4 Pipe district heating system
And the difficulties of knowing what heat qualities are supplied.

Jens Møller Andersen
4 Pipe district heating system

Where is it relevant:
- Process industry that wants to exchange heat
- When having prosumers (e.g. consumer with surplus solar heating)
- Large mixed district heating systems, where consumers have different needs

Other details to consider:
- System responsibility for security of supply
- Can one prosumer always deliver heat independent of the demand?
The 6 different heat qualities

140°C
90°C
60°C
30°C

Heat 140°C - 90°C
Heat 140°C - 60°C
Heat 90°C - 60°C
Heat 90°C - 30°C
Heat 60°C - 30°C
Which heat is sold or purchased?

An example of flow in and out, with temperatures.

Entrance point by one customer

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Flow Rate</th>
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<tbody>
<tr>
<td>140°C</td>
<td>10 kg/s</td>
</tr>
<tr>
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</tr>
<tr>
<td>60°C</td>
<td>3 kg/s</td>
</tr>
<tr>
<td>30°C</td>
<td>-6 kg/s</td>
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Diagram:
- 140°C → Heat 140°C - 90°C
- 90°C → Heat 140°C - 60°C
- 60°C → Heat 140°C - 30°C
- 30°C → Heat 90°C - 30°C
- 90°C → Heat 60°C - 30°C
- 60°C → Heat 60°C - 30°C
- 30°C → Heat 60°C - 30°C
- 7 kg/s → 0 kg/s → 3 kg/s
- 0 kg/s → 0 kg/s
- 3 kg/s
Which heat is sold or purchased?

An example of flow in and out, with temperatures.

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Flow Diagram:

- 140°C to 90°C: 7 kg/s, 0 kg/s, 3 kg/s
- 90°C to 60°C: 0 kg/s, 0 kg/s
- 60°C to 30°C: 3 kg/s
- 30°C to Heat 140°C - 90°C
- Heat 140°C - 90°C to Heat 140°C - 60°C
- Heat 140°C - 60°C to Heat 90°C - 60°C
- Heat 90°C - 60°C to Heat 90°C - 30°C
- Heat 90°C - 30°C to Heat 60°C - 30°C
- Heat 60°C - 30°C to 30°C
Which heat is sold or purchased?

An example of flow in and out, with temperatures.

Possibility 1

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Possibility 2

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The system is under determined, if only flows and temperature in and out is measured!
Additional Principe for defining heat quality

Heat is always delivered to the nearest temperature level. And is therefore settled in parts between the individual temperature levels.
Which heat is sold or purchased?

An example of flow in and out, with temperatures.

Heat is always delivered to the nearest temperature level. And is therefore settled in parts between the individual temperature levels.
Drawback of the principle – an example

Without Principle

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Heat 140°C - 90°C
Heat 140°C - 30°C
Heat 90°C - 60°C
Heat 60°C - 30°C
Drawback of the principle - an example

Without Principle (and many other solutions)

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Heat 140°C - 90°C
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With principle (unique solution)

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Heat 140°C - 90°C
Heat 140°C - 30°C
Heat 90°C - 60°C
Heat 60°C - 30°C

With the principle some heat that is purchased that cannot be measured!
Temperatures – no obvious way to handle

- Return temperature from 140°C- 90°C heat is the supply temperature for the 90-60°C heat (High return temperature is not bad)
- Temperatures need to fit to the demand - Therefore there must be an ongoing negotiation to adjust the temperatures to fit to both producers and consumers.
- It is an independent problem to handle temperature fluctuations If one producers supply heat 3°C below an agreed temperature level, how much is this heat worth then? And do the producers compensate for this?
Heat storage with a 4 pipe system

- Separated storages tanks
- Common storage tank for all temperatures
Heat storage with a 4 pipe system

Common storage tank

- Stratified with 3 separation layers
- Pressure set by highest temperature (if above 100°C)
  Here the minimum pressure will be 4 bar
- Very few components
- Easy flow control
Heat storage with a 4 pipe system

Separated storages tanks

- Only high temperature tank needs to be pressurized
- Difficult flow control
- Valves control the flow
- More pumps needed
Pressures

- A controlled system with differential pressure
- A differential pressure less system
With differential pressure

- Control system becomes more complicated
- Need for more valves
- Less possibility for using check valves

If a customer wants to produce it, needs to be known by the control system.
No differential pressure – simple system

Consumer is pumping water if they have a demand

Producer needs to pumping if they want to produce
Conclusion

- The complexity grow – need for new principle for accounting
- Temperatures needs to be negotiated in each specific case
- Heat storage and system control becomes more complicated
- A differential pressure less system is the simplest.