GENERAL DYNAMICS
Ordnance and Tactical Systems–Canada

Tracer Development in a Non-Conventional Plastic Molded Frangible Projectile

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Outline

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Introduction

- The main challenge is to develop a tracer in a brittle plastic molded projectile. This projectile contains some plastic, metallic powder, and a blue dye.
- Challenges :
  - Consolidation in a brittle projectile
    - Method to maintain the projectile during compression
    - Consolidation pressure cannot be very high due to its brittleness
  - Projectile with the pyrotechnic composition can cause several failures such as tracer ejection, reduction of the trace distance, etc.
  - Since the projectile is brittle, a very small tracer diameter has to be used.

Introduction

- In the past:
  - Encapsulated tracer (pencil tracer)
    - Zirconium and potassium perchlorate composition in a lead sheath
    - Lead sheath had to be inserted into the projectile cavity and retained by compressing the projectile wall.
    - Due to the brittleness of the projectile and the toxicity of the lead sheath, this technology was abandoned
  - Traditional tracer compositions were studied using ignition and tracer compositions such as conventional tracers
    - The small diameter of the tracer cavity did not permit an efficient heat transfer from the ignition composition to the tracing composition

Current Design

- Tracer diameter is very small and the tracer length is short.
- As a result, only one composition is used in the SRTA-T ammunition which contains magnesium as a fuel, barium peroxide as an oxidizer, and calcium resinate as a binder.
  - This composition has to both ignite easily and burn slowly enough to achieve the trace distance.
- The lot-to-lot variation in the ingredients appears to be the most important factor affecting the performances of the tracer at both the ignition point and trace distance.

Current Design

- To achieve optimal performance, the Lean Design for Six Sigma method (LDFSS) was used to select the key characteristics. Tools such as process mapping, Cause and Effects matrix (C&E), Process Failure Mode and Effect Analysis (PFMEA) and Design of Experiment (DOE) were used.
- These documents were prepared for each of the following activites to identify important parameters to be tested:
  - Manufacturing process of the composition
  - Ingredient characterization
  - Manufacturing process for the tracer assembly
  - Molding process

Manufacturing process of the composition

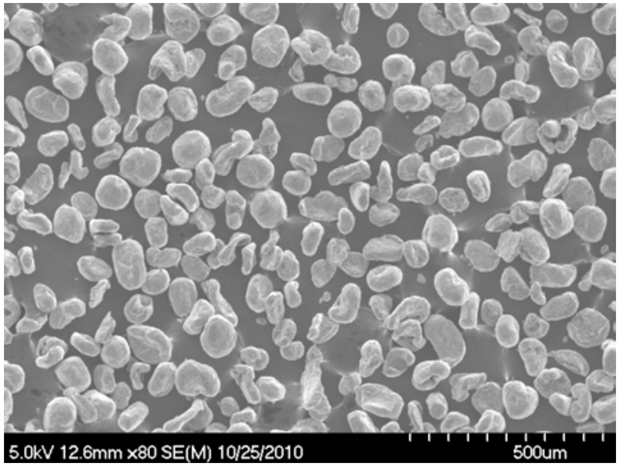
- For the composition manufacturing process, the following characteristics were found to be important when tested in DOE for ignition or for distance trace:
  - Mixing time
  - Solid concentration of the binder
  - Drying time
- The removal of solid particles using decantation leads to a composition with a less variable density; consequently, the composition is easier to assemble especially in this small tracer cavity.
- The composition drying time was studied.

Ingredient Characterization

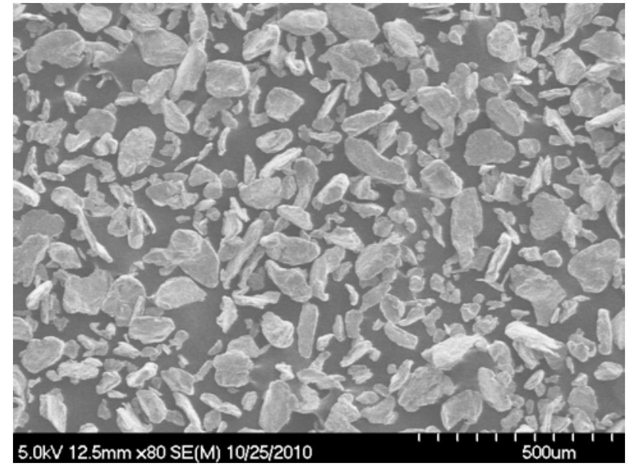
- Magnesium
  - Characteristics tested on magnesium lots:
    - Shape with SEM (Scanning Electon Microscope)
    - Grain size using Lasentec particulate analyser
    - Purity and melting point
  - Conclusions:
    - Magnesium choice is essential to the development of pyrotechnic composition.
    - Purity of the magnesium and melting points were tested but no clear correlations were made with the trace performances.

