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INTELLIGENT REMOTE MONITORING SYSTEM FOR GHP

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ABSTRACT

Gas engine driven heat pump (GHP) is the heat pump air-conditioning system which drives compressors by the gas engine. GHP is the high efficiency, low electric power consumption, and low running cost air-conditioning system. It is widely spread mainly in Japan, where more than 600,000 units have been installed so far.

Since release of GHP in 1985, we have been improving performance of GHP year after year. We have developed high efficiency gas engines, compressors, heat exchangers, and so on to improve its efficiency. The latest GHP series called "GHP XAIR" released in 2011 have top class APF (Annual performance factor) among big capacity VRF (Variable refrigerant flow) air-conditioners including electric heat pump（EHP）.

On the other hand, VRF air-conditioners including GHP are generally not optimized for different usages enough because it is difficult to operate optimally the outdoor-unit which has multiple indoor-units used in different conditions. Recently social needs for energy saving and visualization of energy consumption for air-conditioning become greater and greater. We developed the intelligent remote monitoring system for GHP which can optimize operation of GHPs to much various usages and reduce energy consumption remotely in order to meets these social needs. It has various functions to reduce energy consumption including "Energy-Saving Operation"," Scheduling Management", "Daily Reporting", and so on.

"Energy-Saving Operation" enhances operational efficiency of GHPs by optimizing engine speed and temperature of supply air for usage environment. For example, in cooling mode, it slows down engine speed of GHPs when indoor temperature is in comfortable range to reduce energy consumption. " Scheduling Management" can schedule start-stop, operation mode (Cooling or Heating), temperature setting, air volume, and so on. Additionally, it can automatically set back the temperature settings when they are changed by users and turn off GHPs when users forget to turn off them. It decreases waste of energy even if GHPs are used wasteful manner by various users. "Daily Reporting" is the function that provides operating condition and energy consumption data on a day-to-day basis through Internet. It can help facility managers to find useless operations and make operations more efficient.

We tested this intelligent remote monitoring system at various buildings (offices, stores, fitness studios, and so on) in Japan. As a result, it was proven that it can reduce the energy consumption of GHPs by an average of about 20% a year without degradation of the comfortableness.

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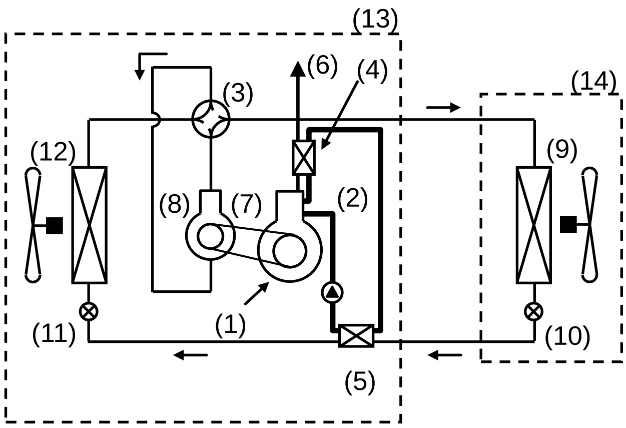
1 INTRODUCTION

1.1 The mechanism of GHP

Gas engine driven heat pump (GHP) is the heat pump air-conditioning system which drives compressors by the gas engine. Figure 1 shows the outward appearance of the typical GHPs and Figure 2 shows schematic of refrigerant and cooling water flow diagram of a typical GHP. Its refrigerant cycle is almost the same as that of the Electric heat pump (EHP). The biggest feature is that the EHP operates an electric motor to drive a compressor, while the GHP operates a gas engine instead of the electric motor. So the GHP consumes only one-tenth electricity of the EHP. In addition, the GHP has higher performance than that of the EHP in heating mode because it can utilize not only aerothermal heat from ambient air but also exhaust heat from gas engine at water-refrigerant heat exchanger.

Figure 1 Outward appearance of the typical GHPs



(1)Engine, (2)Cooling water line, (3)Revercing valve, (4)Exhaust gas heat exchanger, (5)Water-refrigerant heat exchanger, (6)Exhaust gas line, (7)Transmission, (8)Compressor, (9)Indoor unit heat exchanger, (10)indoor unit expansion valve, (11)Outdoor unit expansion valve, (12)Outdoor unit heat exchanger, (13)Outdoor unit, (14)Indoor unit

Figure 2 Schematics of refrigerant and cooling water flow diagram of a typical GHP (Heating mode)

1.2 Development background

Since release of the GHP in 1985, we have been improving performance of the GHP year after year. We have developed high efficiency gas engines, compressors, heat exchangers, and so on to improve its efficiency. The latest GHP series called “GHP XAIR” released in 2011 has top class APF (Annual performance factor) among big capacity VRF (Variable refrigerant flow) air-conditioners including the electric heat pump （EHP）.

