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NUMERICAL STUDY OF DETONATION ENGINES

Abstract

3D numerical modeling of a rotating detonation engine (RDE) combustion chamber is performed based on the original code. The RDE is a new type of engines capable to create higher thrust than the traditional ones based on the combustible mixture deflagration process. The dynamical process of combustion in the RDE is more than 100 times fast than in case of usual slow combustion. This type of an engine has more efficient thermal dynamics.

The combustion chamber under consideration is a co-axial hollow cylinder. The fuel is injected from one side, either premixed with the oxidizer, or from separate injectors. It is ignited in the chamber near the injectors, and this invokes the self-sustaining detonation wave which is then rotates consuming the combustible mixture. The burnt gases are expanded in the central part of the chamber where the internal hollow body changes from cylinder to cone and then vanishes. After the expansion, they leave the chamber from the side opposite to the injectors. The primary ignition is modeled by an energy source strong enough to produce an instant detonation wave.

The calculations are based on the Navier – Stokes system of equations along with the equations for turbulence modeling and the chemical kinetics. The numerical modeling used the MUSCL interpolation of variables from the cells centers to the cell faces, together with the explicit AUSM-plus method stabilizing the scheme. The method was 2nd order both in space and time, except for tiny zones of strong gradients of variables. The chemical kinetics containing 20 reversible elementary reactions with 9 specise, was modified Maas – Warnatz, the reverse reactions kinetics was calculated using the equilibrium constant. The flux from chemical reactions was obtained semi-implicitly.

The computational domain used a regular mesh of uniform cubic elements. The time-critical program parts were parallelized using the OpenMP technique. Our calculations were made at a compact supercomputer APK-5 with a peak performance of 5.5 Tera Flops.

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