IMPLEMENTATION OF A MODIFIED REDLICH-KWONG-AUNGIER EQUATION OF STATE FOR THE CENTRIFUGAL COMPRESSOR SIMULATION IN THE TWO-PHASE CO_2 REGION

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This thesis to review phase transition of the carbon dioxide in centrifugal compressor from two-phase region to supercritical near critical point. Supercritical CO_2 cycles are one of the most perspective approaches for achieving higher efficiency and more effective power conversion due to two-phase working fluid at the compressor inlet, even if design point of the compressor is operated near the critical point. The Redlich-Kwong-Aungier (RKA) equation of state can predict for the computational fluid dynamics tasks supercritical and gases phases of pure fluids with appropriate accuracy (lower than 5%), but for two-phase this equation shows significant difference for the fluid thermodynamics (up to 20% for the liquid phase near saturation line). The modified Redlich-Kwong-Aungier equation of state includes the saturated vapor pressure which is based on the Lee-Kesler method instead of the cubic RKA equation of state. Scale correction was added to the factor A(T) from the Redlich-Kwong-Aungier equation of state. This modification gives an ability to significantly reduce the error for the pressure predictions in a wide temperature range (220 K - 300 K).

The compressor stage designed in 1D AxSTREAM® and after this was imported to 3D AxCFD™ for further three dimensions simulations. Compressor works in the two-phase CO_2 region at the inlet and in the supercritical region at the outlet. The main problem of the solution convergence and indisputable advantage of the developed mathematical model is the possibility of calculating the compressor which working fluid works in a phase transition near the critical point. This mathematical model allows to move from one phase to another, where the fluctuations of the fluid thermodynamic parameters are increased significantly.

The obtained results for the saturation pressure, enthalpy and entropy rises, and for the wetness factor showed a good agreement with the basic values (difference 2-5%) in comparison with the original RKA equation of state (higher than 40%) in a wide temperature region from 220 K to 300 K. Due to the simple form of the equation of state and a small number of empirical coefficients (7 coefficients), the obtained mathematical model can be used for practical of computational fluid dynamics tasks without high computational costs of time.