

Re-initiation of Detonation Waves behind a Perforated Plate

**Jayan Sentanuhady, Yutaka Tsukada, Teruo Yoshihashi, Tetsuro Obara
and Shigeharu Ohyagi**

Department of Mechanical Engineering, Saitama University
Saitama, JAPAN 338-8570

Corresponding author, S.Ohyagi: sohyagi@mech.saitama-u.ac.jp

Introduction

Propagation of detonation through perforated plate located inside a tube is of interest for practical uses to suppress accidental detonation hazards in industries. Fundamentally, it is related to the critical tube diameter problem for an orifice plate with a single hole. Ciccarelli[1] had reported the observation on the detonation propagation through an orifice plate (10 cm orifice in 27.3 cm tube) and argued a critical value of the ratio d/λ . The present paper has been motivated by the practical problems but the discussions should be made based on the critical tube diameter concept. Particular importance lies on the re-initiation phenomena which may be influenced by the presence of the tube wall. This study focuses on the re-initiation process behind a perforated plate with a single hole or multiple holes.

Experimental

The experiments were carried out by using the detonation tube facility in Thermal Engineering Laboratory of Saitama University. Figure 1 shows the schematics of the tube which has a cross-section 25 mm x 30 mm. The perforated plates are 5 mm thick with a hole diameter $d = 1$ to 5 mm. Two types of the plate are prepared, a single hole and multiple holes. For the multiple holes, a distance between each hole is set equal to d . In addition, porous metal plates with porosity 2 to 120 μm are tried. A stoichiometric oxy-hydrogen mixture at 101 kPa is selected as a test gas. The cell size λ of this mixture is about 1.4 mm so that the ratio d/λ ranges from 0.7 to 3.6. Pressure transducers and ionization probes are embedded in the tube wall at 500 mm interval. Soot tracks are recorded behind the plate by using aluminum thin plate attached to the inside tube wall.

Results and Discussion

For the porous plates used, there is no evidence of re-initiation or transmission of the detonation wave and combustion wave. The only effect of the porous plate is the strength of the reflected shock wave. The higher porosity causes the reflected shock wave weaker as expected.

Figures 2 show pressure histories and ionization current records for the single and multiple perforated plates with $d = 1$ mm. It is observed from the pressure record behind the plate that the detonation wave transmits through the plate for both cases. For the single holed plate, it cannot be explained by the critical tube concept which states that the CJ detonation wave will be quenched if $d/\lambda < 13$. But in this case, the thickness of the plate is too small to establish the CJ wave inside the hole. The difference between the single and the multiple appears in the arrival time of the transmitted detonation wave at P3. It shows that a time for re-initiating detonation for the single plate is much larger than that of the multiple holed plate. Figure 3 shows a typical soot track record for the single holed plate. Numeral 250 denotes the distance from the plate in mm. It can be imagined that the re-initiation of detonation occurs at a point near the tube wall and spreads to the whole tube. For the multiple holed plate (Fig.4), there is no clear trace of initiation as that of the single case, but the detonation cellular structure appears earlier.

Concluding Remarks

The re-initiation phenomena are observed behind a thin perforated plate. These phenomena are not only dependent on the ratio d/λ , but also on the thickness as well as the size of the tube.

References

- 1) Ciccarelli, G., Boccio, J. L., Detonation Wave Propagation Through Single Orifice Plate in a Circular Tube, Twenty-seventh Symposium (International) on Combustion, Vol. 2, 1998, pp. 2233-2239.

