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Thermal Responses of PBX-6 Explosives Components

Institute of Chemical Materials, CAEP

Dayuan GAO, Zijian LYU, Luoxia CAO et al

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1 Introduction

The thermal sensitivity and safety of explosive and its component have been paid attention to by domestic and abroad researchers, and the corresponding methods of experiment and evaluation are established.

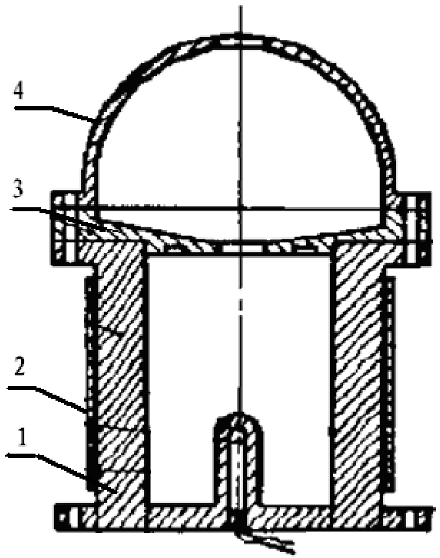
2 Experimental

2.1 Preparation of samples

(a) modeling powder (b) explosive cylinder (c) half sphere

Fig.1 Explosive samples of different sizes

2.2 Method of explosion point test



5s delay explosion temperature(T_{5s})

1000s critical temperature(T_{1000s})

Fig.2 Scheme of explosion point test setup

2.3 Method of thermal explosion test

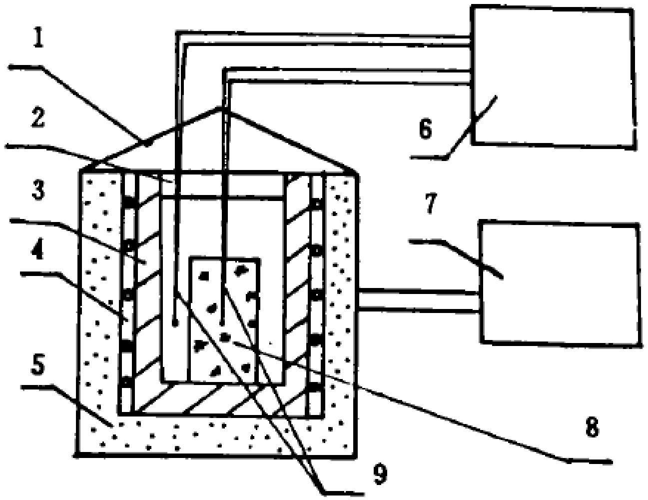


Fig.3 Scheme of Unlimited thermal explosion test setup

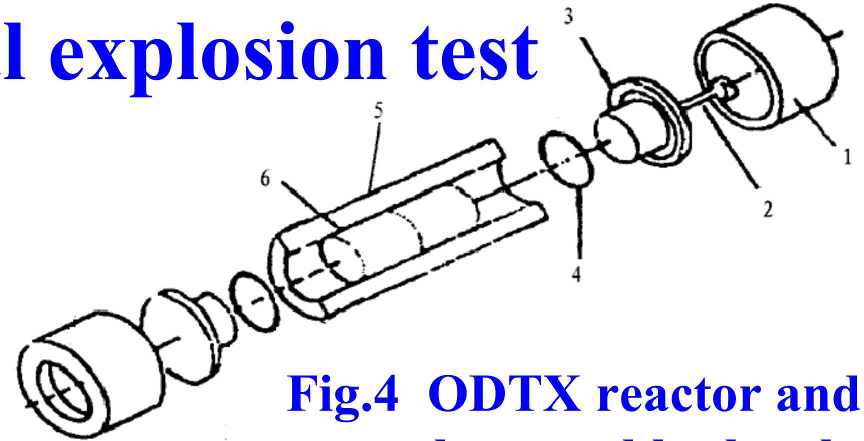


Fig.4 ODTX reactor and sample assemble sketch

one dimension time-to-explosive test is one of standard method to evaluate the safety of explosive component in U.S.A

critical temperature (T_m)
delay time (t)

