19th International Symposium of Ballistics, 7–11 May 2001, Interlaken, Switzerland

A LEADING-DETONATION-TUBE IGNITER AND ITS FIRING RESULTS IN A HIGH LOADING DENSITY SEPARATED-LOADED GUN

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By using fast propagation property of detonation wave, a leading-detonation-tube igniter is designed, in which the leading-detonation-tube is placed in a igniter. The static experiments of the leading-detonation-tube igniter show that its average flamespreading velocity is about 200~500 m/s in a 420 mm igniter. Above all, by controlling the positions of venting holes at the leading-detonation-tube, some points can be ignited in advance. The leading-detonation-tube igniter is used in the main cartridge of a high loading density separated-loaded gun. The firing results show that the pressure wave ($-\Delta\rho_1$) decreases to below 5 MPa, whereas if Bennite propellant or black powder is used in the center-core igniter of main cartridge and other conditions are as usual, the pressure wave is about 60 MPa.

INTRODUCTION

In order to improve gun performances, there are many high-energy propellants used in charge structure and propellants are highly loaded. Especially in a high loading density separated tank gun, ignition non-uniformity is obvious. It is very important to ignite propellant in subsidiary cartridge quickly. In the past years, there are many new type igniters arisen, such as laser ignition, plasma ignition, explosively-networks ignition, new type electric ignition, and so on. By using fast propagation property of detonation wave, a leading-detonation-tube igniter is designed, in which the leading-detonation-tube is placed in a igniter. The leading-detonation tube ignition is one of the most prosperous ignition technology, because it has so many advantages. It may hold solutions to the difficulty of achieving effective ignition of a two-piece cartridge for the tank cannon gun system or the modular artillery charge system for artillery. In this paper, the static experiments of the leading-detonation-tube igniter are conducted. It is shown that its average flamespreading faster than that of black powder at the same conditions. Above all, by controlling the positions of jet holes at the leading-detonation-tube, some points can be ignited in advance. The leading-detonation-tube igniter is also used in the main cartridge of a high loading density separated-loaded gun. The firing results show that the pressure wave is greatly reduced. It play an important role in decreasing pressure wave and improving safety of high loading density separated-loaded gun.

THE STATIC EXPERIMENTS OF THE LEADING-DETONATION-TUBE IGNITER

The leading-detonation-tube igniter is a technology which uses the quick flame-spreading property in a fashion of detonation wave. The quick and uniform ignition can be achieved. The objective of the static experiments of the leading-detonation-tube igniter is to study its ignition & flamespreading property and the relative influencing factors. The static experiments are conducted in the metallic ignition simulators whose length is 210 mm and 420 mm respectively. Because the detonation must be initiated by a shock, the plastic leading-detonation-tube is initiated by an elaborately designed initiator and detonation wave can propagate in the inner of the leading-detonation-tube. If there is no initiator, the plastic leading-detonation-tube can not produce detonation and it can only burn slowly. In some positions, the vent holes are placed to adjust the whole ignition property. In the surrounding, the black powder or Benite propellant is placed. The length of the leading-detonation-tube is same as that of the ignition simulator. There are four piezo-electric transducers used to record the pressure history at four positions along the ignition simulator. By analyzing the pressure curves, the ignition & flamespreading property of the leading-detonation-tube igniter can be detected. The typical experimental curves are shown in Fig. 1~Fig. 3.

