

MULTIPLE EFFECTS WARHEADS FOR DEFEAT OF URBAN STRUCTURES AND ARMOUR

A. J. Whelan¹

QinetiQ, Fort Halstead, Sevenoaks, Kent TN14 7BP, England, UK

The requirement to quickly move from combat in the open battlefield to urban environments is a challenge that necessitates the use of several different weapons, especially if a wide target spectrum is to be engaged. A Multiple Effect Weapon removes the necessity to carry several weapon types during extended conflicts, and in some cases expensive platforms such as fast jets may not be required. QinetiQ has been carrying out research into Multiple Effect Weapons, enabling the attack of hard armour, medium/light armour and domestic/municipal structures, this research has been carried out with the use of insensitive explosive compositions. QinetiQ has demonstrated through modelling and live trials that it is possible to maintain the required level of performance against the wider target set within crew portable system constraints - whilst not using exotic materials – with a single warhead system. Modelling demonstrated that a multi-effects warhead arrangement could successfully address the attack of hard armour, medium/light armour and domestic/municipal structures from a single weapon system.

INTRODUCTION

As part of a MEW (Multiple Effects Weapons) programme conducted on behalf of the UK M.o.D. (Ministry of Defence), QinetiQ has been carrying out research into the attack of armour and domestic structures. This research has been carried with the aim of developing MEW systems. Such a system would be capable of defeating, heavy armour through to concrete structures built with double steel reinforcement.

INITIAL MEW WORK

The use of a tandem emplacement warhead system was researched in great depth in the UAW (Urban Assault Weapon) programme [1]; the emphasis in this technology development programme was to defeat urban structures and to also provide capability to defeat lightly armoured vehicles, this programme informed M.o.D. on the ASM (Anti-Structures Munition) procurement. The UAW tandem consists of a lightweight precursor BiC (Break in Charge) and a lightweight main warhead which contains a blast explosive, developed by QinetiQ at Fort Halstead. An illustration of the UAW projectile can be seen in Figure 1.

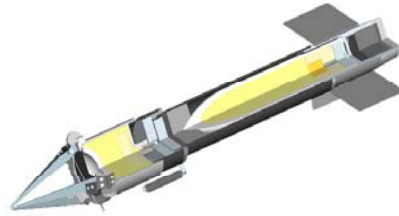


Figure 1; UAW projectile

Although this warhead system enabled defeat of urban structures it did not equip the user with a capability to defeat medium/heavy armour targets, therefore in battle, other weapons would have to be carried to defend against fire from armoured vehicles. This is entirely possible and is true of the current situation for infantry forces; however it does cause issues with logistic loads and it does not make life easy for infantry. A ‘do-it-all’ warhead system with a great deal of utility would reduce logistic loads and enable infantry forces to move without the need to carry more than one type of missile system.

A research programme was carried out to develop warheads that could be integrated into a tandem system. This work focused on peripherally initiated conical lined shaped charges with an FTB (Follow Through Bomb) casing as the warhead body for the main warhead, and compact BiCs (Break in Charges) for the precursor warhead. The precursor warhead was based on an SSJ (Slow Stretching Jet) warhead. The baseline SSJ warhead performed very well at short stand-offs against structural targets, this warhead was initially filled with EDC1s explosive, further research was required to fulfil the current requirements facing most countries, the achievement of type V reaction to IM (Insensitive Munitions) tests. The damage created by the baseline SSJ warhead against armour, and structures targets and can be seen in Figure 2.



Figure 2; Armour and structure targets defeated by copper lined SSJ warhead

The design of the main warhead was based on the high performance ‘D2’ warhead which is a high precision copper lined conical shaped charge warhead which maintains very low off-axis drift velocities in the region of 35 m/s when filled with EDC1s explosive, the ‘D2’ warhead can be seen in Figure 3.

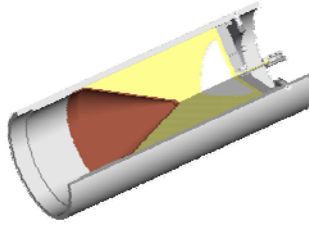


Figure 3; D2 copper lined conical shaped charge

A target set of structural and armour targets were considered for this programme, this is shown in Figure 4. The target set consisted of concrete reinforced with steel bars to the front and rear surfaces of the target, a double skin brick wall reinforced with sandbags and medium to heavily armoured vehicle targets.

