A Semi-Empirical Prediction Model for the Discharge Line Temperature of Hermetic Compressors

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A Semi-Empirical Prediction Model for the Discharge Line Temperature of Hermetic Compressors
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Research Objective: To build a Semi-Empirical prediction model, without using compressor-specific parameters, that produces better correlations with test data by assessing various DLT prediction methods.

Introduction/Motivation

- The compressor draws a mass flow of cool, low pressure refrigerant gas at its inlet (state 2), and discharges hot, high pressure gas (state 3).
- Applying the principle of thermodynamics the state postulate, with given values of $T$ and $p$ at the compressor inlet, the suction density, specific volume, enthalpy and entropy can be determined.
- The compressor performance values are tabulated over a range of evaporator and condenser dew-point temperature.
- The tabular data is represented by a ten-coefficient, third-order polynomial equation of the form:

$$X = C_1 + C_2 T_e + C_3 T_c + C_4 T_e^2 + C_5 T_e T_c + C_6 T_c^2 + C_7 T_e^3 + C_8 T_e T_c^2 + C_9 T_e T_c^2 + C_{10} T_c^3$$

Methodology

- **Entropy Approach**
  Assuming an ideal, adiabatic compression process, the entropy of the exhaust gas will be the same as that of the inlet gas:
  $$s_2 = \alpha s_3$$
  An efficiency measure $\alpha = 1.0233$ is identified by test data.

- **Polytropic Compression Approach**
  Apply the Polytropic process and follow the relationship:
  $$p v^n = C$$
  Assuming the exhaust temperature is equal to the DLT.

- **Energy Balance Approach**
  The energy of electrical power $W$, inlet gas and exhaust gas follow the relationship:
  $$h_3 = (W + m h_2)/m$$

- **Improved Energy Balance Approach**
  Adding the consideration of the heat $Q_{ex}$ that transfer from the hot, high-pressure side of the compressor to the environment.
  $$m h_3 - Q_{ex} = m h_{DL}$$

Conclusions

<table>
<thead>
<tr>
<th>Calculation Approach</th>
<th>Entropy</th>
<th>Polytropic</th>
<th>Energy Balance</th>
<th>Improved Energy Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Error</td>
<td>0.00 F°</td>
<td>0.04 F°</td>
<td>11.6 F°</td>
<td>0.00 F°</td>
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<tr>
<td>Std. Dev.</td>
<td>22.47 F°</td>
<td>19.06 F°</td>
<td>8.72 F°</td>
<td>3.30 F°</td>
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<td>within ± 5 F°</td>
<td>22.77%</td>
<td>35.31%</td>
<td>19.33%</td>
<td>92.41%</td>
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<tr>
<td>within ± 10 F°</td>
<td>39.60%</td>
<td>61.72%</td>
<td>51.00%</td>
<td>98.35%</td>
</tr>
</tbody>
</table>