EXPERIMENTAL INVESTIGATION OF HYDROGEN SELF-IGNITION AT THE DISHARGE INTO THE PRESSURE RELIEF DEVICE

Lenkevich D.A., Volodin V.V., Golub V.V., Baklanov D.I., Ivanov K.V.

Joint Institute for High Temperatures, Russian Academy of Sciences, 13-2 , Izhorskaya Street, Moscow 125412 , Russia, e-mail: dm.lenkevich@gmail.com

A pressure relief device (PRD) is a safety device that protects against failure of a pressure containment system by releasing some or all of the gaseous or liquid contents [1]. The rate of release must be fast enough to prevent a failure of the containment system.

PRD activation can be required by excessive pressure of the containment system. Most PRDs are designed to open, and thus release the system contents, when pressure reaches a predetermined level. For a full container in a hydrogen vehicle the release can last up to 5 minutes.

PRDs are widely used in industry; a large chemical plant can have 500 – 10,000 pressure relief valves [1,2]. The U.S. has 13,425 chemical plants, 16,292 plastics and rubber plants, and 2200 petroleum plants and there are several million PRDs in service in the U.S. [2]. The number of PRDs in service could soar if hydrogen vehicles enter widespread service.

There are two types of PRD failures. Type 1 is a failure where the PRD fails to vent properly. Type 2 is a failure where the PRD vents when it should not. Maintenance and inspection of PRDs is an important issue. These devices can become blocked by dirt or ice and thus not relieve when desired. Or they can become corroded or otherwise damaged such that they relieve pressure when they should not. Rupture disks (described below) are especially sensitive to corrosion and must be replaced at regular intervals [1].

As provided by European safety requirements every hydrogen cylinder must be supply with PRD. According to hydrogen self-ignition mechanism flaming is possible at the moment of burst disk opening. The important objects of investigation in this area are decreasing length of flame discharging from cylinder and possibility of hydrogen self-ignition reduction.

In the paper, self-ignition of high-pressure hydrogen releases into different models of PRD is investigated experimentally. The initial hydrogen pressure in the vessel and the geometry of model, which lead to ignition are analyzed based on an experimental investigation of the reacting gas discharge. Also the paper includes an experimental investigation of impulse jet structure. The transverse shocks being formed at the burst disk failure give rise to the heating and ignition of hydrogen-air mixture.

The goal of this investigation is experimental determination of governing physical phenomena affecting the hydrogen self-ignition at the discharge into the PRD filled with air and making suggestions of its enhancement.

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