An Economical Thermal Network Cogeneration System for Apartment Buildings (Neighboring Cogeneration system)

Hideki Yamaguchi and Yoshinori Hisazumi, Energy Technology Laboratories, Osaka Gas Co., Ltd

1. Introduction

In order to spread economically viable distributed generation systems for apartment buildings, it is essential to develop an efficient and low-cost heat supply system. We have been developing an economical thermal network cogeneration system (Neighboring Co-Generation: NCG). The key concept of this system is to install a heat storage unit equipped with a hot water supply and a space heating function at each household and to connect heat storage units by a single-loop of hot water piping. As a result, time leveling of the heat supply and heat transferring among households become possible. Thus, the costs of the piping and heat source equipment decrease. Furthermore, because of the large capacity of accumulation of the system, the cogeneration can generate according to the electricity demand. Thus, a high operating rate of the cogeneration can be achieved.

In this study, we have developed a new heat storage unit, and installed an NCG system for actually 7 lived-in households in an experimental condominium (NEXT21). It is confirmed that this system could supply heat stably to meet the large heat demand in winter.

2. Idea of the NCG System

The conventional heat supply system circulates hot water full time at a constant flow rate to satisfy the customer's heat demand in the pipe shafts of the building as shown in Fig.1. The plate type heat exchanger in each household receives heat from the hot water pipe and provides hot water, bath water heating, and space heating. Two three-inch insulated pipes are needed for 50 households to meet winter peak heat demands.

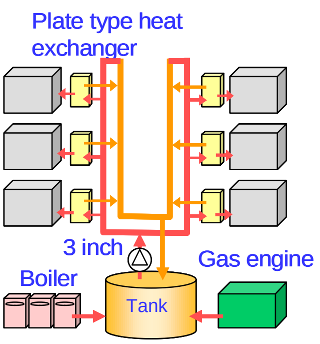

Fig.1 Conventional system.

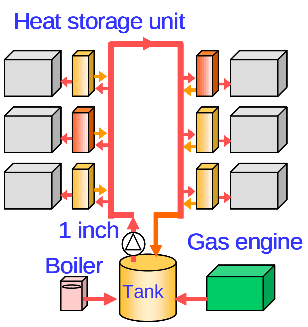

Fig.2 The NGC system.

On the other hand, the NCG system installs a new heat storage unit equipped with a hot water supply and a space heating function in every household, and these units are interconnected by a small one-inch single-loop pipe. Hot water is circulated full time at the flow rate of an inverter pump controlled by heat load of the single-loop pipe as shown in Fig.2.

At the peak of heat demand, the units first supply heat already stored, so that the total heat load of the single-loop pipe is leveled to enable heat supply to 50 households in winter (Fig.3). As a result, the pipe diameter and length of proposed system can be reduced to a third and a half, respectively, compared with conventional system.

For this reason, the pump power and the heat loss from the pipe can be reduced to approximately 1/9 and 1/6, respectively. Thus, our system has a great advantage in operating cost and pipe equipment cost over the conventional system.

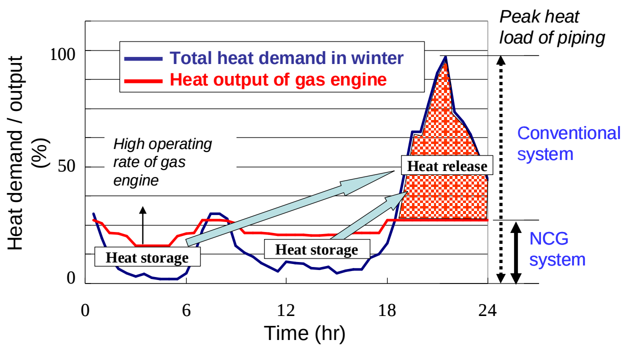

Fig.3 The effect of time leveling of heat supply.

Furthermore, because all the hot water storage units store heat, the total heat storage capacity is large enough for cogeneration to generate according to the electricity demand and with high operating rate. When compared an NCG system which consists of 50 households in the Kansai area of Japan to a system with a boiler in each household, NCG can reduce the primary energy consumption by 15% over the course of a year.

3. Development of a Heat Storage Unit

We developed a new heat storage unit which is equipped with a hot water supply and a space heating function. A system flow and the external appearance of the heat storage unit are shown in Fig.4. The unit consists of a 100 L water tank, three plate heat exchangers (heaters), two pumps, and six control valves.

