Development of Exploding Foil Initiators and Micro Chip EFIs

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Overview

• Introduction
• Why EFI systems
• Exploding Foil Initiator Research
• Research on Explosives
• Conclusions
Introduction
Exploding Foil Initiator Research

- Exploding foil
- Electrical circuit
- Velocity of the flyer
- Driver Explosive
- Secondary flyer
- Acceptor explosive
Shock initiation research at TNO: Mega Ampere Pulsar and Flyer Impact

~4 feet

Wim Prinse
Why an EFI system

• An EFI is intrinsically safer than standard initiators (no primary explosive)
• More reliable (So, no UXO’s)
• Works much faster < microseconds
• Can be smaller (near future)
• Is compliant with new STANAG (4560) regulations
• New opportunities (tandem charges, aim able warheads etc.)

• Disadvantage : More expensive (at the moment)

• Future: Micro Chip EFI (McEFI) \( \rightarrow \) inexpensive
Exploding foil

- Dimension of the foil (length, width, thickness, shape, material)
- Shockwave impedance of the tamper
- Thickness and material of the flyer
- Length and width of the barrel
Electrical circuit

- Optimisation of the circuit
  - low loss capacitor
  - Switch (solid state)
  - transmission line
- Development of measuring techniques (current, voltage, velocity of the flyer)
- 90 % efficiency of energy deposited in the exploding foil (50 % other circuits)
Fabry-Perot system

- Laser-light
- Fabry-Perot etalon
- Fibre
- Lens A
- Lens B
- Lens C
- Slit in coating
- Grin-lens
- Moving Flyer
- Streak camera
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Flyer velocity measurement by F-P Interferometer

- Acceleration of the flyer influenced by:
  - thickness and material
  - exploding foil dimensions and material
  - shockwave impedance of the tamper
- Integrity of the flyer during acceleration
  - Determination of optimum barrel length

4 km/s in 80 ns (2.5 mi/s)
Research on Explosives

- Recrystallisation of HNS II to HNS IV
- The crystals are more uniform (smaller distribution)
- The length to width to thickness is 10:3:2
  a further increase in specific surface area is possible
Research on Explosives

- HNS has a relative low output
- Submicron/nano RDX could be an option
Initiation behaviour of different explosives

- Different types of explosives
  - HNS IV several brands
  - TATB several grades
  - New explosives
- Initiation energy depends on flyer thickness and velocity

5 x 5 mm pellet

![Graph showing energy vs. pressure for HNS IV and TATB explosives.](image)
Initiation of 5 x 5 mm HNS IV pellet

Voltage < 1300Volt

Transmission line
Numerical simulations of flyer impact

- Lee-Tarver model modified with visco-plastic pore collapse model
- Qualitatively the simulations can explain the experiments

Reacted fraction of HNS IV after initiation by 5.4 mm/µs flyer
Initiation of 5 x 5 mm HNS IV pellet

Voltage < 1300 Volt

Transmission line
Secondary flyer acceleration

• Driver explosive (HNS IV), confined

• Secondary flyer material:
  - aluminium
  - stainless steel
  - kapton
  - mylar

• Important properties:
  - spall strength (attenuator)
  - shockwave impedance
  - size and thickness

• Velocity of flyer measured with Fabry-Perot Velocity Interferometer System
# Secondary flyer acceleration test results

<table>
<thead>
<tr>
<th>Flyer material</th>
<th>TATB (ρ = 1.688 g / cm³)</th>
<th>TATB (ρ = 1.842 g / cm³)</th>
<th>Hexocire (RDX/wax)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.15 mm Stainless Steel</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>0.25 mm Stainless Steel</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>0.35 mm Mylar</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>0.3-0.5 mm Aluminium</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>0.43-0.55 mm Kapton</td>
<td>-</td>
<td>Not tested</td>
<td>+</td>
</tr>
<tr>
<td>0.81 mm Kapton</td>
<td>-</td>
<td>Not tested</td>
<td>-</td>
</tr>
</tbody>
</table>
Secondary flyer impact

Acceleration of a 0.25 mm stainless steel flyer by HNS IV
Successful initiation of TATB and RDX by
- 0.15 mm SS steel flyer
- 0.35 mm mylar flyer
- 0.3 - 0.5 mm Al flyer
Development of mini EFI and developer platform for Micro Chip EFI (McEFI)

- Efficient Transmission line with exploding bridge
- Pressed HNS IV
- Electronic component of the shelf (capacitor, HV unit, solid state switch and some standard electronic components)
- Knowledge/experience

• Mini-EFI and developer platform for McEFI
Conclusions

• A very efficient electrical circuit (\(\eta = 90\%\))
• Mini-EFI Works at Voltage lower than 1300 Volt (Solid state switch)
• With “of the shelf components” small IM compliant EFI-detonators can be built (~8cm³ including High Voltage-supply)
• The use of secondary flyers makes the detonation train more reliable (in case of set-back)
• Combining the EFI with the ESAD with Micro Chip technology can make a small and cost effective unit

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