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PREPARATION AND TESTING OF PRESSED PBXs FOR EXPLOSIVE REACTIVE ARMORS.

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ABSTRACT

A series of field tests were performed to assess the initiation and detonation of certain types of explosives under jet attack. These explosives are candidate to be used in the Explosive Reactive Armors boxes (ERA). The used explosives were four different formulations of pressed Plastic Bonded Explosives (PBX_S) prepared on site and a selected type of sheet explosive. The used conical shaped charges and detonators were prepared on site.

The Plastic Bonded Explosives were prepared using Hexogen explosive and the energetic binder Fluorel. The produced PBX_S beads were pressed in a special mold to a density of approximately 1.6 g/cm^3 in order to fabricate explosive sheets with certain dimensions. The residual depths of penetration of the jet in the mild steel in the presence of these compositions have been measured experimentally.

KEY WORDS

Explosives, Plastic Bonded Explosives, ERA, Shaped Charge, Initiation, Detonation.

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1. INTRODUCTION

Explosive sandwiches are the principal element of the well known and universally applied explosive reactive armors (ERA) for protection against shaped charges jets [1-5]. Here the type and thickness of the explosives are expected to have some influence on the performance of such ERA [6]. PBXs are candidate explosives to be used in such sandwiches. However, the precise knowledge of the initiation and detonation of such candidate explosives under jet attack need some investigations [7-8].

In general, PBXs are mainly composed of a polymeric binder, an explosive material and other minor constituents such as curing agents, catalysts, plasticizers and accelerators [9]. Other additives such as emulsifier, dispersing agents, antifreeze thickener, inhibitor and bonding agent, etc, are normally used to enhance the processing and improve some of the chemical or physical characteristics of such formulations. PBXs are characterized by good mechanical properties, good explosive properties, excellent chemical stability and relative insensitivity to handling and shock. In addition, PBXs are of high brisance and great resistance to humidity [10].

In this paper, PBXs based on Hexogen (explosive) and Fluorel (binder) were prepared using the slurry technique [11]. The prepared PBXs beads were pressed using a special mold to fabricate explosive sheets with certain dimensions. Field tests were carried out to study the initiation and detonation of the fabricated sheets and a selected type of sheet explosives under jet attack12]. The composition of the selected sheet explosive is 85% RDX + 15% Estane-Polyurethane [13].

2. EXPERIMENTAL

2.1 Preparation of PBXs based on Hexogen and Fluorel

The preparations were carried out using the slurry technique [12]. Fluorel binder of the chemical formula $[(C_3F_6)_{0.2}\text{-}(C_2H_2F_2)_{0.8}]_n$ and pure Hexogen (a product of Heliopolis Company for Chemical Industry, Egypt) were used. Fluorel is completely dissolved in acetone. On vigorous stirring Hexogen is added slowly to the lacquer. After 20-30 min, distilled water is poured drop-wise. After the complete addition of water, stirring is continued for 20-30 min and temperature is increased to evaporate the solvent. The formed beads are filtered off, washed with water for several times and dried at 70°C for 24 hours. Four PBXs formulations have been prepared according to Table (1). It is worth noticing here that determination of the grain size of Hexogen was of no practical importance since it was completely dissolved in the mother liquor of the binder and the solvent at the ambient temperature.

2.2. The fabrication of the sheet explosives

The prepared PBX_S beads were dried, weighed and filled in a special mold especially made for this work. Then, the beads were pressed at 100 atm using a hydraulic press. The weight of each sample was approximately 50 g and the attained densities were approximately 1.6 g/cm^3. Figure (1) is a photograph of the PBXs sheets after the pressing process. The diameter of the produced sheet was 80 mm and the thickness was 6 mm approximately.

2.3. The fabrication of the shaped charges and detonators

These processes were carried out using a special kit made by PHYWE SYSTEM, Germany. The dimensions of the used shaped charges and the detonator are shown in Figures (2-3). In preparing the shaped charges the used high explosive was waxed RDX (4.0 g) pressed inside the shaped charges at a density of approximately 1.5 g/cm^3, the used liner is made from a copper– tellurium alloy and has a base diameter of 14.9 mm, length of 23.5 mm and 60˚ conical part. The detonator case is made of aluminum with outer diameter of 12 mm and length of 30 mm. The detonators were prepared by pressing pure RDX (0.4 g) and Lead Azide (0.3 g) prepared on the lab scale.

