A NUMERICAL ANALYSIS OF HYDROGEN UNDEREXPANDED JETS UNDER REAL GAS ASSUMPTION

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ABSTRACT

This work examines the fluid dynamic structure of underexpanded gas jets by using a high-performance computing (HPC) methodology in order to untangle the question of whether it is necessary to include the real gas assumption dealing with hydrogen jets. The answer to this question is needed in order to guarantee accurate numerical simulations of such jets in practical engineering applications, such as direct-injection hydrogen engines. An axial symmetric turbulent flow model, which solves the Favre-averaged Navier–Stokes equations for a multicomponent gas mixture, has been implemented and validated. The flow model has been assessed by comparing spreading and centreline property decay rates of subsonic jets at different Mach numbers with those obtained by both theoretical considerations and experimental measurements. Besides, the Mach disk structure of underexpanded jets has been recovered, thus confirming the suitability and reliability of the computational model. To take into account the effects of real gases, both van der Waals and Redlich–Kwong equations of state have been implemented. The analysis of a highly underexpanded hydrogen jet with total pressure equal to 75 MPa, issuing into nitrogen at 5 MPa, shows that the use of real gas equations of state affects significantly the jet structure in terms of temperature, pressure, and Mach number profiles along the jet centerline and also in terms of jet exit conditions, with differences up to 38%.


REFERENCES