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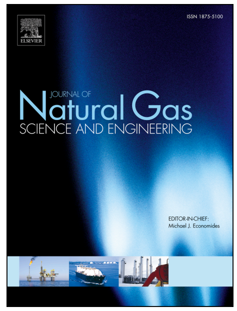

Speed of sound of multiphase and multi-reactive equilibrium streams: A numerical approach for natural gas applications

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Speed of Sound of Multiphase and Multi-Reactive Equilibrium Streams: A Numerical Approach for Natural Gas Applications

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Abstract: A method is presented for calculating the thermodynamic sound speed of multiphase multi-reactive streams. A rigorous formula for the thermodynamic sound speed is developed via a steady-state, unidimensional, horizontal, adiabatic, frictionless, multiphase and multi-reactive equilibrium plug-flow. The main theoretical point is a correspondence between a multiphase multi-reactive plug-flow element and an Equilibrium Closed System (ECS), which has only two equilibrium state coordinates. Momentum and energy flow balances are processed via the ECS framework allowing the sound speed derivation for complex streams. The method uses ECS thermodynamic properties provided by multiphase *Flash*(P,T) of HYSYS 8.8 simulator. Unit Operation Extensions (UOE) are developed for calculating the multiphase multi-reactive sound speed by HYSYS. HYSYS solves the multiphase multi-reactive equilibria, including liquid water separation, to feed the ECS sound speed formula with required properties. The sound speed is also investigated in the critical neighborhood via the Landau Model approach to prove that it does not exhibit $\pm\infty$ singularities at the critical point, despite the critical lambda-shape $\pm\infty$ singularities of $\overline{C}_P$ and (T,P) derivatives of the density. Multiphase examples are solved by the sound speed UOEs for simultaneous adjustments of water and hydrocarbon dew points of natural gas with supersonic separator. Multi-reactive multiphase sound speeds are also predicted in supersonic reactors for natural gas pyrolysis (GTL) and for two-phase methanol oxidation to formaldehyde.

Keywords: Thermodynamic Sound Speed; Multiphase Sound Speed; Multi-Reactive Sound Speed; Supersonic Separator; Landau Model Sound Speed; Natural Gas Pyrolysis.