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IMX REPORT

IMX- 104 High Explosive (HE) Loading of 81mm & 120mm Mortars

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TABLE OF CONTENTS

Abstract

Background

Loading Process Development

Results

Conclusions

LIST OF FIGURES

1. Explosive Screener with Safe line Metallic Detector
2. Metal Parts Preheat Oven
3. 50 Gallon Explosive Melt Kettle
4. 4- Nozzle Pour Machine
5. Controlled Cooling Oven and Load Cart
6. Data Acquisition Main Control Screen

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ABSTRACT

The Armament Research, Development and Engineering Center (ARDEC) has been utilizing the state-of-the-art melt pour loading facility at Bldg 810, Picatinny, NJ, to load 81mm and 120mm mortars with the Insensitive Munitions (IM) fill IMX-104, in support of the development of a replacement fill for Composition B. The Composition B replacement program is being executed by the Program Manager for Cannon Artillery Systems (PM CAS). The IM loading of the mortars, at Picatinny Arsenal, supports this program by supplying loaded mortars for IM and performance testing to validate the IM characteristics and tactical requirements of the candidate replacement, IMX-104. The manufacture of Composition B or IMX-104 loaded mortars must be performed using a tightly controlled process and maintaining a strict adherence to process parameters and loading procedures, in order to meet the explosive cast quality specification requirements of mortars. PM CAS is working toward implementing the IMX-104 into FY12 production, therefore, the typical time required for the development of a melt pour loading process will have to be significantly reduced. The pilot plant melt pour loading facility at Picatinny Arsenal utilized unique data acquisition and analysis tools to deliver projectiles loaded with candidate replacement IM explosives, with minimal process development time added to the overall program schedule.

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BACKGROUND

The pilot plant loading facility at Bldg 810 is equipped with state-of-the-art melt pour equipment and data acquisition systems that were utilized for the development of several IM TNT replacement explosive candidates. The process equipment used is described below:

Explosive Screener

Bulk explosives are fed through a metallic screener to ensure that no foreign objects are placed in the melt kettles. The metallic screener utilizes a magnetic field to identify ferrous and non ferrous metals and automatically rejects contaminated explosives into a separate hopper.

Figure 1 – Safeline Metallic Detector

Metal Parts Preheat Oven

81mm and 120mm mortars are preheated with hot air in an oven, manufactured by New England Oven and Furnace Company (Serial No. 868-1/ID No. 4430-00240). This oven is used to condition the load carts and projectile metal parts. It has interior dimensions of 70” by 57.25” by 60.5” (L x W x H). This oven utilizes four (4) individual forced hot air heaters capable of supplying a maximum temperature of 350°F. Temperature control is achieved by use of an Omron Controller (Model E5AJ) and two (2) J-Type thermocouples cast inside of the oven walls during manufacture.

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Figure 2 – Metal Part Pre-Heat Oven

50 Gallon Explosive Melt Kettle

- A stainless steel mixing bowl, jacketed for steam or hot water containing a single outlet, and two (2) product temperature sensors: one at the bottom of the kettle and one near the top.

- A stainless steel, jacketed kettle lid with ports for product inlet/material feed, vacuum, fire protection, ventilation and operator inspection.

- A steam/hot water heated anchor agitator mounted to the kettle lid and extending into the mixing bowl to mix the explosive. An electrical motor powers the agitator with a variable frequency drive (VFD). The explosion proof motor is located on top of the kettle, while the VFD is located in an adjacent room.


Figure 3 – 50 Gallon Melt Kettle

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4-Nozzle Pour Machine

- Stainless steel hot water jacketed explosive reservoir with a maximum capacity of approximately 260 pounds of explosive.

- Four (4) hot water jacketed pouring nozzles with plug valves located inside the pour machine. Manually actuated pneumatic controls operate the valves.

- Pneumatic blade-style agitator is located in the center of the pour machine to prevent settling of any suspended solids.