On the other hand, VRF air-conditioners including the GHP are generally not optimized for different usages enough because it is difficult to operate optimally the outdoor-unit which has multiple indoor-units used in different conditions. Recently social needs for energy saving and visualization of energy consumption for air-conditioning become greater and greater. We developed the new intelligent remote monitoring system for the GHP which can optimize operation of GHPs to much various usages and reduce energy consumption remotely in order to meets these social needs.

2 INTELLIGENT REMOTE MONITORING SYSTEM

2.1 System outline and new functions

Figure 3 shows the conventional and the new remote monitoring system for the GHP. The conventional system is consisted of GHPs, the adopter which have wireless communication function, the remote monitoring center of gas companies, and so on. For example, it was able to send information to the monitoring center when GHPs break down automatically and to provide simple remote control. So it had been mainly used to find failures of devices, inform failures to maintenance companies, and repair speedily. However the new intelligent system has almost the same constitution as that of the conventional system, we added various functions to reduce energy consumption including “Energy-Saving Operation”, ”Scheduling Management”, ”Daily Reporting”, and so on to the new adopter. These enable customers to set schedule, set energy-saving, get daily reports on the internet. Furthermore, the new adopter is able to predict failures of some parts and inform before the occurrence of failure. Table 1 shows new major functions which we developed.

No	Name	Outline
1	Energy-Saving Operation	It reduces energy consumption by optimizing operation depending on the usage and the installation conditions of a GHP.
2	Scheduling Management	It schedules start-stop, set back the temperature settings, turn off GHPs when users forget to turn off them, and so on.
3	Daily Reporting	It provides operating condition and energy consumption data on a day-to-day basis.
4	Failure Prediction	It predicts failures of some parts and informs before the occurrence of failure.

