Development of compact air heat pump inverter module chiller

Air heat pump chiller DT-R(4 units)

Takuya ITO
Mitsubishi Electric Corporation
Biography

- Belonging The Air-conditioning & Refrigeration systems works
- Have developed the chiller since 1997
- Planning new product & design

Takuya ITO
Mitsubishi Electric Corporation
Procedure of presentation

1. Background • Purpose
2. Features of DT-R
3. Energy-saving technology and downsizing technology
4. Simplification of multiple installation construction
5. High efficiency by the multiple module control
6. Conclusions
1. Background • Purpose

(1) Air-cooled heat pump chillers

• The chillers are usually used as a central heat source machine for outdoor air processing, air conditioning or process cooling.
• The chillers have been taken notice of effectiveness to prevent global warming to reduce the refrigerant of the indoor unit.
1. Background • Purpose

(2) Chiller’s market

- A further improvement of performance was requested for both 100% load and part load conditions from the viewpoint of global warming prevention.
- A smaller footprint and more capacity is needed.

developed the high efficiency, compact new air-cooled heat pump chiller “DT-R”
2. Features of DT-R

(1) Y-structure
The lack of service space is solved between machine rooms by Y-structure.

(2) The highest EER in chiller market (2015/10)
The EER (50HP 3.47) is achieved by using high performance device of refrigeration circuit. Part load performance is better than conventional machines due to the mounted inverter compressor.

(3) High efficiency due to the multiple module control
DT-R is designed for high-efficiency operation that can control a number of units during multiple operations.

---

### Performance

<table>
<thead>
<tr>
<th></th>
<th>DT-R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horsepower</td>
<td>60HP, 50HP</td>
</tr>
<tr>
<td>Cooling Capacity(kW)</td>
<td>180, 150</td>
</tr>
<tr>
<td>EER&lt;sup&gt;1&lt;/sup&gt;</td>
<td>3.12, 3.47</td>
</tr>
<tr>
<td>SEER</td>
<td>4.12, 4.44</td>
</tr>
<tr>
<td>Heating Capacity(kW)</td>
<td>180, 150</td>
</tr>
<tr>
<td>COP</td>
<td>3.24, 3.42</td>
</tr>
<tr>
<td>Dimension</td>
<td>2,350(H)×1,080(W)×3,400(D)</td>
</tr>
<tr>
<td>Refrigerant</td>
<td>R410A</td>
</tr>
<tr>
<td>Capacity per area(kW/m&lt;sup&gt;2&lt;/sup&gt;)</td>
<td>49.02, 40.85</td>
</tr>
</tbody>
</table>

<sup>1</sup> Difference of inlet and outlet water temperature is 7 degree celsius.
3. Energy-saving technology and downsizing technology
3. Energy-saving technology and downsizing technology

(1) Air heat exchanger

1) The new slit fin of high heat transfer rate
   The heat transfer rate was improved against our conventional unit by increasing the thermal boundary layer.

2) Large diameter fan
   The flow rate was increased against our conventional unit.

![Diagram showing new slit fin and large diameter fan]
3) High efficiency mounting

DT-R was shaped for intake from all four sides by mounting the four L-bend air heat exchangers diagonally.

- Inlet air from four directions
- Mount diagonally
- Downsizing of the unit and to reduce space with multiple installation,
3. Energy-saving technology and downsizing technology

(2) dual inverter (High-efficiency scroll compressor and fan motor)

1) inverter compressor
   The inverter compressor reaches maximum EER when at about 60% capacity.

2) inverter fan motor
   the flow rate is low  →  the air heat exchanger cannot function sufficiently.
   the flow rate is high  →  fan motor input is increased

DT-R can drive at high efficiency due to rotational speed control for optimum air flow rate in accordance with the operating conditions of the unit.

Comparison of compressor performance

Performance to change in air flow rate
3. Energy-saving technology and downsizing technology

(2) Dual inverter (High-efficiency scroll compressor and fan motor)

Part load performance (Air temp.: 35°C, Water temp.: 7°C)

- Optimum control of compressor frequency fan rotational speed according to load
- **EER ratio 125%** (at 55% capacity)

![Graph showing EER ratio and cooling capacity ratio](image-url)
3. Energy-saving technology and downsizing technology

(3) Two evaporation temperature cycle

1) Independent refrigeration cycle connected in series on the water side
2) Improvement of EER by raising the evaporation temperature on the upstream side of cold water.

Refrigeration cycle of DT-R
3. Energy-saving technology and downsizing technology

(4) Module coupling structure

By connecting the module, DT-R achieved a great reduction of installation space.

<Air Intake space>
Because of the Y-shaped structure, it’s easy for air intake even with consolidated installation.

Side view of 3 connected units

Y-shaped structure
3. Energy-saving technology and downsizing technology

(4) Module coupling structure

<Comparison of installation area with conventional model (300HP)>
The installation space was 48% compared with the conventional machine greatly reducing the installation area space requirements.

(a) Development model (60HP × 5)
(b) Conventional model (100HP × 3)

Comparison of installation areas
4. Simplification of multiple installation construction
4. Simplification of multiple installation construction

<Selectable water piping specifications>

1. Standard piping
   can be adopted to and customized for various systems.
2. Built-in header
   establish header pipe connection for each module (collection piping) in the machine room.
   **Piping space can be reduced.**
4. Simplification of multiple installation construction

It can easily be constructed and shorten the construction period by reducing the connection points and the piping space at the time of multiple installation.

Example of built-in header

- Piping space can be reduced
- Plumbing connection point
- Built-in header
- Plumbing at the site
- The piping inside the module (Install at the factory)
5. High efficiency by the multiple module control
5. High efficiency by the module multiple control

1. Control of each module
   - Outlet water temperature constant control
   - Optimum control of the number of compressors and frequency and fan rotation speed so that outlet water temperature is constant

2. multiple module control
   - determines the number of units based on the amount of the compressor frequency of all units.
5. High efficiency by the multiple module control

EER ratio at multiple system (60HP x 4)

- Keeping high EER to min-load.
- Determine the optimal number of module.

Comparison of part-load performance of the multiple numbers of controls
5. Conclusions

The new type chiller DT-R was developed to improve the energy saving and the installation area of air-cooled heat pump chiller.

1. The top level of EER3.47(50HP) and in chiller market was achieved by high performance devices.

2. DT-R has achieved a 48% smaller footprint than conventional machines by the following technology:
   a) By the New-Y-Shape structure, the modules can connect unit to unit and the space between the modules can be eliminated.
   b) By using highly-efficient inverter compressors and adopting highly-efficient small air heat exchangers equipped with Zigzag-slit fins, we were able to achieve both high-efficiency and small installation space.
   c) By using application of highly-efficient 2-evaporation temperature cycles, we were able to achieve the reduction in the water heat exchanger.
5. Conclusions

We will continue to push further for high efficiency, compact designs and global environment friendly products.

Thank you all very much for your attention.