EXPERIMENTAL STUDY OF DDT FOR HYDROGEN-METHANE-AIR MIXTURES IN TUBE WITH OBSTACLES

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INTRODUCTION

Many studies on the deflagration-to-detonation transition have been made in recent years in tubes, where weak ignition source was used. The consequence of detonation initiation is the flame acceleration along the tube leading to DDT. The transition phenomenon which is quite well understood today is largely based on the experimental observations in smooth tubes [1]. One of the previous illustration of the physical processes of transition from deflagration to detonation was given by Urtiew and Oppenheim using stroboscopic laser Schlieren photography [2]. Considering experimental research of DDT in obstructed tubes, it should be noted that one of the previous study was conducted by Chapman and Wheeler [3] who placed an orifice plates in a smooth walled tube in order to promote flame acceleration. In their research the maximum flame velocity in the 5 cm inner diameter tube without obstacles for methane-air mixtures was about 10 m/s. But the same tube with orifice plates gave a maximum flame velocity over 400 m/s. Unfortunately, during this experimental research a transition moment was not observed, due to limited diameter of the tube. In the few next decades a lot of experimental investigations were performed to see how the DDT occurs in obstructed channels. Significant work was done in this area by Shchelkin [5, 6], Lee, Knystautas, Teodorczyk [4], Shepherd [7] and others. Shchelkin [5] proposed that flame acceleration was governed by turbulent fluctuations in the unburned gas ahead of the flame that led to an increase in flame area. Since the unburned gas velocity is related to flame velocity there is a feedback loop between the flame velocity and flame area that results in efficient flame acceleration.

According to characteristic features of DDT processes given by Lee and Moen [8] and others, the phenomenon of detonation transition can be generally divided in two phases which are in particular [9]:

a) creation of conditions for the onset of detonation by processes of flame acceleration, vorticity production, formation of jets and mixing of products and reactants,
b) formation of the detonation wave itself or the onset of detonation.

It should be also noted, as given by Dorofeev [10], that in obstructed tubes with relatively small blockage ratio (BR), which is less than roughly 10%, the characteristic features of the flame acceleration process leading to DDT is similar to smooth tubes.

EXPERIMENTAL RESEARCH

To investigate the deflagration-to-detonation transition for stoichiometric hydrogen-methane-air mixtures experimental studies were performed in 6 m long circular cross section tube with inner diameter D = 140 mm (full diameter of 170 mm). The initial conditions of stoichiometric hydrogen-methane-air mixtures were 1 atm and 293 K with different hydrogen content. The flame propagation and pressure wave were monitored by pressure transducers and ion probes. Pressure transducers were located at different positions along the channel to collect data concerning DDT and detonation development. Experimental set-up is shown in Fig. 1.

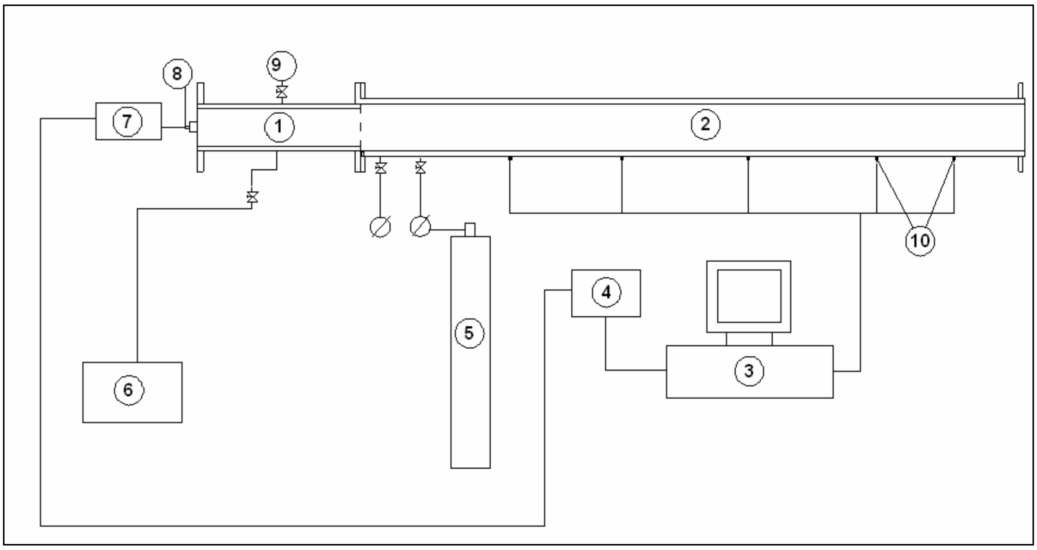

Figure 1. Experimental set-up where: **1** – driver-section tube, **2** – test-section channel, **3** – PC and data acquisition system, **4** – time sequencer, **5** – hydrogen-methane-air cylinder, **6** – pomp, **7** – ignition device, **8** – ignitron plug, **9** – dillution valve, **10** – pressure transducers and ion probes.

Experimental channel is consisted of four sections (2 x 2 m and 2 x 1 m) jointed together and with different configurations of obstructions inside. Configurations of obstacles are used with BR from 0.3 to 0.7. An internal diameter (d) of particular circular obstacles is chosen between 77 mm up to 117 mm and number of obstacles varies from 12 to 35. Obstacles inside the tube are located at various distance which is equal to 1 x D = 140 mm, 2 x D = 280 mm and 3 x D = 420 mm. Fig. 2 shows the schematic location of obstacles along the tube.

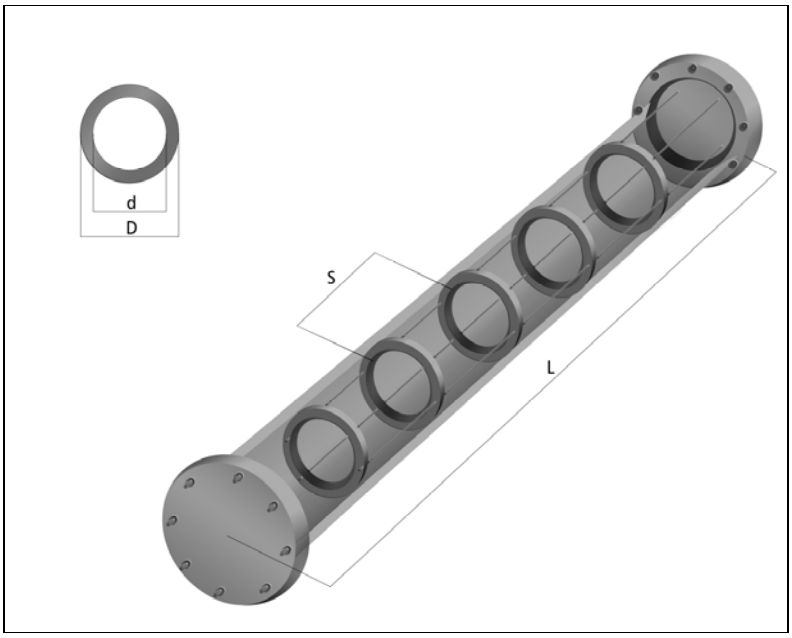

Figure 2. Schematic location of obstacles along the tube.

The aim of this study is to investigate the mechanism of deflagration-to-detonation transition and its physical properties in obstructed channel and the influence of different obstacles regimes which can give a DDT moment for hydrogen-methane-air mixtures in 6 m long tube. Whole results from this study will be presented during the ICDERS on the Work-In-Progress Poster session.

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