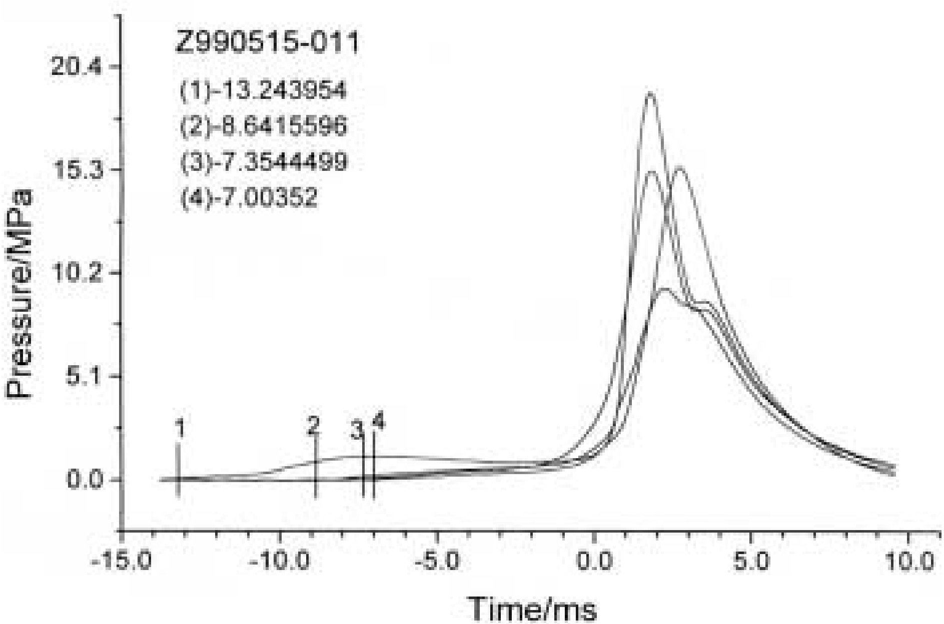

Figure 1: Pressure versus time curves of leading-detonation-tube ignition simulator (3 venting holes, 210 mm).

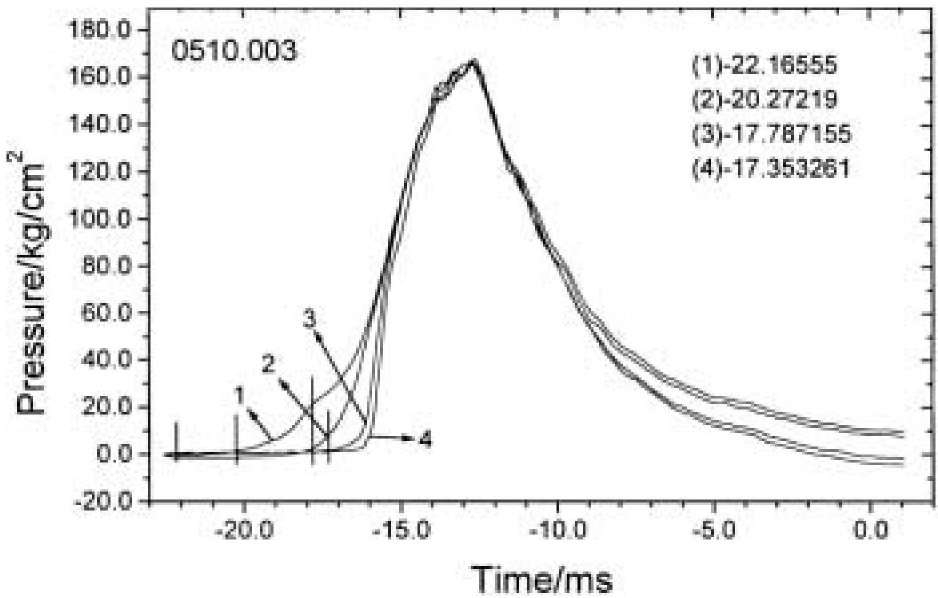

Figure 2: Pressure versus time curves of leading-detonation-tube ignition simulator (3 venting holes, 420 mm).

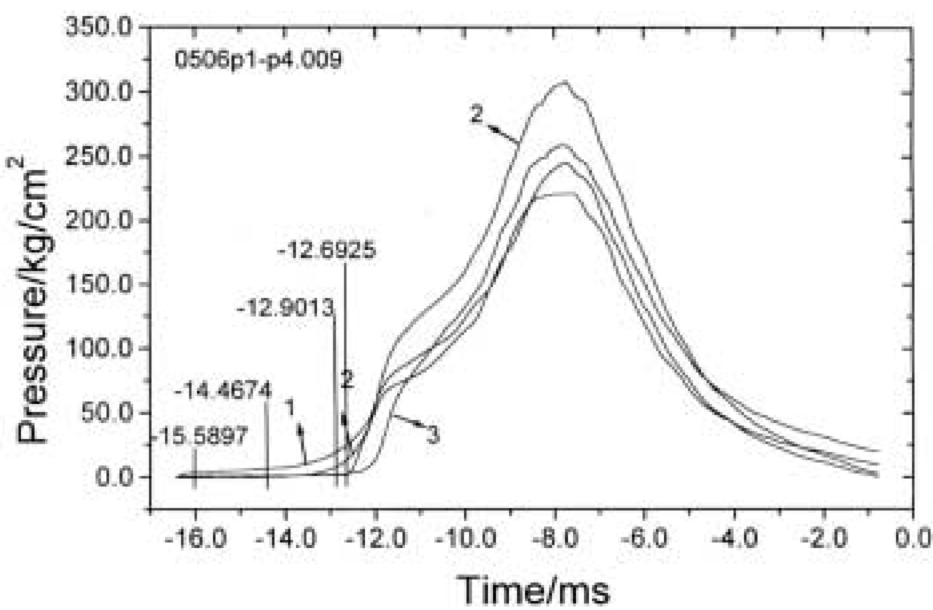

Figure 3: Pressure versus time curves of leading-detonation-tube ignition simulator (1 venting holes, 420 mm).

