Commissioning Process and Operational Improvements in the District Heating and Cooling Plant

Tomoaki TAKASE, Mitsubishi Jisho Sekkei Inc., Osamu TAKADA, Mitsubishi Jisho Sekkei Inc., Kiyoshi SHIMA, Obayashi Corporation, Mitsuru MORIYA, Takasago Thermal Engineering Co., Ltd, Yoshiyuki SHIMODA, Osaka University
(1) To achieve the top-class energy efficiency among the DHC plants in Japan

(2) To evaluate the energy saving effects of commissioning and operational improvements
OUTLINE

• ABOUT THE DHC PLANT
• EXAMPLES OF COMMISSIONING AND OPERATIONAL IMPROVEMENTS
• RESULTS AND CONCLUSION
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DHC plant in Nishi-Umeda district of Osaka, Japan
Total Supply Area : approx. 200,000 m²

The plant supplies both chilled and hot water to commercial facilities, offices, theaters, and the train station, etc.

Ration of Heat Supply Area

- Commercial: 62%
- Office: 20%
- Station: 6%
- Theater: 4%
- Others: 8%

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**Capacity of cold heat generators:** 36,871 kW (10,500RT)  
**Capacity of hot heat generators:** 15,430 kW

<table>
<thead>
<tr>
<th>Symbol</th>
<th>heat generator</th>
<th>Capacity</th>
<th>Number</th>
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| AR1~5   | Gas-fired Absorption Water Chiller Boiler (= Absorption Chiller) | Cooling Capacity : 3,516kW (1,000RT)  
Heating Capacity : 2,900kW | 5      |
| TR1,2   | Centrifugal Chiller (Constant Speed)                | Cooling Capacity : 3,516kW (1,000RT) | 2      |
| TR3,4   | Inverter Centrifugal Chiller                       | Cooling Capacity : 1,758kW (500RT) | 2      |
| BTR1,2  | Centrifugal Chiller for Ice Storage                | Cooling Capacity : 1,571kW (447RT)  
Ice Making Capacity : 1297kW (369RT) | 2      |
| IST1,2  | Ice Storage Tank                                   | Capacity of Thermal Storage :11,603kWh (3,300RTh) | 2      |
| BO1,2   | Hot Water Boiler                                   | Heating Capacity : 465kW        | 2      |
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Commissioning Schedule

2008  2009  2010  2011  2012  2013

System Design

Constructing

Commissioning

Operation Improvement

April: Completion
May: Grand Opening

Commissioning Team

Commissioning Authority
Mitsubishi Jisho Sekkei Inc.,

Designer

Builder

Supervisor

Plant Owner, Operator

Adviser
EXAMPLES OF COMMISSIONING AND OPERATIONAL IMPROVEMENTS

POLICY

- Verification of the designed performance of the systems and the equipment through the commissioning process

- Operational improvements in efficiency, based on the result of the commissioning
Examples of commissioning and operational improvements

1. Search for the most suitable operation method in consideration of efficiency and running cost

2. Commissioning and optimizing the number of operating inverter centrifugal chillers and the start/stop timing

3. Commissioning and optimizing the flow control on the cooling water
Regardless of cooling water temperature, the inverter centrifugal chiller is more efficient than other heat generators.

As cooling water temperature decreases, the inverter centrifugal chiller increases its efficiency, compared to the absorption chiller.
In terms of running costs (heart unit price), the electric system (centrifugal chiller) is more advantageous than the gas system (absorption chiller).

In case of low load period in summer, the ice storage system is more advantageous than others in running costs.
Operation order of the cold heat generators

Operation order (from first to last)

Inverter centrifugal chiller → Constant speed centrifugal chiller → Absorption chiller → Ice storage
Commissioning and optimizing the number of operating inverter centrifugal chillers and the start/stop timing

Efficient operation by controlling number of operated chillers (simulation)

As the cooling water temperature decreases, the system COP improves by adding the second chiller earlier.
SYSTEM COP improved with the 2nd inverter centrifugal chiller starting earlier

Efficient operation by controlling number of operated chillers (measured data)

Commissioning and optimizing the number of operating inverter centrifugal chillers and the start/stop timing

EXAMPLES OF COMMISSIONING AND OPERATIONAL IMPROVEMENTS

Improvement of System COP

Cooling Outputs (Total of two chillers) [RT]

Nov. 2011 - Mar. 2012  Normal Operation
Nov. 2012 - Mar. 2013  Earlier Start of Second Chiller

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Commissioning and optimizing the flow control on the cooling water

Unit COP based on cooling water inlet/outlet temperature

Changes in the unit COP of the inverter centrifugal chiller

The unit COP data published from manufacturers are based on the inlet temperature and the constant flow system. In case of the variable cooling water flow system, the unit COP is affected more by the outlet water temperature than by the inlet water temperature.
Energy simulation

In case of the variable cooling water flow system, the cooling water outlet temperature should be a parameter of control.

Comparison between the variable cooling water flow system and the constant system by simulation.

Based on the simulation, except for the mid summer (July and August), the constant cooling water flow system is more energy saving than the variable system in this plant.
Commissioning and optimizing the flow control on the cooling water

Change in energy consumption by changing the water flow control (measured data)

Variable water flow control

Constant water flow control

The constant cooling water flow control has been applied for the inverter centrifugal chillers from the second year.

Consumed electricity per heat unit [kWh/GJ]

Cooling tower fun
Chilled water pump
Cooling water pump
Chiller

EXAMPLES OF COMMISSIONING AND OPERATIONAL IMPROVEMENTS

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Annual average plant system COP of 1.35 has been achieved at the 3rd year after operation start.

COP 1.35 is the top-class efficiency in Japan.

**Definition of the plant System COP**

\[
\text{Plant System COP} = \frac{Q}{G_p + E_e \cdot e_p}
\]

- **Q**: Total heat supply (chilled water and hot water) [KJ]
- **G_p**: Gas-fired Absorption Water Chiller Boiler [KJ]
- **E**: Total electricity consumption of the plant [kWh]
- **e_p**: Conversion factor to primary energy [9,760kJ/kWh]
(1) Top-class energy efficiency of DHC plants in Japan have been achieved by applying the commissioning process

(2) In order to achieve assured energy savings, the commissioning process and operational improvements based on its results are very important
Search for the most suitable operation method in consideration of efficiency and running cost.
Search for the most suitable operation method in consideration of efficiency and running cost.

**Cooling Water Temperature: 24°C**

- **Inverter Centrifugal Chiller**
- **Centrifugal Chiller**
- **Direct Cooling Mode (Ice Storage System)**
- **Absorption Chiller**
- **Ice Melting Mode (Ice Storage System)**

**Graph Details:**
- **Y-axis:** System COP
- **X-axis:** Load Factor [%]
- **Legend:**
  - Inverter Centrifugal Chiller
  - Centrifugal Chiller
  - Direct Cooling Mode (Ice Storage System)
  - Absorption Chiller
  - Ice Melting Mode (Ice Storage System)

**Graph Notes:**
- The graph illustrates the performance of different cooling methods at a 24°C cooling water temperature.
- Each method is represented by a distinct line and marker color.

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Search for the most suitable operation method in consideration of efficiency and running cost.

**Operation order (from first to last):**

1. Ice storage
2. Absorption chiller
3. Constant speed centrifugal chiller
4. Inverter centrifugal chiller
Definition of the Plant System COP

Plant System COP = \frac{Q}{G_p + E \times e_p}

Q : Total heat supply (chilled water and hot water) [KJ]
E : Total electricity consumption of the plant [kWh]
E_p : Conversion factor to primary energy [9,760 kJ/kWh]