Detonation decay and flame propagation through a channel with porous walls

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We considered the problem of detonation suppression and weakening of the blast wave effects occurring during the combustion of hydrogen-air mixtures in the confined spaces.

Analyzing the combustion inside porous material could reveal the mechanism of flame quenching in porous materials, which is not fully understood. The main reasons for flame quenching seem to be the disappearance of transverse waves, heat losses into porous media, flame stretching, and increased curvature [1]. Metallic wool was used as an explosion-attenuating material since it has a big surface area per unit volume and high thermal conductivity [2]. The mixture composition and porous material thickness can also significantly change the flame propagation parameters [3,4]. Several works were dedicated to the normal shock wave impact on the porous cellular materials [5]. However the dynamics of the porous material under weak tangential shock waves was not studied.

The aim of this work was to study the dynamics of the detonation wave in the channel with porous walls, and to compare the detonation parameters in channels with solid walls and two types of porous materials: polyurethane foam (density of 0.03 g/cm^3, porosity of 95%, pore size of 0.8 mm) and steel wool (density of 0.15 g/cm^3, porosity of 99.8%, fiber size of 0.03 mm).

Detonation propagation was studied using pressure sensors PCB, photodiodes FD-256, high-speed camera "VideoSprint" and IAB-451 schlieren device. In both porous materials, the stationary detonation wave decoupled in the porous section of the channel into the shock wave and the flame front with velocity around the Chapman–Jouguet acoustic velocity. By the end of the porous section, the shock wave pressure reduction of 70% and 85% were achieved while using foam polyurethane and steel wool, respectively. The dependence of the flame velocity on the mixture composition (equivalence ratio) was determined. A non-monotonic influence of the porosity on the evolution of the detonation wave in the channel was observed.

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