NUMERICAL SIMULATION OF CELLULAR DETONATION IN SPACE

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Summary The results of numerical simulation of spontaneous formation of two- and three-dimensional cellular structure of detonation in propane-air mixture are presented. Two-dimensional flows in channels of various configurations are considered: constant cross section, including the curved walls of variable cross section with the divergences, convergences and kinks of side walls, as well as the propagation of diverging cylindrical detonation wave. The results of three-dimensional detonation initiation in channels of fixed square, rectangular, circular and elliptical cross sections are presented and discussed.

INTRODUCTION

Previously, a number of authors have performed theoretical studies devoted to formation and propagation of the two-dimensional cellular detonation in channels. But the flows with divergent detonation waves are of particular interest. These flows were investigated by R.I. Soloukhin in his brilliant experiments. Numerical simulation of cellular divergent detonation is a time-consuming problem by virtue of the necessity to perform high-resolution calculations in a vast spatial region for narrow chemical reaction zones. Three-dimensional cellular detonation is even more difficult to simulate and therefore it is poorly investigated.

CELLULAR STRUCTURE OF DIVERGENT CYLINDRICAL DETONATION WAVES

Processes observed in experiments with the initiation and propagation of divergent detonation in a narrow gap between plates are simulated. The detonation wave is formed in a tube adjoined at a right angle, and this gap passes therein through a circular hole. Due to the complexity of the flow region's geometry, the actual phenomenon is of a three-dimensional nature. But the flow inside the tube is close to one-dimensional, and the size of the interplate gap is sufficiently small. Therefore, transverse waves propagating in the direction normal to the plates are absent, and the two-dimensional divergent cellular detonation is realized within the gap. Figure 1 shows for comparison (a) the experimental pattern and (b) the calculated pattern for wakes of triple points. One can see the good consistency of two-dimensional model for description of the process.

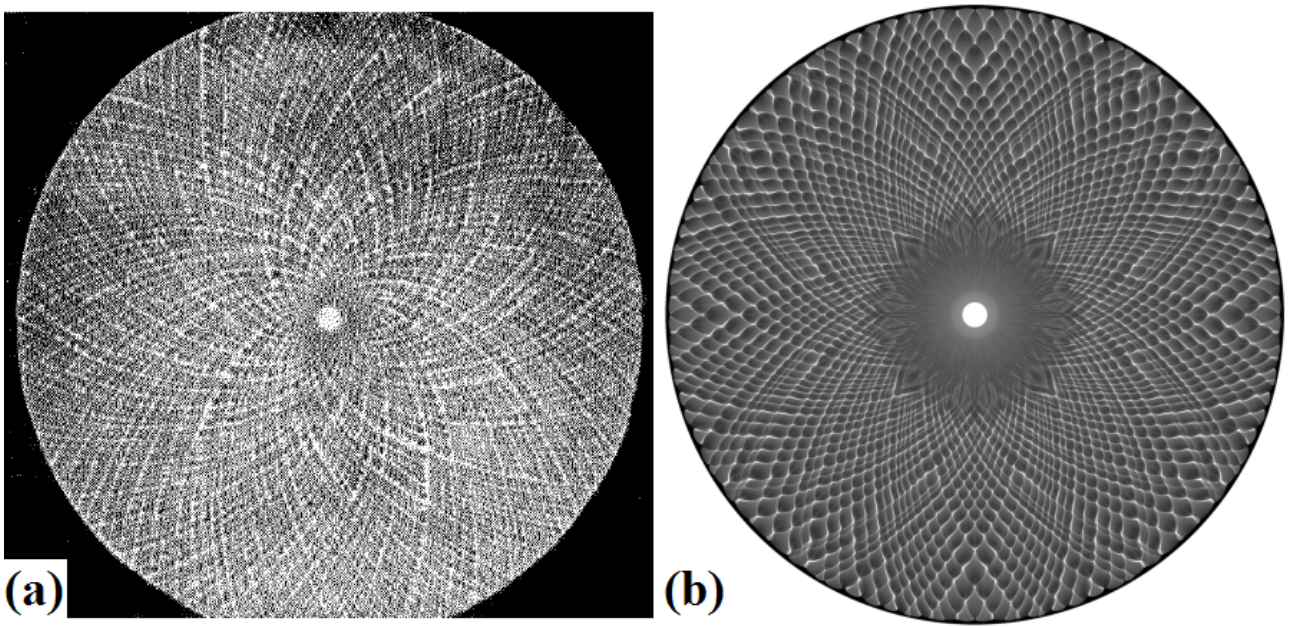

Figure 1. Traces of triple points besides the diverging cylindrical detonation wave. The results of the experiment (a) and calculation (b).

CELLULAR DETONATION IN THREE-DIMENSIONAL CHANNELS

Three-dimensional cellular detonation in semi-closed channels with fixed square, rectangular, circular and elliptical cross sections has been obtained. Formation of cellular structure was spontaneous due to one-dimensional initial

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distribution of gas-dynamic parameters in channels. In all cases the channel was filled with uniform stoichiometric propane-air mixture under room conditions and the initiation of detonation has been performed by significant instant heat supply in a 3-cm zone near the closed end of the channel. The simulations have been performed on Lomonosov supercomputer with several billions of computational cells. Figure 2 shows numerical Schlieren diagram on the surface of circular cylindrical channel, which was obtained in calculation. The radius of the channel presented on the figure is 1 cm.

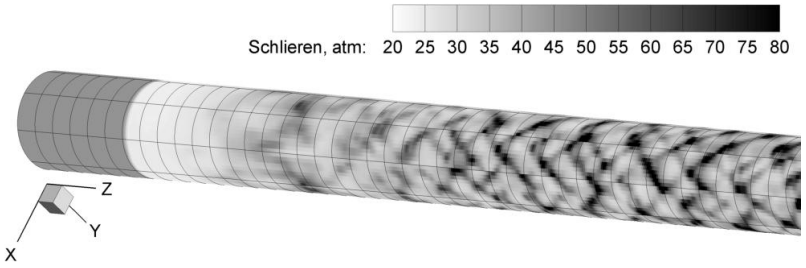

Figure 2. Schlieren diagram of detonation in cylindrical channel of circular cross section.

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