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SOFT RECOVERY OF LARGE CALIBRE FLYING PROCESSORS

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A topic of prime interest is the barrel/projectile interaction during acceleration inside the barrel, in the muzzle brake region and at shot exit. To verify theoretical calculations special projectiles instrumented with flying processors were developed at SW Thun. Such an instrumented projectile contains 3 acceleration gauges up to 100 000 Gs as well as a processing unit and memory boards. Since firing tests have to take place in 200 and 500 m long underground firing tunnels a conventional data telemetry is not feasible.
This paper describes the experiences of the SW Thun with the development of special measuring projectiles (calibre 120/140 mm) and the appropriate recovery technique.

INTRODUCTION

A topic of prime interest is the barrel/projectile interaction during acceleration inside the barrel, in the muzzle brake region and at shot. One specific parameter is the barrel curvature with its influence on transverse accelerations. There is many theoretical work available to this subject [1]. To verify theoretical calculations, rounds instrumented with flying processors and acceleration gauges are used.

The main problem consists of collecting the recorded data. One possibility is to transfer the data by radio after the projectile has left the muzzle. Another procedure is to shoot over a plough field, a lake or the sea where the decelerations are low enough (<200 G) to keep the projectile's integrity. All these techniques require long range firings (>5000 m). Other work describes the soft recovery of high velocity projectiles in materials of increasing density [5].

Since firing tests have to take place in 200 and 500 m long underground firing facilities [4] all these procedures were not feasible. Additional the recovery system has to be cost effective and simply to dismantle (no permanent installation possible).

DEVELOPPMENT OF TIIE SOFT RECOVERY TECHNIQUE

Soft Recovery System

In the early nineties some preliminary work was done at Thun by DPA FA26 [2] for recovering projectiles of different calibres and weapon types in a water tank. The findings were that beyond impact velocities of about 600 m/s all projectiles suffer from heavy damage. A “softer” material with a lower density than water was found with granules from recycled tires. These granules have a size of about 5 to 8 millimeters and a bulk density of about 500 kg/m^3 when filled into a container. SW Thun produces artificial bullet traps for outdoor shooting facilities (300 m rifle firing ranges) which successfully use these granules for stopping the projectiles.

First recovery tests with a 1/3 model of the flying processor launched with a 38 mm research gun (v_0 = 1200 m/s) was successful and proved that there is no danger of a fire. The analysis from a high speed camera showed that the granules act more like a fluid than a solid state. Fig. 1 shows the 1/3 scale recovery box after a test firing; Fig. 2 shows a scale model of the projectile (made by SM Thun).

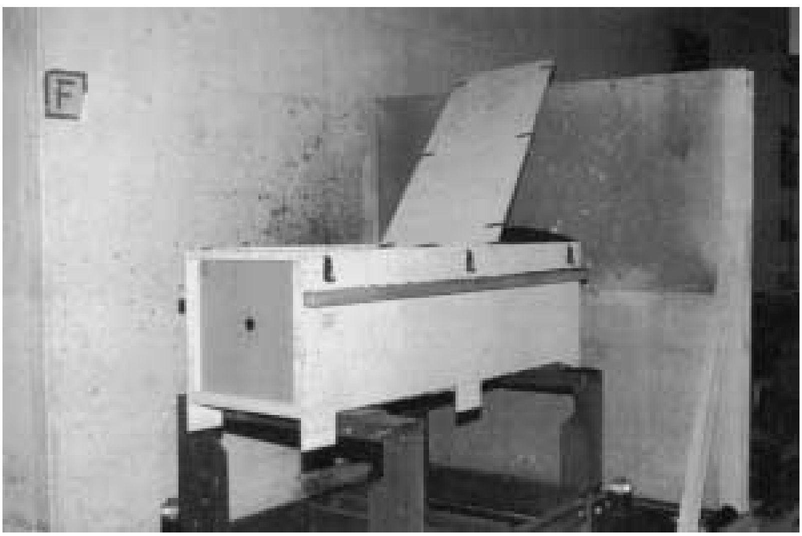


Figure 1.

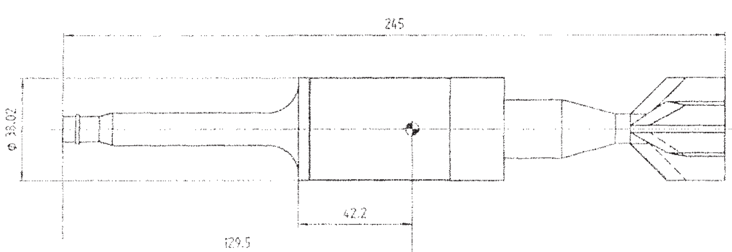


Figure 2.

