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Side-jet effects in high-pressure turbulent flows: Direct Numerical Simulation of nitrogen injected into carbon dioxide

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Abstract

Direct Numerical Simulation realizations were generated of a round jet under high-pressure (high-p) turbulent conditions. In the simulations, a jet of nitrogen was injected into a chamber filled with carbon dioxide for three different jet-to-chamber density ratio, s, and three different chamber pressures, $p_{ch,0}$. The results show that for $s = 0.5$ and 0.35 side jets form whereas no side jets are observed for $s = 1$; thus providing, for the first time, evidence of side jet formation in high-p flows. Due to these side jets, mixing of the jet fluid and chamber fluid is promoted; although the species experience regular diffusional mixing, it is shown that due to turbulent conditions there can be effective uphill thermal conduction. Analysis of the vortical features of the side jets elucidated the process through which the enhanced mixing occurs: fluid from the jet is effectively pumped in the radial direction though the combined action of dilatation/compression and vortex stretching/shrinking. The value of s is shown to control radial and circumferential mixing versus axial mixing which occurs through jet penetration in the flow. Examination of dynamic and