The Effects of the Leading-Detonation-Tube Length

In a 210 mm ignition simulator, 13 g black powder is distributed in the whole length and there are 3 venting holes in the plastic leading-detonation-tube. Pressure versus time curves of 4 piezoelectric transducers are shown in Fig. 1. The average flamespreading velocity between No. 3 and No. 4 transducers is about 165 m/s. On the other hand, In a 420 mm ignition simulator, 18 g black powder is also distributed in the simulator chamber and there are also 3 venting holes in the leading-detonation-tube. Pressure versus time curves of 4 transducers is depicted in Fig. 2. The average flamespreading velocity between No. 3 and No. 4 transducers is about 245 m/s. Because developing detonation is a process, it is beneficial to increase the flamespreading velocity in a longer simulator.

The Effects of Venting Holes in the Leading-Detonation-Tube

In order to study the effects of venting holes, two comparison experiments are conducted in a 420 mm simulator, shown in Fig. 2 and Fig 3. respectively. In Fig. 3, the average flamespreading velocity between No. 3 and No. 4 transducers is about 510 m/s. If there are 3 venting holes in the plastic detonation tube, the detonation pressure decrease and the detonation wave is developed slowly. On the other hand, by placing the venting holes in the plastic detonation tube, the first ignition position can adjust freely.

The Comparison Between Leading-Detonation-Tube igniter and Common Black Powder Snake Bag Igniter

In the same 420 mm ignition simulator, a 18 g black powder snake bag is put in the ignition simulator. By analyzing the experimental results, it is found that the average flamespreading velocity is about 50 m/s.

FIRING RESULTS IN A HIGH LOADING DENSITY SEPARATED LOADED GUN

An armour-piercing ammunition is loaded separately which is composed of a main and a subsidiary cartridges. There is an ullage between the two cartridges, shown in Fig. 4. In this kind of charge structure, the ignition conditions are harsh, the ignition uniformity is very important for gun safety. On the basis of the static experiments of the leading-detonation-tube igniter, the leading-detonation-tube igniter is used in this charge structure. Several charge structures are selected as following.

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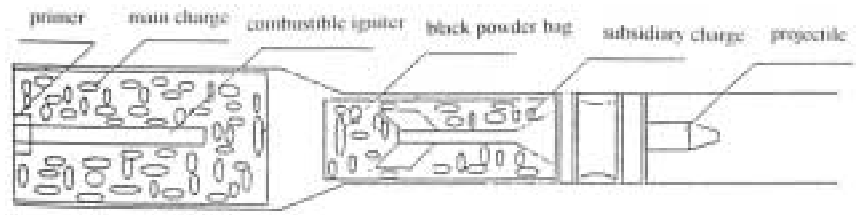

Figure 4: The sketch of a separated loaded charge structure.

(1) Only Benite propellant and black powder in the main cartridge, a black powder bag in the subsidiary cartridge. The firing results show that the pressure wave ($-\Delta\rho_1$) is about 60 MPa. The pressure versus time curve is shown in Fig. 5.

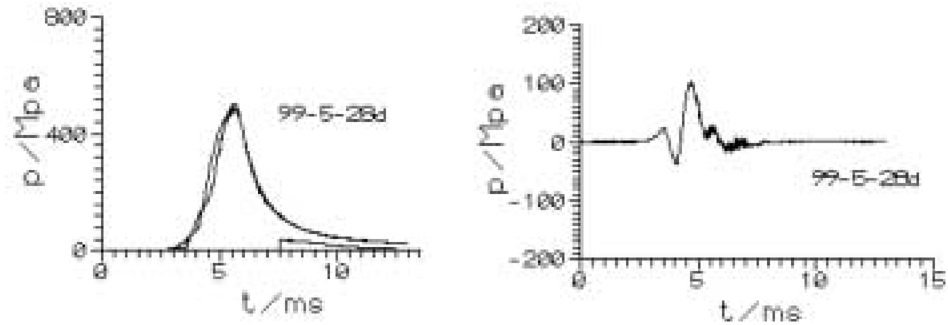

Figure 5: The p ~ t and $-\Delta\rho_1$ ~ t curves of charge structure 1.

(2) Benite propellant and black powder in the main cartridge, a plastic leading-detonation-tube which has a vent hole in the subsidiary cartridge. The pressure wave ($-\Delta\rho_1$) is about 36 MPa, shown in Fig. 6.

