Utilization of low temperature heat for environmentally friendly electricity production

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Utilization of low temperature heat for environmentally friendly electricity production

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1 Motivation

Utilization of low grade heat is not feasible with conventional steam Rankine cycles due to undesirable properties of steam. Instead the organic Rankine cycle (ORC) is typically used, since it enables the choice of a working fluid, e.g. hydrocarbons, with desirable properties.

2 Optimization of working fluids

The aim of this project is to evaluate the feasibility of using mixtures as working fluids in ORCs considering both thermodynamics and economics. The hydrocarbon mixture propane/isobutane has shown high thermodynamic performance in an ORC utilizing a low temperature heat source at T=120 °C [1]. The result of an optimization of propane/isobutane for different mole compositions is shown in Fig. 2.

3 Heat transfer analysis (condenser)

The heat (Q) transferred in a heat exchanger can be expressed as:

\[ Q = UA \Delta T \] (1)

where \( \Delta T \) is the mean temperature difference between the heat exchanging streams, \( U \) is the overall heat transfer coefficient and \( A \) the heat transfer area.

The required heat transfer areas for mixtures are generally higher than those of pure fluids, due to the reduced temperature difference and a lower heat transfer coefficient. Table 1 shows a comparison of the net power and heat transfer parameters for isobutane, propane and two mixtures.

<table>
<thead>
<tr>
<th>Mole composition</th>
<th>0.2/0.8</th>
<th>0.5/0.5</th>
<th>0.8/0.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net power [kW]</td>
<td>1076</td>
<td>1157</td>
<td>1192</td>
</tr>
<tr>
<td>Temperature [°C]</td>
<td>7.6</td>
<td>6.5</td>
<td>5.2</td>
</tr>
<tr>
<td>Heat transfer [%]</td>
<td>1040</td>
<td>1526</td>
<td>2196</td>
</tr>
<tr>
<td>[W/m²-K]</td>
<td>994</td>
<td>1948</td>
<td>1394</td>
</tr>
</tbody>
</table>

4 Conclusion

The use of mixed working fluids in ORCs has the potential of increasing the net power output when utilizing low temperature heat. On the other hand, the use of mixtures requires larger and more expensive heat exchangers compared to pure fluids. It is therefore necessary to carry out economic analyses in order to assess the feasibility of using mixed working fluids in ORCs.

5 References