17th World Conference on Nondestructive Testing, 25-28 Oct 2008, Shanghai, China

Testing of Temperature Field of Explosives in the Cast Process by Infrared Imaging

Hongping ZHOU, Yong TIAN, Weibin ZHANG, Zhanfeng YANG, Hehou ZONG
(Institute of Chemical Materials, CAEP, Mianyang, China
P.O.BOX 919-326, Mianyang, China, 621900
Tel: +86-816-2485379
E-mail:zhpsss@163.com

Abstract

Surface temperature field of two different explosives in the cast and solidification process was tested by infrared imaging technique.The results show the temperature field of explosives in the cast process is symmetry distribution along axial direction ,and reduces gradually from the center to its outside along radial direction. Rate of temperature drop of pure TNT is smaller than that of TNT/RDX in the same experimental conditions.The full process for crystallization of TNT and quality vice such as gas holes of cast moulded explosives are described by thermographys.

Keywords：Temperature field，Explosive，Cast process，Infrared imaging

1. Introduction

Casting is an important moulding technique of explosives. Changes of temperature field of explosives in the cast process have great influence on moulding quality, So measure of temperature field is very important. Compared with regular thermocouple thermometry, Infrared imaging technology based on principle of temperature field distributions has excellences such as none-touch, non-destructive, higher sensitivity, faster response, use of safety and full-field measurements. Now infrared imaging technology have wide application and development in many fields such as spacefligt, aviation, medicine, architecture, electrical power, metallurgy, landification, materials[1-3]. This paper real-time monitored surface temperature field and its change regulars of two different formulation explosives in the cast and solidification process.

2. Materials and experimental method

2.1 Materials

Steel die of Φ110mm×130mm; pure TNT explosive; TNT/RDX mixed explosive.

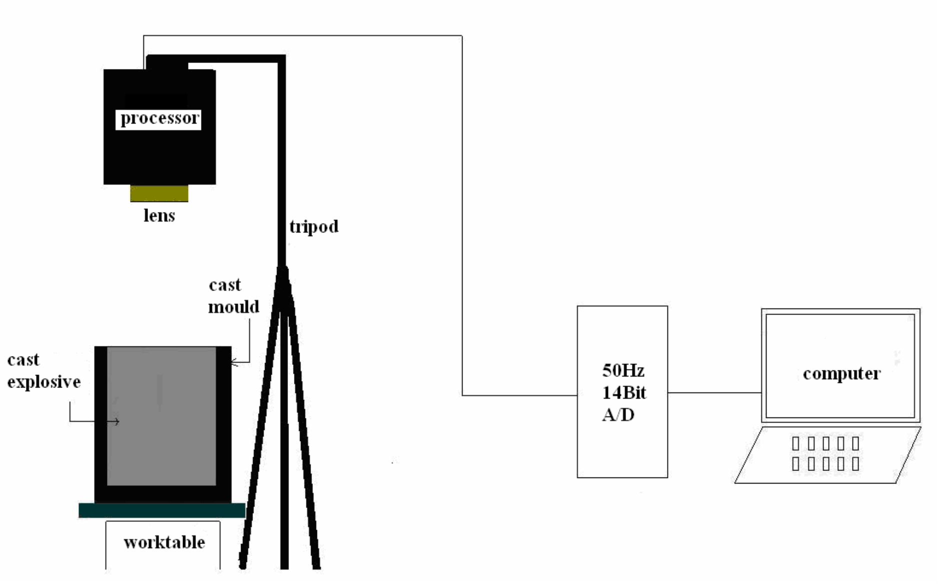
2.2 Experimental method

Every object will bring infrared radiation when its temperature is higer than absolute zero from heat radiative theory. According to Stepan-Boltzman Principle, Energy of infrared radiation has direct ratio with radiate coefficient and the pouth power of absolute temperature of object.

$$E=\varepsilon\delta T4 \qquad (1)$$

In the aboved formular, E is radiate energy , and ε is radiate coefficient, δ is Stepan-Boltzman constant , and T is absolute temperature of object. From formular (1) , There is responsive relation one by one between object's temperature and its radiate energy when wavelength and radiate coefficient have no changes. Infrared imaging system collets infrared radiation from every spot of object, then photo-electric signal change to analog signal after photo-electric conversion. Finally after treating, the temperature distribution image (thermal image) of measured object is got in the LED panel of computer.