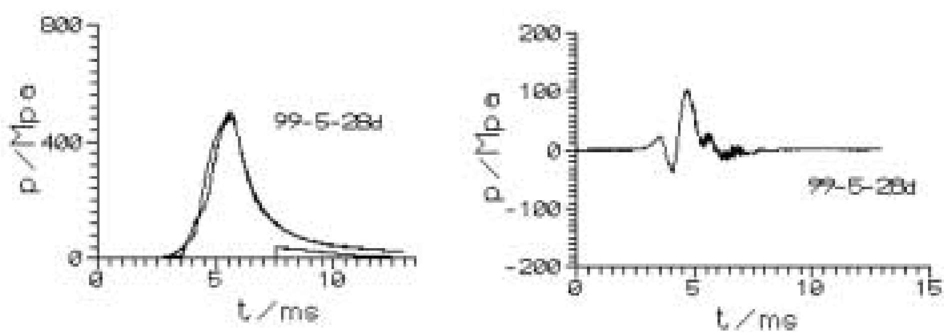

Figure 6: The p ~ t and $-\Delta\rho_1$ ~ t curves of charge structure 2.

(3) Benite propellant and a plastic leading-detonation-tube which has two vent holes in the main cartridge, a black powder bag in the subsidiary cartridge. The pressure wave ($-\Delta\rho_1$) is about 46 MPa, shown in Fig. 7.

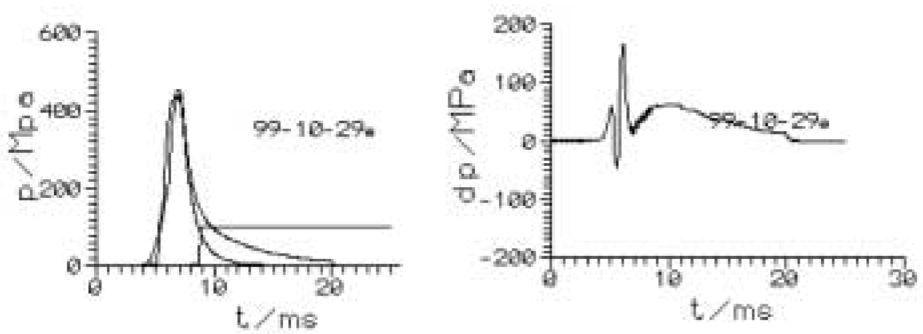

Figure 7: The p ~ t and $-\Delta\rho_1$ ~ t curves of charge structure 3.

(4) Benite propellant and a plastic leading-detonation-tube which has only one vent hole in the top in the main cartridge, a black powder bag in the subsidiary cartridge. The pressure wave ($-\Delta\rho_1$) is lower than 5 MPa, shown in Fig. 8.

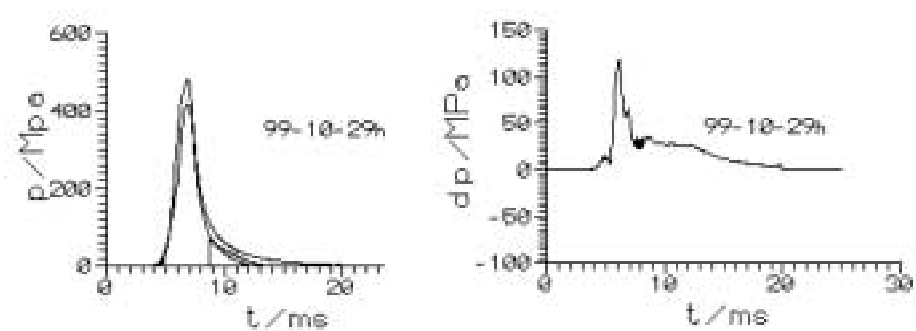

Figure 8: The p ~ t and $-\Delta\rho_1$ ~ t curves of charge structure 4.

According to the above firing experiments, the leading-detonation-tube igniter is a good scheme. But it must match with the charge structure, good experimental results can be obtained.

CONCLUSIONS

(1) On the basis of the static ignition performance experiment, we conclude that the leading-detonation-tube igniter is a good ignition & flamespreading scheme. The flame-spreading velocity increases with the increase leading-detonation-tube length and decrease of the venting holes.

(2) The firing experiments in a high loading density separated loaded gun show that the leading-detonation-tube igniter is a practical igniter and can effectively reduce the pressure wave.

(3) The match of the leading-detonation-tube igniter with the charge structure is very complicated. Further research will concentrate on it.

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2. Zhang,X.B. 2000 Technical measures for restraining pressure wave effectively in high pressure guns. *NLG 2000-069-1*