SOME FEATURES OF TWO-DIMENSIONAL STRUCTURE OF PLANE AND CYLINDRICAL DETONATION IN HYDROGEN-AIR MIXTURE

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Many experimental and theoretical investigations show that the real detonation wave has the complicated three-dimensional structure in general case. However, it is possible to create some special conditions under which the flow becomes two-dimensional one. Usually the special geometry of the space where the wave propagates is used for this purpose. The wishful effect is obtained hear due to the important property of detonation on which from point of view of theory have been pointed out in paper [1]. According to the obtained numerical results, the size of the detonation wave cell has the defined minimal and maximal values depending on the composition of the combustible mixture and thermodynamical parameters of initial stage. Therefore, the sufficient condition for suppression of the flow disturbation in some direction is the small enough thickness of space where the detonation propagates. For the practical purposes the plane and cylindrical geometry of the flow are widely used.

The present paper is devoted to study of initiation and propagation the detonation in hydrogen-oxidant mixtures just for such geometries of the flow.

Under the conditions in question the following elementary stages of the hydrogen oxidation reaction were taken into account:

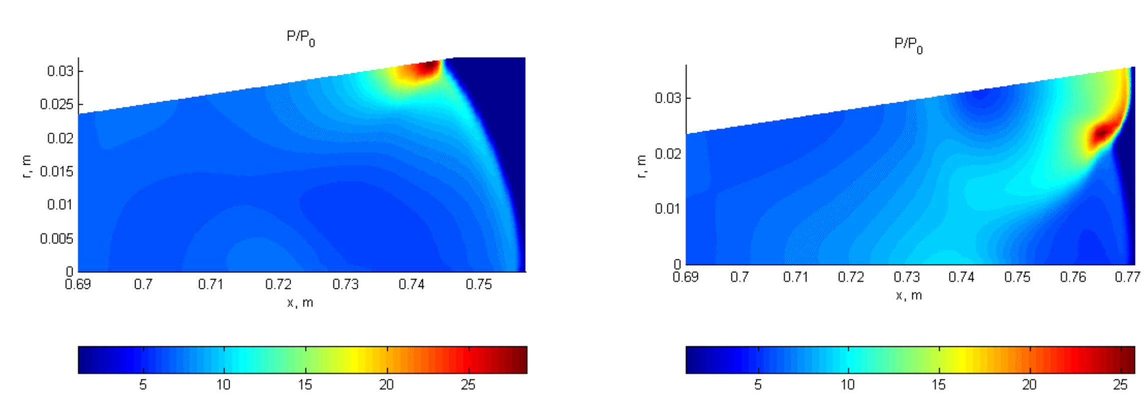
$$\begin{array}{ccc} H_2+O_2=OH+OH, & H+O_2=OH+O, & O+H_2=OH+H, \\ OH+H_2=H_2O+H, & H+H+M=H_2+M, & HO_2+H=OH+OH, \\ H+OH+M=H_2O+M, & H+O_2+M=HO_2+M, & O+H_2O=OH+OH \end{array}$$

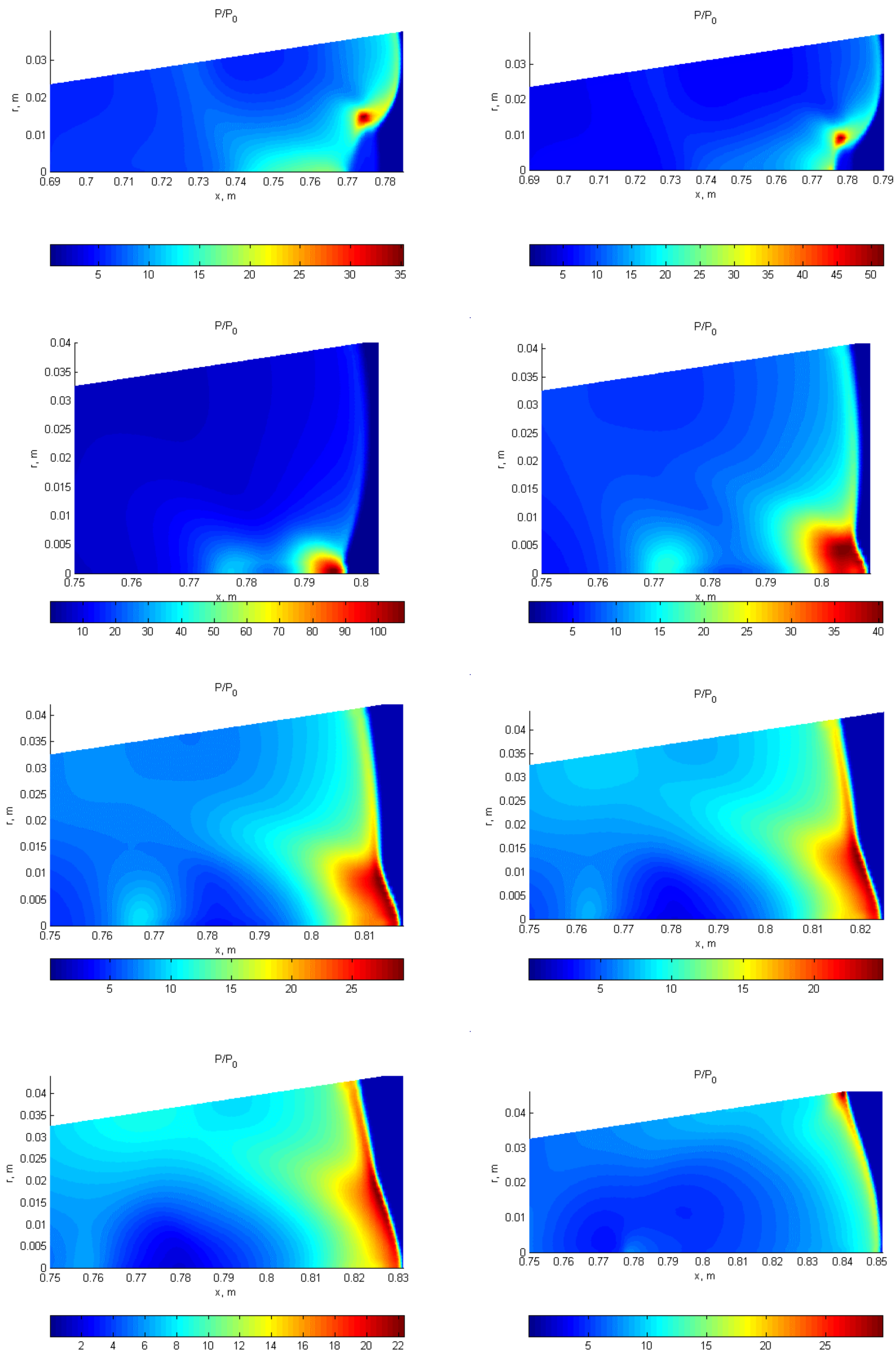
where M denotes a third particle.

