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Effect of firing conditions & release height on terminal performance of submunitions and conditions for optimum height of release

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ABSTRACT

Submunitions should exhibit optimum terminal performance at target end when released from certain pre-determined height. Selection of an optimum height of release of the submunitions depends on the terminal parameters like forward throw, remaining velocity, impact angle and flight time. In this paper, the effects of initial firing conditions and height of release on terminal performance of submunitions discussed in detail. For different height of release, the relation between range and forward throw is also established & validated for a number of firing altitude and rocket configurations.

1. Introduction

The family of scatter-able submunitions adds new dimension to the munition warfare. Submunitions can force the enemy in kill zones, change their direction of attack and spend time in clearing/breeching operation. Submunitions have always played a major role in denying battlefield & obstacle in mobility to armed forces and very effective to provide tactical advantage to the commander in the field. To gain tactical advantage, the submunition fields have to be pre-selected and laid. Laying of submunition fields manually is a time consuming and manpower intensive operation. An artillery rocket with Dual Purpose Improvised Conventional Munition (DPICM) warhead contains around 220 submunitions. The rocket with DPICM warhead follows the same ballistic trajectory similar to the rocket with a conventional high explosive warhead upto a predetermined height wherein it an electronic-time fuze is initiated to release the submunitions. An ejection mechanism eject submunitions from the warhead. A complete salvo firing of such rockets can lay around 2600 submunitions in the target area, in less than a minute. This provides high maneuverability with rapid, flexible means of delaying, harassing, paralyzing, canalizing or wearing down the enemy forces in both offensive and defensive operations [1,2].

Except for a very short duration after release, the submunition follows a steep trajectory until it reaches the designated target or ground. The trajectory of submunitions mainly depends on height, velocity and the flight path angle of the rocket at the point of release. Further, it also depends on the shape, size, mass, ejection velocity of the submunition, the aerodynamics of parachute, firing altitude and prevailing meteorological conditions [3,4].

The submunition trajectory will not be exactly vertical from burst point. The submunition will move forward due to the release velocity, release angle and ejection velocity. This additional travel in down range of the submunition is called the forward throw (see Fig. 1). The forward throw of the submunitions is an essential parameter while computing the fire parameters using either Firing Tables or Fire Prediction Software. This paper describes the effect of height of release, firing altitude and rocket configuration on the

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terminal parameters like impact velocity, impact angle, flight time and forward throw of the submunition at different map range. Achievable minimum and maximum ranges, near vertical impact angle, minimum impact velocity and time of flight are the parameters which govern the selection of an optimum height of release of the submunitions. This paper establishes the relation of forward throw with ranges for given rocket configuration, firing altitude and optimum height of release.

2. Simulation matrix

A six degree of freedom (6-DOF) Trajectory Model used to simulate the rocket trajectory from launch to height of release (HoR) and a Point Mass (PM) Trajectory Model used to simulate the trajectory of a single submunition from the point of its release from the rocket, at a given release height to the target/ground impact. 6 DOF trajectory model computes positions and velocities of the rocket up to given height of release which serves as initial conditions to PM along with ejection conditions and aerodynamics of submunitions. The point mass model simulates the trajectory of a submunition and forward throw and impact parameters of submunition are computed (see Fig. 2).

The simulation of submunition trajectory is carried out for following different cases and their combinations, as discussed in the subsequent paragraphs:

2.1. Height of release

Height of release of the submunitions is a crucial parameter determining the proper functioning of the submunition at an impact. The following six heights of release are selected for the study.

(a) 250 m.
(b) 500 m.
(c) 750 m.
(d) 1000 m.
(e) 1250 m.
(f) 1500 m.

2.2. Firing altitude

The following firing altitudes for both launcher and the target are considered for simulation to take into account of the meteorological effects.

(a) 0 m (Mean Sea Level - MSL).
(b) 2000m.
(c) 4000 m.
(d) 6000 m.

2.3. Effect of braking ring

Effect of two types of braking rings small and big, on the terminal performance of the submunitions is studied at different ranges along with rocket without any braking ring. A brake ring is a simple metallic annular ring attached to the ogive nose of the rocket to increase the drag that reduces the range to achieve steeper angle of descent.

3. Submunition trajectory inputs

The rocket is fired from a launcher and at a pre-designated height, the fuze initiates the warhead wherein the warhead casing splits into three petals with the help of a flexible linear shaped charge (FLSC) system. The submunitions are also given an initial ejection velocity with the help of an ejection mechanism, further aided by rocket's roll. After ejection, the ribbon attached to the submunition gets deployed which causes substantial reduction in the velocity of submunition, and further helps in attaining a steady state velocity.

3.1. Physical & initial inputs

Various inputs and initial conditions of submunition considered for the simulation are given below:

a) Mass = 0.23 kg.
b) Diameter = 25 mm.
c) Length = 50 mm.
d) Stabilization Mechanism = Ribbon.
e) Ejection Velocity in Lateral direction = 4 m/s.
f) Ejection Velocity in Forward direction = 50 m/s.

It is assumed that ejection velocities are constants at all release conditions (see Fig. 3).

3.2. Other inputs

Other inputs that play a significant role in the submunition trajectory are trajectory elements computed by 6-DOF of the rocket at desired height of release and ejection velocity. The C_D-Mach profile of DPICM with ribbon is shown in Fig. 4. All simulations were carried out under ICAO Std. Meteorological conditions. The summary of the input conditions given in Table 1.

4. Analysis of input to submunition trajectory from 6-DOF

The artillery rocket considered for this study can be fired in three different configurations i.e., without brake ring (WBR), with small brake ring (SBR) and with big brake ring (BBR) to achieve optimal angle of impact.

The remaining velocity of rocket at predetermined height of release of submunitions for mean sea level conditions and at high altitude conditions are shown in Figs. 5 and 6. The average rocket velocity at the time it releases the submunitions is ~350 m/s at sea level, for ranges between 20 km and 40 km. At high altitude conditions, the average rocket velocity at release is ~500 m/s for ranges between 40 km and 70 km.

5. Simulation results

The submunition trajectory is terminated as it reaches the firing altitude at the target end. The trajectory chart of submunitions, impact velocity, impact angle and time flight of submunition for different conditions are discussed in subsequent sections.

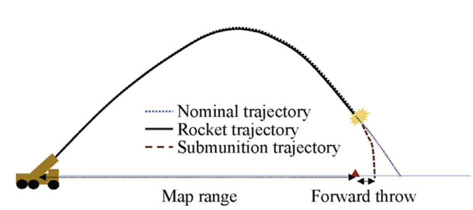

Fig. 1. Sketch of flight trajectory of a rocket with munition warhead.