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Extending ORNL HPDM Capabilities for Design and Optimization of New Refrigerant Blends – FY18 2nd Quarter Milestone Report: Improve HPDM to Adopt New Refrigerant Properties and Correlations

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FY18 2nd Quarter Milestone Report

Extending ORNL HPDM Capabilities for Design and Optimization of New Refrigerant Blends – FY18 2nd Quarterly Milestone: Improve HPDM to Adopt New Refrigerant Properties and Correlations

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Improve HPDM to adopt new refrigerant properties and correlations
(Regular Milestone)

Executive Summary

We added new refrigerant properties of HFO blends to the ORNL HPDM, including R-22 alternatives, i.e. N20b, DR3, ARM20a, ARM20b, R444B, DR93; R-410A alternatives, i.e. R447A, R447B, R452B, R32, ARM71a; R-134a alternatives, i.e. R1234yf and R1234ze. It can also simulate natural refrigerants, e.g. propane (R290), Isobutane (R600a), CO_2 and Ammonia. In addition, latest heat transfer and pressure drop correlations best for low GWP refrigerants were integrated to the equipment design and simulation software.

Adopt New Refrigerant Properties

HPDM have three options to calculate refrigerant properties, as illustrated below.

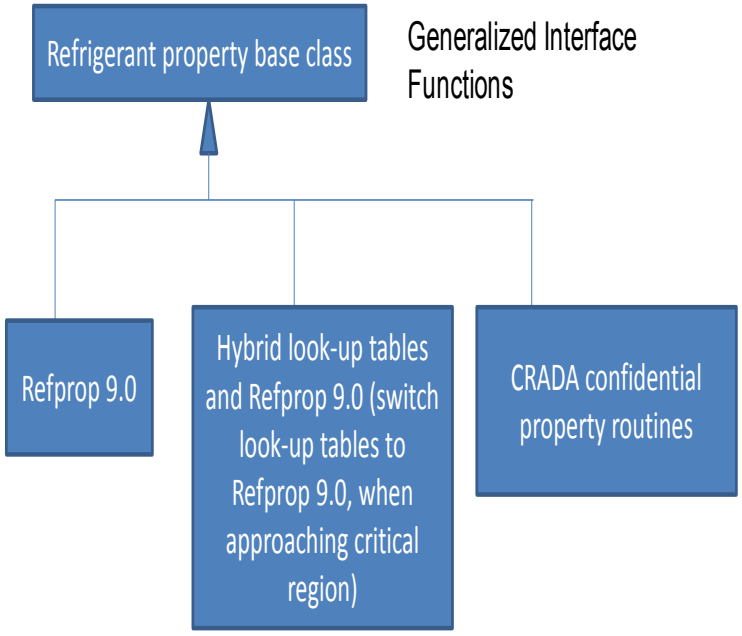

Figure 1. Refrigerant property functions of ORNL Heat Pump Design Model

- Interface to NIST Refprop 9.1: We programmed interface functions to call Refprop 9.1 dynamic link library (DLL) directly; our models accept all the refrigerant types in the Refprop 9.1 database, and we can simulate any new refrigerants by making the refrigerant definition file according to the Refprop 9.1 format.
- Hybrid look-up tables with Refprop 9.1: Refprop 9.1 dynamic link library can be fairly slow, to speed up the calculation, we have an option to generate property look-up tables using Refprop 9.1; our program uses cubic spline algorithms to calculate refrigerant properties via loading the look-up tables, this would greatly boost the calculation speed, having the same accuracy; however, the cubic spline

algorithms are less accurate when approaching to the critical region, in the case, we will switch back to the Refprop 9.1 DLL.

- Confidential property routines of industry partner can be easily added to HPDM using the same interface functions.

All the detailed (segment-to-segment) heat exchanger models in HPDM use look-up tables to facilitate fast computation. The latest HPDM version packs property tables of 30 refrigerants, listed below, including R-22 alternatives, i.e. N20b, DR3, ARM20a, ARM20b, R444B, DR93; R-410A alternatives, i.e. R447A (L412), R447B (L41z), R452B (DR55), R32, ARM71a; R-134a alternatives, i.e. R1234yf and R1234ze. It can also simulate natural refrigerants, e.g. propane (R290), Isobutane (R600a), CO_2 and Ammonia.

