A study on the pressure behaviour during the rupture by gas explosion

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ABSTRACT

The destruction by accident is affected by the blast of explosion. However, there are few of research on the external effect of vented gas explosions. Therefore it is necessary to study the effect of vented explosion.

This study aims to find the characteristics of gas explosion, and the effect of vented gas explosion. Using an explosion chamber, we obtained a LPG explosion characteristics according to the vent size and concentration.

The result of experiment showed that the explosion pressure effect to external space was much stronger than inner space during the course of a gas explosion. And the external pressure become higher in explosion pressure as the vent diameter become smaller.

INTRODUTION

Nowdays, the daily consumption and demand of fuel gas for industry and civil use, such as LPG(Liquefied Petroleum Gas), increase rapidly. And the probability of explosion and fire accident caused by the burning of fuel gas is increasing too. Considerable reseach has been undertaken on the data of the internal explosion pressure and it has resulted in the issue of a number of guidance documents. However, there are few of research on the external effect of vented gas explosions. These external effect need to be considered so that appropriate protection can be provided for people and installation nearby.

The object of this paper is to review available data on the inner characteristics of vented gas explosion and on the external effects. The research is based on the result of studies of Fuel-Air Explosion by T.Hirano[1] and D.M.Sorberg.[2]

EXPERIMENTAL METHOD

Fig. 1. shows the Schematic diagram of experimental apparatus used for the this work. The volume of explosion chamber used for this experiment is 20 ℓ and a rupture disk was fitted into the upper half of the front wall of chamber. The flammable gas was injected into the explosion chamber through rapid acting valve and the valve was positioned in the back side of the chamber. The flammable gas was ignited by 15Kvolt igniter that set at the three points (front, center, rear).

Pressure measurements were made both inside and outside the explosion chamber. The internal pressure transducer was located in the upper of rupture wall. The external pressure transducers were set on the center line of the 20 ℓ chamber at distances of 10 cm, 20cm, 30cm, 40cm and 50cm from the rupture disk. Fig. 2. shows schematically the location of pressure transducer and positions of ignition.

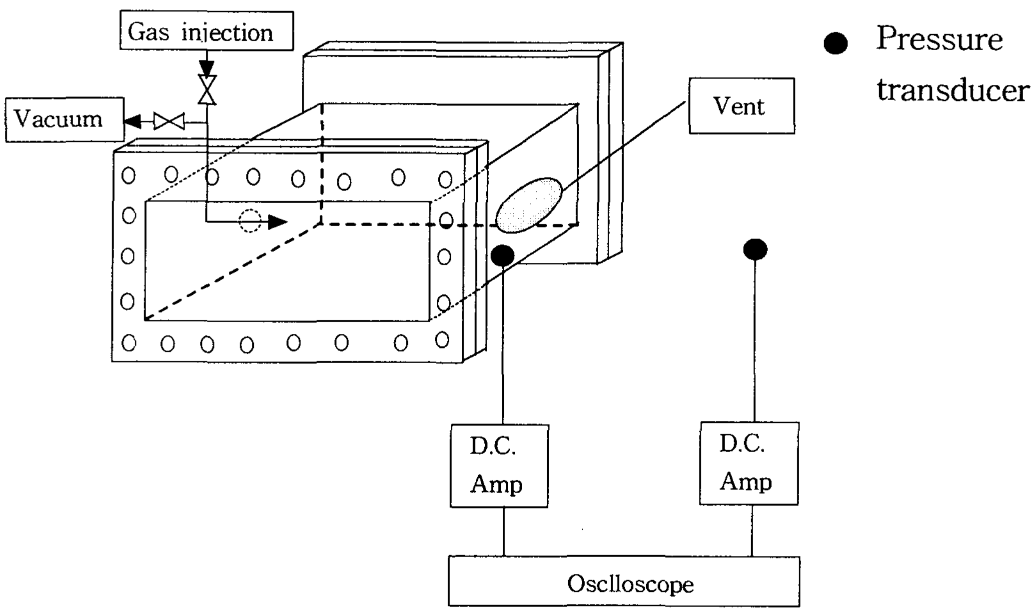


Fig. 1. Schematic diagram of experimental apparatus.