Table 1 New major functions

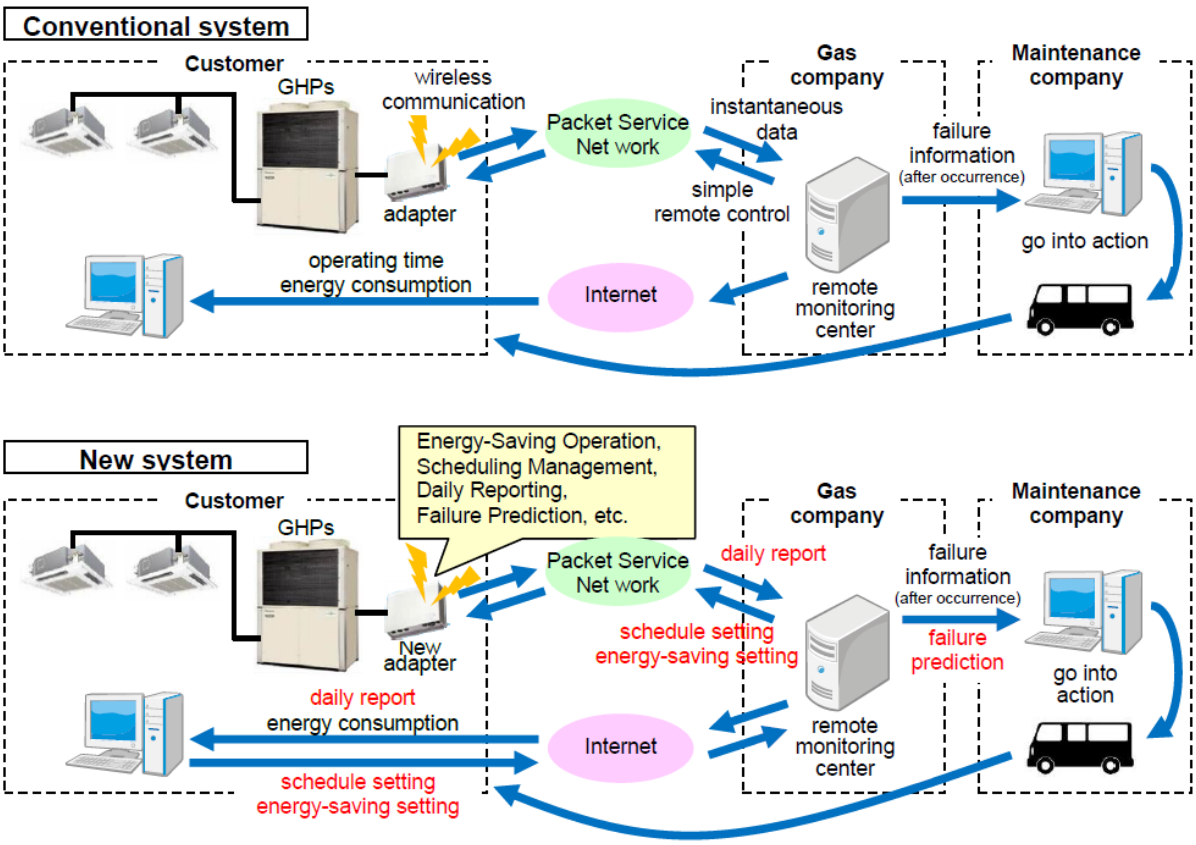


Figure 3 Outline of the conventional and the new remote monitoring system for the GHP

2.2 Energy-Saving Operation

"Energy-Saving Operation" enhances operational efficiency of GHPs by optimizing engine speed and temperature of supply air for usage environment. For example, in cooling mode, it slows down engine speed of GHPs when indoor temperature is in comfortable range to reduce energy consumption.

Figure 4 shows image of indoor temperature transition under Energy-Saving Operation. Energy-Saving Operation has three energy saving levels. The higher the Energy-Saving level, the larger reduction of gas consumption becomes. When indoor temperature is high, the level is zero or low. Then, with drop of indoor temperature, the level gradually gets higher. If indoor temperature rises and exceeds the predetermined rage, the level is lowered step by step to maintain amenity. It is possible to change the range in which each level operates. In Figure 4, level 3 operates when indoor temperature is lower than 27 degree, level 2 operates when indoor temperature is 27 to 28 degree, level 1 operates when indoor temperature is 28 to 29 degree, and Energy-Saving Operation is canceled when indoor temperature is higher than 29 degree. On the other hand, in heating mode, the Energy-Saving level gets higher when indoor temperature gets warmer.

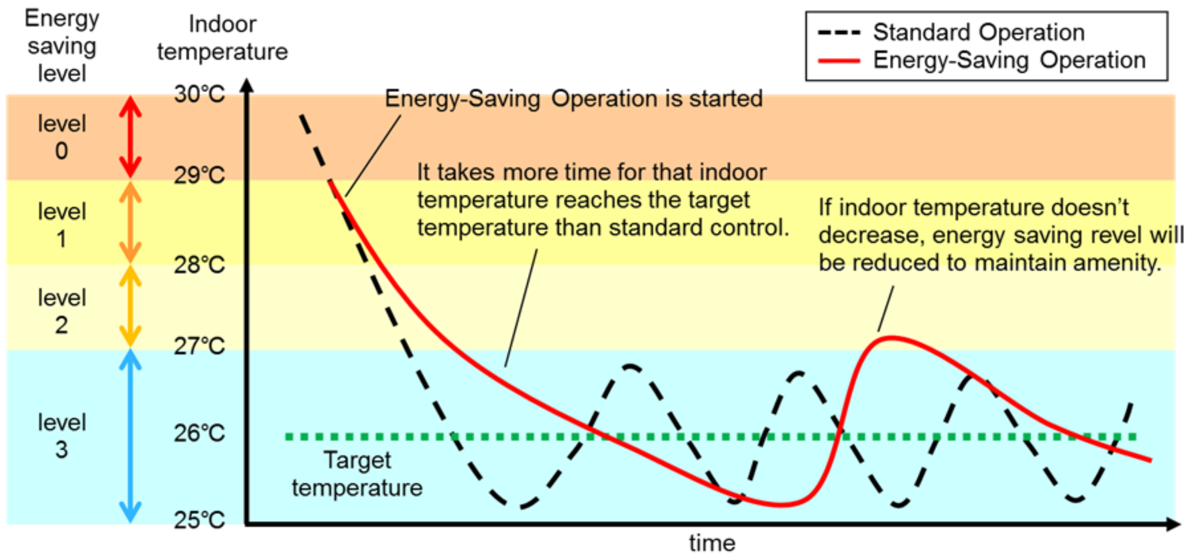


Figure 4 Image of indoor temperature transition under Energy-Saving Operation

2.3 Scheduling Management

It is possible to schedule start-stop, operation mode (Cooling or Heating), temperature setting, air volume, and so on via the Internet. Additionally, it can automatically set back the temperature settings when these are changed by users and turn off GHPs when users forget to turn off them. It decreases waste of energy even if GHPs are used wasteful manner by various users.