The equations of state for the hydrogen-air mixture have the usual form:

$$P = \frac{\rho R T}{\mu},\ \ h = \sum n_i h_i(T),\ \ \mu^{-1} = \sum n_i = \sum \alpha_i m_i^{-1},\ \ i = 1,2\ldots 8\,.$$

The numerical method based on S.K. Godunov scheme is used [2,3]. The detail investigation of initiation by means of electrical discharge using the electrodes of different shape situated near the closed end of plane channel or of cylindrical tube is carried out. The critical parameters of the initiator are determined. The formation of multihead detonation wave at some distance from the place of the initiation is obtained. In some critical cases it appears that detonation wave has one head structure like spin one before becomes the multihead one. The process of detonation wave transition into opened space is studied in details. The proper critical thickness or diameter assuring the reestablishment of detonation wave after the transition is calculated. For the subcritical values of these parameters the problem of detonation transition into linear branching plane channel or cone is investigated. The values of proper minimal critical angles are obtained. The flow picture with one triple point like mentioned above is observed in these cases. Some results of calculations are presented below. For example in Fig.1 the pressure fields for different time moments illustrating the process of reestablishment of detonation after transition from the tube into the cone are presented.




P/P0
0.03
0.02
0.01
0
r, m
0.69 0.7 0.71 0.72 0.73 0.74 0.75 0.76 0.77 0.78
x, m
5 10 15 20 25 30 35
P/P0
0.03
0.02
0.01
0
r, m
0.69 0.7 0.71 0.72 0.73 0.74 0.75 0.76 0.77 0.78 0.79
x, m
5 10 15 20 25 30 35 40 45 50
P/P0
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
r, m
0.75 0.76 0.77 0.78 0.79 0.8
x, m
10 20 30 40 50 60 70 80 90 100
P/P0
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
r, m
0.75 0.76 0.77 0.78 0.79 0.8
x, m
5 10 15 20 25 30 35 40
P/P0
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
r, m
0.75 0.76 0.77 0.78 0.79 0.8 0.81
x, m
5 10 15 20 25
P/P0
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
r, m
0.75 0.76 0.77 0.78 0.79 0.8 0.81 0.82
x, m
5 10 15 20
P/P0
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
r, m
0.75 0.76 0.77 0.78 0.79 0.8 0.81 0.82 0.83
x, m
2 4 6 8 10 12 14 16 18 20 22
P/P0
0.04
0.03
0.02
0.01
0
r, m
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x, m
5 10 15 20 25

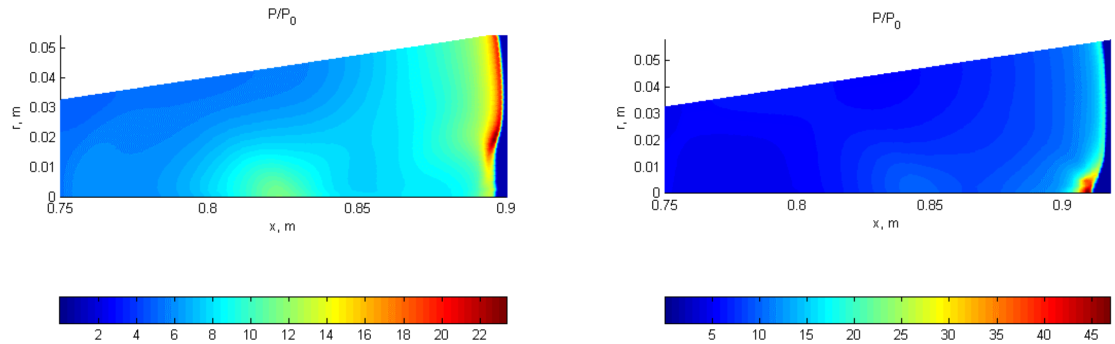

Figure 1. The example of pressure fields in the case when detonation wave is formed in cone.

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