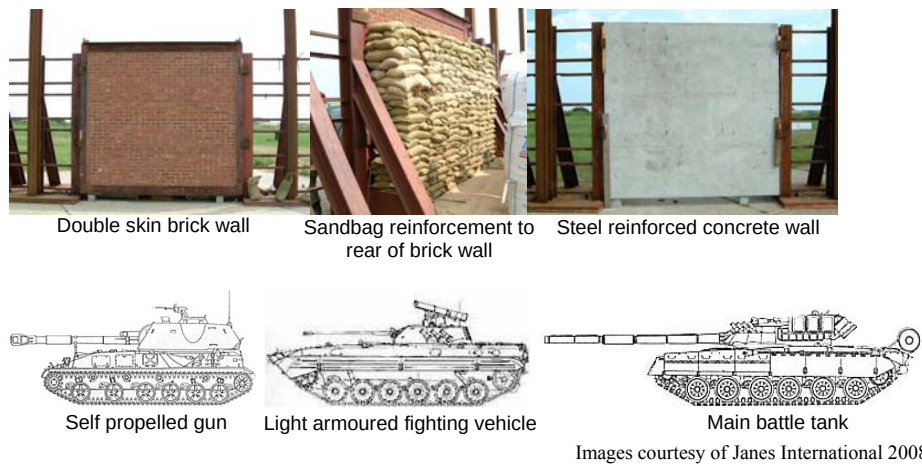


Figure 4; Structural and armour targets

A modelling and trials programme was pursued to observe the effectiveness of the new BiC and FTB/main warhead design against all elements of the target set. A full tandem configuration was not investigated due to time constraints; however a tandem configuration was modelled to observe interaction.

DESIGN STUDY

Performance data of the baseline precursor warhead was used to aid the design process. Before carrying out experimental firings, the warhead concepts were modelled using the GRIM 2-D hydrocode [2] within an axisymmetric Euler mesh. In each model a path dependant material algorithm [3] was used to model the behaviour of the copper jet. The original EDC1s filling was replaced as it was considered to be less IM compliant, a PBX based explosive was used as it was considered to offer advantages with regard to IM. The GRIM hydrocode plots shown in Figure 5 demonstrates that some difference between the baseline design and the new BiC design was observable, although this was expected due to the reduction in CJ pressure in the explosive from $\sim 31\text{GPa}$ to $\sim 29\text{GPa}$ and the reduction in charge mass.

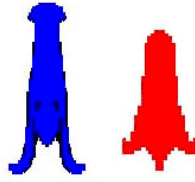


Figure 5; SSJ jet (left) and 'Compact' SSJ jet (right)

This projectile was arrived at following the hydrocode study, the aim of the study was to produce an SSJ projectile that was similar in geometry and velocity to that which the EDC1s filled warhead produced, whilst reducing the warhead mass by approximately 30% to enable eventual exploitation. The SSJ projectile velocity was reduced from the EDC1s filled design by approximately 10%, for this form of warhead, used at such close stand-offs (1CD - 2CD) this drop in velocity is not noticeable. There has been a reduction in length of approximately 18% tip to tail (4% in central portion) and again in this regime the effect on performance should not be noticeable.

The main warhead required an extensive modelling/design study due to the inclusion of an ogive and the replacement of the main filling with a PBX explosive. An ogive was added to the warhead to enable two things, an increased confidence of emplacement into structures at oblique angles, and the removal of a separate inter-charge barrier. The warhead design is shown in Figure 6, it should also be noted that a steel case replaced an aluminium case to provide extra robustness during interaction with the structures targets, the fragmentation effects from the casing would be expected to be greater than that of the aluminium casing.

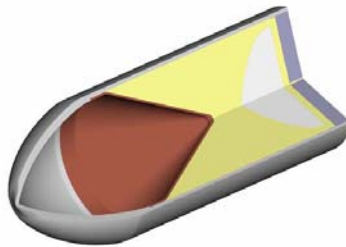


Figure 6; Generic shaped charge FTB

Initial modelling demonstrated that the interaction of the jet with the ogive significantly disrupted jet formation, thereby reducing predicted penetration; this can be seen in Figure 7. Initially a thick ogive with a channel through the apex was thought to offer a compromise between KE (Kinetic Energy) penetration performance and jet formation, however this design compressed gases surrounding the jet, resulting in a severely disrupted jet. To overcome this, the ogive thickness was decreased, the hydrocode predicted that the jet would lose some penetration capability through ogive interaction, but this was small.

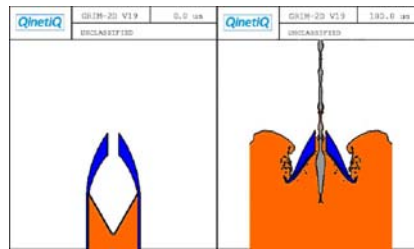


Figure 7; Hydrocode modelling of jet and ogive interaction

To ensure the reduced thickness ogive would remain intact following detonation of the precursor, it was necessary to undertake another hydrocode study to observe damage sustained. An inter-charge distance consistent with in-service ATGWs (Anti-Tank Guided Weapons) was used to ensure that the work would remain relevant. The initial designs failed due to the profile of the ogive, following ten iterations a design that offered very good structural integrity was arrived at, as shown in Figure 8.

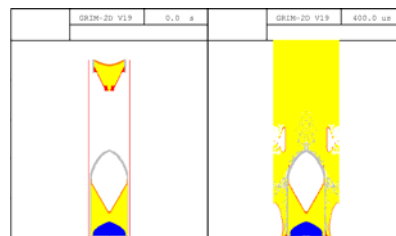


Figure 8; GRIM hydrocode plot of precursor/main charge interaction

FIRING TRIALS

The structural targets were the NATO STANAG 4536 Fortified Domestic and a variant of the STANAG 4536 Municipal target. The results of the trials demonstrated that the precursor warhead had significant capability and could perhaps defeat much tougher targets. The holes produced in the targets allowed the main warhead to pass through the structural targets unimpeded.