The recovery system for the large calibre firings use two standard 20 ft containers which are coupled together and filled with about 30 tons of rubber granules (Fig. 3 and Fig. 4). The impact zone is closed with a thick plate of Airex™ foam. Airex™ is very tough and can be used several times because it does not break due the impact of the projectile (only a hole with the projectile's diameter).

The tests with the 38 mm research gun showed that there is a need for some wave brakers in the first container. The containers are open at the top to prevent deformation caused by the shock wave at impact.

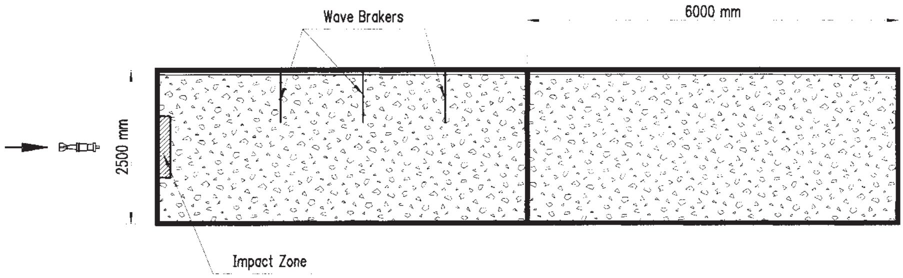


Figure 3.

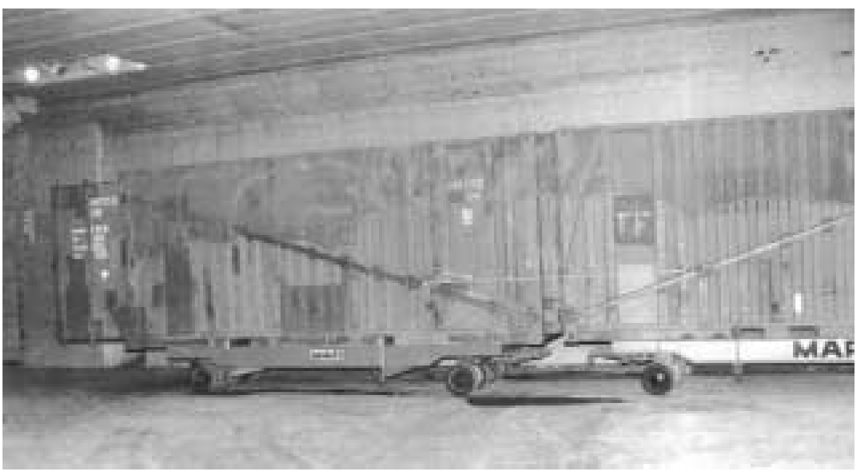


Figure 4.

The system works very well and is easy to handle. For filling the containers and searching for the projectile a standard industrial device for pumping bulk material is used.

This soft recovery technique is only applicable for fin-stabilised projectile. A test with a spin stabilised 155 mm artillery shell showed the predicted instability inside the containers which led to lot of damage.

Projectile Design

The projectile was developed together with Swiss DPA FA26 [2, 3] who contributes the measuring technique and the flying processor. The first projectile was a simple driled-out slug for a 140 mm KE round. This calibre was chosen because it offers more constructive space and because of the availability of very slender research barrels up to L75 (10.5 meters). The first firing test showed rapidly that the aluminum body with the long steel spike (Fig. 5) fails at impact and destroyes the electronic unit.

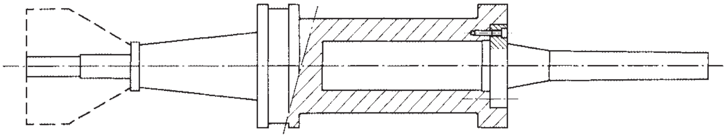


Figure 5.

A projectile of similar design with an strengthened body did not show positive results. The solution was a new design with a steel body (Fig. 6). The main drawback is the increased weight of about 20 kilograms which is now near a multi-purpose round and no more near a KE round.