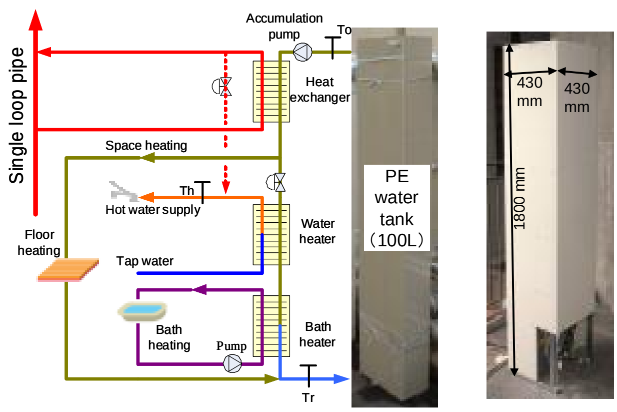

Fig.4 Flow and external appearance of the heat storage unit.

The atmospheric pressure water for space heating is used for the tank water, thus a plastic tank can be used and it can be rectangular in shape. As a result the unit is compact and low cost.

It can store 6 kWh of heat from the single-loop pipe through the heat exchanger. During heat storage, the heat load is controlled not to exceed 10 kW, so that the total heat load of the system is leveled.

Hot water is supplied in two modes. When the tank water temperature is higher than a preset temperature, tap water is heated through the water heater. When the tank water temperature becomes lower, the hot water in the single-loop pipe is directly supplied. In this mode, each resident can use enough hot water without the hot water in the single-loop pipe falling in temperature.

4. Heat Supply Test for 7 Households

4.1. Heat supply system for 7 households

Osaka Gas has an experimental condominium (NEXT21), where we installed a heat supply system for 7 lived-in households. The process flow diagram is shown in Fig.6.

Fig.5 NEXT 21.

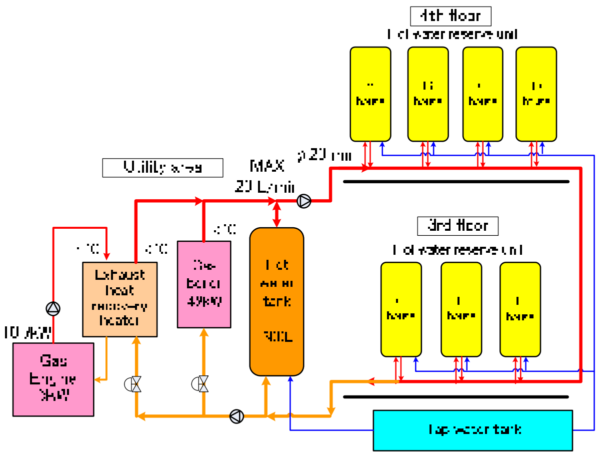

Fig.6 Flow of the heat supply system installed to NEXT 21.

To ensure that all the households, even the last one, can use enough hot water, the outlet flow rate of the single-loop pipe was controlled by a hot water supply inverter pump according to the flow rate and temperature of the return line.

4.2. Heat supply result of one day in winter

A heat supply performance of the total system of one day in winter is shown in Fig.7. Main results are below.

- This system could supply enough heat stably to meet the peak hour heat demand (160 kW) with small heat sources (a gas engine and a backup boiler) and an inner diameter 20 mm single-loop pipe with the help of the accumulation of the heat storage units.
- The gas engine and the backup boiler are operated efficiently according to the heat demand. Operating rate of the backup boiler is controlled to be as low as possible.
- Even the last household could use 55 ºC hot water by the inverter control of the pump of the single-loop pipe.

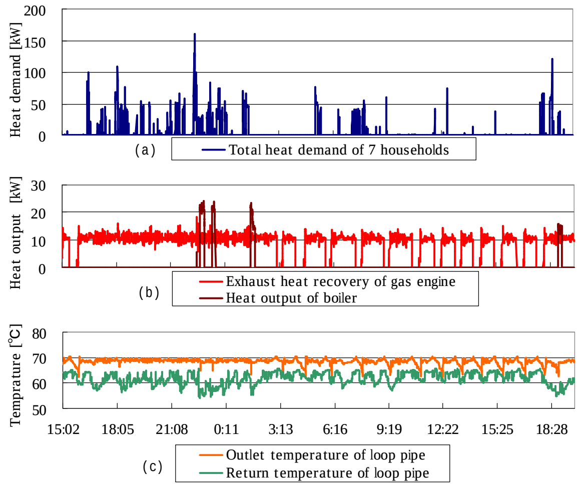

Fig.7 A heat supply performance of one day in winter.

5. Conclusions

The NGC system is a cogeneration system for apartment buildings that is

- Energy saving system
- Low cost piping and heat storage unit
- Consisting of conventional apparatuses with conventional technology so this system could wildly spread.

