Waste heat recovery in industrial batch processes:
analysis of combined heat storage and heat pump application

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Existing situation

- Batch reactors with an intermediate water loop for heating and cooling
- A water loop gives a better process control and the opportunity for direct use of waste heat using a heat pump
- Fluctuating heating and cooling demand
Reference case

The existing water loops of 1 or more batch reactors are used to generate low pressure steam in a flash vessel, as a source for the mechanical vapor recompression (MVR) unit.

MVR unit operates continuous. In case of lack of waste heat (too low thermal power, or too low temperature level) steam of 3 bar will be used as backup source.
Integration of thermal storage

Add thermal storage between batch reactors and MVR to reduce the use of low pressure steam.

The heat storage consists of a pressurized stratified water tank.
Model results

- Input flow of waste heat from the batch reactors (dotted line) and back-up steam supply (green line) for the MVR system, without thermal storage.
Storage 1000 m³
Storage 2500 m³

- Charging storage
- Discharging storage
- 3 bar steam supply

- Entalpy flow (MW)
- Massflow streamnet (kg/s)

- 1-Mar
- 2-Mar
- 3-Mar
- 4-Mar
- 5-Mar
- 6-Mar
<table>
<thead>
<tr>
<th>Rate of return (years)</th>
<th>Investment 600 keuro</th>
<th>Investment 1200 keuro</th>
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<tbody>
<tr>
<td>Savings (Meuro/year)</td>
<td>Storage investment (Meuro)</td>
<td></td>
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<tr>
<td>Storage capacity (m3)</td>
<td>Additional energy costs (Meuro/year)</td>
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Conclusions

- Waste heat of the batch processes can be re-used by using a mechanical vapour recompression heat pump (MVR)
- Integration of a thermal storage system increases this amount of waste heat recovery and replaces low pressure steam backup
- The model simulation predicts an optimal range for the heat storage capacity, based on the fluctuating pattern of waste supply and selected MVR capacity
- Electricity prices have strong impact on the pay back times
- Pay back times of less than 5 years can be realized for the thermal storage system integration

Recommendations

- Process analysis using smaller time steps
- Include site specific requirements for cost estimation of thermal storage and integration.
Thanks for your attention

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