# Mixture of Initial Reagents with Hot Detonation Products as the Subject of Studies in the Shock Tube

**V.I. Tarzhanov**

Russian Federal Nuclear Center – All-Russian Research Institute of Technical Physics, Snezhinsk, Chelyabinsk region, 456770, Russia

E-mail: tar@gdd.ch70.chel.su

Recent publications have formulated basic mechanisms of deflagration-to-detonation transition (DDT) in unconfined clouds of emergency industrial releases of fuel gases. For example, paper [1, 2] states that these are: (*i*) large-scale energetic eddies found in the unburned gas in the turbulent pockets behind obstructions or ahead of flame jets, (*ii*) a sufficiently intense fine structure of turbulence required to enhance the mixing of hot combustion products with initial reagents in the above eddies, (*iii*) a gradient field of induction time in the turbulent pocket; this field is needed to bring about shock wave amplification by the coherent energy release [3, 4].

Publications [5, 6] propose the way and the facility (Fig. 1) which can be used for quantification of the above DDT mechanisms, individually or in complex, in sufficiently insensitive fuel mixtures, i.e. in the propane-air mixture under atmospheric pressure.

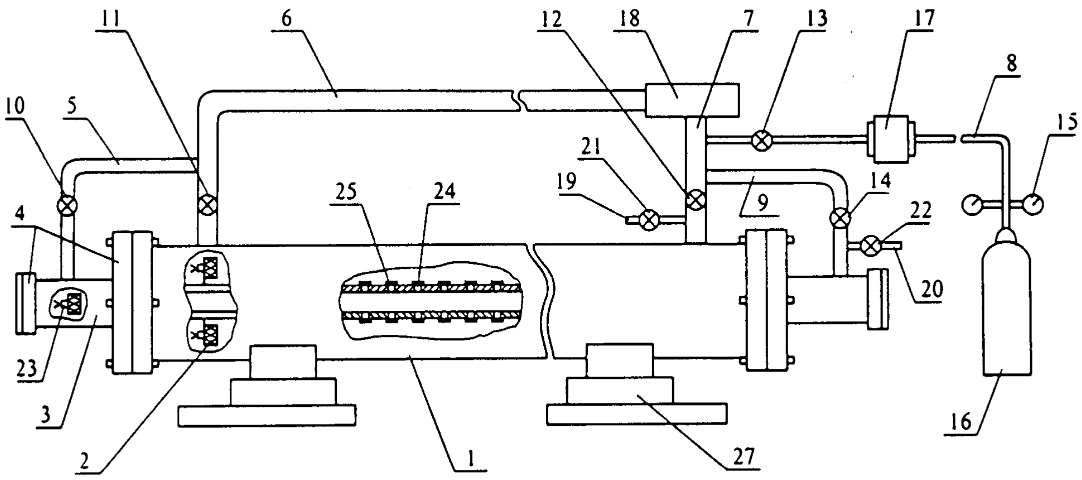


Fig. 1. TSD -01M facility (Tube of Spontaneous Detonation).
1-main tube; 2-detonation initiator (HE charge); 3-small tube for injecting hot detonation products; 4-sealing flanges; 5÷9-tubes with valves 10÷14; 15-pressure regulator; 16-cylinder with propane; 17-gas meter; 18-fan; 19, 20-branch pipes with valves 21, 22 for the connection of mixture volume compensators; 23-initiator of detonation in a small tube;24-holes in the small tube walls; 25-destructible orifice plates (optional); 27-support.

In the case of rapid quasi-homogeneous (in the tube cross-section) injection of hot detonation products from a small perforated tube into the main coaxial tube of the facility the area containing the mixture of initial cold reagents with hot detonation products is formed beyond the perforated portion of the small tube. The rest volume of the main tube continues to be occupied by cold initial reagents. The fastest regime of combustion in the small tube, and namely detonation, can be chosen for attaining maximum possible mixing of hot detonation products into initial reagents. This allows operation within the time scale of radical activity (€ 10 ms). It is also possible to use conventional gas combustion in the small tube with quasi-simultaneous gas ignition in length or with ignition from one of the tube ends. Varying detonation direction in the small tube as well as varying the extent of tube perforation in length areas of the mixture having variable value and sign of HDP concentration gradient including a zero gradient can be created in the facility volume studied. Parameters of small tube perforation (diameter of holes, density of their location, length of the perforated portion) can be associated with parameters of turbulence in the mixture of initial reagents with hot detonation products. In so doing one characterizes three scales of turbulence, which are associated with: (*i*) a single jet of hot detonation products from one hole, (*ii*) multiple jets of hot detonation products, (*iii*) the length of the created area of HDP mixture.

Therefore, in the proposed experimental facility the three above stages of DDT in the unconfined cloud of a fuel gas emergency release are separated out and studied like under the magnifying glass.

Basic parameters of TSD-01M facility:

- Length of the main tube – 17 m.
- Inside diameter of the main tube – 402 mm.
- Outside diameter of the HDP injection tube – 159 mm.
- Inside diameter of HDP injection tube – 149 mm.
- Diameter of perforation holes in the injection tube – 7 mm.
- Number of holes in one cross-section – 8.
- Spacing between lines of holes – 55 mm.
- Type of holes arrangement – triangular.
- Length of the perforated portion – 5500 mm.
- Delay in initiating the mixture with HDP from injection beginning – 0…3 s.
- Maximum attainable concentrations of HDP in the mixture with initial reagents:
  - Normal variant of injection – 10 mass %;
  - Inversion variant of injection – 80 mass %.

The proposed facility has the following diagnostics: 16 pressure gauges, 16 side and one face-end photodiode transducers, the electrocontact procedure (if necessary), the tracing procedure of smoked surfaces.

From among many types of experiments possible at TSD-01M facility the two are basic ones. Experiments of the first type initiate detonation in the small tube of the facility, and the delayed detonation is initiated in the main tube. Objective of these experiments is to identify detonation parameters for the mixture with hot detonation products, which condition detonability of this mixture (i.e. critical initiation energy). In experiments of the second type detonation is initiated only in the small tube of the facility with hot detonation products injected into the main tube. These experiments are aimed at registering spontaneous processes in the mixture with hot detonation products (deflagration flashes and spontaneous detonation). All experiments study detonation transition from the mixture with hot detonation products to cold reagents at the boundary of these areas. Experiments involving mixtures with large concentrations of hot detonation products are performed in the inversion setup when detonation is initiated only in the main tube. In this case hot detonation products are injected from the large volume of the main tube into the smaller volume of the small internal tube.

TSD-01M facility is created by RFNC-VNIITF experts: V.I. Tarzhanov, V.G. Vildanov, I.V.Telich'ko, A.D. Zinchenko, A.E. Makarov, A.F. Khanin, I.G. Koretsky, S.L. Mukhin, A.V. Vorob'ev, A.N. Grachev, V.A. Matkin, V.A. Potashnikov. Many technicians and workers have also greatly contributed to this work. By now more than 100 experiments are carried out at the facility. Some first results are presented in papers [7-9] at this colloquium.

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