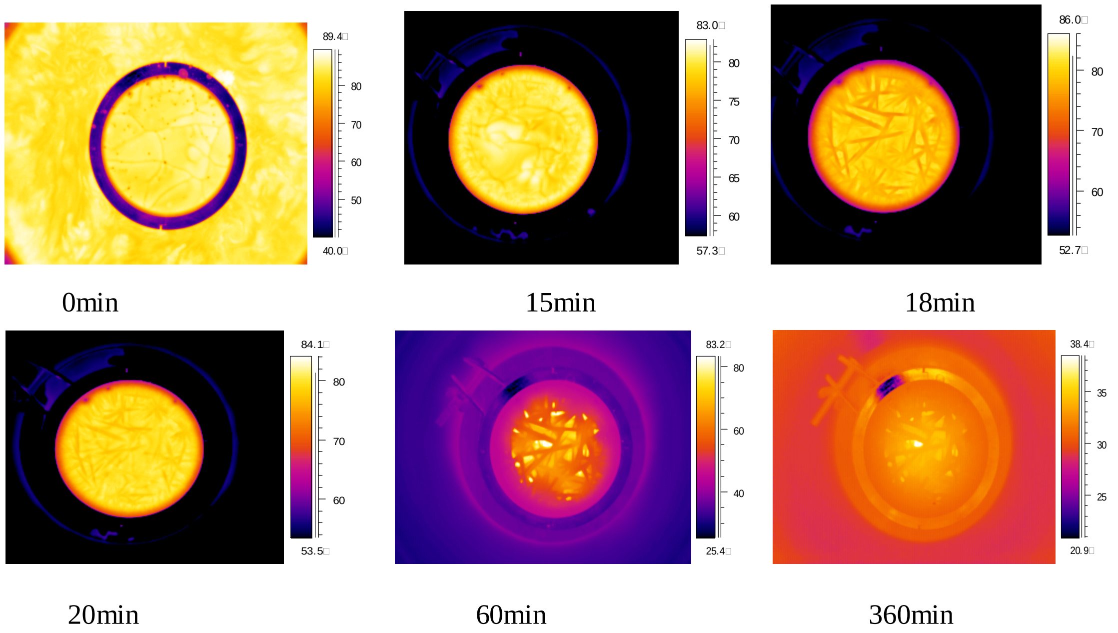
The infrared imaging system used in this paper is shown in figure 1. The ThermaCAM SC 3000 infrared imaging system is produced by American. It utilizes an advanced Quantum Well Infrared Photodetector FPA sensor, extraordinary longwave (8 to 9um) imaging performance, provides extremely high sensitivity of less than 20 mK at 30 °C, with a built-in 20° lens, high rate of up to 50 Hz /s. The field of view is 10°×15°, and the minimum focal length of built-in 20° lens is 0.3m. The instantaneous field of view is 1.1mrad. The infrared radiate coefficient is tested and its value is o.85. The distance is 1.2m from lens of the infrared imaging system to surface of cast explosive. The temperature range is chosen to 10-150℃. Finally focal length is well adjusted and infrared images are recorded.