2.4. Field test

The jet attack test is the main test which shows the efficiencies of the prepared sheets of explosives to decrease the residual depth of penetration of the jets in mild steel. Comparisons between the efficiencies of the prepared sheets of explosives with a selected type of sheet explosive were reported.

Jet attack test

Shaped charges with metallic liner and waxed RDX as explosive material were initiated at certain distances from the surface of the target module. The target components were a disc of explosive placed in a groove inside a mild steel plate and placed over eight mild steel plates (100 mm x 100 mm x 10 mm) fig (4). The tests involved changing the composition of the used sheet explosives, the type of the target material, the stand-off distance, the thickness of the explosive disc and the material of the shaped charge liner. For each charge, the effect of the shaped charge jets on the explosive discs was observed, and the measurements were mainly concerned with the determination of the residual depth of penetration formed by the jet into the rest of the steel plates under each disc of explosive.

3. RESULTS AND DISCUSSIONS

3.1 Effect of PBX_S composition

four shaped charges with cu liner had been initiated at stand-off distance [3D] to show the effect of changing the percentage of explosive in four types of the prepared sheets explosives with thickness= 6 mm. All of the four sheets of explosives had been initiated, and very small difference in the residual depth of penetration of the jet in the mild steel was observed (ranging between 25.2 mm to 26.1 mm), hence the composition (S_4) was selected which has the highest percentage of binder to be used in the next tests because it has the lower sensitivity to different types of stimuli than the other sheets and nearly the same efficiency.

3.2 Effect of target material type

The effect of the prepared PBX (S_4 composition) on decreasing the residual depth of penetration of shaped charge jet was compared with the selected type of sheet explosive and the passive armor of mild steel only. Three Shaped charges with cu liner had been initiated at stand-off distance [3D] to the targets where the thickness of the sheets explosives was 6 mm. It is concluded, from table (2), that the presence of the prepared sheet explosive with the mild steel decreases the residual depth of penetration by nearly 50% while the presence of the selected type of sheet explosive decreases the residual depth of penetration by nearly 44%.

3.3 Effect of stand-off distance

The effect of changing the stand-off distance of the shaped charge on changing the residual depth of penetration (in the passive mild steel, in presence of the prepared PBX [S_4] and in presence of the selected sheet explosive) was observed. Table (3) shows that as the stand-off distance increase from 1D to 6D, the residual depth of penetration decrease in presence of the explosive which means that the sheet explosive affect the penetrated jet performance with high efficiency as the elongation of the jet is completed.

3.4 Effect of explosive sheet thickness

Four different thicknesses of the sheet explosive [2mm, 3mm, 4mm, and 6mm] were prepared and the residual depth of penetration in the mild steel target of the jet formed from charge at 3D stand-off distance in presence of these sheets of explosive was measured. Table (4) shows that the thickness of the sheet explosive has a great effect on the residual depth of penetration of the jet where the residual depth of penetration decreases as the thickness of the sheet explosive increases.

3.5 Effect of shaped charge liner material

Shaped charges with copper liner and others with aluminum liner were prepared and initiated at stand-off distance 3D from the surface of the target, three different thicknesses of the sheet explosive were used over the target. Table (5) shows that the sheet explosive has a good efficiency of decreasing the residual depth of penetration in the mild steel target under the effect of different material type of liners, also by increasing the thickness of sheets explosive, the residual depth of penetration decreases under the effect of aluminum jet and copper jet. It is obvious from table (5) that shaped charge jets of copper liner have more penetration efficiency than shaped charge jets of aluminum liner.

4. CONCLUSIONS

It is concluded that the prepared PBX_S can be pressed in the form of sheets under high pressure and no significant difference was found between the prepared samples and the selected type of sheet explosives under jet attacks. Also, the thickness of the explosive sheet has a great effect on decreasing the residual depth of penetration of the jets. It is obvious that the stand-off distance of three times the base diameter shows the maximum depth of penetration of the jets in absence of the explosive sheet in this study and the copper liner in the used shaped charges give higher depth of penetration than the aluminum liner. Finally, it becomes evident that the prepared explosives demonstrated the same efficiency as the selected type of sheet explosives.

