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Measurement techniques for investigation on heat transfer characteristics of gaseous rotating detonation engine

This paper gives overview of methods and test specimen design used for investigation of heat fluxes to the combustor walls of the rocket-type engine in the regimes of continuous detonation wave propagation.

Design of detonation wave calorimeter chamber presented in this article allows to apply measurement of coolant temperature distribution. Heat flux of cylindrical combustion chamber inner wall were calculated based on quick response of temperature change (thin combustion chamber wall) which influences coolant temperature.

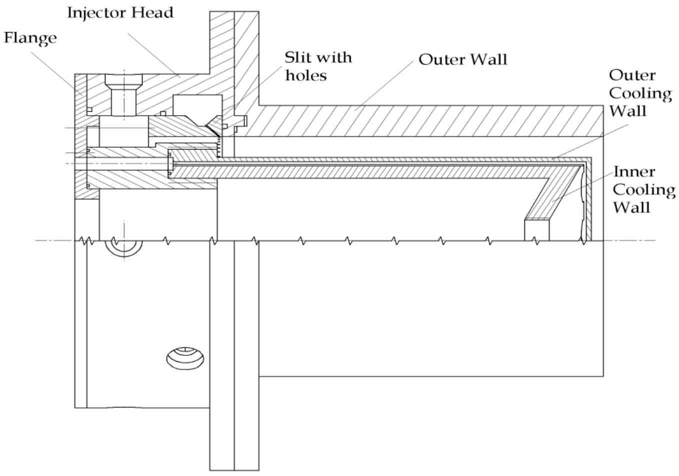

Figure 1. Cross-sectional view of rotating detonation engine.

Detonation simulations were performed with use of REFLOPS code – inviscid Euler with stiff chemistry solver. Tuning of reaction mechanism was a first task during detonation simulation. A one-step Arrhenius chemistry model for methane/oxygen combustion was used.

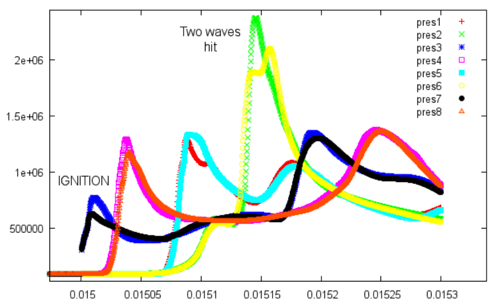

Figure 2. Plot of pressure for circumferentially distributed sensors.

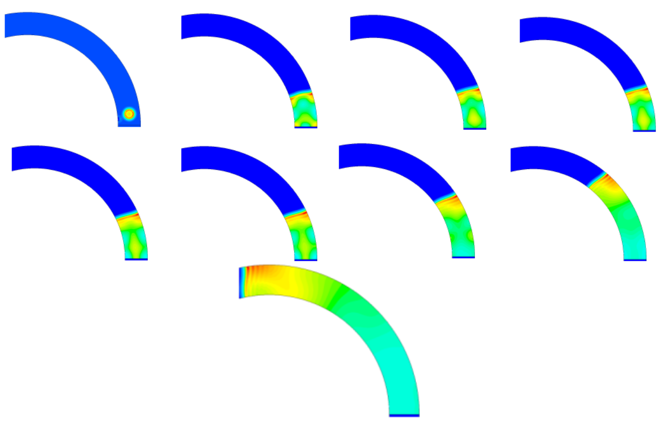

Figure 3. Pressure contours for detonation propagation.

Qualitative modeling of heat fluxes was made on a basis of CFD calculations. Boundary condition was based on Mirels relation between the heat flux q_w and shear τ_w at the wall:

$$q_w = \frac{(h_r - h_w) \cdot \tau_w}{(V_D - V_e) {Pr_m}^{2/3}}$$

Mean conditions in the boundary layer were obtained with the fluid properties based on Eckert's mean enthalpy. Boundary conditions are calculated via UDF with use of equation presented above.

Presented description of results from calorimetric method measurement and simulations focused on:

- quantifying the magnitude and time variation of the heat flux from hot gases behind the detonation wave
- determining zone where maximum heat flux occurs during steady state operation of RDE
- influence of cooling passages on continuous detonation wave propagation
- heat conduction in a chamber wall

Acknowledgments

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