Figue1. Schematic diagram of infrared thermographic testing

3. Experimental Results

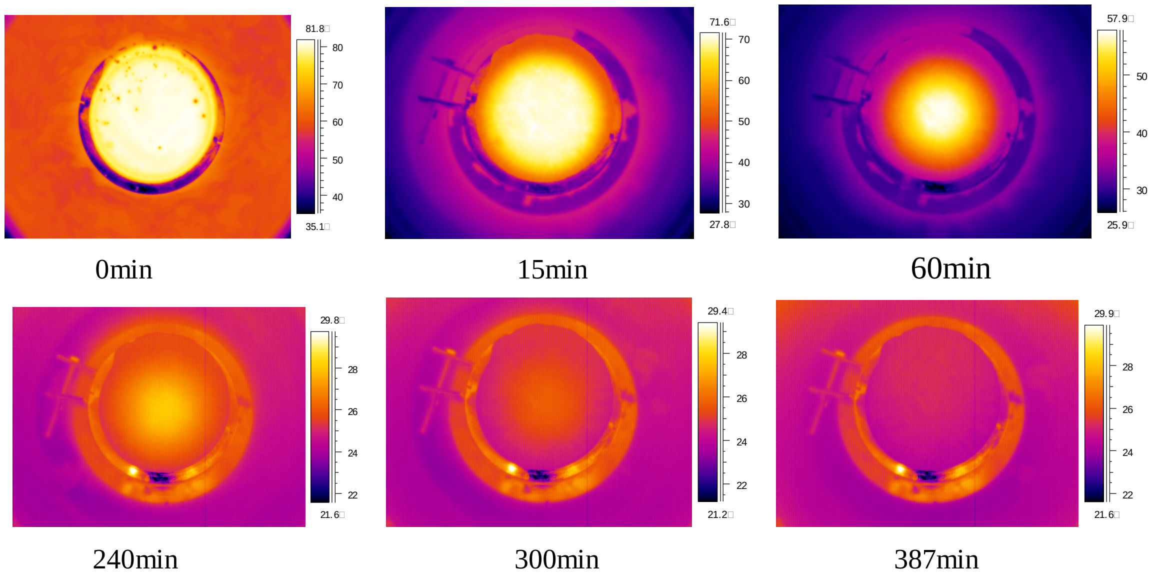
Figure2 and Figure3 gave some representative infrared images of pure TNT explosive and TNT/RDX mixed explosive at the different time in the cast and solidification process.



0min 15min 18min

20min 60min 360min

Figure 2. Infrared images of Pure TNT explosive



0min 15min 60min

240min 300min 387min

Figure 3. Infrared images of TNT/RDX mixed explosive

From Figure2 and Figure3, some experimental results could be obtained. (1) The crystallization process of pure TNT was shown distinctly, and part crystallization at 15min and a great lot cryastallization at 20min then all crystallization at 20min. A great many bulky TNT crystals were shown in the infrared images. But it was very different to TNT/RDX mixed explosive in the cast and solidification process , TNT crystals could not be shown in the figure 3. (2) The solidification process was from outside to inside, so the temperature reduced gradually from inside to outside along radial direction at some moment , but finally the temperature of explosive everywhere was same. (3) There were obvious pores at surface of cast explosives at 0 min from figure 2 and figure 3. These pores were almost circinal or elliptical. The cause of information was air brought to explosive liquid and steel die at the beginning moment of cast. Because air had a better heat transfer than explosive, pores had lower temperature than explosive in the infrared images. Then These pores were filled because of the inner flow and extrusion of molten TNT.

That the temperature field of explosives in the cast and solidification was symmetry distribution along axial direction was proved. Such as TNT/RDX, Figure 4 and figure 5 gave temperature distribution at the horizontal diameter and the vertical diameter at 60min and 387min in the cast and solidification process.

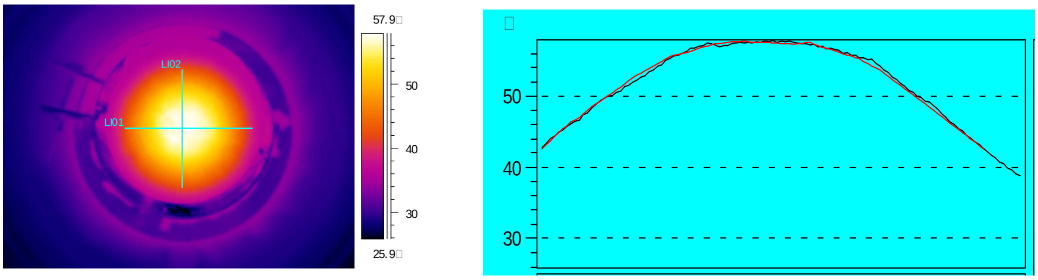


Figure 4. The temperature distributon at horizontal and vertical diameter at 60min