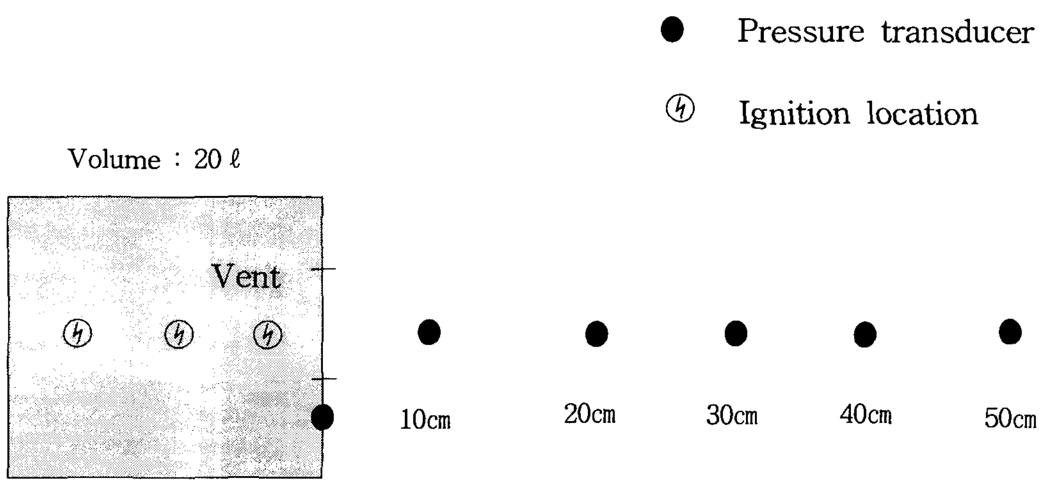


Fig. 2. Schematic diagram of ignition source and pressure transducer location.

The sample gas used in this experiment were volumetric LPG of propane and the composition of mixture were varied from 3.5 to 7.7Vol% in ratio of LPG with air. After vacuumizing chamber, the gases were injected and the gas mixtured in the chamber was ignited by 15 Kvolt ignition switch. After ignition, rapid explosion blast was observed through oscilloscope by pressure transducer. The explosion phenomena was visualized like the Fig. 7.

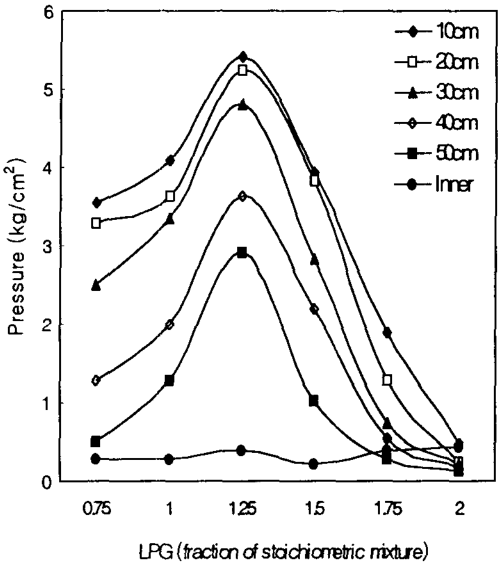
The velocity and pressure of the blast wave were measured by the oscilloscope.. The gas concentration, vent size and ignition position were changed for get the available data. The experiments were performed repeatly by these methods.

Table 1. Specification of experimental apparatus.

Instrumentation equipment	Manufacture	Model number	Capacity
Sensor	Kyo wa	PGM-50KB	50kg/cm²
High voltage ignition unit	KOOK IL	K1-102	15kV
Strain amplifier	San-ei	AS2102	
Osciloscope	LeCroy	LeCory 9400	
Plotter	Hewlett packard	7475A	

RESULTS AND DISCUSSION

The results of this work are presented in Fig.3 to Fig.6. These result shows the maximum external pressure under all experimental conditions.



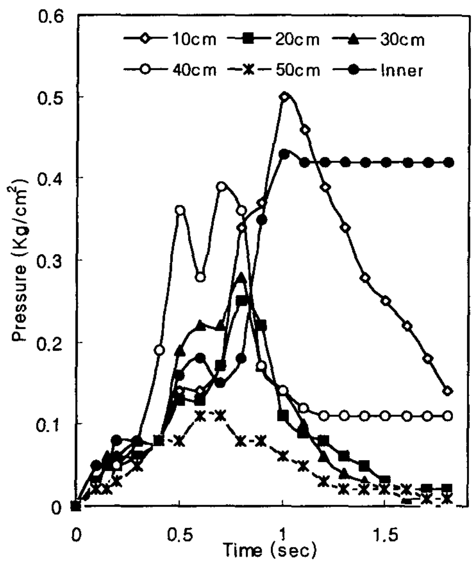


Fig. 3. Maximum explosion pressure and fraction of stoichiometric. (LPG)

Fig. 4. Typical blast pressure history for stoichiometric ratio-2.

