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

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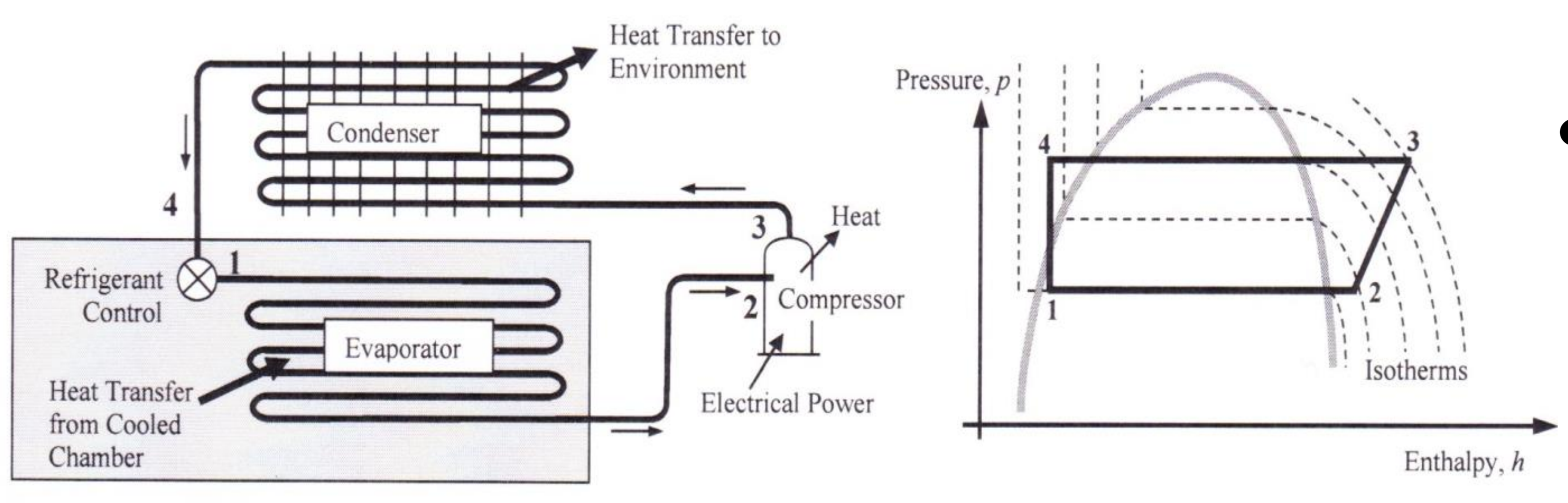
Research Objective: To build a Semi-Empirical prediction model, without using compressor-specific parameters, that produces better correlations with test data by assessing various DLT prediction methods.

Introduction/Motivation



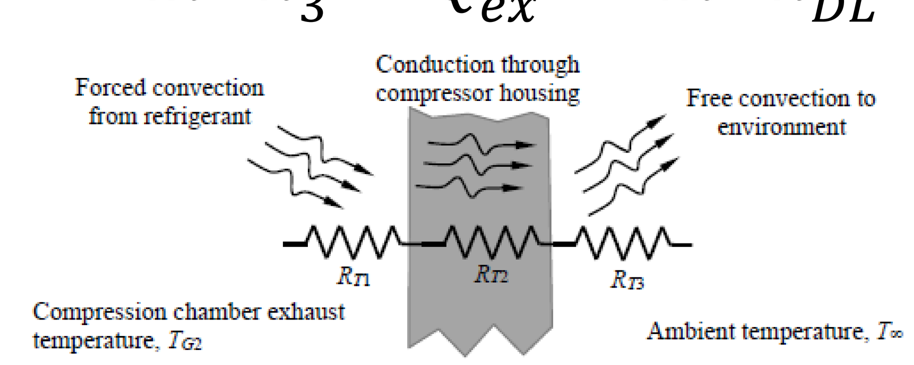
(a) Physical Components (b) Cycle plot on a p-h grid

- The compressor draws a mass flow of cool, low pressure refrigerant gas at its inlet(state2),and discharges hot, high pressure gas (state3).
- Appling 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:

$$X = C_1 + C_2T_e + C_3T_c + C_4T_e^2 + C_5T_eT_c + C_6T_c^2 + C_7T_e^3 + C_8T_e^2T_c + C_9T_eT_c^2 + C_{10}T_c^3$$

