TNO | Knowledge for business

TNO research in EFI's in relation to Insensitive Munition

The research on EFI's (Exploding Foil Initiator) comprises the circuit that delivers the electrical energy to the exploding foil, the exploding foil that converts the electrical energy into movement of the flyer and the explosive that is initiated by the impact energy of the flyer. All the elements in this chain have to be optimised to achieve a high reliable detonation train. The use of only secondary explosives overrules the use of a mechanical Safety & Arming Device.

EFI's are the most important initiators in Insensitive Munition because of its intrinsic insensitivity to external influences and its reliability. This reduces the probability of inadvertent initiation and increases the probability of intended initiation thus avoiding Unexploded Ordnance. Furthermore in the application of smart munitions the EFI is mostly the only available initiator to fulfil the complex tasks of accurate timing in for example hard target penetration, deformable and aimable warheads.

Exploding foil research

The electrical circuit of an EFI-sytem is a very simple yet a very demanding capacitor discharge circuit.

By careful design of the circuit and choosing of the components the energy in the exploding foil can be optimised to achieve that 90 % of the energy is dissipated in the foil. During the deposition of the energy the foil evaporates and turns into a high density plasma that drives the flyer-plate.

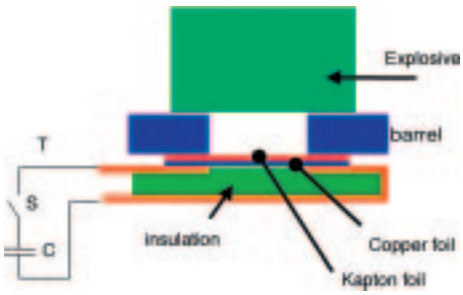

Figure 1: Schematic diagram of an EFI with capacitor discharge circuit.

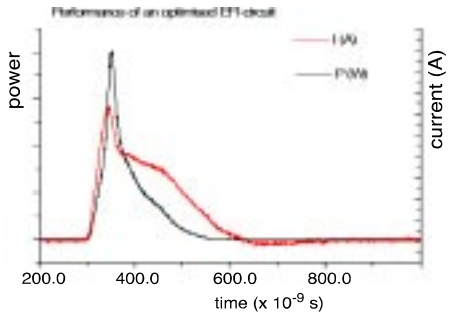

Figure 2: Current through and power developed in the exploding foil of an EFI.

To be able to investigate all these parameters the velocity of the flyer-plate is measured with a Fabry-Perot system.

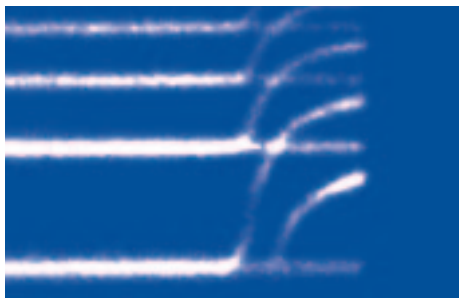

Figure 3: Fabry-Perot record of the flyer velocity of an EFI.

Several parameters can be deduced from F-P record:

- the flyer plate velocity as a function of time and distance;
- acceleration of the flyer;
- the integrity of the flyer during acceleration

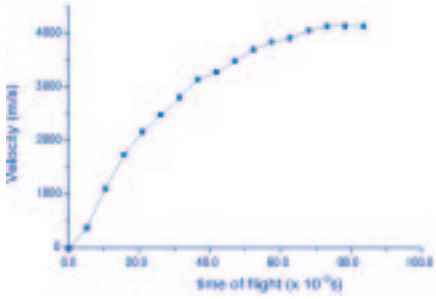

Figure 4: Velocity as a function of time of flight calculated from the Fabry-Perot signal.

Research on explosives

The possibility of using different types of explosives has been investigated. This has resulted in a unique method of crystallisation of HNS to HNS IV, to achieve more optimal grain dimensions. An example of a SEM-picture is given in the next figure.

Figure 5: SEM-picture of recrystallised HNS-IV.

The behaviour of the explosive is investigated with a high speed camera, to measure the detonation velocity at the side of the pellet.

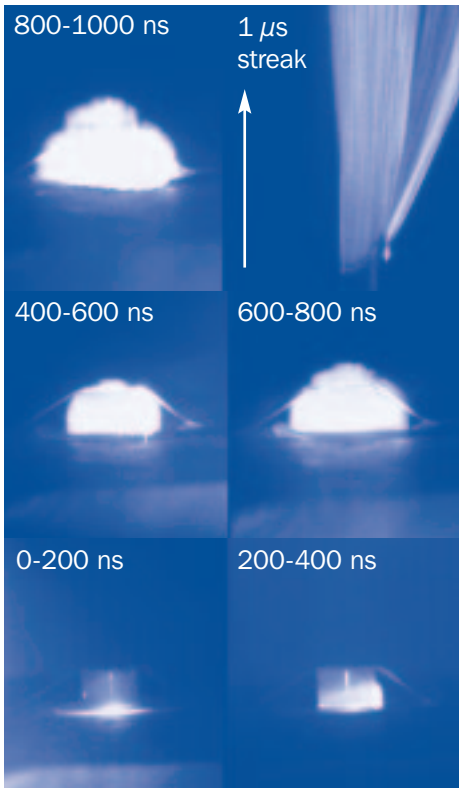

Figure 6: Five framing pictures and one streak picture of a detonating HNS IV pellet (5x5 mm).

Numerical simulations have been performed to see if existing model are able to explain the initiation behaviour of HNS IV with flyer impact.

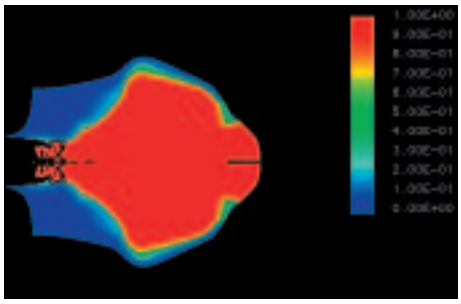

Figure 7: Numerical simulations of the impact initiation by flyer impact.

A number of candidate explosives have been investigated on there sensitivity to flyer impact. The impact energy can be varied by the velocity and the the thickness of the flyerplate. Impact pressure is a function of the flyer velocity. It appears that every explosive has a minimum in the specific energy to detonation.

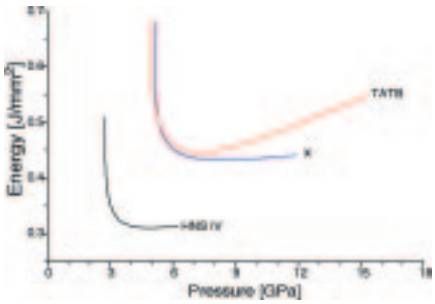

Figure 8: Comparison of the energy to detonation as a function of the applied pressure for the different explosives.

Conclusion

By optimisation of the capacitor discharge circuit, the parameters of the exploding foil and the explosive, the different components can be integrated to give the possibility of constructing the EFI with MEMS technology. This will result in a much cheaper, yet reliable EFI.

TNO Defence, Security and Safety

'TNO Defence, Security and Safety' is the title under which TNO operates as a strategic partner for the Dutch Ministry of Defence and makes innovative contributions to enhancing the security of the Netherlands both at home and abroad. We also use our accumulated knowledge for foreign governments and for defence-related industries.

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