U.S.A
twoΦ0.5×1 inch

→

China
twoΦ13×26 mm

destruction degree of sample reactor

→

(a) non-reaction

(b) middle pressure release

(c) low level reaction

(d) high level reaction

Fig.5 Evaluated method of reaction grades in ODTX test

2.4 Method of cook-off test

bonfire stimulation **slow heating stimulati**

Fig.6 Photograph of fast cook-off test for explosive component

Fig.7 Photograph of slow cook-off test setup of encased thermocouples and explosive components

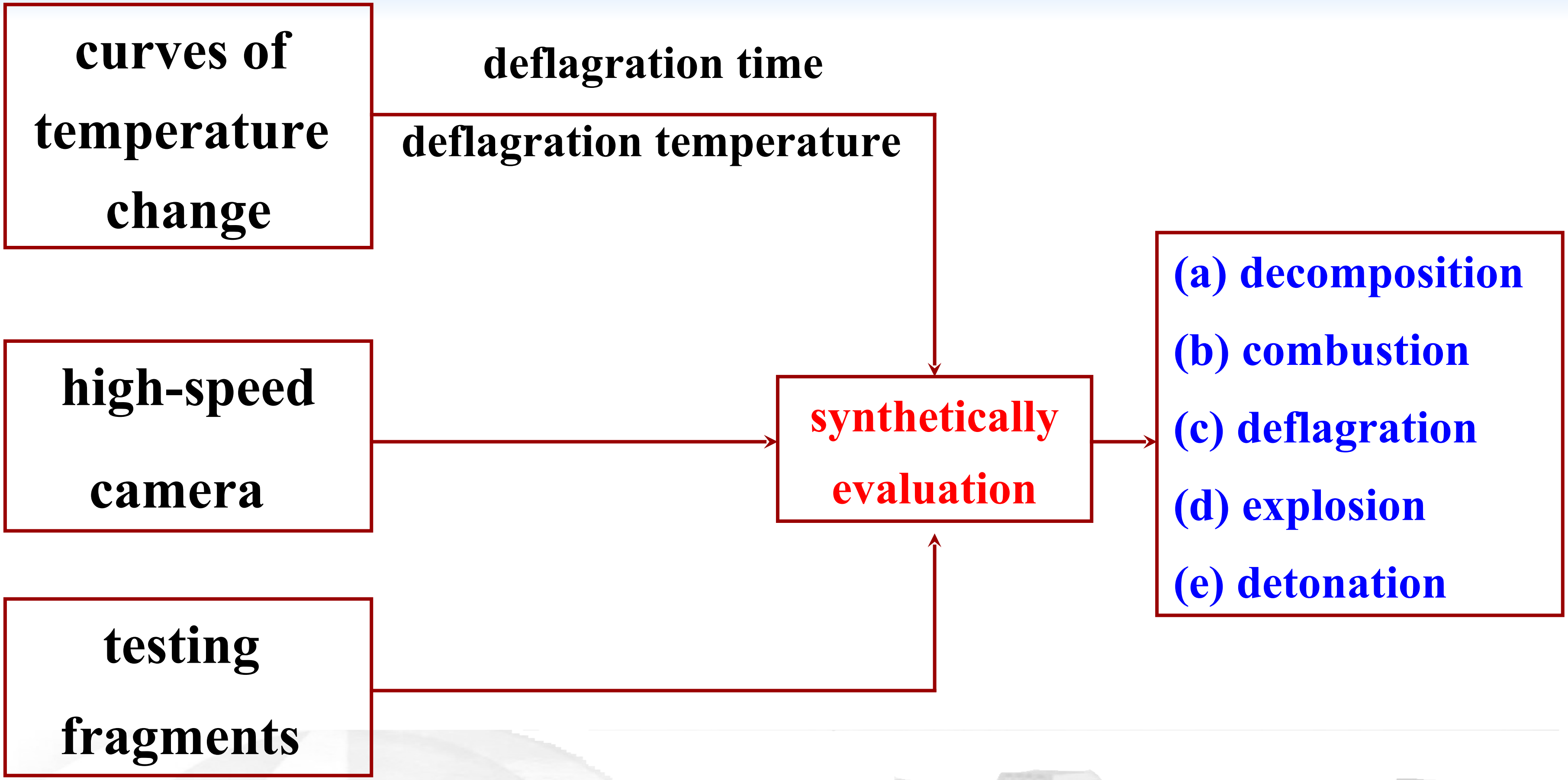


Fig.8 Evaluated method of reaction grades in cook-off test

3 Results and discussion

3.1 Explosion points of small-scale explosive

The thermal sensitivity of small-scale explosive were characterized by T_{5s} and T_{1000s}. The bigger of those values, the lower of the thermal sensitivity.

PBX-6: T_{5s}=330℃ T_{1000s}=255℃

3.2 Critical temperatures and delay times of thermal explosion

□ Unlimited state

Table 1 Thermal explosion testing results of PBX-6 explosive cylinder

size	T_a /℃	ΔT /℃	t / s	phenomena	T_m /℃
Φ10mm×10mm	212.0\`	11.2	13860	TE	210.0
	208.0	8.9	36000	TD	
Φ20mm×20mm	200.5	7.6	31200	TE	200.2
	199.9	7.0	36000	TD	
Φ30mm×30mm	198.0	7.9	29640	TE	197.5
	197.0	8.0	36000	TD	

The relationship of the critical parameter *δ*, the radius *r* and the critical temperature T_m can be expressed as

$$\ln\left(\frac{\delta T_m^2}{r^2}\right) = 162.34 - \left(\frac{115692}{T_m}\right)$$

***Φ*40mm×40mm**

T_m=194.6℃

The experiential relationship between the delay time *t* of thermal explosion and the environment temperature T_a is as follows.