The experimental conditions used in the study are summarised below:

- Vent diameter - 75mm
- Ignition position - center of chamber
- Stoichiometric ratio - 0.75 ~ 2

Fig. 3 shows that the maximum explosion pressures were observed at the stoichiometric ratio 1 ~ 1.5 and when distance was far from the relief vent, explosion pressure was decreased.

Fig. 4 shows the data which are characteristics of explosion pressure for distance at the stoichiometric ratio of 2 and the change of pressure was feeble. It showed that the pressure of explosion was hardly generated because the effect of combustion was superior to that of explosion when the expolsion pressure was below 1kg/㎠.

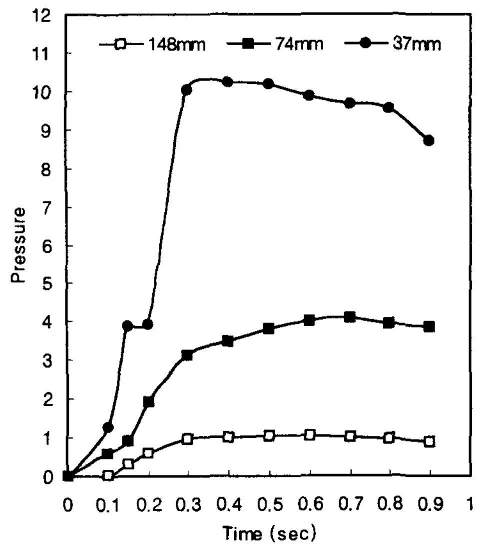


Fig. 5. Typical blast pressure history for various vent sizes at 10cm. (stoichiometric ratio=1)

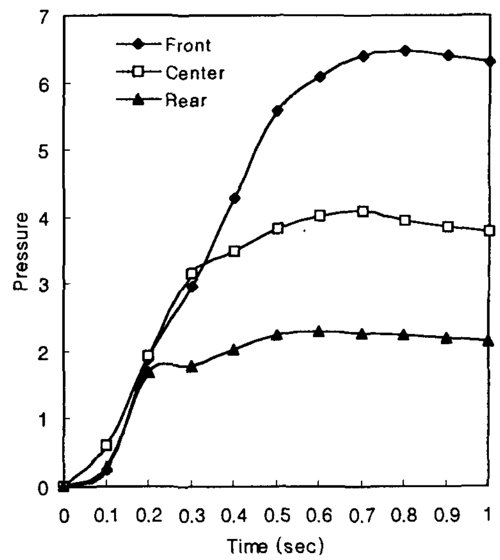


Fig. 6. Typical blast pressure history for ignition points at 10cm. (stoichiometric ratio=1)

Fig. 5 is a plot of showing the external explosion pressures measured at the distance of 10cm from the vent opening. The experiment method was showen in Fig. 2. Genernally, pressure variation in unconfined explosion is related to gas flow.[3] We varied the vent size, but internal explosion pressure time history did not changed. On the contrary, external pressure effect varied vigorously. On the condition of different vent size, the maximum explosion pressure increase quickly with the decrement of vent diameter. These phenomena can be explained by the effect of the rate of pressure rise of explosion and the rate of gas release through the vent.

When the vent diameter was 37mm, the rate of pressure rise appreared higher than the rate of gas release and in case of 148mm the pressure history did not changed so much, because the rate of pressure rise and rate of gas release were almost the same. These phenomena of explosion behavior can be obtained at the other concentration. The explosion pressure distribution in smaller vented area was similar to that of closed space.[4]

As shown in Fig. 6, the explosion pressure was affected by ignition position. In vented vessels, ignition at near the vent opening had high explosion pressure. It is owing to the fact that explosion pressure was reinfoced by the effect of reflected waves.

