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An algorithmic approach towards finding better refrigerant substitutes of CFCs in terms of the second law of thermodynamics

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Abstract

In this study, rational efficiency (RE) and component based irreversibility ratios of a cooling system based on the second law of thermodynamics using HFC and HC based pure refrigerants, such as, R32, R125, R134a, R143a, R152a, R290, R600a and their binary and ternary mixtures, along with R12, R22 and R502 (i.e. CFCs) have been numerically calculated. The effect of temperature glide, occurring at the condenser and evaporator, on the RE of the cooling system has been evaluated. The calculations are based on a constant cooling load on a cooling system with suction/line heat exchanger (SLHE). To be able to calculate the performance of the cooling system, an algorithm that uses the state point properties provided by REFPROP has been employed. We have targeted finding better mixture substitutes in terms of rational efficiency. For example, despite the suggestions in the literature; for R22, the mass percentage level of 20/80 of R32/R134a has provided the best RE level. The highest irreversibility (in percentages) is found at the condenser. The results also suggest that for both binary and ternary mixtures, a general trend of increases in RE level is observed against temperature glide increases occurring at this system component.

Keywords: Refrigerant mixtures; CFC replacements; Rational efficiency; Irreversibility; REFPROP

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Nomenclature

c	specific heat
C	condenser
CFC	chlorofluorocarbon
Com	compressor
COP	coefficient of performance
CTG	condenser temperature glide
E	evaporator, exergy
EV	expansion valve
h	enthalpy
HC	hydrocarbon
HFC	hydrofluorocarbon
I	irreversibility rate
m	mass flow rate
MP	mass percentage
P	pressure
ΔP	pressure difference
RE	rational efficiency
s	entropy
SLHE	suction line heat exchanger
T	temperature
TG	temperature glide
Q	heat transfer
W	work

Subscripts

a	air
c	condenser
com	compressor
cs	cooling system
e	evaporator
ev	expansion valve
gen	generation
IR	irreversibility ratio
r	refrigerant
s	source
SLHE	suction line heat exchanger
0	ambient