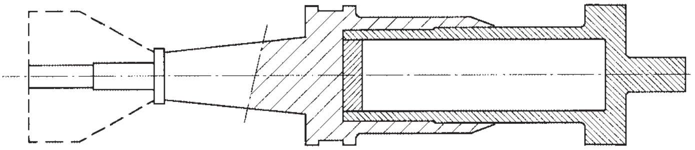


Figure 6.

This version was launched with muzzle velocities of 800 to 900 m/s and recovered successfully a dozen times. The free flight is very stable, with a good precision. The high aerodynamic drag remarkably reduces the velocity of about 200 m/s over the flight distance of 200 meters. Fig. 7 shows a recovered projectile with just no damage.

The path through the rubber granulate is very straight and stable, too. The transversal dispersion is about 0.5 meters from the line of sight. The stopping distance is about eight meters long, for the velocities mentioned above.

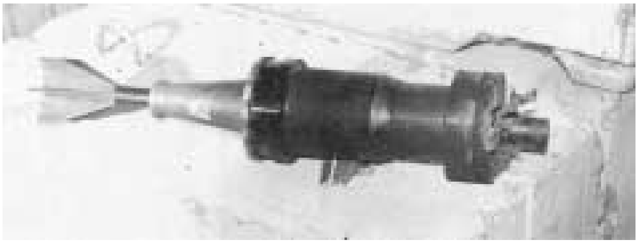
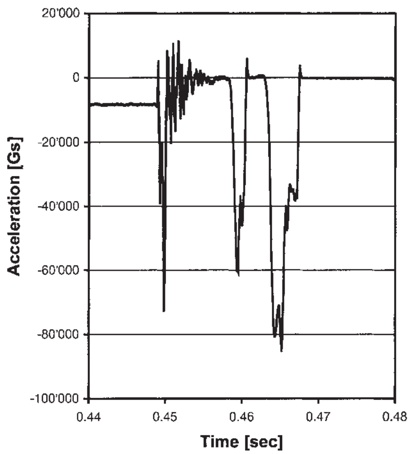


Figure 7.

The main drawback of this design is the high impact decelerations up to 80000 Gs (Fig. 8). These high impact forces led sometimes to failures of the flying processor unit. The improved design has a better aerodynamic shape and is stabilized with deployable fins (Fig. 10). Even with a higher impact velocity than its predecessors (less drag) this design reduced the impact loads down to about 6000 Gs, less than one tenth of the former values (Fig. 9).

Unfortunately this design is not stable inside the rubber granulate which caused heavy damage to the containers. The main reason is probably the loss of the fins during impact. Because this design is far more expensive too, a new approach was searched. The idea is a new nose which combines the benefits of both earlier designs: reasonable costs, stable flight, low impact forces.

The new nose (Fig. 11) is a combinanon of the designs showed in Fig. 6 and Fig. 10. This projectile flew successfully in the 140 mm version. The first transition to 120 mm was not stable, yet.



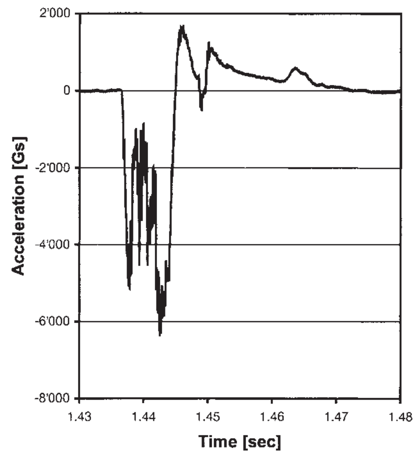


Figure 8.

Figure 9.

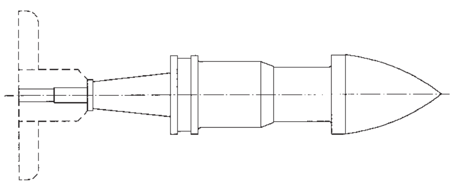


Figure 10.

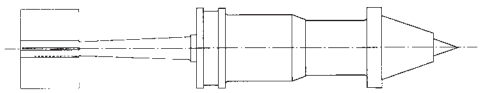


Figure 11.

CONCLUSIONS AND FUTURE WORK

The selection of rubber granules as recovering media has proved to be very successfully in many firing tests as a simple and cheap solution. The developed projectiles are robust enough to withstand the impact loads and to protect the flying processor.

There is some future work to do in designing a stable and cheap projectile which reduces the loads on the onboard electronics. One way is a new nose design, another the integration of some kind of "crash box" inside.

The planned future test programs will be a comparison of different 120 mm tank barrels.

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