

Critical Point Energy Storage

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The heat capacity (C_p) 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 ($T_c \pm 0.5^\circ\text{C}$) and pressure ($P_c \pm 0.15 \text{ bar}$), 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 T_c . With pressure being uniform, P_c was maintained through a precision regulator. After stabilizing the fluid at its critical point within the target tolerance, the thermal energy, in terms of C_p , was calorimetrically quantified. Both a pure fluid and a fluid mixture were tested. The fluid mixture C_p increased moderately over the sum of its component C_p 's due to the weak divergence of C_p and sensitivity of composition variations. For pure fluids, NIST's C_p data are "undefined" within $T_c \pm 0.5^\circ\text{C}$. The C_p average over the calorimetry temperature measurement range was used to gauge the energy storage performance. The average C_p measured for the pure fluid was 4.5 times the NIST average. The "undefined" C_p within $T_c \pm 0.5^\circ\text{C}$, calculated from the measured C_p , reached $613 \text{ kJ/kg}^\circ\text{C}$, which dwarfed C_p 's for water (4.18) and hydrogen (14.3). The pure fluid results were disruptive, as well as applicable to fluids with different T_c 's via the principle of corresponding states.

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