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A look-up table method based on unstructured grids and its application to non-ideal compressible fluid dynamic simulations

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Abstract

Fast and accurate computation of thermo-physical properties is essential in computationally expensive simulations involving fluid flows that significantly depart from the ideal gas or ideal liquid behavior. A look-up table algorithm based on unstructured grids is proposed and applied to non-ideal compressible fluid dynamics simulations. The algorithm grants the possibility of a fully-automated generation of the tabulated thermodynamic region for any boundary and to use mesh refinement. Results show that the proposed algorithm leads to a computational cost reduction up to one order of magnitude, while retaining the same accuracy level compared to simulations based on more complex equation of state. Furthermore, a comparison of the LuT algorithm with a uniformly spaced quadrilateral tabulation method resulted in similar performance and accuracy.

Keywords: look-up table, trapezoidal map, unstructured mesh, thermodynamic modeling, interpolation, real-gas flows, non-ideal compressible flow, NICFD, CFD

1. Introduction

The accurate estimation of the thermo-physical properties of fluids is essential for many engineering and scientific applications, and it requires complex models in case the behavior of the fluid departs from that of the ideal gas or ideal liquid. Fluids exhibiting non-ideal behavior are involved in various technologies such as advanced power and propulsion systems, refrigeration and air conditioning systems, oil and gas processes, etc. [1, 2, 3, 4]. In these cases, the evaluation of thermo-physical properties is often necessary for system design and performance evaluation or to simulate the flow behavior within components. Fluid

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