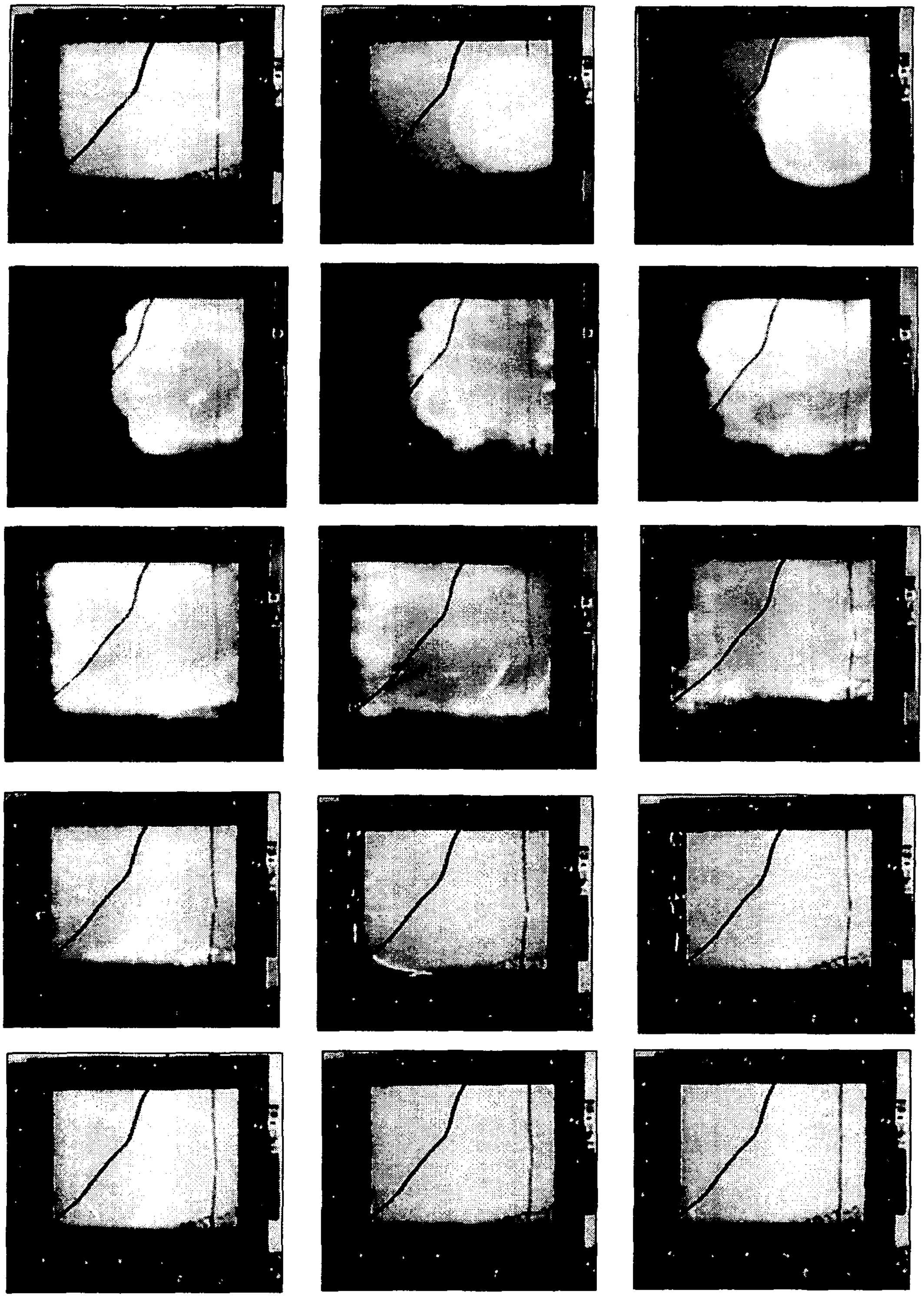


Fig. 7. Frame mode photographs of the development of pressure in stoichiometric LPG, (45ms/frame) : the inner part of the chamber.

CONCLUSIONS

The pressures generated by the vented gas explosion have been measured and the effects on vent size or ignition position have been observed. The results are shown as following:

- The dependancy of concentration were presented that stochiometric ratio of 1～1.5 had high explosion pressure and the phenomena of combustion was observed in stochiometric ratio of 2.

- The maximum rise rate of explosion pressure varied increasingly from 3.6 to 60.7㎏/㎠/sec in stochiometric ratio of 1.

- When ignition point was far from the relief vent in stochiometric ratio of 1, the maximum explosion pressure varied decreasingly from 6.48 to 2.29㎏/㎠.

REFERENCE

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