EUROPEAN HEAT PUMP SUMMIT
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Industrial | Commercial | Residential
Heating & Cooling | Components & Equipment

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Application of Heat Pumps to Cutting and Washing Processes

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Chubu Electric Power Co., Inc.

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University of Tsukuba
## Overview

<table>
<thead>
<tr>
<th>Industry</th>
<th>Automobile parts production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site</td>
<td>Gamagoori Plant, AISIN AW Co., Ltd.</td>
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<tr>
<td></td>
<td>Aichi Prefecture, Japan</td>
</tr>
<tr>
<td>Processes</td>
<td>Cutting, washing</td>
</tr>
<tr>
<td>Purpose</td>
<td>Reduction of boiler steam (fuel: crude oil)</td>
</tr>
<tr>
<td>System</td>
<td>● Waste heat recovery heat pumps with heating capacity 22 kW (6 units)</td>
</tr>
<tr>
<td></td>
<td>● Air-source heat pumps with heating capacity 44 kW (8 units)</td>
</tr>
</tbody>
</table>

The amount of industrial shipment of Aichi occupy approximately 15% of Japan.
Conventional system

- **Cooling COP = 2**
- **Cutting liquid 20 °C**
- **Washing liquid 60 °C**
- **Total thermal Efficiency = 0.2**

- **Boiler**
- **Chiller**

1. **Input energy (Electric power)**
2. **Input energy (Gas)**

- **Cooling energy**
- **Heating energy**

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Ground plan of the factory

Steam is supplied from the boiler to the 300 m away washing machines. Large heat loss was caused.
Application of heat pumps to cutting and washing processes

Cutting liquid 20 °C

Washing liquid 60 °C

Cooling energy

Heating energy

Evaporator

Condenser

Compressor

Input energy (Electric power)
Application of heat pumps to cutting and washing processes

Simultaneous cooling and heating

Total COP = 5

2 Cooling energy

3 Heating energy

Input energy (Electric power)

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There were no heat pumps which were able to applied to both cutting and washing processes in 2007.


Technical issues

1. Highly efficient hot water circulation heating (60-65°C)
   - Selection of the best refrigerant

2. Countermeasure against contamination of air-refrigerant heat exchangers with oil mist and dust
   - Standard equipment of oil mist filters

3. Countermeasure against unbalance between heating and cooling demands

Development of heat pumps was carried out.
Countermeasure against unbalance between heating and cooling demands

Simultaneous heating & cooling operation mode

Heating operation mode

Cooling operation mode

Switching three operation modes
Simultaneous heating & cooling operation mode

1. Input energy (Electric power)
   Heat exchanger between water and refrigerant

2. Cooling energy
   Heat exchanger between water and refrigerant

3. Heating energy
   Heat exchanger between water and refrigerant

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Heat exchanger between air and refrigerant

Heating operation mode

Compressor

Heat exchanger between water and refrigerant

Input energy (Electric power)

Heat energy

1

2

3

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Cooling operation mode

Cooling energy

Heat exchanger between water and refrigerant

Input energy (Electric power)
The heat pump has been installed here for field tests.
Installation of the heat pump

Six cutting liquid baths
Heat pump
One washing liquid bath

Cold water
10 °C
15 °C

Plate type heat exchanger

Hot water
68 °C
62 °C
65 °C

Washing liquid
63 °C

Heat exchangers
Cutting liquid bath
Heat Pump
Washing liquid bath

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Field test results (temperatures)

Temperature of washing liquid ≈ 62 °C

Temperature of cutting liquid

Temperature of cutting machine
The developed heat pump can cope with a variation in unbalance of heating and cooling demands.
### Effects of application of heat pumps (Energy)

<table>
<thead>
<tr>
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<th>Before application of heat pumps</th>
<th>After application of heat pumps</th>
<th>Reduction achieved</th>
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<tbody>
<tr>
<td><strong>Power consumption</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(MWh/year)</td>
<td>193 (100%)</td>
<td>570 (295%)</td>
<td>+377 (+195%)</td>
</tr>
<tr>
<td></td>
<td>&lt;Boiler auxiliary equipment, Cooler&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>570 (295%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fuel oil consumption</strong></td>
<td>470 (100%)</td>
<td>0 (0%)</td>
<td>-470 (-100%)</td>
</tr>
<tr>
<td>(Kilo Litters/year)</td>
<td>&lt;Boiler fuel oil&gt;</td>
<td>&lt;Heat pump&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0 (0%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Water consumption</strong></td>
<td>6,953 (100%)</td>
<td>0 (0%)</td>
<td>-6,953 (-100%)</td>
</tr>
<tr>
<td>(KL/year)</td>
<td>&lt;Steam&gt;</td>
<td>&lt;Heat pump&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0 (0%)</td>
<td></td>
<td></td>
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<tr>
<td><strong>Energy saving</strong></td>
<td>522 (100%)</td>
<td>85 (16%)</td>
<td>-437 (-84%)</td>
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<tr>
<td>(Fuel oil equivalent, KL/year)</td>
<td>&lt;Boiler, Cooler&gt;</td>
<td>&lt;Heat pump&gt;</td>
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<td>522 (100%)</td>
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<td><strong>CO₂ emissions</strong></td>
<td>1,364 (100%)</td>
<td>270 (20%)</td>
<td>-1,094 (-80%)</td>
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<td>(Tons of CO₂/year)</td>
<td>&lt;Boiler, Cooler&gt;</td>
<td>&lt;Heat pump&gt;</td>
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**Effects of application of heat pumps (Cost)**

Initial equipment investment cost: 91,000,000 JPY  
Running cost reduction: 26,030,000 JPY/year, Pay back time: 3.5 years

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<td><strong>Investment cost</strong></td>
<td>Boiler (Including piping): 75,300,000 JPY</td>
<td>Heat pump system (14 units)</td>
<td>45,200,000 JPY or 33.2%</td>
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<td>Steam heater: 10,500,000 JPY</td>
<td>Total 91,000,000 JPY (66.8%)</td>
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<td>Cooler: 50,400,000 JPY</td>
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<td>Total: 136,200,000 JPY (100%)</td>
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<td><strong>Annual running cost</strong></td>
<td>Electricity: 193MWh, 2,340,000 JPY</td>
<td>Electricity: 570MWh, 6,890,000 JPY</td>
<td>26,030,000 JPY or 79.1%</td>
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<td>Fuel oil: 470KL, 28,130,000 JPY</td>
<td>Total: 6,890,000 JPY (20.9%)</td>
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<td>Water: 6,953KL, 2,450,000 JPY</td>
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<td>Total: 32,920,000 JPY (100%)</td>
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Total 91,000,000 JPY(66.8%) | 45,200,000 JPY or 33.2% |
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Total: 32,920,000 JPY(100%) | Electricity: 570MWh, 6,890,000 JPY  
Total: 6,890,000 JPY(20.9%) | 26,030,000 JPY or 79.1% |

When a factory is newly founded, both initial investment and running cost of the heat pump system are lower than those of the conventional steam supply system and chillers.
Heat pumps for cutting and washing processes are superior in Energy saving, Economy, and Environmental conservation.

14 heat pumps are operating in the plant.

Around 110 heat pumps are operating in Japan and Japan's neighbors in 2017.
Reference documents

Thank you for your attention!
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