Sixteen (16) 81mm or 120mm pre-heated mortars with funnels (pre-heated separately), held in a 8 x 2 array in the pouring cart, are manually transported beneath the pour unit. A pneumatic piston stops the cart at a location where the funnels are properly aligned with the pour nozzles. The placement is such that the HE streams hit the sidewalls of the funnels no more than 1.25" from their respective lips. The height of explosive in the riser is controlled manually. After the first set of projectiles is loaded, the piston retracts and the cart is manually pushed forward and the next set of four (4) projectiles is filled.

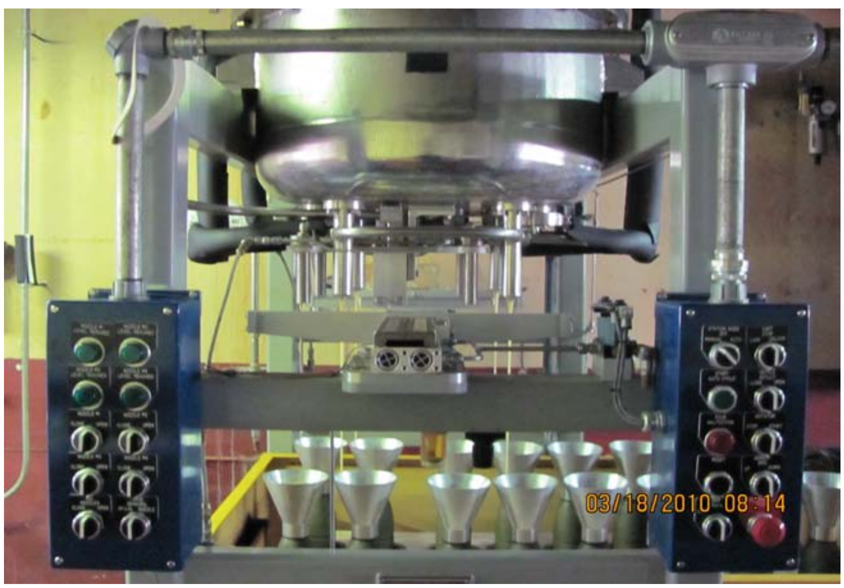

Figure 4 – 4 Nozzle Pour Machine

Controlled Cooling Oven & Load Cart

The controlled cooling oven has two (2) sets of panels that are heated with hot water which allows the funnels on the load carts to be actively heated during the cooling process. The panels have the capability to be controlled up to 270°F. The enclosed cooling cart is fitted with quick disconnect connections which are utilized to fill the cart with the cooling water and maintain the required flow rate in order to keep the cooling water at the desired temperature. Also, a level sensor is utilized in the loading cart to measure the water height in cart during the cooling process. The level sensor allows the cooling water level to be set at any height (+/- .2

inches) for a specified duration of time. This provides the pilot facility with very precise control of the cooling water temperature and height that is used to cool the mortars.

Figure 5- Control Cooling Oven and Load Cart

Data Acquisition

The data acquisition system that is employed in the pilot loading facility allows the process to be tightly controlled and monitored during the development of any melt pour loading process. The system consists of a main control terminal, level sensor, and thermocouple probes for the projectiles. The main control terminal allows the operator to generate recipes to control temperature, water height, and duration in the cooling oven. It also collects data from the many thermocouples that are placed throughout the system. The level sensor is placed inside the cart once it is in the oven. The sensor allows for the water height to be controlled to within 0.2 inches. The thermocouple probes that are placed in the mortars provide temperature information as to how the explosive is cooling. These tools allow for a process to be developed and characterized in a timelier manner and ultimately optimize the manufacturing process through real time data acquisition.