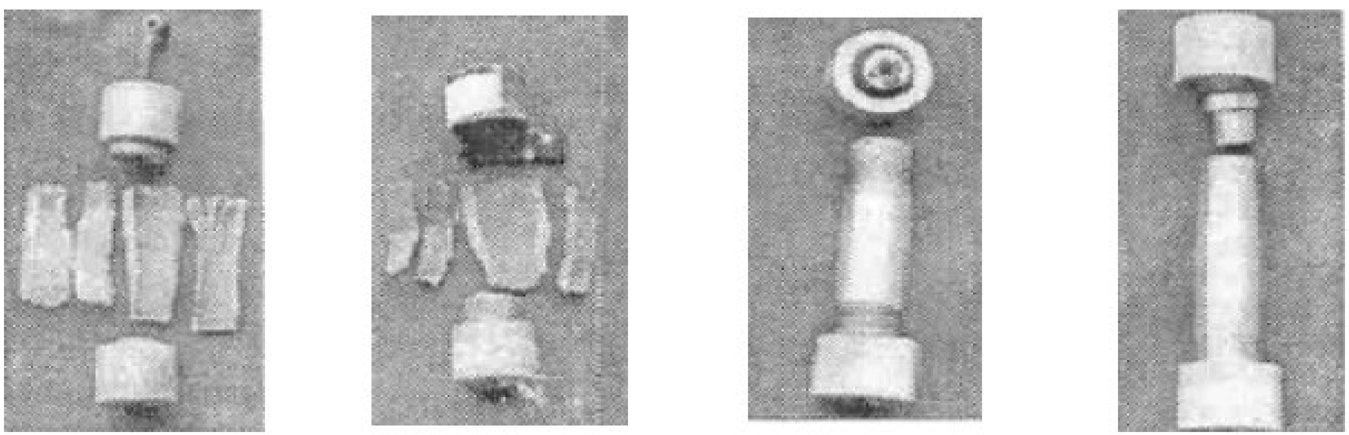
$$\ln t = C_2 + \frac{E}{RT_a}$$

$T_a > T_m \rightarrow$ calculation *t*

□ Limited state

Table 2 ODTX results of PBX-6 explosive cylinder

No.	T_a /℃	t /s	phenomena	grades	T_m /℃
PBX-6-3#	194	14940	TE	high level reaction	
PBX-6-4#	192	15420	TE	high level reaction	
PBX-6-5#	187	36000	TD	no reaction	
PBX-6-6#	179	36000	TD	no reaction	189.5



PBX-6-3# PBX-6-4# PBX-6-5# PBX-6-6#

Fig.9 Deformation degree of tube contained sample



□ Constraint effect

Unlimited		Limited
OneΦ30×30mm	$\Delta\Phi$=-17.3mm	twoΦ12.7×25.4mm
T_m=197.5 ℃	ΔT_m=-8 ℃	T_m=189.5℃

Because the explosive cylinders are confined, product of thermal decomposition is not easy to come out and the heat is not easy to convey to environment, and make it easier to reach the critical condition of thermal explosion comparing to the unlimited one.

3.3 Time and temperature of deflagration for cook-off test

□ Bonfire heating

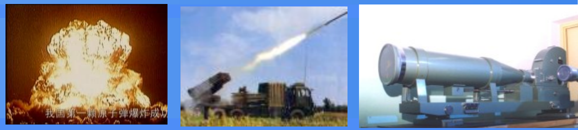
bonfire

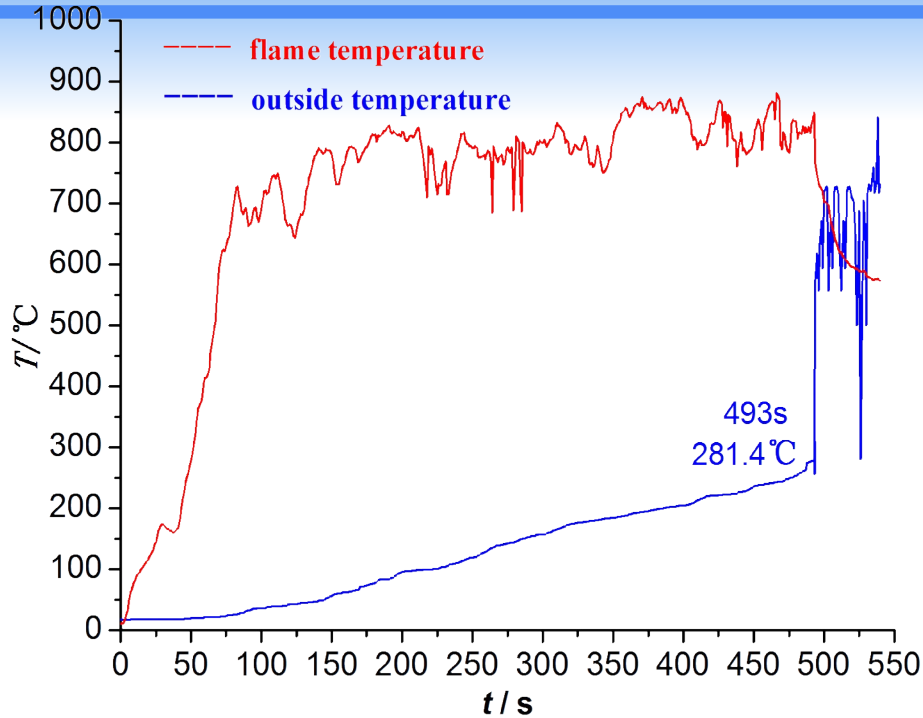
thermal decomposition

combustion

explosion

Fig.10 photographs of DV kinescope in fast cook-off test





HS-2# sample (65℃, 180d)

