

The Comparison between Measured and Calculated Temperature at Focusing of Shock Wave in Hydrogen-Air Mixture

Sergey P. Medvedev, Vyacheslav V. Zhukov, Sergey V. Khomik, Boris E. Gelfand

Laboratory of Heterogeneous Combustion, Semenov Institute of Chemical Physics RAS
Kosygina str. 4, 119991 Moscow, Russia

The investigation of shock focusing in lean (7-9%) hydrogen-air mixtures was performed in [1] with the aid of a shock tube with the endwall shaped in the form of a concave symmetric wedge reflector. It was found that shock focusing serves as a powerful technique for initiation of detonation and deflagration regimes. Along with pressure recording and optical visualization the specially designed double-wavelength photodiode detector was used for the emission/temperature measurements. It was found that maximum temperature levels are attained in the vicinity of the reflector apex. The measured value of peak temperature T_p grows up with the increase of the Mach number M of the incident shock wave. Typical values of peak temperature fall in the range of $T_p = 2000 - 4000$ K at $M = 2.5 - 3$. The T_p evaluation is important due to the fact that the process of detonation initiation is controlled by the high-temperature regions arising after the shock focusing inside a reflector cavity.

To get further insight into the problem of shock focusing in reactive gaseous media the numerical simulations were performed with the help of GasDynamicsTool (GDT Software Group) package [2]. The 2D calculations were executed at a rectangular non-adaptive grid accepted in GDT. The dimension of the calculation cell was 0.1 mm. The physical length of the calculation domain varied in the range of $L=100-200$ mm and the height was specified as 27 mm (to reproduce half of the rectangular shock tube of 54×54 mm² [1]). The typical calculation step was 100 ns.

The numerical simulation demonstrates all basic features of detonation and deflagration initiation revealed in the experiments of [1] by optical visualization. It was found that measured and calculated temperature histories in the vicinity of the apex of a reflector are in satisfactory agreement. The advantage of the numerical simulation is the possibility to elucidate the peculiarities of transient regimes when detonation is initiated outside of the reflector cavity.

References

- [1] Medvedev SP, Zhukov VV, Khomik SV, et al. (2000) Application of double-wavelength photodiode detector to study of hydrogen combustion induced by shock focussing. Proc. 22nd Intern. Symp. on Shock Waves, 1, 315.
- [2] Zibarov AV, Babaev DM, Shadskiy AM (2000) Gas Dynamics Tool 4.0. Advanced technology for personal computer. SAPR i Grafika, 10, 44.