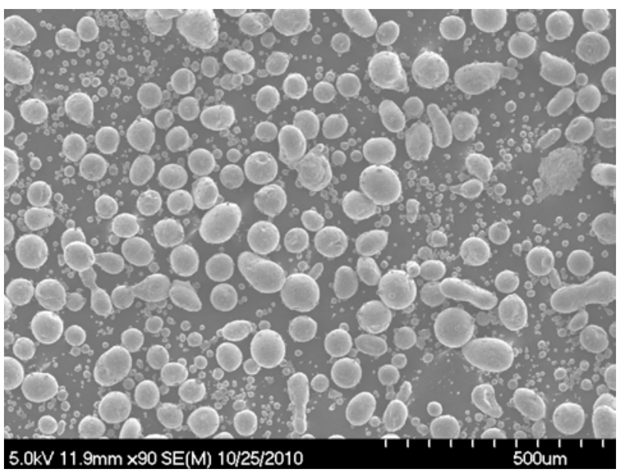
Ingredient Characterization

- Magnesium shape photos



Mg from one supplier, two different lots





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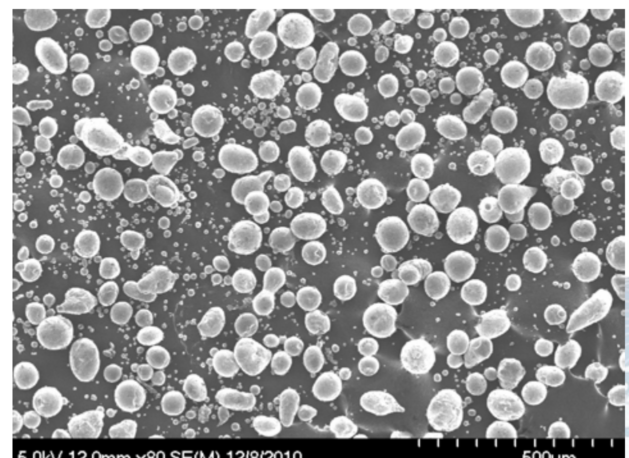

Ingredient Characterization

- Barium peroxide
  - Following are the characteristics studied for the barium peroxide :
    - Melting point, enthalpy and oxygen content.
    - Particle size
  - No significant difference was observed between the three lots tested and trace distance was still different.
  - Other tests have to be performed.

Plastic Molded Projectile Characterization

- Plastic molded frangible projectiles contain
  - plastic,
  - a powdered metal,
  - and a blue dye.
- Projectile lots have an effect on the trace performance
- Compound formulation, manufacturing process, and ingredient characteristics were studied.

Tracer Manufacturing Process

- Only a small quantity of pyrotechnic composition could be inserted in the small cavity. The pyrotechnic composition is both mechanically difficult to insert and to keep a stable quantity.
  - A variation of only 10 mg of the composition in the projectile has significant impact on the trace distance.
- For a conventional projectile and tracer compositions, the consolidation dead load is in the range of 2000 lbs. The dead load is considerably reduced in the non-conventional frangible projectile process; due to the projectile being too brittle and the pressure can cause a fracture.
  - Consequently, the maximum dead load can not exceed the fracture capacity of the projectile.

Conclusions

- Results presented demonstrate the complexity involved in the development of a tracer in plastic molded frangible projectiles. Several key characteristics were identified:
  - Tracer cavity diameter which is related to the brittleness of the projectile has to be defined at the beginning of the development.
  - Choice of the composition, in this case, only one composition is used. This composition has to both ignite easily and attain the trace distance.
  - Binder has to produce a homogeneous composition and be consistent in density to help in the manufacturing process.
  - Choice of ingredients and their characteristics could affect ignition of the tracer and trace distance.
  - The manufacturing processes of the projectile and the assembly of the tracer have to be consistent. A small change could cause a trace failure.

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