The RHA penetration performance of the main warhead was tested. The warhead was fired at various stand-offs to enable comparisons with D2 warhead data, and also to provide information on the possible performance at systems related stand-offs. Flash radiography was used to capture images of the jet as it stretched out, providing vital information on jet geometry and velocity. FXR (Flash X-Ray radiography) analysis permitted observation of the jet, and also enabled jet characterisation to be carried out. The radiographs taken during the trial can be seen in Figure 10.

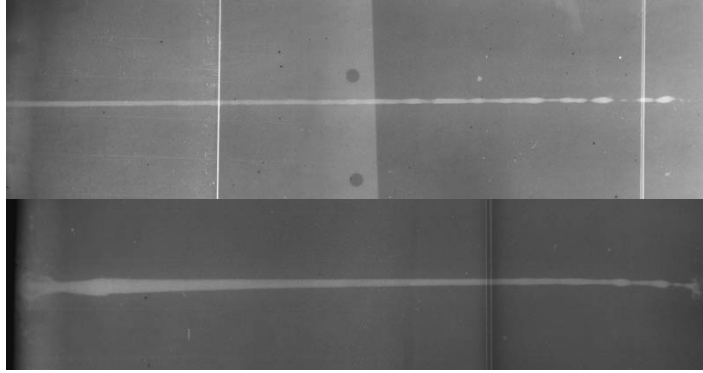


Figure 10; Radiography of two FTB/MC firings, (from top) at 100 μ s, and 170 μ s

From analysis of the target blocks and the radiography, it is evident that curvature in the jet was present. The extent to which the curvature exists can clearly be seen in most of the radiographs. However, although the radiograph for firing six appears normal, following observation of the target blocks it was obvious that there is significant curvature in the plane in which the radiograph was taken. It is also apparent that the tip of the jet is more particulated than would normally be the case; this can be related to the initial formation that occurred inside the nose of the warhead. It is possible that gas trapped in the nose of the warhead has caused an early onset of jet particulation. Although this has not occurred to any great extent, it can be seen in Figure 11 that the particulation is more advanced in the FTB/MC than in the 150mm diameter PBXN-110 filled D2. Even though the magnification factors are slightly different, these images serve as a good indicator that the tip of the jet has been affected by the gaseous confinement in the nose of the warhead body, and also by penetration of the warhead ogive. These effects become more apparent in the >8CD stand-off regime, whereas the main warhead will normally operate in the <4CD stand-off regime when these effects are not prevalent.

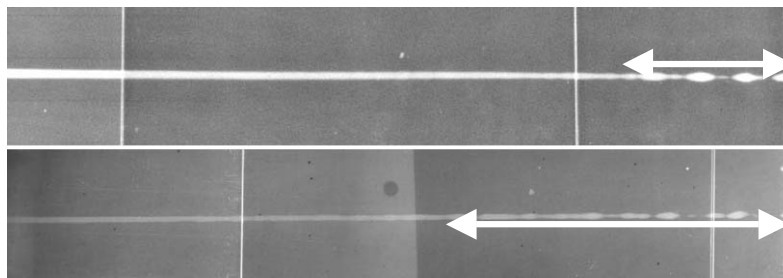


Figure 11; PBXN-110 filled D2 warhead with no ogive (top) PBXN-110 filled FTB/MC (bottom)

The results of the trial are given in Table 1. In comparison to the PBXN-110 filled D2, the penetration performance is reduced.

Warhead #	Stand-off (CD)	Average Penetration Reduction (%)	NOTES
1	8	19	Jet curvature observed, Jet velocity 8.5mm/μs
2	4	N/A	
3	4	N/A	
4	5	N/A	Jet curvature observed on radiography
5	5		Curvature at front of jet, jet tip unusual geometry
6	10	17	Target key-holed, jet particulation appears advanced
7	8	19	Jet curvature observed on radiography
8	8	19	Jet velocity 8.65mm/μs

Table 1; Anti-Armour trial results

There is a large difference in penetration performance between the two warhead types, with the FTB/MC being the worst performer. Jet curvature is the main reason for this performance drop; the jet tip speed has also been reduced from approximately 9mm/μs (PBXN-110 filled D2) to 8.6mm/μs (FTB/MC).

CONCLUSION

A hydrocode modelling study and live firing trials have demonstrated that the BiC can maintain the required level of performance against structural and armour targets even with the inclusion of a lower powered explosive and reduced mass.

A hydrocode modelling study and the live firing trials have demonstrated that the FTB/MC can produce a shaped charge jet capable of penetrating thick RHA targets; however the inclusion of a rubbery PBX fill has caused some asymmetry in jet formation.

The hydrocode modelling study has indicated that the tandem system will operate correctly without the need for an extra inter-charge barrier.

ACKNOWLEDGMENTS

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References

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