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C1Or2D-05: A numerical investigation on vapor-liquid equilibrium of mixed-refrigerants by solving the Rachford-Rice equation

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Mixed-refrigerants are desired for near ambient temperature refrigeration and cryogenic cooling systems, to obtain enhanced cooling performances, relative to pure refrigerants, and to comply with new global environmental regulations. Therefore, the vapor-liquid equilibrium (VLE) of light hydrocarbon mixtures is numerically studied by solving the Rachford-Rice flash equations, based on the Peng-Robinson equation of state and the van der Waals mixing rules. In a previous research, the method has been validated against experimental results of several mixtures, and it is published elsewhere. The VLE of a mixture is the most basic data which is required for determining new refrigerants.

The main advantage of the presented method, relative to many other methods for calculating VLE of multi-component systems, is the fact that it doesn't involve numerical iterations. As a results, the presented method doesn't have convergence problems, it is fast, and therefore, it allows extensive investigations of different mixture compositions at various pressures and temperatures. The method allows generating VLE diagrams either at a constant pressure or at a constant temperature, for binary mixtures, and phase diagram of ternary mixtures at given pressure and temperature. The method also enables to calculate a specific VLE state of mixtures with any number of components, at any pressure and temperature.

In the current research we investigate binary and ternary mixed-refrigerants for Joule-Thomson cryocoolers, aiming for cryogenic cooling applications at temperatures between 80 and 180 K. Numerous mixtures were investigated, consisting of nitrogen, argon, methane, ethane, propane, n-butane, n-pentane, and carbon dioxide. The presented mixtures are the most interesting mixtures, which provide relatively high coefficient of performances (COPs). The COP is defined as the ratio between the cooling power and the compression work. The cooling power is determined by the isothermal Joule-Thomson effect, and the compression work is the adiabatic compression work, between the operating pressures. In order to reduce the number of degrees of freedom in this complex research question, and to focus on available compressors, a fixed pressure ratio of eight is maintained in the current research.

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