Critical Point Energy Storage

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The heat capacity (Cp) divergence of a fluid at its critical point has fascinated researchers for over 60 years. This singularity offers unlimited energy storage potential, but achieving it remains impractical, let alone maintaining it. In this project, it was hypothesized that by maintaining temperature and pressure of a fluid close to its critical temperature (Tc±0.5oC) and pressure (Pc±0.15 bar), the amount of thermal energy stored would increase following the power law. The approach was to create a temperature gradient in a vessel filled with a working fluid such that a portion of the fluid was at Tc. With pressure being uniform, Pc was maintained through a precision regulator. After stabilizing the fluid at its critical point within the target tolerance, the thermal energy, in terms of Cp, was calorimetrically quantified. Both a pure fluid and a fluid mixture were tested. The fluid mixture Cp increased moderately over the sum of its component Cp's due to the weak divergence of Cp and sensitivity of composition variations. For pure fluids, NIST's Cp data are "undefined" within Tc±0.5°C. The Cp average over the calorimetry temperature measurement range was used to gauge the energy storage performance. The average Cp measured for the pure fluid was 4.5 times the NIST average. The "undefined" Cp within Tc±0.5°C, calculated from the measured Cp, reached 613 kJ/kg°C, which dwarfed Cp's for water (4.18) and hydrogen (14.3). The pure fluid results were disruptive, as well as applicable to fluids with different Tc's via the principle of corresponding states.