Thermoeconomic Optimization of Cascade Refrigeration System Using Mixed Carbon Dioxide and Hydrocarbons at Low Temperature Circuit

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Abstrak

Many applications and industrial processes require very low cooling temperature, such as cold storage in the biomedical
field, requiring temperature below -80 °C. However, single-cycle refrigeration systems can only achieve the effective
cooling temperature of -40 °C and, also, the performance of the cycle will decrease drastically for cooling temperatures
lower than -35°C. Currently, most of cascade refrigeration systems use refrigerants that have ozone depletion potential
(ODP) and global warming potential (GWP), therefore, in this study, a cascade system is simulated using a mixture of
environmentally friendly refrigerants, namely, carbon dioxide and a hydrocarbon (propane, ethane or ethylene) as the
refrigerant of the low temperature circuit. A thermodynamic analysis is performed to determine the optimal composition
of the mixture of carbon dioxide and hydrocarbons in the scope of certain operating parameters. In addition, an
economic analysis was also performed to determine the annual cost to be incurred from the cascade refrigeration system.
The multi-objective/thermoeconomic optimization points out optimal operating parameter values of the system, to
addressing both exergy efficiency and its relation to the costs to be incurred.