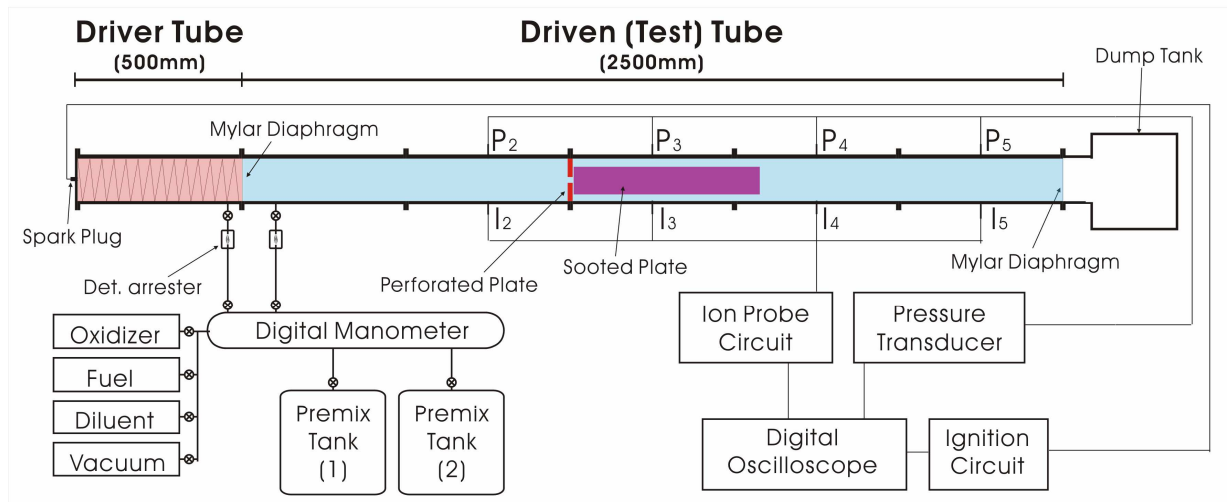


Fig. 1 Schematics of Experimental Apparatus

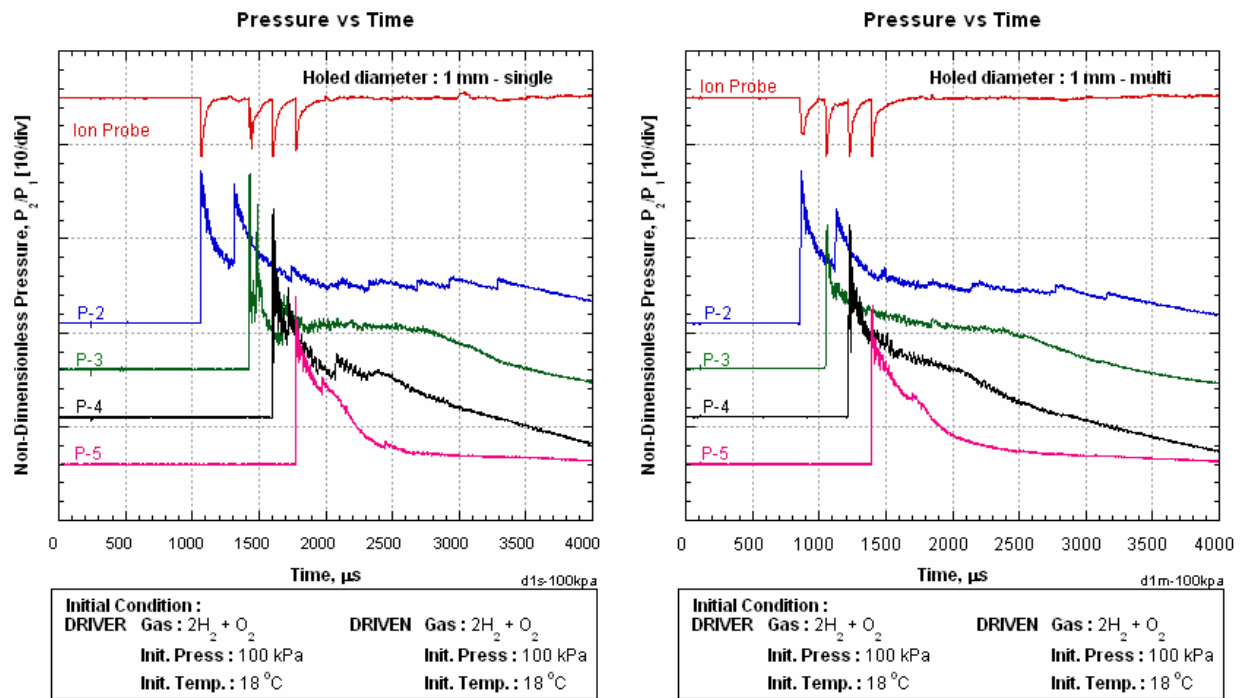


Fig.2 Pressure and Ionization Current Records for Single Holed Plate (left) and Multiple Holed Plate (right), $d = 1$ mm

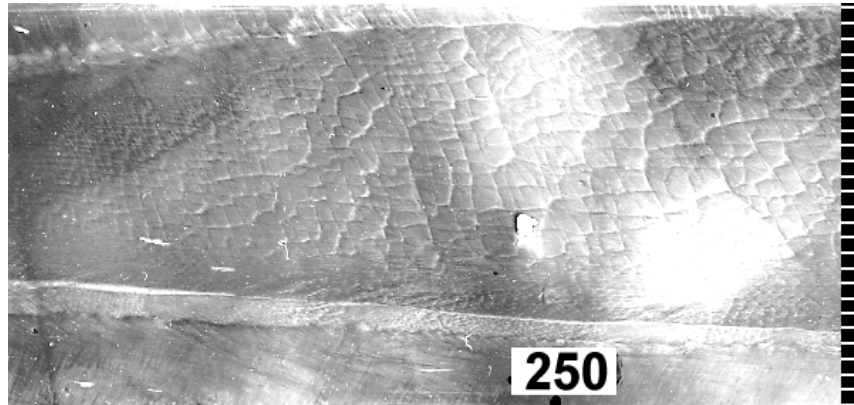


Fig.3 Typical Soot Track Record of the Re-initiation from a Single Holed Plate



Fig.4 Typical Soot Track Record of the Re-initiation from a Multiple Holed Plate