In this study we conclude

- A low-cost heat storage unit that was suitable for the single-loop interconnected heat supply system was developed.
- A heat supply system for 7 households was constructed with a 5 kW gas engine and a 42 kW boiler as heat sources.
- By means of the heat supply test for 7 households, it was confirmed that this system could supply heat stably to meet the large heat demand in winter and time leveling of the heat supply became possible. Thus, the cogeneration can generate with a high operating rate.

As the next step, we will commercialize the heat storage unit, and install an NGC system to larger apartments.

6. References

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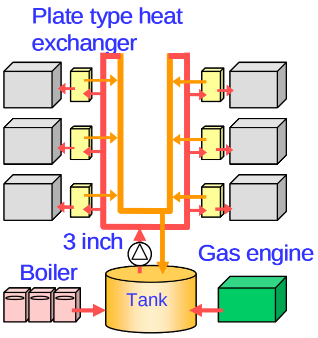

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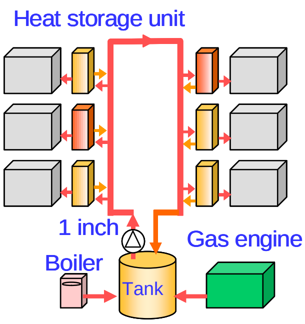

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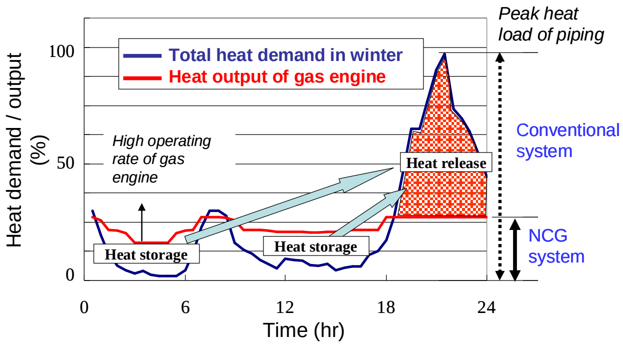

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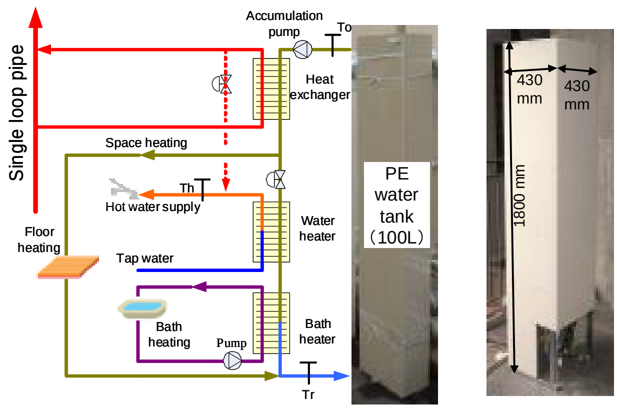

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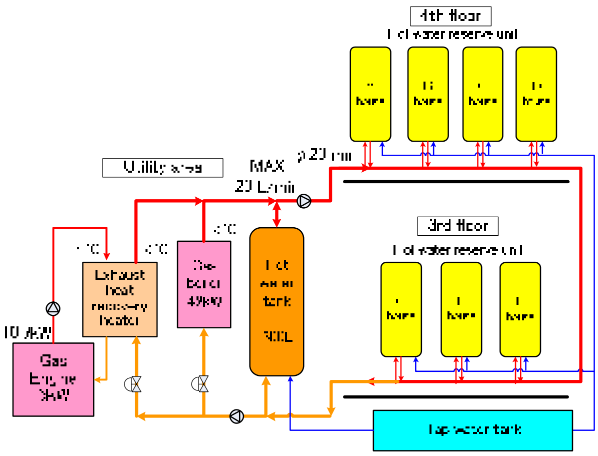

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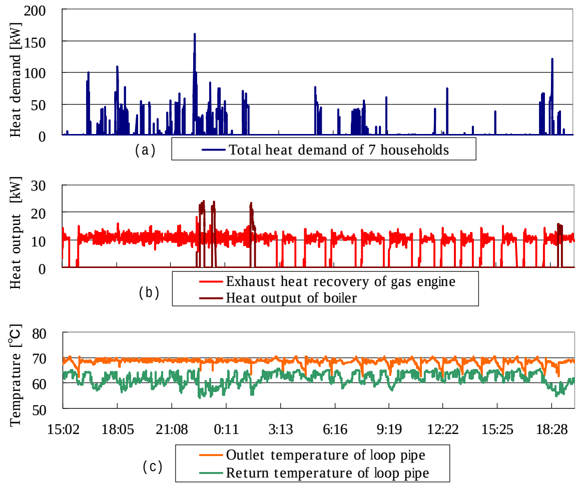

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