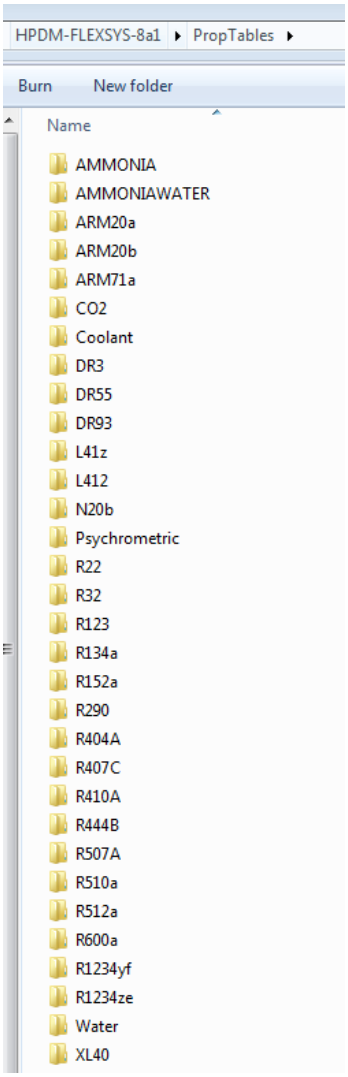

Figure 2. Folders of refrigerant property tables in the HPDM install directory

Adopt new heat transfer correlations

Through an extensive literature survey, we identified heat transfer and pressure drop correlations best for modeling and optimizing air conditioners and heat pumps using low GWP refrigerants, which have been added to HPDM. The new correlations are given in Table 1.

Table 1. Selected correlations for heat transfer and pressure drop

Application	Correlation
Fin-&-tube heat exchanger (FTC) -Evaporation heat transfer	Kedzierski (2016) [1]
FTC-Condensation heat transfer	Cavallini et al. (2009) [6]
FTC-Evaporation pressure drop	Kedzierski and Choi (1999) [2]
FTC-Condensation pressure drop	Kedzierski and Choi (1999) [2]
Micro-channel heat exchanger (MHX)-Evaporation heat transfer	Kim and Mudawar (2014) [3]
MHX-Condensation heat transfer	Cavallini et al. (2006) [5]
MHX-Evaporation pressure drop	Kim and Mudawar (2014) [4]
MHX-Condensation pressure drop	Kim and Mudawar (2014) [4]

References

[1] Mark A. Kedzierski & Donggyu Kang (2016), "Horizontal convective boiling of R448A, R449A, and R452B within a micro-fin tube", Science and Technology for the Built Environment, 22:8, 1090-1103, DOI: 10.1080/23744731.2016.1186460

[2] Kedzierski, M. A., and Choi J. Y., "A generalized pressure drop correlations for evaporation and condensation of alternative refrigerants in smooth and micro-fin tubes" NISTIR 6333, 1999

[3] S.M. Kim, I. Mudawar, Review of databases and predictive methods for heat transfer in condensing and boiling mini/micro-channel flows, Int. J. Heat Mass Transf. 77 (2014, 1) 627–652.

[4] Sung - Min Kim, Issam Mudawar, Review of databases and predictive methods for pressure drop in adiabatic, condensing and boiling mini / micro - channel flows, International Journal of Heat and Mass Transfer, Volume 77,(2014,2), Pages 74 - 97, ISSN 0017 – 9310

[5] A. Cavallini, D.D. Col, L. Doretti, et al., Condensation in horizontal smooth tubes: a new heat transfer model for heat exchanger design, Heat Transfer Eng. 27 (8) (2006) 1–38.

[6] A.Cavallini, D.Del Col, S.Mancin, L.Rossetto, "Condensation of pure and near - azeotropic refrigerants in microfin tubes : A new computational procedure", International Journal of Refrigeration, Volume 32, Issue 1, 2009, Pages 162 - 174