Methodology

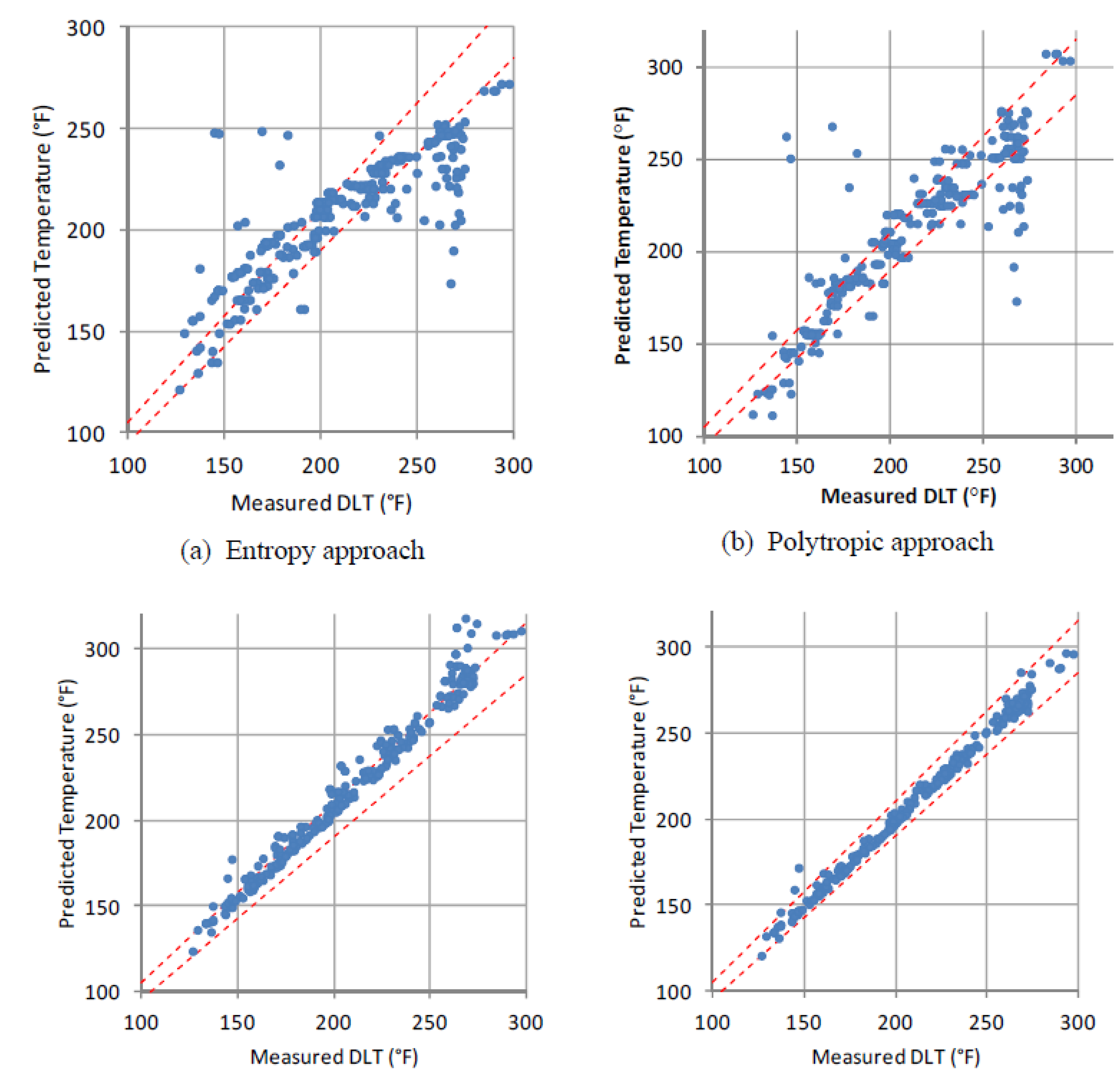
- **Entropy Approach**
  Assuming an ideal, adiabatic compression process, the entropy of the exhaust gas will be the same as that of the inlet gas
  $$s_2 = \alpha s_3$$
  An efficiency measure α = 1.0233 is identified by test data.
- **Polytropic Compression Approach**
  Apply the Polytropic process 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.
  $$m\ h_3 - Q_{ex} = m\ h_{DL}$$



Heat transfer from the refrigerant exiting the compression chamber to environment.

Conclusions

	Calculation Approach			
	Entropy	Polytropic	Energy Balance	Improved Energy Balance
Mean Error	0.00 F°	0.04 F°	11.6 F°	0.00 F°
Std. Dev.	22.47 F°	19.06 F°	8.72 F°	3.30 F°
within ± 5 F°	22.77%	35.31%	19.33%	92.41%
within ± 10 F°	39.60%	61.72%	51.00%	98.35%



(a) Entropy approach (b) Polytropic approach (c) Energy approach (d) Improved energy approach