5. REFRENCES

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Table 1. The compositions of the prepared PBX_S

Item	Explosive compositions (wt %)			
	S_1	S_2	S_3	S_4
Fluorel	5	10	15	20
Hexogen	95	90	85	80

Table 2. The residual depth of penetration in presence of different target material at 3D stand-off distance

Target type	Residual depth of penetration (mm)
Mild steel	**54**
Mild steel + PBX	**26.6**
Mild steel + the selected sheet	**30**

Table 3. The effect of the stand-off distance on the residual depth of penetration

Stand-off distance (Base diameter)	Residual depth of penetration in passive mild steel (mm)	Residual depth of penetration in presence of the prepared [S_4] (mm)	Residual depth of penetration in presence of the selected sheet explosive (mm)
1D	**42.5**	**33.2**	**34.3**
3D	**54**	**26.1**	**30**
6D	**52**	**20**	**22.4**

Table 4. The effect of explosive sheet thickness on the residual depth of penetration

Thickness of sheet explosive	Residual depth of penetration
2 mm	**43.4 mm**
3 mm	**40.6 mm**
4 mm	**37.5 mm**
6 mm	**30 mm**

Table 5. The residual depth of penetration of aluminum jet and copper jet in presence of different thicknesses of the explosive sheets

Thickness of sheet explosive (mm)	Residual depth of penetration Aluminum jet (mm)	Residual depth of penetration Copper jet (mm)
2	**35**	**43.4**
4	**27**	**37.5**
6	**21**	**30**

