Damage response of stationary and moving targets to ballistic impact

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Abstract. The present work outlines results of ballistic impact experiments and hydrocode modelling for aluminium and composite target panels. The present work focuses on the aluminium targets. The tests have been conducted using a gas gun with anti-rotation barrel which allows the authors to simulate conditions of stationary and moving targets. The damage patterns obtained in the targets agree with the absorbed energy calculated from the impact and residual velocities which are obtained by high-speed photography. The projectiles were represented by 12.7mm calibre inert ball projectiles. The CTH modelling results confirm the robustness of the set-up and correlation of the damage patterns with those obtained in the experiments.

Introduction

The moving target approximation against fixed targets was first considered in [1] and discussed in [2]. However, the moving target condition considered in [1] was created by tumbling of a projectile. Therefore, a rotating momentum distorted the moving target scenario. Moving targets at relatively low target velocities with respect to the impact velocity have been directly tested in [3]. The present work eliminates the tumbling effects by direct impact of a saboted projectile at 20 degrees against an angled target, thus, simulating the moving target at a high relative velocity and with minimised tumbling at the point of projectile target interaction.

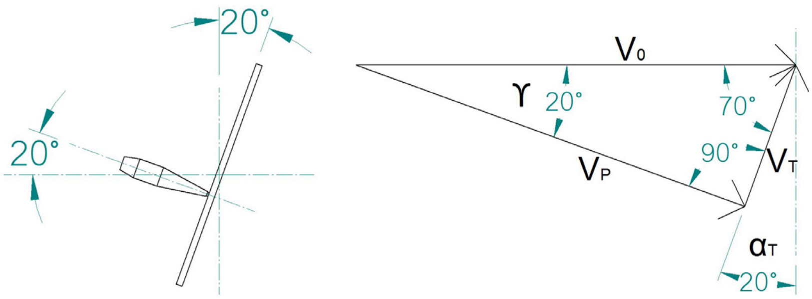

Figure 1. The incidence schematic (left) and corresponding velocity diagram (right) with the projectile positioned along the V_P-line and the target positioned along the V_T-line. The projectile in sabot has initial velocity V_0 and the present scenario simulates impact against a target moving with the velocity V_T calculated from the diagram.

Experimental results

The experiments have been conducted for various conditions of impact incidence including variations in the vertical alignment of target (angle α in Fig. 1) and initial the angle of inclination of the bullet to the line of firing before (γ_0) and after (γ_R) impact. V_R is the residual velocity of projectile in meters per second.

Table 1: Test data for 6061-T6 Aluminium targets.

Shot	α (o)	γ_0 (o)	γ_R (o)	V_0	V_R	V_T	V_P	V_{50}
40	0	-	0.6	384.2	340.5	-	-	178
46	20	19.2	46	372	290.9	122.3	349.6	231.9
57	10	21.25	24.63	369.5	306.6	135.5	371.0	206.22
55	20	20.77	36.87	381	284	135.1	358.1	253.98
56	20	20.85	35.53	373.1	289.4	132.8	350.6	235.48
54	30	22.24	49.94	355	254.3	135.6	310.3	247.7
63	30	20.9	-	362.5	-	131	317.9	-
56	30	19.24	47.82	372.1	257.6	124.8	328	268.5

The results demonstrate an increase in damage associated with the V_{50} calculated from the energy conservation law with the increase of α for the moving target scenario of impact.

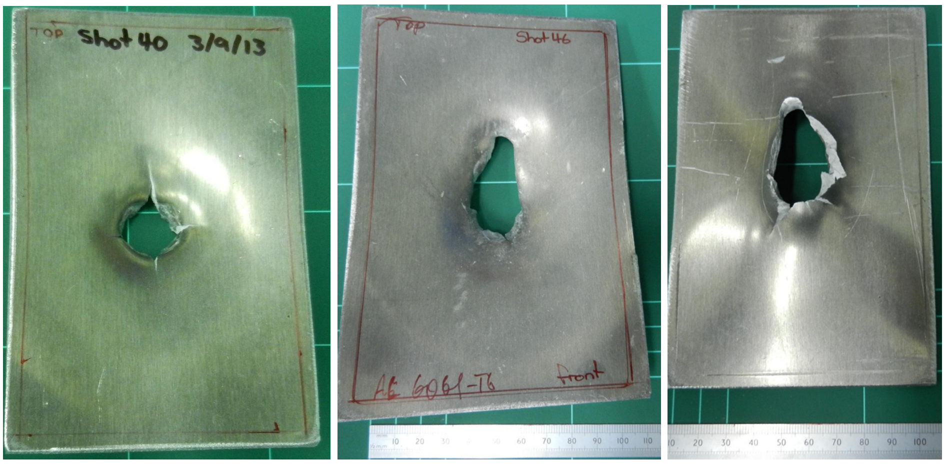

Figure 2. The damage patterns of aluminium targets at normal impact against a stationary target (left photograph) and at normal impact against a moving target (front and rear views).

The increased damage is obvious from observations of the recovered post-impact targets, as shown in Fig. 2. for tests 40 and 46.

Modelling

The modelling results, conducted with the Sandia Laboratories hydrocode CTH [4], is shown in Fig. 3 for the moving target scenario.

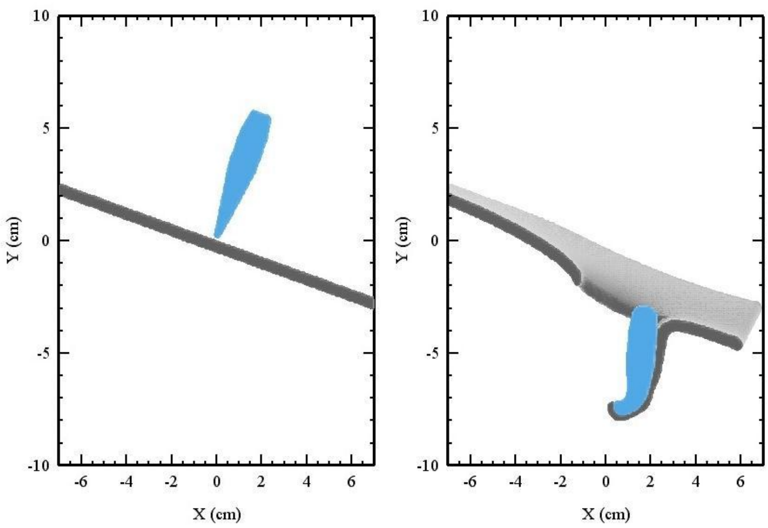

Figure 3. The CTH modelling results simulating the experimental moving target scenario (set-up, left, and the projectile-damage snapshot at 50 msec after impact). The damage pattern of the target agrees with the experimental observation in Fig. 2.

Conclusion

A test methodology has been established for experimental simulation of stationary and moving targets subject to high-velocity projectiles. This methodology allowed us to achieve realistic target velocities and avoid any projectile tumbling before the projectile-target interaction. The damage patterns correlate well with the absorbed energy calculated from the ballistic limit velocity. The modelling results demonstrate a reasonable agreement of the target damage with that observed in the experiment.

References

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