2.4 Daily Reporting

This is the function that provides operating condition and energy consumption data on a day-to-day basis through the Internet. Data preservation interval can be changed 15 to 60 minutes. The adaptor processes various data at predetermined time interval and sends day-to-day basis data to the remote monitoring center once a day. It can help facility managers to find useless operations and make operations more efficient.

2.5 Failure Prediction

The adopter monitors outdoor units and indoor units appropriately and predicts failures of some parts. If it detects a sign of trouble, it sends that information to the remote monitoring center automatically. Trouble stops can be avoided by carrying out preventive maintenance such as the part exchange based on foresight information that the center received. It can predict failures of the engine starter motor, the refrigerant system sensors, and so on.

3 FIELD TEST

We tested this new intelligent monitoring system at various buildings in Japan. In this paper, we mainly report the result measured at a certain office building (office A) as an example.

3.1 Testing Site

Figure 5 shows pictures of office A. It is on the second floor of the 4-story building in Tokyo. One 16HP GHP and one 20HP GHP installed for that floor. The area of the floor is 400 m2.

Figure 5 Pictures of office A

3.2 Testing Method

We repeated a day to use these operations (Energy-Saving Operation day) and a day not to do (Standard Operation day). Then we compared the gas consumption of both to confirm the energy saving effect of these operations. We also compared the indoor amenity by Predicted Mean Vote (PMV) which is an index to evaluate comfort. The operation data of GHPs was collected by Daily Reporting function. The data of outdoor temperature, indoor temperature, indoor humidity and gas consumption were measured and collected by sensors and data loggers installed in the site. The test was carried out from July, 2012 to February, 2013.

3.3 Test Result

The test result shown in Figure 6 and 7. In Figure 6, the horizontal axis shows the average ambient temperature a day, and the vertical axis shows the gas consumption per day. In comparison with the gas consumption of Standard Operation day based on linear approximation, the gas consumption of Energy-Saving Operation day downed about 30% in cooling mode, downed about 10% in heating mode and downed about 20% in a year. In Figure 7, the horizontal axis shows the average outdoor temperature a day, and the vertical axis shows the average PMV a day. The PMV of Energy-Saving Operation day was kept in comfortable range, so it was proved that this Energy-Saving

Operation can reduce energy consumption without spoiling comfort.