HS-1#

HS-2#

HS-3#

Fig.11 Temperature curves of explosive components measured in fast cook-off test

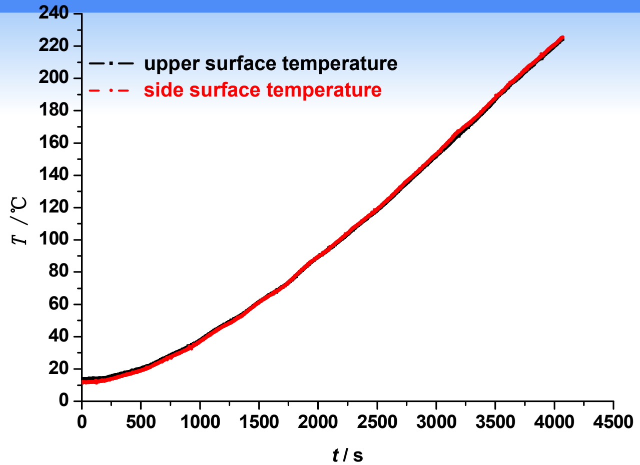
Fig.12 Photographs of scrap in fast cook-off test for PBX-6 explosive component

Table 3 Results of fast cook-off test for PBX-6 explosive components

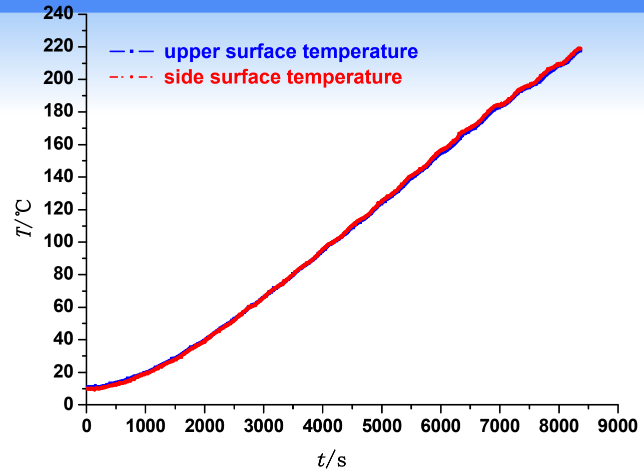
No.	condition of aging	ρ /(g·cm^{-3})	deflagration time / s	deflagration temperature/℃	grade
HS-1#	unaging	1.843	519	311.0	deflagration
HS-2#	65℃, 180d	1.838	493	281.4	
HS-3#	65℃, 365d	1.836	477	269.5	

The deflagration time was shortened, and the deflagration temperature was lowered with increasing of the aging time.

□ Slow heating



（ a ） 5℃/min



（ b ） 2℃/min

Fig.13 Change curves of surface temperature for the explosive spheres

MK-1# (5℃·min^{-1})

MK-2# (2℃·min^{-1})

Fig.14 Photographs of scrap in slow cook-off test of explosive components



Table 4 Results of slow cook-off test for PBX-6 explosive components

No.	heating rates /(°C·min^{-1})	deflagration time /s	deflagration temperature /°C	shock wave overpressure /kPa	grade
MK-1$^{\#}$	5	4074	224.9	21.8	deflagration
MK-2$^{\#}$	2	8373	218.5	-	reaction

The deflagration time was shortened, and the deflagration temperature was increased with increasing of the heating rate.

4 Conclusions



(1) The methods of explosion point test of small scale explosive, thermal explosion test of explosive cylinder, and cook-off test of explosive spheres have been established.

(2) The thermal sensitivity and safety for PBX-6 explosive samples of different scales are synthetically evaluated by analyzing the response characteristics at various thermal stimulus.

5 Progress and trends



(1) The cook-off test of specimens under conditions of different accelerated aging and long-term stored will been developed.

(2) The numerical simulation will been carried out. Combining testing and numerical results, the effects of aging on thermal safety of explosive components will been investigated.


Thank you