Fig. 1. Photograph of the prepared PBXs Sheets

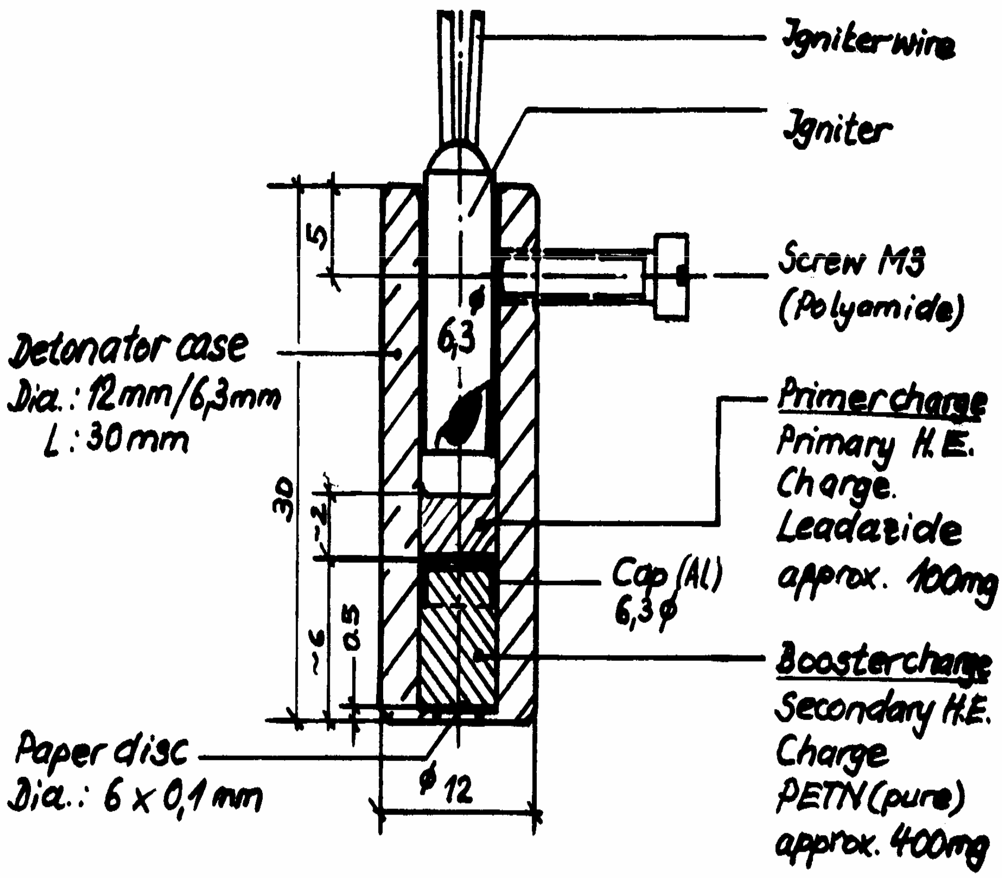

Fig. 2. Cross Section of the used detonator

