercial power backup in place, any shortage of electric energy generated will be automatically made up for by commercial power.

2.1.2 Major Specifications

After development of this system jointly with Sanyo Electric Co., Ltd., Osaka Gas Co., Ltd. released the Multi System Series for buildings with 56 kW type (cooling capacity: 56kW), 45 kW type, and 35.5 kW type in October 2003. The major specifications of the 56kW type (Sanyo Electric Co., Ltd.) are shown in Table 1.

Although High Power Multi has the same dimensions and cooling capacity as the conventional GHP, they differ in electric power and gas consumption. Since High Power Multi generates 0.87kW to 0.97kW electricity under rated conditions, the power consumption has been reduced to 0.1kW, and gas consumption has increased by 2.2kW to 2.3 kW compared with the conventional GHP.
In this system, centering on the engine, the generator is installed on the opposite side of the compressor, and these units are driven through belts. The converter board is installed below the control board for air-conditioning, which has been installed in conventional GHP.

![System Outline of High Power Multi](image)

**Figure 1. System Outline of High Power Multi**

<table>
<thead>
<tr>
<th></th>
<th>Conventional GHP</th>
<th>High Power Multi</th>
</tr>
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<tbody>
<tr>
<td>Cooling Capacity</td>
<td>kW</td>
<td>56</td>
</tr>
<tr>
<td>Heating Capacity</td>
<td>kW</td>
<td>63</td>
</tr>
<tr>
<td>Power Source</td>
<td>3-phase 200V</td>
<td></td>
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<tr>
<td>Power Consumption (Cooling Rated)</td>
<td>kW</td>
<td>0.97</td>
</tr>
<tr>
<td>Power Consumption (Heating Rated)</td>
<td>kW</td>
<td>1.07</td>
</tr>
<tr>
<td>Gas Consumption (Cooling Rated)</td>
<td>kW</td>
<td>39.0</td>
</tr>
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<td>Gas Consumption (Heating Rated)</td>
<td>kW</td>
<td>43.0</td>
</tr>
<tr>
<td>Generator Capacity</td>
<td>kW</td>
<td>--</td>
</tr>
<tr>
<td>Generator Type</td>
<td>Permanent Magnet Type</td>
<td></td>
</tr>
<tr>
<td>Dimensions</td>
<td>W1735<em>D1000</em>H2208</td>
<td></td>
</tr>
<tr>
<td>Net Weight</td>
<td>kg</td>
<td>910</td>
</tr>
<tr>
<td>Noise</td>
<td>dB(A)</td>
<td>58</td>
</tr>
</tbody>
</table>

**Table 1. Specifications of the Conventional GHP and High Power Multi (SANYO 56kW type)**

(“**” mark indicates the data in the case where electricity is not generated.)
2.1.3 Features

**Lowest Power Consumption In The Air-conditioning Industry**

In the new system, the power consumption of the outdoor unit has been reduced to approximately one-twelfth that of conventional gas heat pump air-conditioners, and approximately one-hundredth that of electric heat pump air-conditioners of the equivalent class. By adjusting electric energy output according to operational status of the fan, etc., the system minimizes surplus power or shortage of power supply.

**Low Running Costs**

By adding a power-generating system, the new air-conditioning system consumes slightly more gas. However, due to lower contract demand and high-efficiency power generation, the running cost merit has increased 6%, compared to conventional gas heat pump air-conditioners.

**Higher-efficiency Power Generation Than Large Generators**

Since surplus capacity of the gas engine is used for power generation, the engine is operated with higher load, leading to improved thermal efficiency of the engine. As a result, the new system achieved power generation efficiency* of approximately 45-46% (in terms of low calorific value) either under rated cooling conditions or under rated heating conditions, surpassing large generators.

* The power-generating efficiency of a generator installed in an outdoor unit is obtained by the following equation (1):

\[
\text{Generated efficiency} = \frac{\text{Generated output (kW)}}{\text{Gas consumption increased by power generation (kW)}} \tag{1}
\]

2.1.4 How high-efficiency power generation is possible

As engine power output increases, the efficiency improves. At the time of lower output, the efficiency is low due to the engine base friction and heat loss. At the time of higher output, such loss has relatively insignificant influence.

Based on Figure2 is prepared to show the correlation between additional input necessary to add power output and the engine efficiency based on added output. At the time of lower power output of the engine, a large amount of input is required. However, after the output reaches a certain level, necessary additional input level is almost constant and low and the engine efficiency based on added output remains high.

In other words, the new system achieves both high engine efficiency and high power generating efficiency by adding power output, which will be used to drive a small generator, to power output of the engine, which drives the compressor for air-conditioning.
2.2 Product Variety of HIGH POWER MULTI

We launched the sale of High Power Multi with the variation of the type from 35.5kW to 56kW type in October, 2003 with Sanyo Electric Co., Ltd., (only 1 manufacturer). All GHP manufacturers are going to commercialize High Power Multi in the FY2005, a variation is due to be expanded to 35.5kW – 84kW type. Table2 shows the product variety of High Power Multi. Also, the model to which the power-generating function was attached to GHP, such as the combination system and the renewal type, is commercialized.

