Numerical Simulation of Reactive Gas Mixes Flows in The Detonation Engine

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Accurate mathematical model is needed for correct numerical simulation of detonation wave appearance and propagating in spin detonation engine, in particular, for ones using hydrogen as the fuel. As the matter of fact such engine does not exist. Detonation wave is connected with appearance of point explosion of gas mix. The origin of such explosion is mechanism of chain reaction in hydrogen-oxygen mix. In contradiction, in propagation of detonation wave chain reaction doesn't play significant role, as influence of temperature failure inside of shock wave.

Mathematical model for simultaneous decision of gas dynamics equations and full system of the equations of kinetics was used for numerical simulation of gas mix flow in axial detonation engine of Jdan-Bykovsky [1]. Gas was assumed non viscous. Transition to characteristic variables of full system of the equations for any number of components of gas mix is carried out. Boundary conditions for the flow from Laval's nozzle for regimes with periodically closing, was discussed. System of the equations of kinetics for 21 reactions was used. Additional formulae where used for speed of reactions with catalisators. Specific formulae where carried out for speed of chain reactions [2] in initial period of detonation wave appearance.

The Chakravarthy-Osher scheme [3] of third order of accuracy for space approximation and the Runge-Kutta third order explicit scheme for temporal approximation where used for calculations on essential curvilinear two and three –dimensional structural grids.

References

[1] Bykovsky F.A., Zhdan S.A., Vedernikov F.F. (2009). Continuous spin and pulse detonation of hydrogen-air mixtures in supersonic flow generated by a detonation wave. Proc. Of 22-th ICDERS, Minsk, Belarus.

[2] Semenov N.N. (1985) Chain reactions. M. Nauka, 535 p.

[3] Chakravarthy S.R., Osher S. (1985) A new class of high-accuracy TVD schemes. AIAA Paper. 85-0363.