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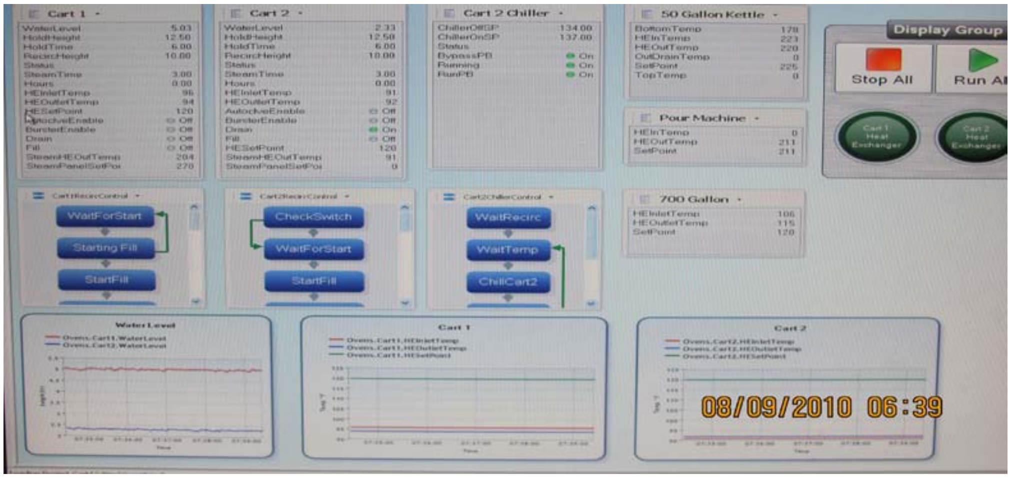

Figure 6 – Main Control Screen for Data Acquisition System

Process Development

IMX-104

The melt pour pilot facility has been actively engaged in IM explosive development for mortars since 2007 beginning with IMX-104 as a replacement candidate for Composition B. This formulation is produced by combining DNAN, NTO, and RDX. The early loading studies revealed that this formulation begins to solidify at a faster rate than Comp B and more efficient heating during the cooling process would be needed to promote bottom up cooling.

The IMX-104 mortar development program was initiated utilizing a cooling oven that had been previously used for Comp B loading of mortars. The oven is a (3' X 2.6' X 8') tunnel that consists of three steam panels supplied with 15 lbs of steam and air is used as the cooling media. Acceptable 81mm Body Loaded Assemblies (BLAs) and 120mm BLAs were conditioned in the oven but acceptable cast were not achieved on a consistent basis. The unacceptable mortars were rejected for piping defects due to the inefficient heating in the mortar oven. During the cooling process in the oven, the minimal temperature gradient that was present from the riser to the base of the mortar did not allow the mortars to cool from the bottom up. The mouth of the mortar would solidify before the remainder of the cast, therefore preventing the molten material above from backfilling to account for the shrinkage of the cast. A thermocouple tree was placed in the oven to determine the temperature gradient within the oven. The results of the temperature profile showed that there was minimal change in temperature from the riser to the base of the mortar round. The small temperature gradient in conjunction with the quick solidification of IMX-104 created an environment that facilitated piping defects within the mortars. To address this issue, a 155mm loading cart was modified to load 81 and 120mm mortars under the 4-nozzle pour machine (See Figure 5). The modified load cart would allow the mortars to be placed in the 155mm cooling oven. This oven has two rows of heating panels that can focus the heating onto the riser of the mortar. Also by utilizing the 155mm loading carts, water can be used as the cooling media to promote bottom up cooling with much more control than air. After switching the cooling of the mortars to the 155mm cooling oven, acceptable 81mm and 120mm BLAs were produced with repeatable results.

Results

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81mm Mortar loading study yielded 362 acceptable mortars for use in various insensitive munitions testing for characterization and qualification of IMX-104 in the 81mm mortar. A loading study on the 120mm Mortar has produced 21 acceptable mortars to date for various testing with additional loading scheduled in the near future.

Conclusion

The transition from the mortar cooling oven to the 155mm cooling oven proved to be beneficial in the development of a repeatable process that provided acceptable 81mm and 120mm mortars. The heating panels in conjunction with the water used to condition the mortars created a temperature gradient that promoted the desired bottom up cooling effect.