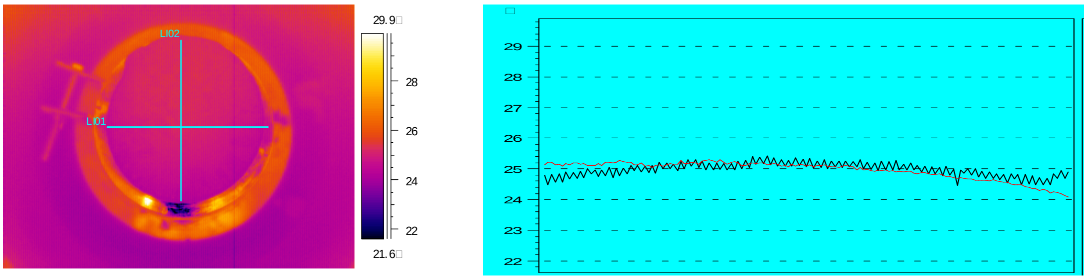
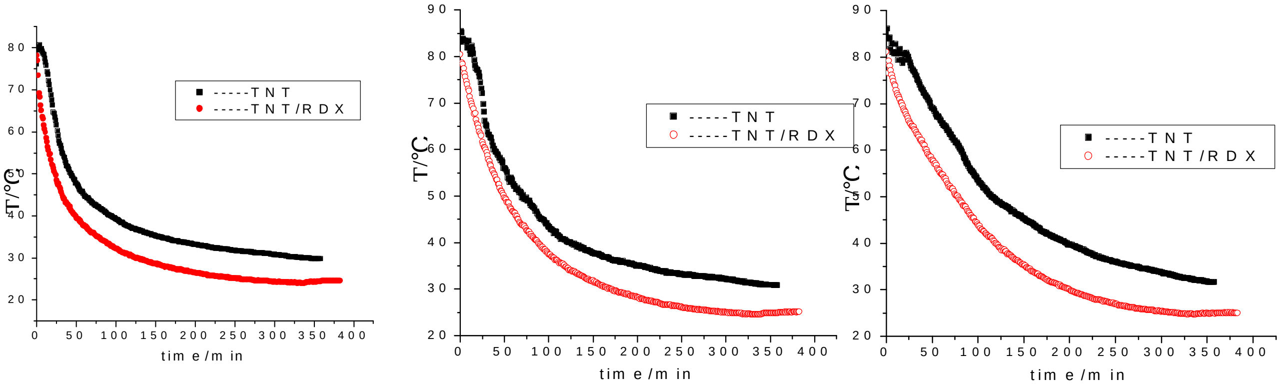


Figure 5. The temperature distributon at horizontal and vertical diameter at 387min

The temperature changes with cast and solidification time at the same 3 pots of pure TNT and TNT/RDX mixed explosives were shown in the figure 6, and pot 1 and pot 2 and pot 3 were three positions from outside to inside along radii.



point 1 point 2 point 3

Figure 6. The temperature changes with time of three pots of different explosives

Rate of temperature drop of pure TNT was a little lower than TNT/RDX mixed explosive at the same experimental condition. when RDX solid grains were added to molten TNT, the numer of nucleation was increased and it induced more faster solidification. Final TNT/RDX cast explosive products were with fine crystals and compact, While pure TNT cast explosive products were with bulky crystals and loose because of a great deal of interspace among crystals. In a word , The product quality of TNT/RDX mixed cast explosive was more super than pure TNT explosive. This was also proved by figure 2 and figure 3.

4. Conclusions

(1) The temperature field of explosives in the cast process is symmetry distribution along axial direction ,and reduces gradually from the center to its outside along radial direction.

(2) There are circinal or elliptical pores at cast explosives surface because of air brought to explosive melting liquid and mould at the beginning moment of cast. Then these pores are filled because of the inner flow and extrusion of molten TNT.

(3) Rate of temperature drop of pure TNT is a little smaller than that of TNT/RDX in the same experimental conditions. TNT/RDX cast explosive products are with fine crystals and compact while pure TNT cast explosive products are with bulky crystals and a great deal of interspace. The product quality of TNT/RDX is more super than pure TNT.

Acknowledgement. This work was supported by the fund of science and technology research of CAEP industry（2005Z0504）.

References

[1] Wan Fang, et al, Application of Thermal Imaging System for the Observation of the Operating Petro-Chemical Equipment
Infrared technology,1995,p35-40.

[2] Zeng Keling, et al, Applications of IR Imaging System on the Ceramic Industry
Laser & Infrared, Apr.1996,p118-120.

[3] Carosena Meola, Giovanni M.Carlomagno, Luca Giorleo: “ The use of infrared thermography for materials characterization”, Journal of Materials Processing Technology, 155-156, 2004,p1132-1137.