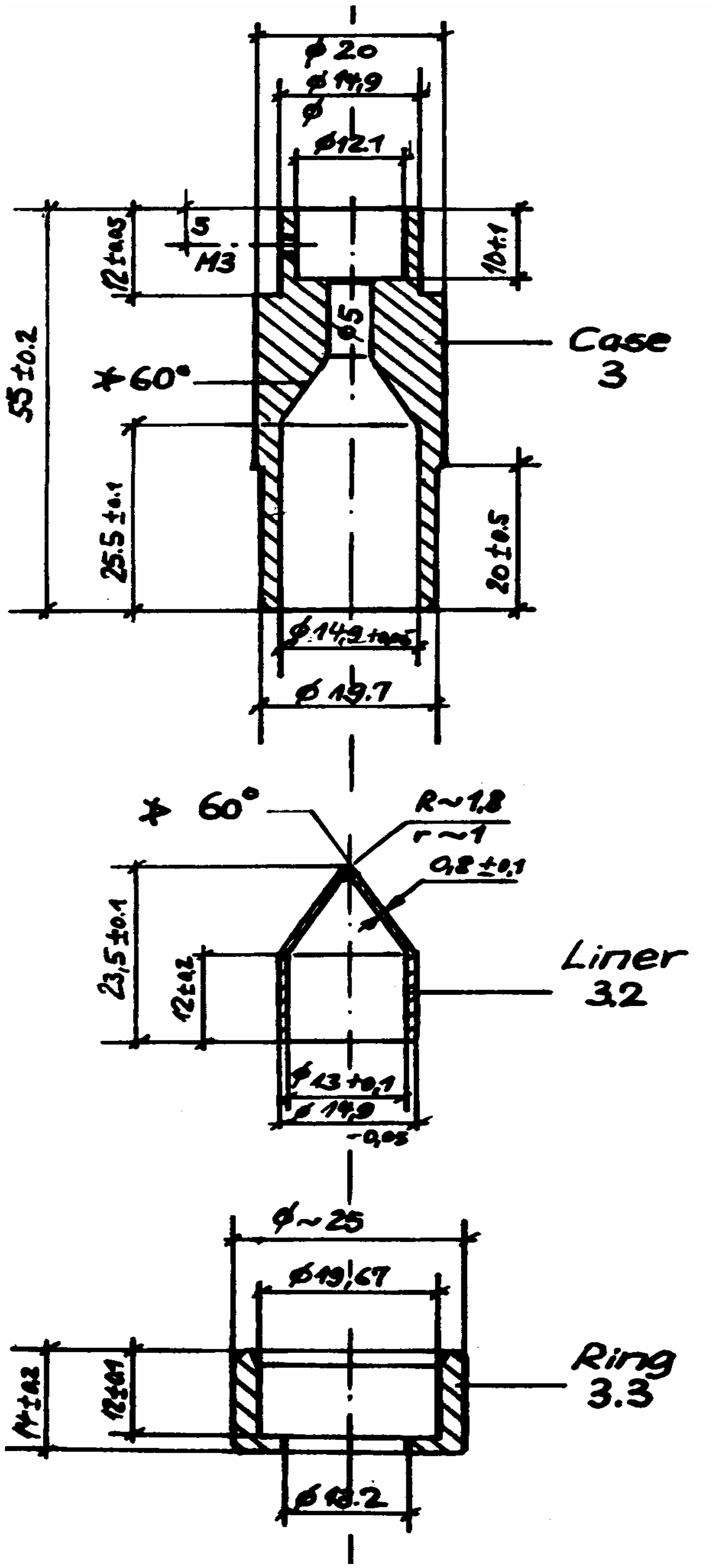

Fig. 3. Main components of the used shaped charges

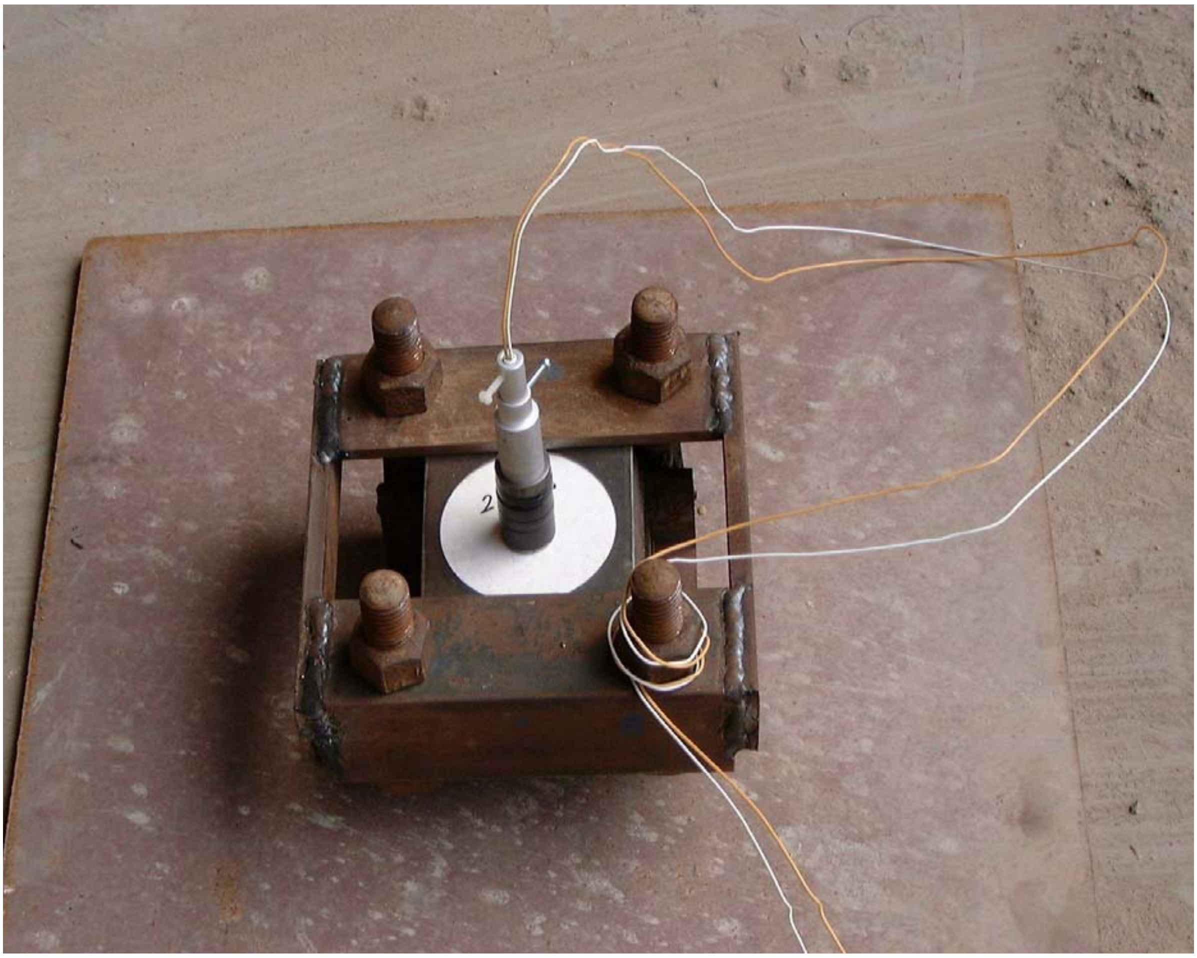

Fig. 4. The set-up of the jet attack test