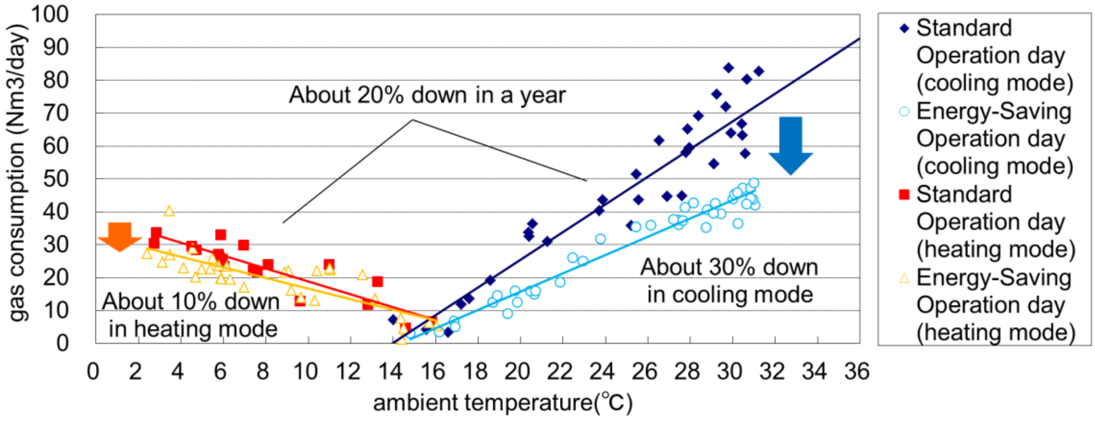


Figure 6 Gas consumption data of Standard Operation day and Energy-Saving day

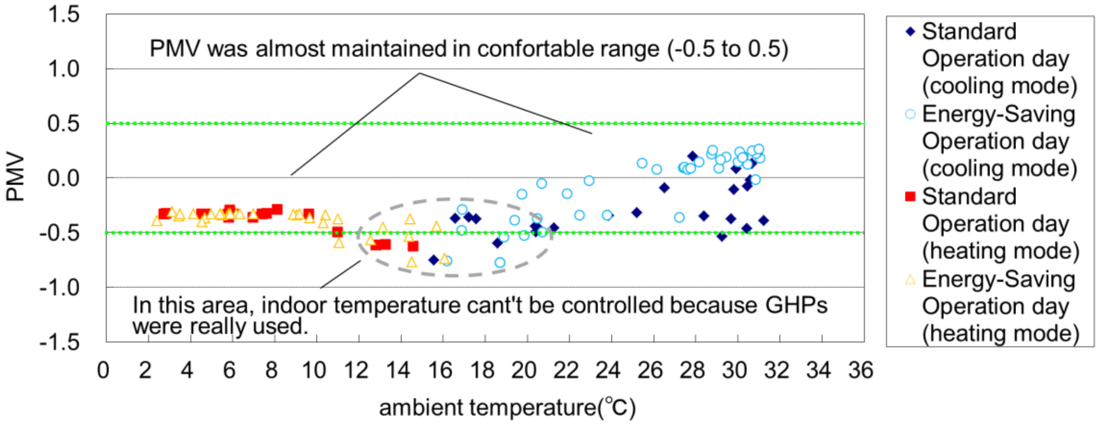


Figure 7 PMV data of Standard Operation day and Energy-Saving day

3.4 Test Result of Other Site

Table 2 shows test result of various sites other than office A. Energy saving effect of all the year were about 20% at each site. It was proved that this new intelligent monitoring system is effective for various buildings of different use.

Site Name	**Building Use**	**Energy Saving Effect**		
		Cooling	**Heating**	**All the Year**
B	Office	24.1%	8.4%	18.5%
C	Furniture store	13.3%	22.3%	16.8%
D	Home improvement store	not measured	14.1%	-
E	Supermarket	not measured	17.7%	-
F	Gym	26.6%	17.9%	23.6%
G	Bank	not measured	14.6%	-

Table 2 Test result list of other site

4 CONCLUSION

We developed the new intelligent remote monitoring system for GHP. It has four new major functions described below:

- Energy-Saving Operation: It reduces energy consumption by optimizing operation depending on the usage and the installation conditions of a GHP.
- Scheduling Management: It schedules start-stop, sets back the temperature settings, turns off GHPs when users forget to turn off them, and so on.
- Daily Reporting: It provides operating condition and energy consumption data on a day-to-day basis.
- Failure Prediction: It predicts failures of some parts and informs before the occurrence of failure.

Then we tested this new system at various buildings in Japan. In this paper, we described the result measured at office A in Tokyo as an example. As a result, the following things were proven:

- It can reduce the energy consumption of GHPs by an average of about 20% a year.
- It can reduce the energy consumption without spoiling comfort.

5 REFERENCE

1. Takeshi Yokoyama, Takashi Murakami, Yuma Furuhashi, “APPLICATION STUDY OF GAS ENGINE DRIVEN HEAT PUMP TO HEATING EQUIPMENTS FOR COLD CLIMATE”, 10th IEA Heat Pump Conference, 2011.

2. Naruhiro Sekine, Yuma Furuhashi, and Shigeki Kametani. "The Simple Performance Evaluation Method of VRF System Using Volumetric Efficiency of Compressor", International Refrigeration and Air Conditioning Conference, 2012.

3. Yuma Furuhashi, “A Study on the Energy-Saving Operation of GHP Part1 Testing Method and Test Result of Cooling Mode”, The Society of Heating, Air-Conditioning and Sanitary Engineering of Japan, 2013.

4. Takuya Yoshida, “A Study on the Energy-Saving Operation of GHP Part2 Test Result of Heating Mode and Estimation of Annual Energy-Saving Effect”, The Society of Heating, Air-Conditioning and Sanitary Engineering of Japan, 2013.