<table>
<thead>
<tr>
<th>Type</th>
<th>Building Multi</th>
<th>Renewal</th>
<th>Combination System</th>
</tr>
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<tbody>
<tr>
<td>Cooling capacity (kW)</td>
<td>35.5 45 56 71</td>
<td>84</td>
<td>35.5 45 56 71</td>
</tr>
<tr>
<td>SANYO</td>
<td>○ ○ ○ ○</td>
<td>○ ○ ○</td>
<td>○ ○ ○ ○</td>
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<tr>
<td>AISIN</td>
<td>○ ○ ○ ○</td>
<td>○ ○ ○</td>
<td>○ ○ ○ ○</td>
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<tr>
<td>Mitsubishi Heavy</td>
<td>○ ○ ○ ○</td>
<td>○ ○ ○</td>
<td></td>
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<tr>
<td>Industries</td>
<td>○ ○ ○ ○</td>
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<tr>
<td>YANMAR</td>
<td>○ ○ ○ ○</td>
<td>○ ○</td>
<td></td>
</tr>
</tbody>
</table>

Table2. Product Variety of High Power Multi
2.3 Current Status of HIGH POWER MULTI installations

The total shipment number of High Power Multi in the Osaka Gas service area became 2839 units at the end of the first half of FY2004, although only one manufacturer sells this system among 4 manufacturers.

Speaking of the 56kW type, High Power Multi forms 42% of all the number of selling of 56kW type in the first of FY2005. It is due to the fact that we have developed High Power Multi by epoch-making reduction in cost (Although the 200,000-300,000 yen per kW was cost when it was CGS of this class, this system realized it by 1/2-1/3.), we have realized the same maintenance, durability, and the installation space as the conventional GHP, and the society has accepted High Power Multi which gives merit to a gas company, user, and society.

We firmly believe that GHP equipped with the generator will be standardize and spread from now on.

3. DEVELOPMENT OF GHP WITH POWER-GENERATING FUNCTION (GHP GRID CONNECTION TYPE)

3.1 System Outline and Specifications

We have also tackled development of GHP with a power-generating function equipped with the generator whose maximum power generation output is about 4kW. Figure3 shows the system outline of this system.
This system not only provides the outdoor unit cooling fan and pump, but also can supply the generated power by the grid connection out of an outdoor unit. In this system, the enlarged generator and the power conditioner for grid connection are additionally installed in this system. High-frequency AC power produced by the generator is converted into DC power by the converter, and its DC power is converted by the inverter in the same voltage and frequency as a commercial power. The generated power and the commercial power are connected by the grid connection by AC power. In collaboration with SANYO Electric Co., Ltd., we are developing based on 56kW type GHP for building multi.

Since 1998 Osaka Gas has positively promoted development and sales of the low cost and small (5-10kW class) CGS (MCGS) that uses common parts, such as engine, heat exchanger, radiator fan etc. with GHP. As of the end of the FY2004, the cumulative total of our MCGS sales reached approximately 1500 units. It is the market share that occupies about 60 percent in Japan. GHP grid connection type belongs to the new category that unites the power generation technology of MCGS and GHP technology which we had accumulated through the marketing over 400,000 units.

3.2 Features

The same high efficient power generation as High Power Multi

This system generates electricity by the remaining power of engine at the time of air conditioning. High Efficiency power generation is possible for this system by the same principle as High Power Multi.

Further reduction of contract demand

The power consumption of High Power Multi is about 1/140 of the power consumption of EHP, the contract demand can be reduced by installing High Power Multi. Since the amount of power generation is larger than High Power Multi, as for this system, the contract demand can be further reduced rather than the time of High Power Multi-installation, and a customer merit increases.

Reduction in cost by combining two systems

It is the system which combined GHP and MCGS, this is a low initial cost, and moreover, an installation space is small and it ends rather than it installs GHP and MCGS separately.

4. FUTURE PROSPECTS

Since High Power Multi has been put on the market in October, 2003, the total installation number of the end of the first half of FY2005 is 2839 units in only one year and a half. During the FY2005, High Power Multi will be commercialized from all GHP manufacturers, and a variation will be also expanded 35.5kW to 84kW type. We would like further development that all GHP equip with a power-generating function.

Moreover, by making the use of the feature of the air-conditioner which frequently operates under
partial load, we have been engaged in the technical development in order to use the surplus power of the engine to the full as the engine is driven at the point of the maximum efficiency, and the system development for effectively making the use of the engine exhaust heat. We would like to contribute to the energy saving and the reduction of CO2 emission by investigating the possibility of GHP thoroughly.